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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 windfalls amplify this inefficiency through the classic Dutch disease mechanism. I characterize state-contingent subsidies that implement the efficient allocation and compare them to a simpler subsidy rule that ameliorates the externality. Evidence from spreads, natural-resource rents, and sectoral investment data support the main findings of the model.

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 curse" coined 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. Intermediate goods are produced using capital, which is installed in each sector one period in advance and accumulated by the households. Households fail to internalize how these dynamic choices (capital accumulation and its sectoral allocation) affect 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

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

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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 this portfolio externality.

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. 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 capital that implement the planner's allocation as a competitive equilibrium. These are countercyclical and positively correlated with spreads, which highlights how the inefficiency is amplified in periods of distress. Implementing the planner's allocation is difficult in practice because computing the subsidies requires knowing the state of the economy and the price schedule of bonds. I instead consider subsidy rules for each type of capital that are linear in spreads. I use simulations of the subsidies that implement the planner's allocation to estimate the linear rules that better fit these time series with OLS. These subsidy rules yield welfare gains of 0.19 percent, which is roughly one third of the gains from implementing the planner's allocation.

Finally, I present evidence for a panel of countries of the main mechanisms in 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) policies that smooth sharp increases in tradable income—such as the accumulation of international reserves during commodity windfalls—dampen the reallocation of production factors that amplifies the inefficiency highlighted in the model.

Related literature.—This paper is related to the strand of literature that studies the Dutch disease. Corden and Neary (1982) developed the benchmark model to analyze the reallocation of production factors and the process of de-industrialization. Benigno and Fornaro (2014) present a model in which periods of large capital inflows 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 et al. (2023) 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 et al. (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 is similar to theirs but features 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 a reallocation of capital from traded to non-traded production increases default incentives. Hamann et al. (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. Unlike the analysis in the following section, both of these papers study models in which a benevolent government makes all production and borrowing decisions in a centralized fashion.

Layout.—Section 2 presents the model, 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 in the class of models that follow Eaton and Gersovitz (1981) with production in two sectors (a traded and a non-traded one), commodity endowments, and capital accumulation. The key assumptions are that all capital allocations are chosen by domestic households and that capital cannot be reallocated from one sector to another within the same period. The latter assumption implies that the sectoral allocation of capital is a dynamic choice and thus affects future default incentives and present borrowing terms. Income from commodity exports diverts capital from the traded into the non-traded sector, and the Dutch disease is, in fact, a "disease" because households do not internalize how the reallocation of capital affects the economy's ability to borrow.

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 $p_{C,t} \in \left\{ p_{C,L}, p_{C,H} \right\}$ 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.[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 $\sigma > 0$. Households own all firms and two stocks of capital: one for the non-traded sector $k_{N,t}$ and one for the traded sector $k_{T,t}$. Households produce their own capital goods and pay adjustment costs $\Psi\left(k_{j,t+1}, k_{j,t}\right) = \frac{\phi}{2} \frac{\left(k_{j,t+1} - k_{j,t}\right)^2}{k_{j,t}}$ with $j \in \{N, T\}$. In period t, the budget constraint of a household is:

$$P_t \left[c_t + \sum_{j=N,T} \left(i_{j,t} + \Psi\left(k_{j,t+1}, k_{j,t}\right) \right) \right] \leq \sum_{j=N,T} r_{j,t} k_{j,t} + p_{C,t} y_C + \Pi_t + G_t \tag{4}$$

where P_t is the price of the final good, $i_{j,t} = k_{j,t+1} - (1-\delta) k_{j,t}$ is investment in capital j and δ is the capital depreciation rate, $r_{j,t}$ is the rental rate of capital $j \in \{N, T\}$, 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 long-term bonds 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^*. Each period, a fraction γ of bonds matures while the rest is carried over to the next period. The government's budget constraint is:

$$G_t = q_t \left[B_{t+1} - (1-\gamma) B_t \right] - \gamma B_t \tag{5}$$

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 all shocks are realized. Then, the government observes the shocks, the aggregate capital stocks $K_{N,t}$ and $K_{T,t}$, 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 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 borrowing and default in the current period 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, which is purposely ruled out here.

[2] The model abstracts from the strategic exploitation of natural resources and their interaction with default risk. Esquivel (2024a) and Hamann et al. (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.

[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.

2.2. Recursive formulation and equilibrium

The aggregate state of the economy is (s, x), where $x = (K, B)$, $K = \left(K_N, K_T\right)$, and $s = \left(z, p_C, d\right)$ 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, k, x) with $k = \left(k_N, k_T\right)$.

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

$$H^P(s,k,x;G) = \max_{c,k'} \left\{ u(c) + \beta \mathbb{E}\left[H^D\left(s',k',K'\right) | d' = 1\right] + \beta \mathbb{E}\left[H^P\left(s',k',x';G'\right) | d' = 0\right] \right\} \tag{6}$$

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:

$$H^D(s,k,K) = \max_{c,k'} \left\{ u(c) + \beta\theta \mathbb{E}\left[H^P\left(s',k',x';G'\right)\right] + \beta(1-\theta)\mathbb{E}\left[H^D\left(s',k',K'\right)\right] \right\} \tag{7}$$

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 $x' = \Gamma_H^D(s,K)$.

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

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

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:

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

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

$$\begin{aligned} V^P(s,x) &= \max_{B',G} H^P(s,K,x;G) \\ s.t. \quad G &= q\left(s,x'\right)\left[B' - (1-\gamma)B\right] - \gamma B \\ K' &= k^P(s,K,x;G) \end{aligned} \tag{10}$$

where $k^P(s,K,x;G) = \left(k_N^P(s,K,x;G), k_T^P(s,K,x;G)\right)$ 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:

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

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

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

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

where d is the government's default policy function and x'' denotes the aggregate capital and debt choices in the following period when the state is $\left(s',x'\right)$.

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:

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

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

$$\begin{aligned}\Omega^D(s,K) = \max_{c,K'} &\left\{u(c) + \beta\theta\mathbb{E}\left[\Omega\left(s',\left(K',0\right)\right)\right] + \beta(1-\theta)\mathbb{E}\left[\Omega^D\left(s',K'\right)\right]\right\} \\ s.t.\quad c + &\sum_{j=N,T}\left(I_j + \Psi\left(K'_j,K_j\right)\right) = Y^D(s,x) \\ &I_j = K'_j - (1-\delta)K_j, \quad j = N,T\end{aligned} \tag{15}$$

where production of the final good in default is

$$Y^D(s,x) = Y\left(z_D(z)K_N^{\alpha_N}, z_D(z)K_T^{\alpha_T} + y_C\right). \tag{16}$$

The value of repayment is:

$$\begin{aligned}\Omega^P(s,x) = \max_{c,x'} &\left\{u(c) + \beta\mathbb{E}\left[\Omega\left(s',x'\right)\right]\right\} \\ s.t.\quad c + &\sum_{j=N,T}\left(I_j + \Psi\left(K'_j,K_j\right)\right) = Y^P\left(s,x,x'\right) \\ &I_j = K'_j - (1-\delta)K_j, \quad j = N,T\end{aligned} \tag{17}$$

where aggregate production in repayment is

$$Y^P\left(s,x,x'\right) = Y\left(zK_N^{\alpha_N}, zK_T^{\alpha_T} + y_C + \hat{q}\left(s,x'\right)\left[B' - (1-\gamma)B\right] - \gamma B\right) \tag{18}$$

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

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

where $\hat{d}$ is the planner's default policy function and $\hat{x}''$ denotes the planner's capital and debt choices in the following period.

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

2.4. Discussion

Eqs. (13) and (19) show that in the presence of default risk the economy's ability to borrow depends on the aggregate capital allocations. To ease exposition I assume in this Subsection that capital adjustment costs are zero, but the following analysis holds when these are positive.

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 equations in repayment are:

$$u'\left(\tilde{c}_t\right) = \mathbb{E}_t\left[\beta u'\left(\tilde{c}_{t+1}\right)\tilde{R}_{j,t+1}\right], \quad j = N,T \tag{20}$$

where $\tilde{c}_t$ and $\tilde{c}_{t+1}$ are the households consumption choices given the state at t and $t+1$, and

$$\tilde{R}_{j,t+1} = \frac{\tilde{r}_{j,t+1}}{\tilde{P}_{j,t+1}} + (1-\delta) \tag{21}$$

is the return to capital in sector j evaluated at the equilibrium allocations (denoted by the "tildes"). The expectation is conditional on information at period t and considers the government's default policy in $t+1$ (and its corresponding productivity cost). Similarly, assuming that $\hat{q}$ is differentiable, the Euler equations from the planner's problem in repayment are:

$$u'\left(\hat{C}_t\right)\left[1 - \frac{\partial\hat{q}\left(s_t,x_{t+1}\right)}{\partial K_{j,t+1}}\frac{\hat{B}_{t+1} - (1-\gamma)\hat{B}_t}{\hat{P}_t}\right] = \mathbb{E}_t\left[\beta u'\left(\hat{C}_{t+1}\right)\hat{R}_{j,t+1}\right], \quad j = N,T \tag{22}$$

where $1/\hat{P}_t$ is the marginal product of tradable intermediates (isomorphic to the reciprocal of the price index of the final good), $\hat{C}_t$ and $\hat{C}_{t+1}$ are the planner's consumption choices given the state at t and $t+1$, $\hat{R}_{j,t+1}$ is the return to capital in sector j evaluated at the planner's allocation (denoted by the "hats"), and $\frac{\partial\hat{q}(s_t,\hat{x}_{t+1})}{\partial K_{j,t+1}}$ is the derivative of the price of the planner's debt with respect to capital in sector j. The planner considers how the level of each stock of capital chosen for $t+1$ affects borrowing terms in t.

From the above equations it follows that the planner's allocation can be decentralized as a competitive equilibrium with appropriate state-contingent subsidies in t to each unit of future capital $\hat{\tau}_{j,t}k_{j,t+1}$ financed with lump-sum taxes.[4] With these subsidies in place the left-hand-side of Eq. (20) becomes $u'\left(\tilde{c}_t\right)\left[1 - \hat{\tau}_{j,t}/\hat{P}_t\right]$, which makes the household's Euler equations identical to those

[4] The budget constraint of a household in repayment with these subsidies is $P_t\left[c_t + \sum_{j=N,T}\left(i_{j,t} + \Psi\left(k_{j,t+1},k_{j,t}\right)\right)\right] - \sum_{j=N,T}\hat{\tau}_{j,t}k_{j,t+1} \le \sum_{j=N,T} r_{j,t}k_{j,t} + p_{C,t}y_C + \Pi_t + G_t$, where the term G_t includes a lump-sum transfer equal to $\sum_{j=N,T}\hat{\tau}_{j,t}k_{j,t+1}$.

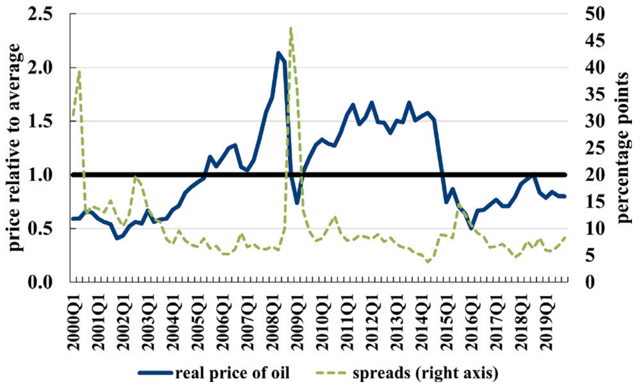

Fig. 1. Real price of oil and spreads for Ecuadors.
Spreads are from J.P. Morgan's EMBI+ index. The price of oil is the quarterly average price in US dollars for the West Texas Intermediate (WTI) deflated by the US CPI.

of the planner if $\hat{\tau}_{j,t} = \frac{\partial \hat{q}(s_t,\hat{x}_{t+1})}{\partial K_{j,t+1}}\left[\hat{B}_{t+1} - (1-\gamma)\hat{B}_t\right]$. Subtracting the household's Euler equations we get the following no-arbitrage condition for capital:

$$u'\left(\tilde{c}_t\right)\left[\frac{\hat{\tau}_{T,t} - \hat{\tau}_{N,t}}{\hat{P}_t}\right] = \mathbb{E}_t\left[\beta u'\left(\tilde{c}_{t+1}\right)\left(\tilde{R}_{N,t+1} - \tilde{R}_{T,t+1}\right)\right]. \tag{23}$$

Note that absent default risk $\hat{q}$ would be constant and $\hat{\tau}_{j,t} = 0$; that is, there would be no inefficiency and the no-arbitrage condition under the planner's allocation would equate the expected discounted returns to capital. Under default risk $\hat{q}$ changes with the capital allocations and if the difference $\hat{\tau}_{T,t} - \hat{\tau}_{N,t}$ is positive (that is, a higher subsidy to traded capital is required to implement the planner's allocation) then under the planner's allocation

$$\mathbb{E}_t\left[\beta u'\left(\hat{C}_{t+1}\right)\left(\hat{R}_{N,t+1} - \hat{R}_{T,t+1}\right)\right] \geq 0, \tag{24}$$

which implies that households "overinvest" in the non-traded sector absent differentiated subsidies. Esquivel (2024b) proves that when $\eta < 1$ default incentives are increasing in the relative size of the non-traded sector, which leads to overinvestment in this sector. Section 3 illustrates how this result holds in this model under a conservative calibration for the elasticity of substitution η—a value of 0.83 which is the upper bound of a range of values used in the literature—and how the severity of the inefficiency is stronger for a lower elasticity.

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

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

is strictly increasing in the commodity endowment y_C for any given state and choices. All else equal, an increase in commodity income increases p_N, which in turn increases the returns to capital in the non-traded sector relative to the traded. Households adjust their capital portfolio to make Eq. (23) hold. Whether this reallocation is inefficient or not (and, if so, how severe the inefficiency is) depends on how the difference in $\hat{\tau}_{T,t} - \hat{\tau}_{N,t}$ changes. This is a function of how capital allocations and commodity income jointly affect default risk and the sensitivity of $\hat{q}$, which is the main focus of the following quantitative Section.

3. Quantitative analysis

The model is calibrated to Ecuador, a small-open economy subject to default risk in which commodity exports (mostly oil) are a significant share of GDP. Fig. 1 shows the evolution of Ecuadorean sovereign spreads and the real price of oil relative to its average between 2000 and 2019. 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 doubled 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 affect the externality from capital allocations.

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
γ	bond maturity rate	0.017	average maturity
δ	capital depreciation rate	0.05	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	0.8186	price of oil data
p_{CH}	high commodity price	1.2215	price of oil data
$\pi_{LL} = \pi_{HH}$	$Pr\left(p_{C,t+1} = p_{Cj} \vert p_{C,t} = p_{Cj}\right),\ j = H, L$	0.855	price of oil data

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 2001 to the last quarter of 2022.

The risk-free interest rate is $r^* = 0.01$, the CRRA parameter is $\sigma = 2$, the capital depreciation rate is $\delta = 0.05$, 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 Section 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 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. I set $\gamma = 0.017$ so that bonds in the model have an average duration of 14.5 years (58 quarters), which is the weighted average of the contracted maturity for all Ecuadorean external bonds.[7]

The commodity price follows a two-state Markov chain $p_C \in \left\{p_{CL}, p_{CH}\right\}$ with transition probabilities π_{ij} for $i, j \in \{L, H\}$. Using the data from Fig. 1, I estimate an AR(1) process for the natural logarithm of the real price of oil (detrended using the HP-Filter) and approximate it with a two-state Markov chain using the method from Tauchen (1986). This yields the values $p_{CL} = 0.8186$ and $p_{CH} = 1.2215$ and transition probabilities $\pi_{LL} = \pi_{HH} = 0.855$ (the price is normalized so that its average is 1).

Solving for the decentralized equilibrium is computationally demanding, so the moment matching exercise proceeds with two intermediate steps that use simpler versions of the benchmark model. First, I consider a version of the model with no borrowing and set the capital adjustment cost parameter ϕ, the commodity endowment y_C, and the parameters governing the productivity process ρ_z and σ_z to jointly match the following moments: (i) a volatility of investment relative to GDP of 2.3, (ii) a GDP share of commodities of 0.22, and (iii) the persistence ρ_y and (iv) volatility parameters σ_y from the AR(1) process

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

where y_t is the cyclical component of real GDP.[8]

Then, for the parameters governing the default penalty ψ_0 and ψ_1 I consider an economy with a fixed capital stock $\bar{K}$ equal to the average total capital stock in the economy without borrowing. Here, households choose the share of capital allocated to each sector one period in advance. Let λ_t be the share of capital that an individual household allocates to the traded sector and Λ_t the corresponding aggregate share. This case simplifies the solution because there are two endogenous states (Λ, B) instead of three $\left(K_N, K_T, B\right)$, while the capital allocation remains a dynamic choice. The parameters are set to jointly match an average spread of 11 percent and an average debt-to-GDP ratio of 0.40.[9] Table 2 summarizes the moment-matching exercise. The moments in the full benchmark model are close to the targets, which suggests that the calibration strategy using the simplified models is reasonable.

[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.

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

[7] The data are from Ecuador's Ministry of Finance. Using all bonds (external and domestic) yields a similar value for γ.

[8] Nominal GDP in this economy is $nGDP_t = P_t Y_t + p_{C,t} y_C + \left(y_{T,t} - c_{T,t}\right)$ and the balance of payments is $p_{C,t} y_C + y_{T,t} - c_{T,t} = \gamma B_t - q_t \left[B_{t+1} - (1-\gamma) B_t\right]$. Real GDP is measured using base-period prices $GDP_t = P_0 Y_t + p_{C,0} y_C + \left(y_{T,t} - c_{T,t}\right)$. Both in the data and the model GDP data is detrended using the HP Filter with a smoothing parameter of 1600.

[9] The data for debt corresponds to general government gross debt reported by the IMF.

Table 2
Parameters chosen to match moments.

Parameter	Value	Moment	Data	Simplified models (targeted)	Benchmark model (untargeted)
ψ_0	−0.2109	$Av(r-r^*)$	0.11	0.11	0.11
ψ_1	0.3375	$Av\left(\frac{B}{nGDP}\right)$	0.40	0.44	0.56
ρ_z	0.95	ρ_y	0.698	0.701	0.715
σ_z	0.017	σ_y	0.017	0.014	0.013
y_C	4.2661	$Av\left(\frac{p_C y_C}{nGDP}\right)$	0.22	0.22	0.23
ϕ	27.187	$\frac{\sigma_{inv}}{\sigma_{GDP}}$	2.3	2.4	1.9

The annualized yield on government bonds is $r_t = ((\gamma + (1-\gamma)q_t)/q_t)^4 - 1$ and the annualized risk-free interest rate is $r^* = 0.04$. Spreads are $100 * (r_t - r^*)$. Both in the data and the model real GDP and investment are 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.

Table 3
Business-cycle moments.

	$\Pr(d=1)$	μ_{r-r^*}	σ_{r-r^*}	$\frac{B}{4*nGDP}$	σ_y
Data	0.060	0.11	0.08	0.40	2.5
Decentralized	0.010	0.11	0.31	0.56	1.9
Planner	0.004	0.05	0.09	0.57	1.8
	σ_c/σ_y	σ_{inv}/σ_y	$\sigma_{tb/y}$	$\rho_{(r-r^*,y)}$	$\rho_{(tb/y,y)}$
Data	1.1	2.3	3.8	−0.19	−0.03
Decentralized	1.6	1.9	2.3	−0.19	−0.04
Planner	1.7	1.6	2.0	−0.16	−0.04

The annualized yield on government bonds is $r_t = ((\gamma + (1-\gamma)q_t)/q_t)^4 - 1$. Both in the data and the model real GDP, investment, 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. Model moments are the average across 100 samples of 400 quarters each after droping the first 1000 periods. In the column titles, the terms μ_x, σ_x, and $\rho_{x,y}$ correspond to the mean and standard deviation of x, and to the correlation between x and y, respectively.

Table 3 compares relevant business cycle moments between the planner, the decentralized economy, and the data. Spreads are lower and less volatile for the planner than for the decentralized economy. This is a direct result of the planner being able to jointly choose all capital allocations while taking into account how they affect borrowing terms.

Volatility of real GDP in the model is similar to that of the data and consumption is more volatile than GDP. The model also generates countercyclical spreads and trade balance, which are common features in the data for emerging economies. The volatility of spreads in the model 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).

3.2. The Dutch disease

Fig. 2 presents the spreads implied by the price schedule of bonds as a function of borrowing and the capital allocations for the next period. The top-left panel shows how spreads are increasing in bonds issued because higher borrowing increases default risk. When the commodity price is high default risk decreases and the spread schedule shifts to the right. This is because high commodity income loosens the resource constraint in repayment and because the price of commodities is persistent.

The bottom panels show how spreads change with capital allocations and the interaction of this dependence with borrowing choices. With low borrowing default risk is low and capital allocations have virtually no effect on borrowing terms, as illustrated by the blue solid lines. When borrowing is high, however, default risk is significant and capital allocations matter for borrowing terms. The orange dotted lines in the bottom panels show that borrowing terms improve with higher capital, all else equal, and that they are more sensitive to capital in the traded sector. This implies that the difference $\hat{\tau}_{T,t} - \hat{\tau}_{N,t}$ discussed in Eq. (23) will tend to be positive because the subsidies $\hat{\tau}_{i,t}$ depend on the slope of the price with respect to capital. The top-right panel summarizes these effects by showing how borrowing terms improve as the share of capital in the traded sector increases for a fixed aggregate capital stock equal to its long-run average.

As discussed in Section 2.4, the severity of the externality on borrowing terms depends on how sensitive the price schedule q is to households' capital allocations. It also follows from the Euler equations and the no-arbitrage condition (Eqs. (20) through (24)) that this severity is also proportional to the magnitude of the state-contingent subsidies that implement the planner's allocation and the difference between them. Fig. 2 suggests that the relationship between commodity windfalls, spreads, and the severity of the externality is not straightforward because high commodity prices induce a lower allocation of capital to the traded sector (the classic Dutch disease effect), but also induce lower spreads and higher borrowing.

Fig. 3 shows the average paths of different variables around a typical commodity windfall in the model. Each line is the average of 10,000 simulation paths where the state in the initial period $t = -1$ corresponds to a random draw from the ergodic distribution

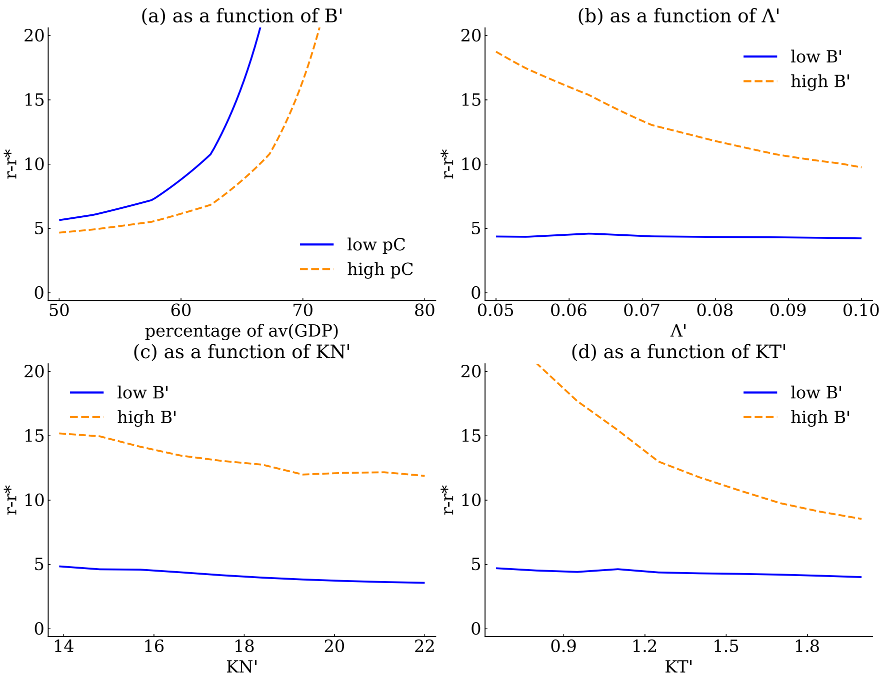

Fig. 2. Spreads schedule of bonds.
The annualized yield on government bonds is $r_t = ((\gamma + (1-\gamma)q_t)/q_t)^4 - 1$ and the annualized risk-free interest rate is $r^* = 0.04$. Spreads are $100 * (r_t - r^*)$. The price q is evaluated at the long-run average for the productivity shock $\bar{z}$. In the top-right panel, the price is evaluated at $q(B', \bar{K}\Lambda', \bar{K}(1-\Lambda'), \bar{z}, p_{CL})$ where $\bar{K}$ is the long-run average for $K = K_N + K_T$. The solid-blue and dashed-orange lines in the top-right and bottom panels correspond to q evaluated at the long-run average for B' minus and plus one standard deviation, respectively.

in good standing with a low commodity price $p_C = p_{CL}$. In all paths the price increases in $t = 0$ and remains high until $t = 16$, which is the average duration of commodity windfalls implied by the calibration.

The evolution of spreads in the top-right panel is consistent with the data from Fig. 1. At the beginning of a commodity windfall spreads drop and remain low during the periods when commodity income is high and when the price of commodities drops. The mid-left panel shows how the commodity windfall induces an investment boom in the non-traded sector, which is larger in the decentralized economy. In both economies the increase in investment in the non-traded sector is larger than in the traded sector, which generates a drop in the relative size of the traded sector as depicted by the mid-right panel. These drops for both the planner and the decentralized economy illustrate the classic Dutch disease mechanism: more tradable income from commodity exports shifts production factors from the traded to the non-traded sector. Note that the relative size of the traded sector is always larger for the planner than for the decentralized economy because households fail to internalize how capital allocations affect default risk, which allows the planner to borrow at lower spreads. The drop in the share of capital in the traded sector is slightly smaller in the decentralized economy not because the Dutch disease is less severe, but because it falls from a lower value to begin with.

The bottom-left panel shows the evolution of the welfare losses from implementing the competitive equilibrium instead of the planner's allocation.[10] When the positive commodity shock is realized welfare losses drop because with lower default risk the inefficiencies are less severe. This is also illustrated by the bottom-right panel, which shows that the difference between the capital subsidies $\tau_{T,t} - \tau_{N,t}$ that implement the planner's allocation drops when the higher commodity price is realized. As discussed in Section 2.4, this difference creates a wedge in the no-arbitrage condition for both types of capital (Eq. (23)). A smaller wedge implies a less severe inefficiency, which explains lower welfare losses. During the commodity windfall, however, welfare losses increase back to almost their original level due to the capital reallocation induced by the Dutch disease, which is reflected in an increase in the wedge on the bottom-right panel. Then, when the commodity windfall ends welfare losses sharply increase to a higher level than before the windfall because now the economy has the same initial commodity income and a relatively smaller traded sector.

[10] Welfare losses are expressed in consumption equivalent units. Let H be the value function of the representative household in the decentralized economy and Ω the value function of the representative household in the planner economy. Given a state (s,x), welfare losses are $wl(s,x) = 100 * \left[\left(\frac{H(s,K,x)}{\Omega(s,x)}\right)^{\frac{1}{1-\sigma}} - 1\right]$. That is, the percentage drop in permanent consumption under the planner allocation that yields the same value as the decentralized economy.

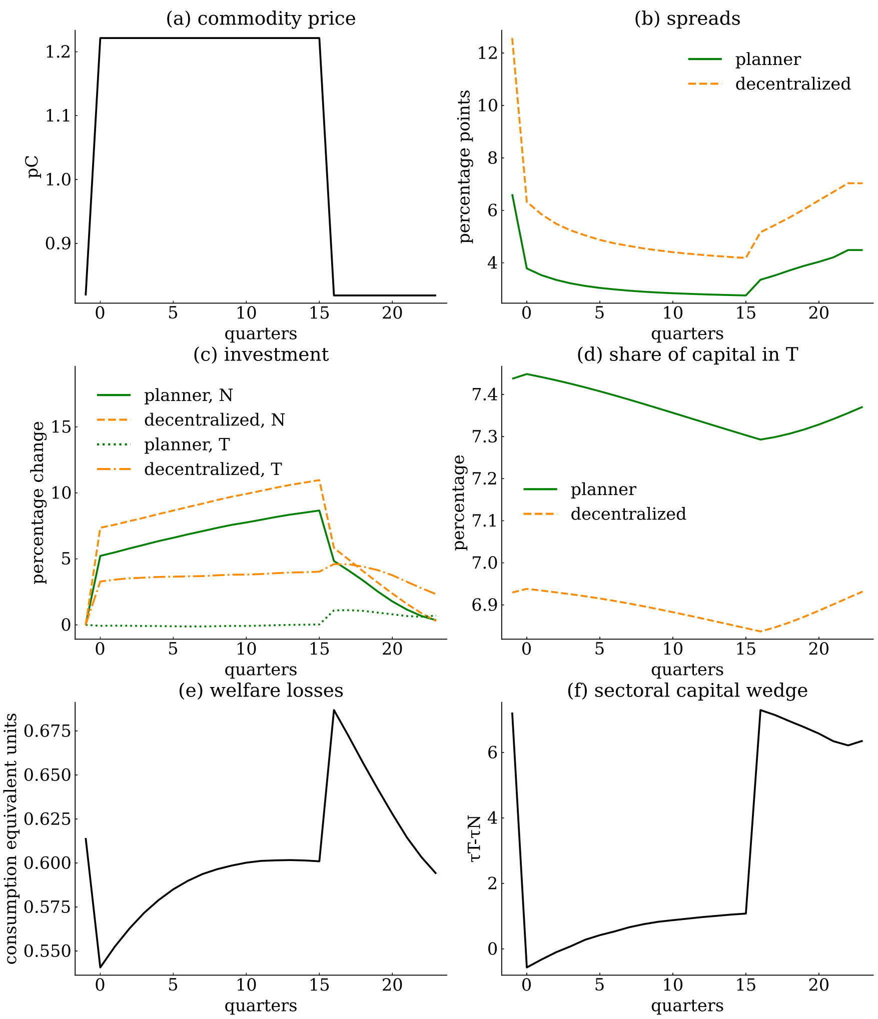

Fig. 3. Commodity windfalls.Each line averages across 10,000 paths around a commodity windfall with a duration of 16 quarters starting in $t = 0$.

Table 4 presents long-run statistics of the optimal state-contingent subsidies (expressed in percentage points) that implement the planner's allocation and their average welfare gains over the ergodic distribution.[11] First, note in column (1) that the average optimal subsidy for capital in the traded sector is an order of magnitude larger than that for non-traded capital. This is a result of the price schedule being much flatter in K_N than in K_T, as illustrated in Fig. 2. Both subsidies are counter-cyclical (column (3)), negatively correlated with the commodity price (column (4)), and positively correlated with spreads (column (5)). This further stresses the fact that the disagreement regarding capital allocations is more severe in periods of distress.

Implementing the optimal subsidies $\hat{\tau}_{i,t}$, $i = N, T$ requires knowing the realized state of the economy and the price schedule of bonds. Consider instead a subsidy rule that is linear in spreads

$$100 * \tau_{i,t} = a_{i,0} + a_{i,1} * \left(r_t - r^*\right), \tag{25}$$

where $\left(a_{i,0}, a_{i,1}\right)_{i=N,T}$ are some fixed coefficients. I estimate these coefficients by simulating 100,000 periods in the model and running an OLS regression on Eq. (25) using the optimal subsidies as dependent variables. The estimated coefficients are $a_{N,0} = 0.635$, $a_{N,1} = -0.053$, $a_{T,1} = 4.401$, and $a_{T,1} = 0.535$. Consistent with Table 4, the unconditional average of the subsidy to capital in the traded sector is much larger than the one for capital in the non-traded sector and is positively correlated with spreads. Implementing the subsidy rule in Eq. (25) with these fixed coefficients yields welfare gains of 0.19 percent.

[11] Welfare gains are expressed in consumption equivalent units. Let H be the value function of the representative household in the decentralized economy and Ω the value function of the representative household in the planner economy. Given a state (s, x), welfare gains are $wg\,(s, x) = 100 * \left[\left(\frac{\Omega(s,x)}{H(s,K,x)}\right)^{\frac{1}{1-\sigma}} - 1\right]$. That is, the percentage increase in permanent consumption under the decentralized economy that yields the same value as the planner's allocation.

Table 4
Optimal subsidies and welfare gains.

		(1) μ_x	(2) σ_x	(3) $\rho_{x,y}$	(4) ρ_{x,p_C}	(5) $\rho_{x,r-r^*}$	(6) welfare gains
benchmark	$100 * \tau_N$	0.63	0.65	−0.21	−0.76	0.10	0.64
	$100 * \tau_T$	4.45	4.48	−0.16	−0.87	0.04	
$\eta = 0.5$	τ_N	7.34	4.44	−0.45	−0.47	0.26	1.19
	τ_T	2.01	7.09	0.03	−0.17	−0.10	

Subsidies are expressed in percentage units. 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. In the column titles, the terms μ_x, σ_x, and $\rho_{x,y}$ correspond to the mean and standard deviation of x, and to the correlation between x and y, respectively.

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 the share of capital allocated to the traded sector 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 (2017) empirical estimates for this parameter are much lower, closer to 0.5. The two bottom rows of Table 4 correspond to an economy similar to the benchmark but with a lower elasticity of substitution $\eta = 0.5$. Implementing the planner's allocation in this case requires more volatile state contingent subsidies and welfare gains roughly double to 1.19 percent.

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 et al., 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. I control for the accumulation of international reserves because it is a policy tool typically used to tame sharp increases in inflows of traded income (such as commodity windfalls). The empirical results show that this policy tool induces a reallocation of capital back into the traded sector, in general, but this effect is lower when it is accompanied by a commodity windfall. This illustrates the Dutch-disease effect of commodity windfalls in the data and its interaction with policies that 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.[12] For the second, I use the Institutional Investor Index (III) to construct measures of spreads for other countries for which sovereign bonds spread data 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:

$$\ln\left(\text{spread}_{i,t}\right) = \gamma_0 + \gamma_1 \ln\left(III_{i,t}\right) + \kappa_i + \mu_t + \epsilon_{i,t} \tag{26}$$

[12] 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.

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).
* $p < 0.1$
** $p < 0.05$
*** $p < 0.01$

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.[13] I then use Eq. (26) 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 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:

$$s_{i,t} = \beta_0 + \beta_1 \overline{NR}_i + \beta_2 Res_{i,t} + \beta_3 B_{i,t} + \beta_4 III_{i,t} + \mu_t + u_{i,t} \tag{27}$$

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

[13] 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 $R^2 = 0.64$.

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).
* $p < 0.1$
** $p < 0.05$
*** $p < 0.01$

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.

To look at these estimates in light of the model, consider an economy parameterized with the calibration described in Section 3.1 but with no commodities $y_C = 0$. Under the benchmark calibration of y_C rents from the commodity sector are 23 percent of GDP in the model (see Table 2), so the estimate in column (1) suggests that spreads should be 177 basis points lower in the alternative economy with $y_C = 0$. I solve for the decentralized equilibrium of this alternative economy and find that average spreads are 9 percent, which is 200 basis points lower than the benchmark 11 percent.

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:

$$\Lambda^M_{i,t} = \chi_0 + \chi_1 NR_{i,t} + \chi_2 NR^2_{i,t} + \chi_3 Res_{i,t} + \chi_4 Res_{i,t} * NR_{i,t} + \kappa_i + \mu_t + \upsilon_{i,t} \tag{28}$$

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 $\upsilon_{i,t}$ 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).

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 larger. It is important to note that Λ^M in these economies is already small to begin with, so it is natural that reductions are smaller for smaller initial shares. This is consistent with the model behavior in Fig. 3, where the share of capital in the traded sector drops less in the decentralized economy where the share was already smaller at the beginning of the windfall.

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. This Dutch disease effect amplifies the sectoral misallocation of capital, which results in higher borrowing costs. The planner's allocation can be decentralized with a state-contingent subsidy to the share of capital in the traded sector. Roughly one third of the welfare gains from implementing the planner's allocation can be attained with a simple subsidy rule that is linear on spreads.

Sterilization policies that tame the volatility of tradable income, such as accumulation of international reserves, have effects that are consistent with the subsidies that decentralize the planner's allocation in the model: 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.

Data availability

Data will be made available on request.

Appendix A. Supplementary data

Supplementary material related to this article can be found online at https://doi.org/10.1016/j.jmoneco.2024.103663.

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