Sovereign Risk and Dutch Disease ⋆

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Abstract

I study how, in the presence of default risk, the Dutch disease amplifies an inefficiency in the sectoral allocation of capital. In a sovereign default model with commodities and production of traded and non-traded goods, default incentives increase when more capital is allocated to non-traded production. Households do not internalize this, giving rise to an inefficiently large non-traded sector. Commodity income amplifies this inefficiency through the classic Dutch disease mechanism. I characterize state-contingent subsidies that implement the efficient allocation and compare them to simpler subsidy rules that ameliorate the externality. Evidence from spreads, natural-resource rents, and sectoral investment data support the main findings of the model.

Keywords: Sovereign default, Dutch disease, Real exchange rates

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1. Introduction

There is a large literature on the effects that the Dutch disease has on economic growth, which inspired the concept of "natural resource course" coined

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by Auty (1993).[1] The relation between the Dutch disease and sovereign default risk, however, has been less studied. This paper shows how, in the presence of default risk, the Dutch disease amplifies an inefficiency in the sectoral allocation of capital that directly affects default incentives and the borrowing terms that governments face.

I develop a quantitative sovereign default model with production in traded and non-traded sectors, and income from commodity exports. Households have preferences for consumption of a composite aggregate of the traded and non-traded goods, own all the firms and capital in the economy, and receive an endowment of a tradable commodity. The government borrows on behalf of the households, who lack access to international financial markets, by issuing non-contingent defaultable debt denominated in terms of the traded good. The stock of capital is fixed and can be freely allocated into the two productive sectors, but this allocation must be chosen one period in advance. Households fail to internalize how this dynamic choice affects future default incentives and, through these, present borrowing costs for the economy.

In this environment, default incentives are increasing in the share of capital allocated in the non-traded sector. In a competitive equilibrium households' choices equate the expected return of capital in both sectors. In the presence of default risk this allocation is inefficient as households over-invest in the non-traded sector relative to what a benevolent centralized planner would choose. This is because more capital in the traded sector—relative to capital in the non-traded sector—reduces default risk and allows the government to borrow more under better terms. This is the "portfolio externality" studied by Esquivel (2024b). The availability of commodity income as an additional source of resources to finance consumption of the traded good has the classic "Dutch disease" effect of shifting production factors away from the traded sector, which amplifies the portfolio externality.

[1] Sachs and Warner (1995) document that countries with large natural resource wealth grow more slowly.

The severity of the disagreement between households and the government is proportional to both the desired borrowing level and to how sensitive default incentives are to the investment portfolio. A commodity windfall increases borrowing in order to smooth consumption and shifts capital from the traded to the non-traded sector, which is supported by an appreciation of the real exchange rate. This Dutch disease effect amplifies the sectoral misallocation of capital, which results in higher default risk. This is the "disease" part of the Dutch disease in this environment.

The model is calibrated to Ecuador, which is a small-open economy subject to default risk in which commodity exports are a significant share of GDP. I compute the state-contingent subsidies to the share of capital in the traded sector that implement the efficient allocation as a competitive equilibrium. These are countercyclical and positively correlated with spreads, which highlights how the inefficiency is amplified in periods of distress. Compared to those from an economy with no commodity income these subsidies are larger, more volatile, and yield higher welfare gains. Implementing the efficient allocation is difficult in practice because computing the subsidies requires knowing the state of the economy and the price schedule that the planner would face. I instead consider a fixed subsidy rule financed by lump-sum transfers. The best of these subsidies yields roughly half of the welfare gains attained by the optimal state-contingent subsidy.

Finally, I present evidence for a panel of countries of the main mechanisms in the model: (i) "resource-rich" economies face higher default risk, which is reflected in higher interest rate spreads; (ii) income from natural resources shifts investment away from the manufacturing sector; and (iii) policies that depreciate the real exchange rate—such as the accumulation of international reserves—dampen the inefficient reallocation highlighted in the model.

Related literature.—This paper is related to the strand of literature that studies the Dutch disease and its relation to production and real exchange rates. Corden and Neary (1982) developed the benchmark model to analyze the reallocation of production factors and the process of de-industrialization. More recently, Benigno and Fornaro (2013) present a model that features episodes of abundant access to foreign capital coupled with weak productivity growth. They show that periods of large capital inflows, triggered by a fall in the interest rate, may result in inefficient outcomes in the presence of productivity externalities in the tradable sector. Alberola and Benigno (2017) study an environment in which the Dutch disease delays a commodity exporter's convergence to the world technological frontier because of the presence of an externality in dynamic productivity gains in the manufacturing sector. Benguria, Saffie and Urzua (2021) study how commodity price super-cycles affect the economy through the (sticky) reallocation of labor. They find that models in which commodity output is an endowment only account for 45 percent of the intersectoral labor reallocation between traded and non-traded sectors. These findings suggest that the results below may be conservative because a richer model with production of commodities would induce an even bigger reallocation out of the traded sector.

This paper is also related to the literature that studies sovereign default risk and its relation to the production structure of the economy and commodity exports. Arellano, Bai and Mihalache (2018) document how sovereign debt crises have disproportionately negative effects on non-traded sectors. They develop a model with capital, production in two sectors, and one period debt. The model in Section 2 builds on theirs with two key differences: exogenous commodity income and decentralized capital allocations, which are inefficient in equilibrium in the presence of default risk. Related to the latter, Esquivel (2024b) derives the general conditions under which an increase in the stock of capital lowers default incentives and a reallocation of capital from traded to non-traded production increases them. Hamann, Mendoza and Restrepo-Echavarria (2023) study the relation between oil exports, proved oil reserves, and sovereign risk. They document that sovereign risk is lower when oil production increases, but higher when reserves increase. Similarly, Esquivel (2024a) documents that sovereign interest rate spreads increase substantially following news of giant oil field discoveries. Both of these papers also develop models in which a benevolent government makes all production and borrowing decisions in a centralized fashion.

In a recent paper, Galli (2021) studies an environment with fiscal policy and private capital accumulation. In his environment, multiple equilibria exist where the expectations of lenders are self-fulfilling. In the bad equilibrium, pessimistic beliefs about investment make borrowing more costly. The government responds by increasing taxation, which depresses investment and makes these beliefs self-fulfilling. There are two key differences between his paper and this. First, multiplicity of equilibria is central to his analysis, while for this paper what is central is the pecuniary externality from the sectoral allocation of capital, which can be studied more clearly in an environment with a unique equilibrium. Second, he focuses on how borrowing terms depend on the absolute level of capital, while in this paper I highlight their relation to the sectoral allocation of capital. To make this point clearer, I fix the level of capital to turn the focus to the role of its sectoral allocation.

Layout.—Section 2 presents the model and the theoretical analysis, Section 3 describes the calibration and presents the quantitative results, Section 4 presents the empirical analysis, and Section 5 concludes.

2. Model

The model falls into the class of models that follow Eaton and Gersovitz (1981) with production in two sectors (a traded and a non-traded one) and commodities. I build on the work by Arellano, Bai and Mihalache (2018) with two key distinctions: the economy receives a commodity endowment and capital allocations are chosen by the households. Income from commodity exports diverts capital from the traded into the non-traded sector. In this environment, the Dutch disease is, in fact, a “disease” because default incentives—and thus, borrowing costs—are affected by the sectoral allocation of capital. This is not internalized by the households, giving rise to a pecuniary externality that is more severe when commodity income is higher.

2.1. Environment

There is a small open economy with a measure one of identical households, competitive firms, and a benevolent government. Households own all the firms and capital in the economy, as well as an endowment of a tradable commodity. They choose capital allocations but lack access to international financial markets. The benevolent government borrows on behalf of the households by issuing non-contingent debt and cannot commit to repay it.

Technology.—There is a final non-traded good that is used for consumption and investment. It is produced by a competitive firm with technology

$$Y\left(c_{N,t}, c_{T,t}\right) = \left[\omega^{\frac{1}{\eta}} c_{N,t}^{\frac{\eta-1}{\eta}} + (1-\omega)^{\frac{1}{\eta}} c_{T,t}^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}}, \tag{1}$$

where $\eta > 0$ is the elasticity of substitution, $\omega \in (0,1)$, and $c_{T,t}$ and $c_{N,t}$ are intermediate traded and non-traded goods, respectively. All prices are expressed in terms of the traded intermediate, so from the firm's maximization problem we get that the relative price of the non-traded intermediate is

$$p_{N,t} = \left(\frac{\omega}{1-\omega}\frac{c_{T,t}}{c_{N,t}}\right)^{\frac{1}{\eta}}, \tag{2}$$

and the price of the final good is

$$P_t = \left[\omega\left(p_{N,t}\right)^{1-\eta} + (1-\omega)\right]^{\frac{1}{1-\eta}}. \tag{3}$$

The intermediate goods are produced by competitive firms using technologies $y_{T,t} = z_t K_{T,t}^{\alpha_T}$ and $y_{N,t} = z_t K_{N,t}^{\alpha_N}$; where $\alpha_T, \alpha_N \in (0,1)$, z_t is a common productivity shock, and $K_{T,t}$ and $K_{N,t}$ are the amounts of capital rented by each firm. From the firms' profit maximization problems we get that the rental rates of each type of capital are $r_{T,t} = \alpha_T z_t K_{T,t}^{\alpha_T - 1}$ and $r_{N,t} = p_{N,t}\alpha_N z_t K_{N,t}^{\alpha_N - 1}$. Productivity follows an AR(1) process $z_t = \rho_z \log z_{t-1} + \epsilon_t$ with $\epsilon_t \sim N\left(0, \sigma_z^2\right)$.

Commodities.—The economy receives in each period an endowment of a perishable commodity y_C which can be sold in international markets for a price $p_{C,t}$. The endowment is the same in every period, which reflects the economy's capacity to export commodities. Its price takes two values $p_{C,t} \in \{p_{C,L}, p_{C,H}\}$ and follows a Markov chain with transition probabilities $\pi_{ij},\ i,j \in \{L,H\}$. Income from commodity exports serves as an alternative source to finance tradable consumption. This drives a reallocation of capital away from the tradable sector and amplifies the pecuniary externality that this sectoral allocation has on default risk.[2]

Households.—A representative household has preferences for streams of consumption of the final good represented by $\mathbb{E}_0\left[\sum_{t=0}^{\infty}\beta^t\frac{c_t^{1-\sigma}}{1-\sigma}\right]$ where $\beta \in (0,1)$ is the discount factor and $\sigma > 0$. Each household owns a fixed stock of capital $\bar{k}$ which does not depreciate and cannot be increased or sold. Households choose how much capital to rent to each of the productive sectors but must do so one period in advance. Let λ_t denote the share of $\bar{k}$ allocated by a representative household to the traded sector T in period $t-1$; then $k_{N,t} = (1-\lambda_t)\,\bar{k}$. This simplifying assumption allows the model to focus on the dynamic inefficiency that arises from the sectoral allocation of capital while only adding one state variable (the capital allocation λ_t).

Households own all the firms and the endowment of the commodity. The budget constraint at time t of a representative household is:

$$P_t c_t \leq \left[(1-\lambda_t)\,r_{N,t} + \lambda_t r_{T,t}\right]\bar{k} + p_{C,t}y_C + \Pi_t + G_t \tag{4}$$

where P_t is the price of the final good, $r_{h,t}$ is the rental rate of capital $h \in \{N,T\}$, Π_t are profits from all the firms in the economy and G_t is a lump-sum transfer from the government.

Government debt and default.—The government issues short-term bonds

[2]The model abstracts from the strategic exploitation of natural resources and their interaction with default risk. Esquivel (2024a) and Hamann, Mendoza and Restrepo-Echavarria (2023) do an exhaustive analysis of these interactions in environments with centralized production. In their models, the distinctive feature of the commodity sector is the presence of natural resources as an additional production factor, which is simplified here by the fixed endowment.

and lacks commitment to repay. Bonds are denominated in terms of the tradable good and are purchased by risk-neutral international lenders who have access to a risk-free bond with an interest rate of r^*. The government's budget constraint is:

$$G_t = q_t B_{t+1} - B_t \tag{5}$$

where q_t is the market price of the government debt. Note how this formulation is isomorphic to one in which the government owns the commodity endowment. In that case, $p_{C,t}y_C$ would appear on the right-hand-side of the government's budget constraint and would then be transferred in a lump-sum fashion to the households.[3]

The government takes the price schedule q as given, as well as the behavior of households and firms. If the government defaults then productivity is $z_D(z) = z - \max\left\{0, \psi_0 z + \psi_1 z^2\right\}$, with $\psi_0 < 0 < \psi_1$, and the government gets excluded from financial markets for a random number of periods. The government gets readmitted with probability θ and all debt forgiven.

Timing within a period.—At the beginning of a period the productivity shock is realized. The government then observes the shock, the aggregate allocation of capital $K_{N,t} = (1 - \Lambda_t)\bar{k}$ and $K_{T,t} = \Lambda_t \bar{k}$ (where $\Lambda_t = \int_0^1 \lambda_t di$ aggregates over all households $i \in [0, 1]$), and the current stock of debt B_t and decides whether to default or not. If the government does not default then it decides how much debt to issue B_{t+1} and commits to repay B_t by the end of the period. Then, households observe the shock and B_{t+1} and make their individual decisions taking all prices as given. Finally, lenders observe B_{t+1} and aggregate investment, and price the government debt in an actuarially fair fashion.

These assumptions rule out the multiplicities of equilibria studied by Galli (2021) and Cole and Kehoe (2000). In the former, lenders price the government debt before capital allocations are decided, which makes their expectations

[3] This equivalence would no longer hold in an environment with distortionary taxation or with political economy frictions in which the government no longer behaves as a benevolent agent. Those cases are beyond the scope of this paper.

about future capital self-fulfilling. In the latter, lenders price the bonds before the government repays outstanding debt obligations, which can make their beliefs about present borrowing and default self-fulfilling. A crucial assumption for multiplicity in Cole and Kehoe (2000) is that legacy debt can be defaulted on at the beginning *and* at the end of the period.

2.2. Recursive formulation and equilibrium

The aggregate state of the economy is (s, x), where $x = (\Lambda, B)$, and $s = (z, p_C, d)$ is a vector with the shocks and an indicator of whether the government is in default $d = 1$ or in good standing $d = 0$. The state of a representative household is (s, λ, x).

Households.—Given a transfer G from the government, the value of a representative household in repayment is:

$$\begin{aligned} H^P(s, \lambda, x; G) = \max_{c,\lambda'} \big\{ & u(c) + \beta \mathbb{E}\left[H^D(s', \lambda', \Lambda') \,|d' = 1 \right] \\ & + \beta \mathbb{E}\left[H^P(s', \lambda', x'; G') \,|d' = 0 \right] \big\} \end{aligned} \tag{6}$$

subject to the household's budget constraint 4. The expectations are conditional on the government's default decision in the following period d', which depends on the aggregate state then. The representative household understands that G satisfies the government's budget constraint, and has beliefs for the law of motion of the aggregate state in repayment denoted by $x' = \Gamma_H^P(s, x; G)$.

The value of the household when the government is in default is:

$$\begin{aligned} H^D(s, \lambda, \Lambda) = \max_{c,\lambda'} \big\{ & u(c) + \beta\theta \mathbb{E}\left[H^P(s', \lambda', x'; G') \right] \\ & + \beta(1-\theta) \mathbb{E}\left[H^D(s', \lambda', \Lambda') \right] \big\} \end{aligned} \tag{7}$$

subject to the household's budget constraint and the laws of motion of capital. To ease the exposition, I (correctly) assume that, upon reentry into financial markets, the government will not default on 0 debt. The household's beliefs for the law of motion of the aggregate state in this case are $x' = \Gamma_H^D(s, \Lambda)$.

Government.—At the beginning of a period in good standing the value of the government is:

$$V(s,x) = \max_{d\in\{0,1\}} \left\{ dV^D(s,\Lambda) + (1-d)\,V^P(s,x) \right\} \tag{8}$$

where V^D is the value of defaulting and V^P is the value of repayment. Since the government is benevolent, the value of defaulting is the value of a representative household:

$$V^D(s,\Lambda) = V^D(s,\Lambda,\Lambda) \tag{9}$$

where $\lambda = \Lambda$ because all households are identical. If the government decides to repay, then the value is:

$$\begin{aligned} V^P(s,x) &= \max_{B',G} H^P(s,\Lambda,x;G) && (10) \\ s.t. \qquad G &= q(s,x')\,B' - B \\ \Lambda' &= \lambda^P(s,\Lambda,x;G) \end{aligned}$$

where $\lambda^P(s,\Lambda,x;G)$ is the policy function of a representative household in repayment.

Definition 1: (Recursive Competitive Equilibrium) A recursive competitive equilibrium is value and policy functions for the households, value and policy functions for the government, a price schedule, and beliefs for the households such that: (i) given all prices and the household's beliefs, the value and policy functions solve the household's problem in default (7) and in repayment (6) for any value of G; (ii) given the price schedule and the household's value and policy functions, the government's value and policy functions solve its problems in (8) and (10); (iii) the beliefs of the households are consistent with policy functions:

$$\Gamma_H^P(s,x;G) = \left(\lambda^P(s,\Lambda,x;G),\, B(s,x)\right) \tag{11}$$

$$\Gamma_H^D(s,\Lambda) = \left(\lambda^D(s,\Lambda,\Lambda),\, 0\right), \tag{12}$$

and (vi) the price schedule satisfies the lenders' no-arbitrage condition:

$$q\left(s,x'\right)=\frac{\mathbb{E}\left[1-d\left(s',x'\right)\right]}{1+r^{*}} \tag{13}$$

where d is the government's default policy function.

2.3. Efficiency

Consider a benevolent social planner who, like the government, borrows and defaults on behalf of the households but is able to choose all the allocations in the economy. The value of the planner in good financial standing is:

$$\Omega\left(s,x\right)=\max_{d}\left\{d\Omega^{D}\left(s,K\right)+\left(1-d\right)\Omega^{P}\left(s,x\right)\right\} \tag{14}$$

where d is the default decision and Ω^{D} and Ω^{P} are the value of defaulting and repaying, respectively. The value of defaulting is

$$\begin{aligned}\Omega^{D}\left(s,\Lambda\right)=\max_{c,\Lambda'}&\left\{u\left(c\right)+\beta\theta\mathbb{E}\left[\Omega\left(s',\left(\Lambda',0\right)\right)\right]+\beta\left(1-\theta\right)\mathbb{E}\left[\Omega^{D}\left(s',\Lambda'\right)\right]\right\} \qquad (15)\\ s.t.\quad & c=Y^{D}\left(s,x\right)\end{aligned}$$

where production of the final good in default is

$$Y^{D}\left(s,x\right)=Y\left(z_{D}\left(z\right)\left[\left(1-\Lambda\right)\bar{k}\right]^{\alpha_{N}},z_{D}\left(z\right)\left(\Lambda\bar{k}\right)^{\alpha_{T}}+y_{C}\right). \tag{16}$$

The value of repayment is:

$$\begin{aligned}\Omega^{P}\left(s,x\right)=\max_{c,x'}&\left\{u\left(c\right)+\beta\mathbb{E}\left[\Omega\left(s',x'\right)\right]\right\} \qquad (17)\\ s.t.\quad & c=Y^{P}\left(s,x,x'\right)\end{aligned}$$

where aggregate production in repayment is

$$Y^{P}\left(s,x,x'\right)=Y\left(z\left[\left(1-\Lambda\right)\bar{k}\right]^{\alpha_{N}},z\left(\Lambda\bar{k}\right)^{\alpha_{T}}+y_{C}+\hat{q}\left(s,x'\right)B'-B\right) \tag{18}$$

where $\hat{q}$ is the price schedule for the planner's debt. Lender's price the planner's debt according to

$$\hat{q}\left(s,x'\right)=\frac{\mathbb{E}\left[1-\hat{d}\left(s',x'\right)\right]}{1+r^{*}} \tag{19}$$

where $\hat{d}$ is the planner's default policy function.

Definition 2: (Efficient Allocations) Given a state (s,x), an allocation $\left(\hat{\Lambda}',\hat{B}'\right)$ is efficient if it coincides with the planners policy functions.

2.4. Discussion

Equations (13) and (19) show that in the presence of default risk the economy's ability to borrow depends on the sectoral allocation of capital. Households fail to internalize how this allocation affects default incentives, which is the *portfolio externality* studied by Esquivel (2024b). The following discussion illustrates how the portfolio externality emerges in the above environment and how it is affected by the commodity endowment.

Portfolio externality.—To ease exposition, denote with a "tilde" all variables that correspond to the competitive equilibrium and with a "hat" those that correspond to efficient allocations. The household's Euler equation for the capital allocation is:

$$0=\beta\mathbb{E}_t\left[\beta\frac{u'\left(\tilde{c}_{t+1}\right)}{u'\left(\tilde{c}_t\right)}\frac{\tilde{r}_{N,t+1}-\tilde{r}_{T,t+1}}{\tilde{P}_{t+1}}\bar{k}\right] \tag{20}$$

where the expectation is conditional on information at period t and considers the government's default policy in $t+1$. Similarly, assuming that $\hat{q}$ is differentiable, the corresponding Euler equation from the planner's problem is:

$$\frac{\partial\hat{q}\left(s_t,\hat{x}_{t+1}\right)}{\partial\Lambda_{t+1}}\frac{\hat{B}_{t+1}}{\hat{P}_t}=\beta\mathbb{E}_t\left[\beta\frac{u'\left(\hat{c}_{t+1}\right)}{u'\left(\hat{c}_t\right)}\frac{\hat{r}_{N,t+1}-\hat{r}_{T,t+1}}{\hat{P}_{t+1}}\bar{k}\right] \tag{21}$$

where $1/\hat{P}_t$ is the marginal product of tradable intermediates (akin to the reciprocal of the price index of the final good), $\hat{r}_{j,t+1}$ is the marginal product of capital in sector j evaluated at the planner's allocation, and $\frac{\partial\hat{q}(s_t,\hat{x}_{t+1})}{\partial\Lambda_{t+1}}$ is the derivative of the price of the planner's debt with respect to the capital allocation. The planner considers how the sectoral portfolio of capital chosen for $t+1$ affects borrowing terms in t.

Esquivel (2024b) shows that as long as traded and non-traded goods are "complementary enough" ($\eta < 1$) default incentives are decreasing in the share of capital allocated to the traded sector.[4] Intuitively, a larger traded sector in $t+1$ reduces the utility cost of repaying foreign debt because tradable resources are more abundant for any realization of shocks. This implies that $\hat{q}$ is increasing in Λ_{t+1} and the left-hand-side of equation 21 is positive.

From the above equations it follows that the planner's allocation can be decentralized as a competitive equilibrium with with a state-contingent subsidy to λ_{t+1} equal to $\hat{\tau}_t = \left(\partial \hat{q}/\partial \Lambda_{t+1}\right) \hat{B}_{t+1}/\hat{P}_t$. The Euler equation of the household in this case becomes

$$\hat{\tau}_t = \beta \mathbb{E}_t \left[\beta \frac{u'\left(\hat{c}_{t+1}\right)}{u'\left(\hat{c}_t\right)} \frac{\hat{r}_{N,t+1} - \hat{r}_{T,t+1}}{\hat{P}_{t+1}} \bar{k} \right] \tag{22}$$

where $\hat{\tau}_t$ is expressed in terms of the final good and financed with lump-sum taxes. Note that absent default risk $\hat{q}$ would be constant and $\hat{\tau}_t = 0$; that is, there would be no inefficiency. The magnitude of $\hat{\tau}_t$ can be interpreted as the severity of the portfolio externality, which is larger when borrowing needs are large and when the price schedule is steep.

The Dutch disease.—Commodity income has the classic "Dutch disease" effect: it redirects capital toward the non-traded sector. Note that the relative price of non-traded intermediates

$$p_{N,t} = \left(\frac{\omega}{1-\omega} \frac{z_t \left(\Lambda_t \bar{k}\right)^{\alpha_T} + p_{C,t} y_C + \hat{q}_t B_{t+1} - B_t}{z_t \left[\left(1 - \Lambda_t\right) \bar{k} \right]^{\alpha_N}} \right)^{\frac{1}{\eta}}$$

is strictly increasing in the commodity endowment y_C for any given state and choices. All else equal, a larger commodity endowment appreciates the real

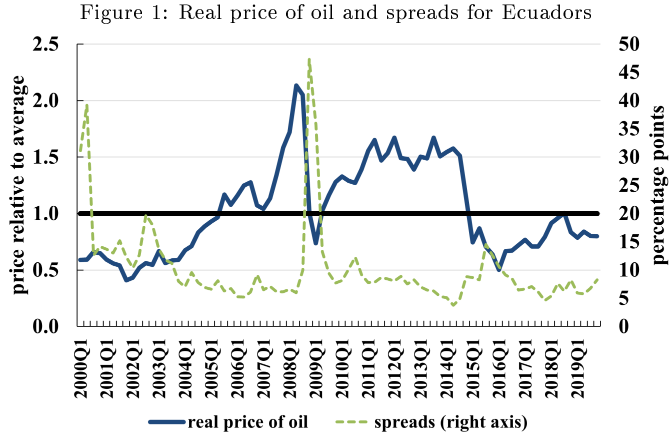
[4] See Esquivel (2024b) for a general proof and a discussion of the sufficient condition $\eta < 1$.

exchange rate, which increases the returns to capital in the non-traded sector relative to the traded. Households adjust their capital portfolio to make equation (22) hold. As the aggregate share Λ_{t+1} shrinks default risk increases and $\hat{q}$ becomes steeper, which increases the size of the required subsidy to dampen the negative effect on borrowing costs. This larger $\hat{\tau}_t$ illustrates how commodity income amplifies the severity of the *portfolio externality*, making the "Dutch disease", in fact, a disease.

3. Quantitative analysis

The model is calibrated to Ecuador, which is a small-open economy subject to default risk in which commodity exports (mostly oil) are a significant share of GDP. Figure 1 shows the evolution of Ecuadorean sovereign spreads and the real price of oil relative to its average between 2000 and 2019. Spreads are from J.P. Morgan's EMBI+ for Ecuadorean government bonds. The price of oil is the quarterly average price in US dollars for the West Texas Intermediate (WTI) deflated by the US CPI.

Figure 1: Real price of oil and spreads for Ecuadors



Spreads are from J.P. Morgan's EMBI+ index. The price of oil is the quarterly average price in US dollars for the West Texas Intermediate (WTI) deflated by the US CPI.

The data show a strong negative relationship between sovereign risk and commodity booms. This is particularly stark around the 2008-2009 global financial crisis, where the price of oil dropped by more than half from its peak and Ecuador defaulted on its debt. The price of oil picked up shortly after and spreads went back to pre-crisis levels despite Ecuador being in the midst of a debt restructuring process. The commodity boom ended in 2015 when the price of oil dropped 25 and 34 percent during the third and fourth quarters of 2014, respectively. Spreads increased from 4 to 8 percent in the same period and reached 14.5 percent by the third quarter of 2015. The quantitative analysis below uses the model to elucidate the forces driving this co-movement and on how commodity boom-and-bust cycles amplify the portfolio externality.

3.1. Calibration

A period in the model corresponds to one quarter. There are two sets of parameters. The first corresponds to standard values taken from the literature and directly from the data, which are summarized in Table 1. The second is chosen to match some business cycle features for Ecuador and summarized in Table 2. Unless specified otherwise, the data for Ecuador are from the first quarter of 2000 to the last quarter of 2019.

The risk-free interest rate is $r^* = 0.01$, the CRRA parameter is $\sigma = 2$, and the discount factor is $\beta = 0.95$, which are standard values in business cycle and sovereign default studies. The share of non-traded goods in the final good production function is $\omega = 0.66$, which corresponds to the share of non-traded value added from Ecuadorian national accounts.[5] The elasticity of substitution between traded and non-traded goods is $\eta = 0.83$, which is an upper bound for this parameters as discussed by Bianchi (2011) (see discussion in Subsection 3.3 below). The capital shares are $\alpha_N = \alpha_T = 0.36$.

The probability of reentry is $\theta = 0.039$, which gives an average exclusion of 6.3 years after default. Ecuador had three default episodes between 1980

[5] The non-traded sectors are electricity and water supply, construction, retail, lodging, transportation, mail and telecommunications, financial services, professional services, education, public services and defense, domestic services, and other services.

and 2019: 1982, 1999, and 2008.[6] The 1982 episode was resolved in 1994 with the issuance of Brady bonds. In 1999 Ecuador defaulted on its Brady bonds, which were restructured a year later in 2000. Ecuador defaulted again in 2008 and started a slow process of bond repurchasing and restructuring. This event was resolved in 2014 when Ecuador was able to issue new debt in international markets. These three events had durations of 12, 1, and 6 years, respectively, for an average exclusion of 6.3 years.

Table 1: Independently calibrated parameters

	Parameter	Value	Source
r^*	risk-free rate	0.01	standard value
σ	CRRA parameter	2.00	standard value
β	discount factor	0.95	standard value
θ	probability of reentry	0.039	6.3 years av. exclusion
η	elasticity of substitution	0.83	Bianchi (2011)
ω	weight, non-traded	0.66	value-added data
α_N, α_T	capital shares	0.36	standard value
p_{CL}	low commodity price	0.594	price of oil data
p_{CH}	high commodity price	1.406	price of oil data
π_{LH}	$Pr\left(p_{C,t+1} = p_{CH} \| p_{C,t} = p_{CL}\right)$	0.078	price of oil data
π_{HL}	$Pr\left(p_{C,t+1} = p_{CL} \| p_{C,t} = p_{CH}\right)$	0.081	price of oil data

The commodity price follows a two-state Markov chain $p_C \in \{p_{CL}, p_{CH}\}$ with transition probabilities π_{ij} for $i, j \in \{L, H\}$. Using the data from Figure 1, the average deviation from the mean is 0.406 so $p_{CL} = 0.594$ and $p_{CH} = 1.406$. The average duration below and above the mean are 12.8 and 12.3 quarters, respectively, so $\pi_{LH} = 0.078$ and $\pi_{HL} = 0.081$.

Finally, the parameters governing the default penalty ψ_0 and ψ_1, the parameters governing the productivity process ρ_z and σ_z, and the commodity endowment y_C are set to jointly match the following moments in the decentralized economy: (i) an average spread of 11 percent, (ii) an average debt service of 4 percent of GDP, (iii) the persistence ρ_y and (iv) volatility parameters σ_y from the AR(1)

[6] See Cueva and Diaz (2021) for a detailed monetary and fiscal history of Ecuador from 1960 to 2017.

process

$$\log y_t = \rho_y \log y_{t-1} + \sigma_y \varepsilon_{y,t}$$

where y_t is real GDP, and (v) an average ratio of commodity value added to total value added of 0.22. Table 2 summarizes the moment-matching exercise. Nominal GDP in this economy is $nGDP_t = P_t Y_t + p_{C,t} y_C + (y_{T,t} - c_{T,t})$ and the balance of payments is $p_{C,t} y_C + y_{T,t} - c_{T,t} = B_t - q_t B_{t+1}$, where the left-hand-side is the trade balance and B_t is the debt service. Real GDP is measured using base-period prices $GDP_t = P_0 Y_t + p_{C,0} y_C + (y_{T,t} - c_{T,t})$.

Table 2: Parameters chosen to match moments

Parameter	Value	Moment	Data	Decentralized (targeted)	Planner (untargeted)
ψ_0	0.01	$Av\,(r - r^*)$	0.11	0.11	0.09
ψ_1	2.00	$Av\left(\frac{B}{nGDP}\right)$	0.04	0.03	0.02
ρ_z	0.95	ρ_y	0.698	0.697	0.698
σ_z	0.017	σ_y	0.017	0.016	0.016
y_C	1.45	$Av\left(\frac{p_C y_C}{nGDP}\right)$	0.22	0.21	0.21

The return on government bonds is $r_t = (1/q_t) - 1$. Both in the data and the model, real GDP is measured with base-period prices and detrended using an HPfilter with a smoothing parameter of 1600. Model moments are the average across 100 samples of 400 quarters each after droping the first 1000 periods.

The moments targeted in the decentralized economy are very similar to those in the planner's case (which are untargeted) except for the average spread, which is two percentage points lower. The planner's ability to jointly choose Λ_{t+1} and B_{t+1} allows similar levels of borrowing at lower spreads. Table 3 reports other untargeted moments for both the planner and the decentralized economy. Volatility of real GDP in the model is similar to that of the data and consumption is more volatile than GDP, as in the data. The model also generates countercyclical spreads and trade balance, which are common features in the data for emerging economies. The volatility of spreads is much larger than in the data, which is mostly driven by large spikes during periods of distress (low productivity shocks with low commodity prices).

Table 3: Untargeted moments

Moment	Data	Decentralized	Planner
$Std\,(r-r^{*})$	0.08	0.27	0.25
σ_{GDP}	2.5	2.3	2.3
σ_c/σ_{GDP}	1.1	1.02	2.7
$\sigma_{TB/GDP}$	3.8	0.9	1.0
σ_{RER}	3.2	21.9	21.8
$Cor\,(r-r^{*}, GDP)$	-0.19	-0.27	-0.26
$Cor\left(\frac{tb}{GDP}, GDP\right)$	-0.03	-0.07	-0.07
$Cor\,(rer, GDP)$	0.05	-0.13	-0.13

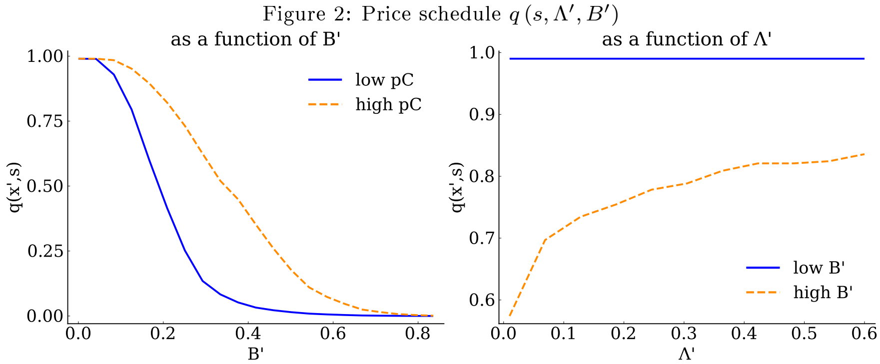
The return on government bonds is $r_t = (1/q_t) - 1$. Both in the data and the model, real GDP and consumption are measured with base-period prices. All time series except spreads and tb/GDP are detrended using an HPfilter with a smoothing parameter of 1600. The real exchange rate in the data is the ratio P^{*}/P where P^{*} and P are GDP deflators for the U.S. and Ecuador, respectively. In the model, the real exchange rate is $1/P$. Model moments are the average across 100 samples of 400 quarters each after droping the first 1000 periods.

The real exchange rate is also more volatile and countercyclical in the model. The real exchange rate in the data is P^{*}/P where P^{*} and P are the GDP deflators for the U.S. and Ecuador, respectively (Ecuador has used the US dollar for all domestic transactions since 2000). In the model, the real exchange rate is $1/P$. It is well known that standard international business cycle models cannot account for the empirical properties of real exchange rates. Fitting their behavior is beyond the scope of this paper.

3.2. The Dutch disease

Figure 2 presents the price schedule of bonds as a function of borrowing and the capital allocation for the next period. The left panel shows how q is decreasing in bonds issued because higher borrowing increases default incentives in the next period. The right panel illustrates the result from Esquivel (2024b) that q is increasing in Λ' and that this relationship is stronger when default incentives are high (like when debt issuance is high). This suggests that the subsidy to Λ' that implements the efficient allocation is positive and negatively correlated with spreads.

Figure 2: Price schedule $q\left(s,\Lambda',B'\right)$

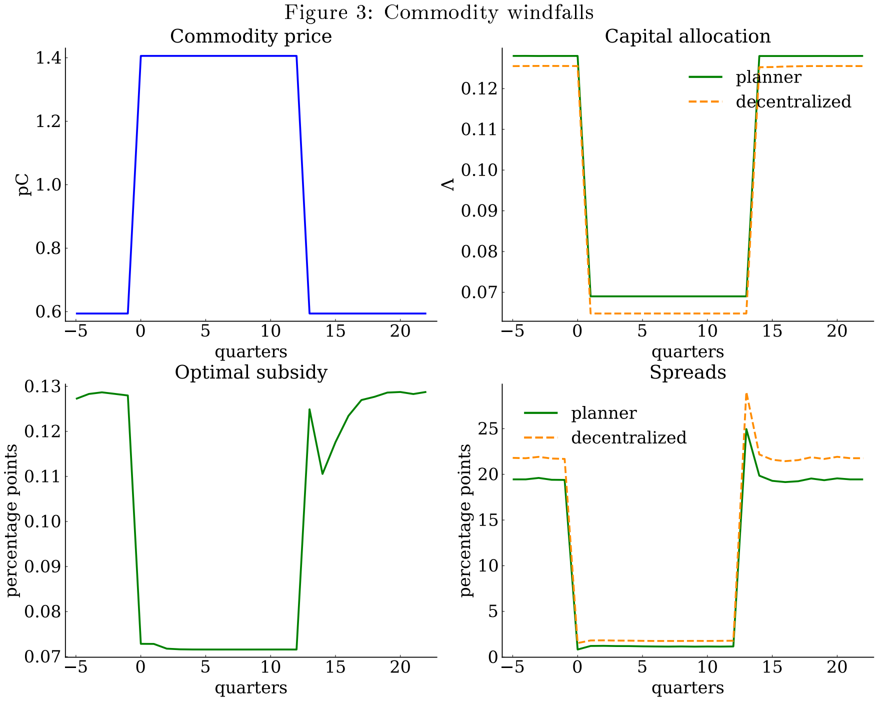


The price q is evaluated at the long-run average for the productivity shock z in both panels. In the left panel, the price is evaluated at the long-run average for Λ' and the two values for the commodity price p_C. The solid-blue and dashed-orange lines in the right panel correspond to q evaluated at the long-run average for B' minus and plus two standard deviations, respectively.

The relationship between commodity prices, spreads, and the optimal subsidy is not straightforward because high commodity prices induce a lower allocation of capital to the traded sector Λ' and higher borrowing, but also induce lower spreads due to the higher income level. Figure 3 shows the average paths of spreads, the capital allocation, and the optimal subsidy around a typical commodity windfall.

First, note that the evolution of spreads through the commodity windfall is consistent with the data from Figure 1. Spreads drop and remain low during the periods when commodity income is high and sharply increase on impact when the price of commodities drops. The behavior of the optimal subsidy mimics that of spreads, showing that the portfolio externality is more pronounced in periods of high default risk. The right panels compare spreads and the capital allocation Λ of the planner and the decentralized economy. As shown in Table 2, spreads are lower for the planner and the Dutch disease is more pronounced in the decentralized economy. The share of capital in the traded sector drops more during the commodity windfall in the decentralized economy because households fail to internalize that default risk is higher with a lower Λ. Once the commodity windfall ends, spreads sharply increase and do so more in the decentralized economy because of the low state of Λ.

Figure 3: Commodity windfalls



Each line averages across 10,000 paths around a commodity windfall witha duration of 12 quarters starting in $t = 0$.

Table 4 presents long-run statistics of the optimal subsidy and welfare gains of implementing the efficient allocation for different cases. The first row reports the statistics for the benchmark economy using the calibration described above. The second row corresponds to the same economy without commodity income $y_C = 0$.[7] Welfare gains in column (6) are positive in both cases but larger with commodities than without. This highlights how the Dutch disease amplifies the degree of inefficiency implied by the portfolio externality. Column (1) shows that the average optimal subsidy is larger in the economy with commodities than in the economy without. Column (2) shows that it is also more volatile. In both economies the optimal subsidy is countercyclical and positively correlated with spreads (columns (3) and (5)), as suggested by Figure 2. The subsidy

[7]The third and fourth rows are discussed below in Subsection 3.3.

is negatively correlated with the price of commodities, indicating that in the tension mentioned above between the Dutch disease reallocation and the lower default risk, the latter dominates in the simulations. This correlation is virtually zero in the economy with no commodities because the commodity shock is irrelevant by construction.

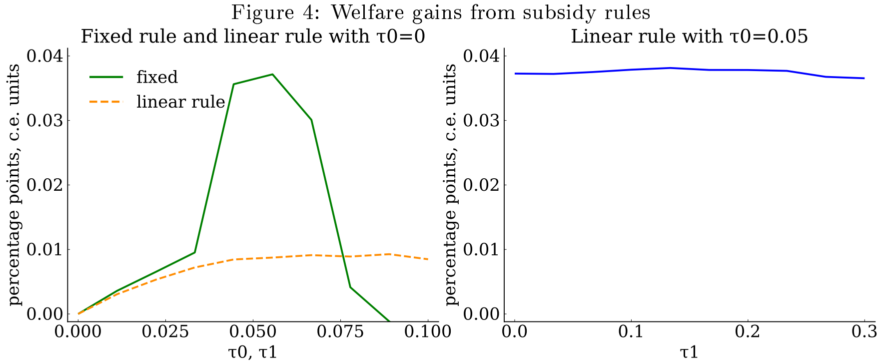
Table 4: Optimal subsidies and welfare gains

		(1) μ_τ	(2) σ_τ	(3) $\rho_{\tau,GDP}$	(4) ρ_{τ,p_C}	(5) $\rho_{\tau,r-r^*}$	(6) welfare gains
benchmark,	$y_C = 1.45$	0.03	0.05	-0.65	-0.63	0.25	0.08
$\eta = 0.83$	$y_C = 0$	0.01	0.02	-0.69	-0.01	0.54	0.06
$\eta = 0.5$	$y_C = 1.45$	0.12	0.31	-0.45	-0.43	0.28	0.22
	$y_C = 0$	0.02	0.03	-0.65	-0.01	0.52	0.04

The moments for the optimal subsidy are calculated using a sample of 101,000 periods after dropping the first 1,000. Welfare gains of implementing the efficient allocation are averaged across 10,000 initial states drawn from the ergodic distribution.

Implementing the optimal subsidy $\hat{\tau}_t$ requires knowing the state of the economy and the price schedule that the planner faces. Consider instead a subsidy rule that is linear in spreads $\tau_t = \tau_0 + \tau_1 * (r_t - r^*)$. The left panel in Figure 4 plots the average welfare gains of implementing this rule for different values of τ_0 keeping $\tau_1 = 0$ (solid green line) and for different values of τ_1 keeping $\tau_0 = 0$. Interestingly, the largest gains come from implementing a simple fixed subsidy equal to $\tau_0 = 0.05$, which yields welfare gains of 0.037 percent. This is roughly half of the gains from implementing the efficient allocation.

Figure 4: Welfare gains from subsidy rules



The right panel of Figure 4 plots the welfare gains of implementing a linear subsidy rule with $\tau_0 = 0.05$ and different values of τ_1. The largest gains are attained at $\tau_1 = 0.13$ and are equal to 0.038, virtually the same as the gains attained by the best fixed subsidy.

3.3. Role of the elasticity of substitution

One of the main theoretical results in Esquivel (2024b) is that default incentives are unambiguously decreasing in Λ as long as the elasticity of substitution between traded and non-traded goods is less than 1. Intuitively, increasing Λ has two effects on default incentives. The first can be thought of as the classic *income effect*, where having more capital installed in the traded sector makes servicing the debt less painful. The second, a *substitution effect*, has to do with how default affects the mix of intermediate goods that is consumed: the productivity penalty reduces c_N and reneging on the debt increases c_T. Thus, the cost of defaulting has two components: a direct one through lower c_N and an indirect one through an unbalanced consumption bundle. If intermediate goods are perfect substitutes, then the latter cost is absent and the former becomes negligible as Λ increases. With high enough Λ, default incentives could be increasing in Λ. On the other hand, as the elasticity of substitution decreases both of these components of the cost of default become more relevant and default incentives become more sensitive to Λ.

The above intuition suggests that the results for the calibration with $\eta = 0.83$ are conservative, since the Dutch disease could have a stronger amplification of the portfolio externality if default incentives are more sensitive to Λ with a lower value for this parameter. As pointed out by Bianchi (2011), 0.83 is the upper bound for the range of values used in the quantitative literature. Moreover, as surveyed by Akinci (2011) empirical estimates for this parameter are much lower, closer to 0.5. The third and fourth columns of Table 4 correspond to an economy similar to the benchmark but with a lower elasticity of substitution $\eta = 0.5$. The same comparison between the economy with and without commodities goes through but the differences are starker. The optimal subsidy is 0.12 percent with commodities and 0.02 without. Welfare gains of implementing the optimal allocation are 0.22 with commodities and 0.04 without.

4. Empirical analysis

This section makes two empirical points, which support the main conclusions from the model. The first is that, in the long-run, resource-rich economies face more stringent borrowing terms (similar evidence has been documented by Esquivel (2024a) and Hamann, Mendoza and Restrepo-Echavarria (2023)). The second point sheds light on the main mechanism in the model: income from natural resources induces a reallocation of capital away from the manufacturing sector. The accumulation of international reserves induces a reallocation of capital back into this sector but its effect is lower when it is accompanied by a commodity windfall. This illustrates the Dutch-disease effect of commodity windfalls in the data and how policies that depreciate the real exchange rate—such as the accumulation of natural reserves—dampen the inefficient reallocation highlighted in the model.

4.1. Data description

Unless indicated otherwise, all data are yearly and taken from The World Bank (2021) and the International Monetary Fund (2021). All countries with available data for the years 1979–2015 are considered.

I use two measures of default risk. The first is the interest rate spreads from JP Morgan's Emerging Markets Bonds Index (EMBI), which are widely used in the literature. These data are available for 37 countries starting no earlier than 1993.[8] For the second, I use the Institutional Investor Index (III) to construct measures of spreads for other countries for which sovereign bonds spread data

[8] The 37 countries are: Argentina, Belize, Brazil, Bulgaria, Chile, China, Colombia, Dominican Republic, Ecuador, Egypt, El Salvador, Gabon, Ghana, Hungary, Indonesia, Iraq, Jamaica, Kazakhstan, Republic of Korea, Lebanon, Malaysia, Mexico, Pakistan, Panama, Peru, Philippines, Poland, Russian Federation, Serbia, South Africa, Sri Lanka, Tunisia, Turkey, Ukraine, Uruguay, Venezuela, and Vietnam.

are not available. The III is a measure of sovereign risk that was published biannually by the Institutional Investor magazine between 1979 and 2015. It measures country risk by aggregating into an index a collection of risk-related variables that are related to investing in a foreign country, including political risk, exchange rate risk, economic risk, sovereign risk and transfer risk. The III takes values between 0 and 100, where 100 indicates lowest risk and 0 the most risk. To assess how the III explains sovereign spreads, I estimate the following econometric model:

$$\ln\left(\text{spread}_{i,t}\right) = \gamma_0 + \gamma_1 \ln\left(III_{i,t}\right) + \kappa_i + \mu_t + \epsilon_{i,t} \tag{23}$$

where κ_i are country fixed effects, μ_t are year fixed effects, $III_{i,t}$ is the average index for country i in year t, and $\epsilon_{i,t}$ is the error term.[9] I then use equation (23) and III data to construct time-series of spreads for all countries.

I use data on total natural resource rents as a fraction of GDP. Natural resource rents are calculated as the difference between the price of a commodity and the average cost of producing it. These unit rents are then multiplied by the physical quantities that countries extract to determine the rents for each commodity. Total natural resource rents are the sum of oil rents, natural gas rents, coal rents, other mineral rents, and forest rents.

I use two measures of foreign debt: total external debt stocks and central government debt, both as a fraction of GDP. The former includes both private and public debt, while the latter includes only government debt but is available for a smaller set of countries. I use international reserves excluding gold as a fraction of GDP. Finally, the investment data are from Table 2.6 from the National Accounts Official Country Database compiled by the United Nations

[9]The estimated coefficients are

$$\ln\left(\text{spread}_{i,t}\right) = \underset{(0.629)}{8.791} - \underset{(0.177)}{1.958} \ln\left(III_{i,t}\right)$$

where the numbers in parenthesis are clustered standard errors. The III is significant at the 0.01 level and the $R^2 = 0.64$.

Statistics Division.

4.2. Default risk and natural resources

First, to show the long-run relation between being a commodity exporter and spreads, I estimate the following panel regression:

$$s_{i,t} = \beta_0 + \beta_1 \overline{NR}_i + \beta_2 Res_{i,t} + \beta_3 B_{i,t} + \beta_4 III_{i,t} + \mu_t + u_{i,t} \tag{24}$$

where subscripts i refer to countries and t to years, $s_{i,t}$ are interest rate spreads, $\overline{NR}_i$ is the average natural resource rents as a percentage of GDP for country i over the available time period, $Res_{i,t}$ and $B_{i,t}$ are international reserves and debt as a percentage of GDP, respectively, $III_{i,t}$ is the institutional investor index for country i in year t, μ_t are year fixed effects, and $u_{i,t}$ is the error term. Table 5 summarizes the estimation results for different measures of spreads and government debt.

The specifications in columns (1) and (2) include the institutional investor index to control for the institutional quality of a country. This is important because countries with a large share of natural resource rents may also be countries with poor institutional quality, which could translate into higher spreads. Columns (3) and (4) do not control for this index because they use the constructed EMBI measure described above.

The first row shows that the estimates of β_1 are positive and statistically different from 0 (except for column (2), which has the least number of observations). The variable $\overline{NR}_i$ is a country-specific "shifter" scaled by the country's relative dependence on natural resources. The positive sign of β_1 indicates that countries for which natural resource rents are relatively large face higher default risk for any given level of foreign debt and assets (and any given level of institutional quality in columns (1) and (2)). The estimate in column (1) indicates that a 1 percent higher share of rents from commodities on GDP implies that average government spreads are 7.7 basis points higher.

Table 5: Commodity exporters and default risk

	(1) EMBI	(2) EMBI	(3) Fitted EMBI	(4) Fitted EMBI
Av (NR rents)	0.077*	0.168	0.208**	0.926***
	(0.0383)	(0.112)	(0.0804)	(0.281)
Reserves	-0.0851**	-0.0523	-0.360***	-0.0853***
	(0.0351)	(0.0479)	(0.0358)	(0.0285)
Inst. Investor Index	-0.173***	-0.168***		
	(0.0187)	(0.0256)		
Total Debt	0.0411		0.167***	
	(0.0272)		(0.0237)	
Gov Debt		0.0181		0.122***
		(0.0175)		(0.0380)
Constant	12.09**	11.69***	4.438***	-5.040**
	(0.920)	(1.310)	(0.975)	(1.829)
Year FE	Yes	Yes	Yes	Yes
Observations	520	246	2,645	1,033
Number of countries	43	31	105	84
R-squared	0.404	0.512	0.216	0.292

Robust standard errors in parenthesis based on Driscoll and Kraay (1998).
*** p<0.01, ** p<0.05, * p<0.1

4.3. The Dutch disease and reserve accumulation

To explore the relationship between the sectoral allocation of capital and commodity windfalls I estimate the following regression:

$$\Lambda^M_{i,t} = \chi_0 + \chi_1 NR_{i,t} + \chi_2 NR^2_{i,t} + \chi_3 Res_{i,t} + \chi_4 Res_{i,t} * NR_{i,t} + \kappa_i + \mu_t + v_{i,t} \quad (25)$$

where the dependent variable $\Lambda^M_{i,t}$ is investment in the manufacturing sector as a percentage of total investment in country i in year t, $NR_{i,t}$ and $Res_{i,t}$ are natural resource rents and international reserves as a percentage of GDP, κ_i are country fixed effects, μ_t are year fixed effects, and $v_{i,t}$ is the error term.

Table 6 reports the estimated coefficients. There is a significant non-linear negative relationship between rents from natural resources and the share of investment in the manufacturing sector. The accumulation of international reserves increases the share of investment in the manufacturing sector but its effect is dampened when rents from natural resources increase (the coefficient χ_4 on the interaction term is negative).

Table 6: Relation between sectoral investment and commodity windfalls

	(1)	(2)	(3)	(4)
NR rents	-0.117	-0.411***	-0.419***	-0.255*
	(0.0717)	(0.133)	(0.133)	(0.134)
$(\text{NRrents})^2$		0.00677**	0.00649**	0.00910***
		(0.00258)	(0.00259)	(0.00243)
Reserves			0.0753***	0.0954***
			(0.0154)	(0.0194)
Reserves*NRrents				-0.0130***
				(0.00183)
Constant	16.66***	15.19***	16.12***	15.86***
	(0.0787)	(0.244)	(0.161)	(0.234)
Year FE	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes
Observations	771	771	769	769
Number of countries	44	44	43	43
R-squared	0.136	0.140	0.171	0.196

Robust standard errors in parenthesis based on Driscoll and Kraay (1998).
*** p<0.01, ** p<0.05, * p<0.1

A commodity windfall reduces the share of investment in the manufacturing sector but does so by a smaller percentage in economies where natural resource rents are already large. It is important to note that Λ^M in these economies is already small to begin with, so it is natural that reductions become smaller as the share approaches zero. To illustrate this point, consider the regression $\bar{\Lambda}_i^M = \alpha_0 + \alpha_1 \overline{NR}_i + \epsilon_i$ where $\bar{\Lambda}_i^M$ is the average share $\Lambda_{i,t}^M$ for country i over all the available years. The coefficients estimated by OLS (with standard errors in parentheses) are $\hat{\alpha}_0 = \underset{(0.246)}{16.32}$ and $\hat{\alpha}_1 = -\underset{(0.055)}{0.333}$. In the long-run, each additional point of natural resource rents as a percentage of GDP reduces the long-run share of investment in the manufacturing sector by 0.3 percent.

5. Conclusion

This paper presented an environment with production in traded and non-traded sectors in which, in the presence of default risk, households allocate an inefficiently high share of capital to the non-traded sector. Misallocation of capital is a result of the private sector failing to internalize how these decisions affect ex-post default incentives and ex-ante borrowing terms.

The degree of this inefficiency is proportional to both the desired borrowing level and to the sensitivity of default incentives to the investment portfolio. Commodity windfalls shift capital from the traded to the non-traded sector, which is supported by an appreciation of the real exchange rate. This Dutch disease effect amplifies the sectoral misallocation of capital, which results in higher borrowing costs. The efficient allocation can be decentralized with a state-contingent subsidy to the share of capital in the traded sector. Half of the welfare gains from implementing the efficient allocation can be attained with a simple fixed subsidy rule that does not vary with the state.

Sterilization policies that tame the volatility of the real exchange rate, such as accumulation of international reserves, have effects that are consistent with the best fixed subsidy rule in the model: ex-post, they depreciate the real exchange rate and reduce the realized return to capital in non-traded sectors; ex-ante they reduce the incentives to overinvest in non-traded sectors, which reduces the capital misallocation highlighted by the model. The empirical evidence supports the two main implications from the model: (i) "resource-rich" economies face higher interest rate spreads; (ii) income from natural resources shifts investment away from the manufacturing sector; and (iii) the accumulation of international reserves dampens the inefficient reallocation highlighted in the model.

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