Sustainable growth and financial markets in a natural resource rich country

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June 2015

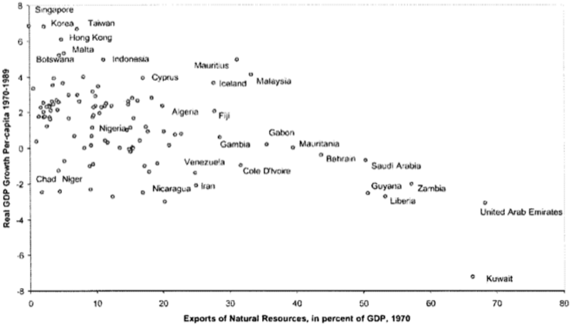
Outline

Introduction
Stylized facts

- **Natural resource Curse** (Sachs an d Warner, 1997)
  = Countries with great natural resource (NR) wealth tend to grow more slowly than resource-poor countries
- Natural resource rich countries (*ex*: oil, gaz) are usually indebted countries.
  Ex : In 2000-2002, the public debt-GDP ratio is 78% for Gabon, 92% for Angola the 2nd oil producer of Africa

Introduction
Stylized facts

Figure : **Growth and natural resource abundance** *(Real Growth per capita 1970-1989 and Exports of natural resources in percent of GDP)*

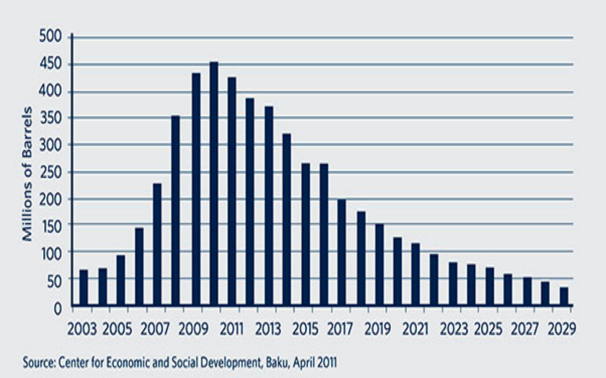


Source: Sachs and Warner, 2001

Introduction
Stylized facts

Figure : Oil Production Forecasts in Azerbaijan

(In millions of barrels between 2003 and 2029)



Introduction
Literature

- Our paper is at the crossroads of two literatures:
  - sustainable growth with natural resources in a closed economy: **Stiglitz**(1974), **Solow** (1974), **Dasgupta and Heal** (1974)
  - extensions of the Ramsey model to an open economy: **Barro and Sala-i-Martin** (2003)
- Gap in the literature that focuses only on sustainable growth in closed economies.

Introduction
Contribution

- Can a small open economy with non renewable NR have sustainable growth thanks to international borrowing ?
- We introduce international borrowing in an exogenous Ramsey growth model with exhaustible non renewable natural resources.
  - *1st step*: we consider a **constant interest rate**
  - *2nd step*: we introduce a **debt-elastic interest rate** with constant natural resource prices, and then with increasing prices

The general model

- The production function:

$$Y = F(K, R) = K^{\alpha}((1-\gamma)R)^{1-\alpha}, 0 < \alpha < 1$$

- The man-made capital depreciates at rate δ:

$$\dot{K}(t) = I(t) - \delta K(t), \delta \in [0, 1] \tag{1}$$

- Natural resource sector

$$\dot{S}(t) = -R(t) \tag{2}$$

with S the stock of natural resource (NR)

The general model

The government

The intertemporal utility function is:

$$\int_0^{\infty} e^{-\rho t} U(C(t))\mathrm{d}t$$

with U(C(t)) $= \frac{C^{1-\eta}-1}{1-\eta}$ for $\eta \neq 1$, $\eta > 0$
and U(C(t)) $=$ ln(C(t)) for $\eta = 1$
The government's dynamic budget constraint is:

$$\dot{B}(t) = C(t) + rB(t) + I(t) - Y(t) - \gamma p R(t) \quad (3)$$

The general model
The government

$$max_{\{C,I,R\}} \int_0^\infty e^{-\rho t} U(C(t)) \mathrm{d}t$$

s.t.

$$\dot{K}(t) = I(t) - \delta K(t)$$

$$\dot{S}(t) = -R(t)$$

$$\dot{B}(t) = C(t) + rB(t) + I(t) - Y(t) - \gamma p R(t)$$

$$K(0) > 0, S(0) > 0$$

The benchmark model with a constant interest rate

- From the optimality conditions, Marginal productivity of capital:

$$F_K = \delta + r \tag{4}$$

- Marginal productivity of natural resources:

$$F_R + \gamma p = -\frac{\lambda_2(0)}{\lambda_3(0)} e^{rt} \tag{5}$$

- Then the ratio capital natural resource is given by:

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

The benchmark model with a constant interest rate

- **Proposition**: *The optimal rate of consumption is given by*

$$\frac{\dot{C}}{C} = \frac{r-\rho}{\eta}, \eta > 1$$

- As $r \leq \rho$, the rate of consumtion is negative, thus C is constant or

$$\lim_{t \to +\infty} C = 0$$

$\Rightarrow$ confirms the literature extending the Ramsey model to an open economy with international borrowing

The benchmark model with a constant interest rate

- **Proposition**: *The optimal path of output and stock of capital approach zero.*
- NR are exhaustible, so that the rate of extraction of those resources tends towards zero:

$$\lim_{t \to +\infty} R = 0$$

- Since the ratio $\frac{K}{R}$ is constant, the accumulation of capital also approaches zero:

$$\lim_{t \to +\infty} K = 0; \lim_{t \to +\infty} I = 0$$

$$\lim_{t \to +\infty} Y = 0$$

$\Rightarrow$ refutes the literature extending the Ramsey model to an open economy with international borrowing

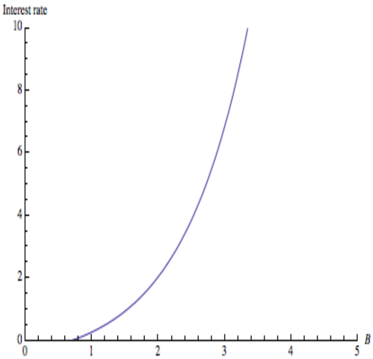
The benchmark model with a constant interest rate
Conclusion

- Counterfactual no-output and no-growth results
- Therefore, in a small open economy with exhaustible NR and a constant interest rate, positive growth cannot be sustained in the long run.
- Attempts to improve those results in the litterature:by introducing a constraint on international borrowing or adjustment costs.
  We will do it by endogenizing the interest rate.

The model with a debt-elastic interest rate

- The interest rate r(B) depends now on the level of debt: r(B) rises when the country's debt increases.

Figure : Interest rate r(B) in function of the level of debt



The model with a debt-elastic interest rate

Constant prices

- **Proposition**: *When the interest rate is exponential, the optimal level of debt decreases and output falls to zero in the long-run.*
  We refer to Schmitt-Grohe and Uribe (2003) debt-elastic interest-rate premium:
  $r(B) = r^* + \psi(e^{B-D} - 1)$
- This expression implies $r(B) > 0$, $r'(B) > 0$

The model with a debt-elastic interest rate

Constant prices

- Using the optimality conditions of the general model, the ratio capital to natural resource:

$$\frac{K}{(1-\gamma)R} = (\frac{\delta + r'(B).B + r(B)}{\alpha})^{\frac{1}{\alpha-1}}$$

- By reorganizing our equations, we can find the following autonomous differential equation:

$$\dot{B} = (r'(B).B + r(B)) * \frac{\alpha}{G(B) * r'(B)}$$

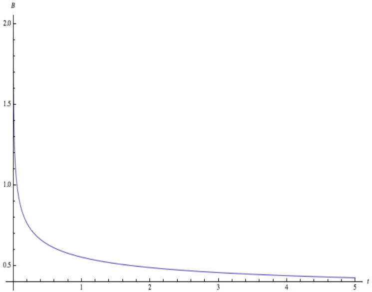
- As $r(B) > 0$ and $r'(B) > 0$, and $G(B) < 0$,
  $\Rightarrow \dot{B} < 0$
  $\Rightarrow$ the optimal level of debt B decreases with time.

The model with a debt-elastic interest rate
Constant prices

- As the level of debt B is decreasing towards zero, the ratio $\frac{K}{(1-\gamma)R}$ tends asymptotically towards a constant.
  $\Rightarrow$ same counterfactual results from the benchmark model with a constant interest rate r
  $\Rightarrow$ K, I, Y decrease asymptotically towards zero.
- We calibrate the debt path in function of time when the interest rate is exponential (Figure 2)
  We set $\alpha = 0,32$, $\delta = 0,1$, $p = 1$, $\gamma = 0,5$, $r^* = 0,04$, $\psi = 0,8$ and $D = 0,7442$

The model with a debt-elastic interest rate
Constant prices

Figure : Debt pattern in function of time



The model with a debt-elastic interest rate
Constant prices

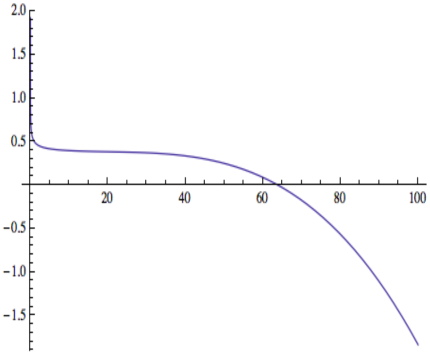
- **Proposition**: *The growth rate of consumption is given by:*

$$g_C = \frac{\dot{C}}{C} = \frac{r'(B)B + r(B) - \rho}{\eta}, \eta > 1$$

- During the transitional dynamics, consumption grows at a positive rate.
- But in the long-run, as B tends towards zero, g_C finally declines.

The model with a debt-elastic interest rate
Constant prices

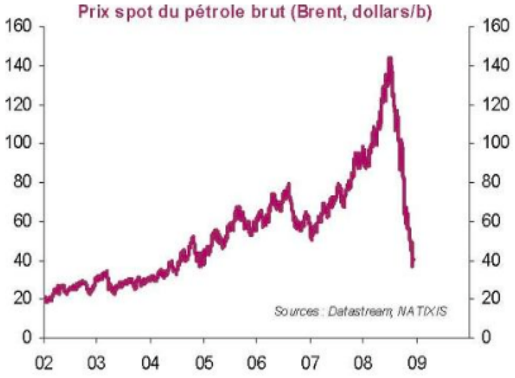
Figure : Consumption growth rate in function of time



The model with a debt-elastic interest rate

Increasing prices

Figure : Oil prices from 2002 to 2009, in dollars per barrel



The model with a debt-elastic interest rate

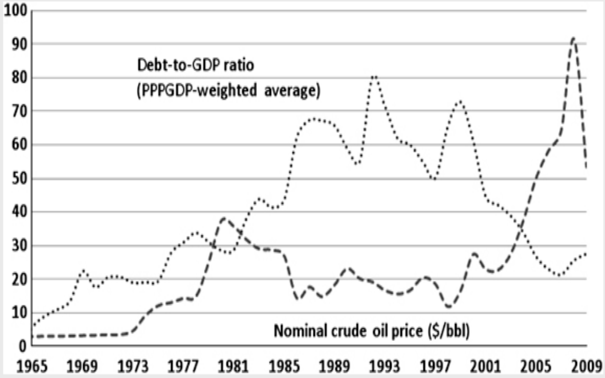
Increasing prices

- We now assume prices to increase at a rate θ, with:
  $p(t) = p(0)e^{\theta t}$
  Ex: 2002-2008 oil price went from 20$ to 140$
- We reexpress our equations as the following non autonomous differential equation, as p depends now on time:

$$\dot{B} = \frac{\alpha(r'(B).B + r(B)) - \gamma\dot{p}}{G(B) * r'(B)}$$

  As we know from below $r(B) > 0$, $r'(B) > 0$, $G(B) < 0$, $\gamma > 0$ and $\dot{p} > 0$
- Therefore, if $\alpha(r'(B).B + r(B)) > \gamma\dot{p}$ then $H_2(B) = \dot{B} < 0$ $\Rightarrow$ the optimal level of debt is still decreasing, even though prices are increasing.

Figure : Commodity Prices and Public Debt: The Case of Oil Producers (*Debt ratios in percent of GDP, oil prices in dollar per billon of barrels)*



Source: IMF

Conclusion

- In the model with a constant interest rate, output and consumption growth are not sustainable.
- In the debt elastic interest rate model:
  - Consumption grows for a while during the transitional dynamics and then decreases in the long-run
  - The level of debt decreases asymptotically to zero, so do the output and the accumulation of capital

Conclusion

- Next steps to improve the model:
  - Introducing decreasing returns to scales
  - Endogenize the γ, the share of natural resources exported abroad
- Ongoing and future research:
  - Empirical work on sovereign default risk in emerging natural resource rich countries
  - Impact of the variation of oil price on oil countries' Credit Default Swaps (CDS)