



Department of Economics

Macroeconomic Aspects in Resource-Rich Countries

Luis Rey Los Santos

Thesis submitted for assessment with a view to obtaining the degree of
Doctor of Economics of the European University Institute

Florence, November 2010

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EUROPEAN UNIVERSITY INSTITUTE

Abstract

DEPARTMENT OF ECONOMICS

Doctor of Philosophy

by [Luis Rey Los Santos](#)

Natural resources represent a good opportunity for economic growth and development in many resource-rich countries. However, not all these countries have benefited from the wealth stemming from natural resources. The empirical evidence shows that the economic performance of many resource-rich countries is poorer than the average. This has come to be known as the "natural resource curse". The interesting questions are why do some countries perform badly despite their natural wealth, what are the mechanisms that cause lower growth rates and how can they be avoided.

Different arguments have been proposed to explain the natural resource curse. Some authors claim that resource abundance elicits corruption and rent seeking. Others argue that the high volatility of commodity prices lead to macroeconomic volatility, and volatility harms economic growth. However, the soundest explanation for the natural resource curse is based on the notion of the Dutch disease.

The first chapter of the thesis analyses the mechanism behind the Dutch disease. The extra wealth generated by the sale of natural resources induces an appreciation of the real exchange rate and a corresponding contraction of the traded sector. If we consider that most of the economic growth is caused by technological progress acquired through "learning-by-doing" (LBD) which is mainly present in the traded sector, a temporary decline in that sector may imply lower economic growth.

A number of oil producing countries have attempted to avoid the Dutch disease through stabilization funds. The second chapter of the thesis analyses the economic consequences of stabilization funds. These funds permit oil producing countries to adjust government spending and cushion the domestic economy from the sharp and unpredictable variations in oil prices and revenue.

Given that natural resources are exhaustible, the last chapter of the thesis looks for an optimal revenue distribution between current and future generations. Previous models based on the permanent-income hypothesis are enriched, including essential features of resource-rich countries, productive government spending and Dutch disease effects.

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Contents

Abstract	i
Acknowledgements	iii
List of Figures	vi
List of Tables	vii
1 Introduction	1
1.1 The Dutch disease	2
1.2 Stabilization Funds	3
2 The Dutch Disease in a dependent economy with intersectoral adjustment cost for capital	7
2.1 Introduction	8
2.2 Dependent economy with costly intersectoral adjustment of capital	10
2.2.1 Firms producing tradables	11
2.2.2 Firms producing non-tradables	12
2.2.3 Households	12
2.2.4 Current account	16
2.2.5 Learning by Doing (LBD) and borrowing premium	16
2.3 Macroeconomic Equilibrium	17
2.4 Calibration	19
2.5 Steady State properties	20
2.5.1 No Growth	20
2.5.2 Growth	22
2.6 Simulation of a natural resource bonanza	23
2.6.1 Permanent oil shock in a non-growing economy	24
2.6.2 Permanent oil shock in a growing economy	25
2.6.3 Temporal oil shock in a growing economy	26
2.7 Conclusion	27
2.8 References	28
3 Macroeconomic Aspects of Stabilization Funds in Resource-rich Countries	33
3.1 Introduction	34
3.2 The model	36
3.2.1 Households	36

3.2.2	Firms	40
3.2.2.1	Firms producing tradables	40
3.2.2.2	Firms producing non-tradables	41
3.2.3	Fiscal Policy	41
3.2.3.1	Increase in government spending	42
3.2.3.2	Stabilization Fund	42
3.2.3.3	Dividend Program	43
3.2.4	Market clearing	43
3.2.5	Calibration	44
3.3	Consequences of a temporary oil shock	45
3.3.1	Increase in Government spending	45
3.3.2	Stabilization Fund	47
3.3.3	Dividend program	48
3.4	Conclusion	49
3.5	References	50
4	Natural-Resource Depletion and Optimal Fiscal Policy: Lessons from Mexico	56
4.1	Introduction	57
4.2	Oil sector in Mexico	60
4.3	Benchmark: A Model of Permanent Income	61
4.4	A model of productive government consumption and Dutch disease effects	62
4.4.1	Production	62
4.4.2	Households	64
4.4.3	Government	64
4.4.4	Optimal government consumption	67
4.5	Model Calibration and Results	69
4.5.1	Results	70
4.5.1.1	Without Growth	71
4.5.1.2	Only one source of growth	72
4.5.1.3	Two sources of growth	73
4.5.1.4	Sensitivity analysis	75
4.6	Conclusion	77
4.7	Appendix	81
5	Conclusion	84

List of Figures

1.1	Non-oil current account and oil revenue	3
1.2	Oil revenue and public spending in Norway	4
1.3	Oil revenue and public spending in Venezuela	5
1.4	Oil revenue and public spending in Mexico	6
2.1	Temporary 1% increase in oil-output ratio. No growth (no LBD)	30
2.2	Temporary 1% increase in oil-output ratio. With LBD	31
2.3	Permanent 1% increase in oil-output ratio. With LBD	32
3.1	Oil revenue and government expenditure in Mexico and Norway	36
3.2	Increase in Government spending	53
3.3	Stabilization Fund	54
3.4	Dividend Program	55
4.1	Oil Production in Mexico	61
4.2	Real oil price forecast	69
4.3	Optimal paths without growth (percent of non-oil GDP)	71
4.4	Optimal path with productive public goods (percent of non-oil GDP)	72
4.5	Optimal path with Dutch disease effects (percent of non-oil GDP)	73
4.6	Optimal paths with two sources of growth (percent of non-oil GDP)	74
4.7	Non-oil balance optimal paths for different scenarios	75
4.8	Non-oil balance optimal paths for different values of γ	76
4.9	Non-oil balance optimal paths for different values of r	77

List of Tables

2.1	Parameter Values	19
2.2	Structure of the theoretical economy	20
2.3	Steady State Response to a permanent oil shocks	29
3.1	Parameter Values	45
3.2	Structure of the theoretical economy	45
4.1	Data from governments in oil-exporting countries (2005)	58

Chapter 1

Introduction

Natural resources represent a good opportunity for economic growth and development in many resource-rich countries. However, not all these countries have benefited from the wealth stemming from natural resources. The empirical evidence shows that the economic performance of many resource-rich countries is poorer than the average. This has come to be known as the "natural resource curse". The interesting questions are why do some countries perform badly despite their natural wealth, what are the mechanisms that cause lower growth rates and how can they be avoided.

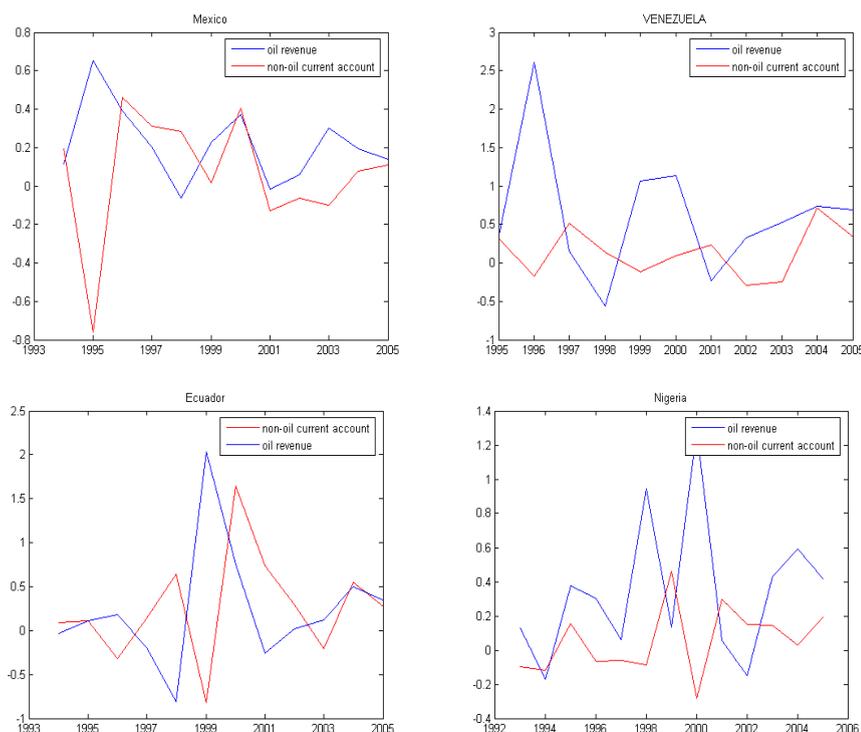
The empirical evidence suggesting that there is a negative link between natural resources' revenue and economic growth, is very large. One of the first studies that analyzes cross-country evidence for the natural resource curse, was by Sachs and Warner (1995). In their work, they analyzed the period between 1970 and 1989, and showed that resource-rich countries grew, on average, one percentage point less during this period. The results appear robust, given that they remain significant even after controlling for a large number of variables such as GDP growth, openness in policy, investment and human capital accumulation. However, other studies claimed the need to control for additional variables, especially, the efficiency of government institutions. Sachs and Warner (1997) show that the negative link between natural resource abundance and growth, remains significant even after controlling for institutions' quality. The adverse effects of resource abundance on economic growth survive even after allowing for geographical factors such as distance to closest airport, percentage of land in tropics or incidence of malaria (Sachs and Warner, 2001).

Other authors have also provided cross-country evidence and proved the natural resource curse; Sala-i-Martin (1997), Sala-i-Martin and Subramanian (2003), Arezki and van der Ploeg (2007), Gylfason et. al. (1999), Leite and Weidmann (1999), Busby, et. al. (2002), etc.

1.1 The Dutch disease

Different arguments have been proposed to explain the natural resource curse. Some authors claim that resource abundance elicits corruption and rent seeking. Others argue that the high volatility of commodity prices lead to macroeconomic volatility, and volatility harms economic growth. However, the soundest explanation for the natural resource curse is based on the notion of the Dutch disease. The idea behind the Dutch disease is that the extra wealth generated by the sale of natural resources induces an appreciation of the real exchange rate and a corresponding contraction of the traded sector. If we consider that most of the economic growth is caused by technological progress acquired through "learning-by-doing" (LBD) which is mainly present in the traded sector, a temporary decline in that sector may imply lower economic growth. There is microeconomic evidence supporting the assumption of learning-by-doing externalities in the traded sector. Van Biesebroeck (2005) finds that the productivity of manufacturing plants in African countries increases after entering export markets. Blalock and Gertler (2004) show that Indonesian firms become more productive by learning through exporting. Fernandes and Isgut (2005) present evidence of "learning by exporting" by young Colombian manufacturing plants between 1981 and 1991. Figure 1.1 shows how the non-oil external current account has evolved compared to the oil revenue in some oil exporting countries (Venezuela, Mexico, Nigeria and Ecuador). We can see a negative correlation between these two variables. Periods of high oil revenue are usually followed with non-oil current account deficits. One way to explain this fact is that an increase in oil revenue causes a real exchange rate appreciation. Non oil exporters find it more difficult to trade their goods; hence, there is a decline in the traded sector. This is the main idea behind the Dutch disease.

FIGURE 1.1: Non-oil current account and oil revenue



1.2 Stabilization Funds

Resource rich countries are exposed to sudden increases or decreases in commodity prices or discoveries of new reserves. This can lead to boom and bust cycles. There exists empirical evidence that the high volatility of commodity prices in the world market has negative effects on growth performance in resource-rich countries (van der Ploeg and Poelhekke, 2007). There is also cross-country evidence that real exchange rate volatility can harm productivity in the long-run, especially in countries with low levels of financial development (Aghion, et. Al, 2006).

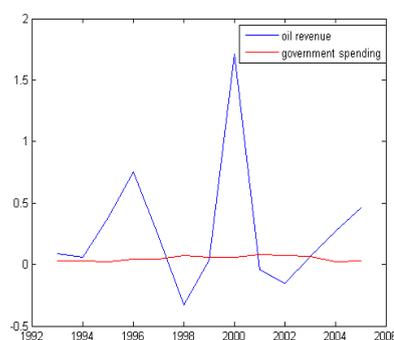
A number of oil producing countries have attempted to address these issues through

stabilization funds. The purpose of these funds is to adjust government spending and cushion the domestic economy from the sharp and unpredictable variations in oil prices and revenue. Oil producing countries such as Norway, Venezuela, Oman and Kuwait have adopted different types of stabilization funds. However, the experience of oil funds has been very different across countries. While Norway and Kuwait have achieved to isolate government spending from oil revenue, government spending in Venezuela and Oman has a high correlation with oil revenue.

In 1990, Norway established the State Petroleum Fund (SPF). The objective was to create a mechanism to insulate non-oil economy from windfall oil revenue. According to the SPF policy, the assets are invested in a range of foreign financial assets and only the return from the assets can be used for government purchases.

The SPF can be considered a successful tool for managing oil resources. The following figure shows the percentage change in government spending and oil revenue in Norway. We can observe that the SPF has achieved its objective; government spending has kept an independent path from oil revenue. Actually, government spending growth rate has been almost constant over time. On the other hand, oil price volatility led to sharp increases and decreases in oil revenue. In 2000, Norwegian government more than doubled the revenue stemming from oil, however public spending did not increase significantly.

FIGURE 1.2: Oil revenue and public spending in Norway



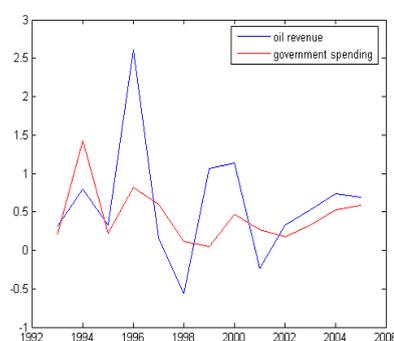
Venezuelan experience with stabilization funds has been very different. In 1998, Venezuela established a Macroeconomic Stabilization Fund (MSF). The objective was very similar

to Norwegian State Petroleum Fund. The fund was created to insulate the government budget and the economy from fluctuations in oil prices.

The mechanism that drives Venezuelan fund is different from the Norwegian. The Venezuelan fund focuses on short-term stabilization. A share of oil revenue is saved when oil price is above a reference value, and withdrawals are made when it is below this value. Although in the first year the fund had transparent rules, important modifications were introduced in 1999. The most important one is the president's ability to withdraw money from the fund without approval by Congress.

The figure below shows the high correlation between the government's oil revenue and public spending. Oil price volatility led to government spending increases and decreases. While, in Norway, high oil prices in 2000 did not affect public spending, Venezuelan government increased expenditure by 50

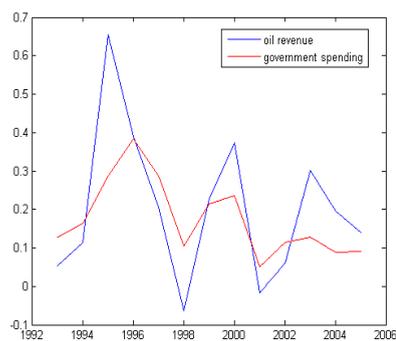
FIGURE 1.3: Oil revenue and public spending in Venezuela



In contrast to these countries, there have been other resource rich countries which have not established stabilization funds. For e.g., Mexico where oil revenue represents 30 percent of total government revenue. Mexico has not adopted any rule, and therefore, oil revenue is spent under government discretion. We can see that the consequences for Mexican economy have been negative. Government spending has followed a similar path to oil revenue. Periods of high oil prices implied high growth in public spending.

It is well known that volatility is bad for growth (Ramey and Ramey, 1995). This is especially true for resource-rich countries, where government income is dependent on

FIGURE 1.4: Oil revenue and public spending in Mexico



resource revenue. Stabilization funds have been considered the best way to address the problems caused by high volatility.

Chapter 2

The Dutch Disease in a dependent economy with intersectoral adjustment cost for capital

The notion of the Dutch disease has been the most widespread explanation for the poor economic performance of some resource-rich countries. Empirical evidence shows that resource bonanzas lead to real exchange rate appreciations and consequently, a decline of the non-oil traded sector. When we consider that the traded sector benefits from "learning-by-doing" externalities, natural resource booms imply lower growth rates. Previous literature on the Dutch disease is based on two sector models where perfect mobility of the production factors is assumed, and thus, the real exchange rate is determined by the world interest rate and technology. We enrich previous models by adopting a dynamic framework with intersectoral adjustment cost for capital. Under this approach, in the short run, the real exchange rate is no longer fully determined by the supply side and does not adjust instantaneously.

2.1 Introduction

Natural resources are an important source of revenue for many developing countries. What could actually represent an opportunity to enhance economic growth, natural resources have surprisingly become a curse in many countries. The empirical evidence has shown that some resource-exporting countries experience lower growth rates in the long-run¹. Most of the arguments that have been proposed in the various literature to explain this phenomenon are based on the notion of the Dutch disease. The idea behind the Dutch disease is that the extra wealth generated by the sale of natural resources induces an appreciation of the real exchange rate and a corresponding contraction of the traded sector. If we consider that most of economic growth is caused by technological progress acquired through learning-by-doing (LBD) which is mainly present in the traded sector, a decline of that sector may imply lower economic growth (Corden and Neary, 1982; Corden, 1984).

There is substantial microeconomic evidence supporting the assumption of LBD externalities in the export sector of developing countries. For example, Van Biesebroeck (2005) finds that productivity of manufacturing plants in African countries increase after entering export markets. Blalock and Gertler (2004) show that Indonesian firms become more productive by learning through exporting. Fernandes and Isgut (2005) present evidence of “learning by exporting” by young Colombian manufacturing plants between 1981 and 1991.

While there are numerous theoretical analyses of the Dutch disease effects, they have largely used partial equilibrium and static frameworks. Most of the models have also ignored the dynamics of the real exchange rate. Previous works on the Dutch disease usually assume that, while it is costly to convert new output to capital, it is costless to transform one form of existing capital to another. That is, capital is perfectly mobile between the traded and non-traded sector. One consequence of this assumption is that there is not impact of resource booms on the real exchange rate. In fact, the real exchange rate, the wage and the capital intensities are pinned down by the world interest rate and technology (Sachs and Warner, 1995).

¹See, for instance, Auty (2001), Sachs and Warner (1995).

This paper tries to enrich previous models of the Dutch disease adopting a dynamic framework with intersectoral adjustment cost for capital. We investigate the consequences of a resource boom in an economy with costly sectoral reallocation of capital between non-traded and traded sectors. For this purpose, we follow the framework developed by Morshed and Turnovsky (2003), where they assume that the movement of capital across sectors involves convex intersectoral adjustment costs. In this way, the real exchange rate is now subject to transitional dynamics, and thus, it is not determined by the interest rate. After an increase in natural resource revenues, the stock of capital can not adjust immediately, and consequently the real exchange rate appreciates. We also assume that capital is produced only in the non-traded sector, and we abstract from adjustment costs associated with aggregate capital formation.

Just like Sachs and Warner (1995), we employ an endogenous growth model where the source of growth is labor-augmenting technological progress. The key assumption is that the accumulation of knowledge is only generated in the traded sector. However, not only the traded sector benefits from the technological progress but also the non-traded sector. Thus, if an increase in natural resource revenues leads to a decline of the traded sector, the economy will experience lower growth rates.

The framework which we use is a dynamic stochastic general equilibrium model with three sectors and two factors of production. The sectors are oil, traded and non-traded. We assume that production of oil requires no factor inputs, and can be sold in the world markets at an exogenous world price. This model makes no distinction between resource booms that occur because of discoveries or because of increases in resource prices.

The two factors of production are labor and capital. Labor can move freely between sectors but not internationally. Capital is obtained in the non-traded sector, and has a cost attached to transfer it from one sector to the other. Households can borrow internationally at the real interest rate. We assume that world capital markets assess an economy's ability to service debt costs and the associated default risk, the key indicator of which is the country's debt-output ratio.

2.2 Dependent economy with costly intersectoral adjustment of capital

We consider a small open economy with a large number of identical infinitely lived households and a large number of identical firms. The typical household consumes both non-traded goods, which are produced in the non-traded sector, and traded goods, which are produced either at home or abroad. Households provide labor at the competitive wage to firms in both the traded and the non-traded sectors. They also accumulate capital that they rent to production firms.

Therefore, three goods are produced in the economy, non-traded goods, traded goods and oil. Production of oil requires no factor inputs, and all its production is exported. Prices of traded goods, including oil, are determined internationally.

Following Morshed and Turnovsky (2003), we assume that the traded good is used only for consumption, while the non-traded good can be either consumed or converted into capital. We further assume that the capital stock does not depreciate and that it can not move freely across sectors. Only non-traded output can be converted into capital, and once it becomes capital good in the non-traded sector, it can be transferred to the traded sector under some adjustment cost. Thus, capital accumulation in the economy is described by,

$$K_{Tt+1} - K_{Tt} = X_t \tag{2.1}$$

$$K_{Nt+1} - K_{Nt} = I_t - X_t \left(1 + \frac{hX_t}{2K_{Nt}} \right) \tag{2.2}$$

where X is the amount of capital transferred from the non-traded to the traded sector, and I is the amount of output that is not consumed in the non-traded sector, and therefore, converted into capital. The coefficient $h > 0$ parameterizes the degree of the sectoral adjustment cost. In order to provide X units of capital to the traded sector, the amount of capital in the non-traded sector must be reduced by more than X . This excess amount, $hX^2/2K_N$, represents the intersectoral adjustment costs.

We assume inelastic supply of labor. Moreover, labor is perfectly mobile across sectors and the labor market always clears. Thus, the following equation would hold good all the time

$$L_T + L_N = 1 \tag{2.3}$$

where L_T and L_N are the labor employed in the traded and non-traded sector, respectively. Notice that we normalize the total amount of labor to one.

2.2.1 Firms producing tradables

The representative firm in the traded sector employs labor and capital in a Cobb-Douglas production function in order to produce traded goods.

$$Y_{Tt} = K_{Tt}^\alpha (A_t L_{Tt})^{1-\alpha} \tag{2.4}$$

where A is labor-augmenting technological progress. Firms in the traded sector operate under perfect competition. Their decision is to choose capital and labor allocation K_T and L_T to maximize the firms profits in units of tradables. Profits maximization behavior implies the following equations:

$$(1 - \alpha) K_{Tt}^\alpha A_t (A_t L_{Tt})^{-\alpha} = w_t \tag{2.5}$$

$$\alpha K_{Tt}^{\alpha-1} (A_t L_{Tt})^{1-\alpha} = R_{Tt} \tag{2.6}$$

where the price of traded goods is normalized to one, and R_T represents the return on capital employed in the traded sector. Equation (2.5) and (2.6) describe demand for labor and capital inputs in the traded sector. The marginal product of the labor employed in the traded sector equals the wage rate in the economy, w .

2.2.2 Firms producing non-tradables

The representative firm in the non-traded sector also employs capital and labor in a Cobb-Douglas production function in order to produce non-traded good.

$$Y_{Nt} = K_{Nt}^\gamma (A_t L_{Nt})^{1-\gamma} \quad (2.7)$$

The firm chooses capital and labor allocation K_N and L_N , to maximize the firms profits in units of tradables, under a perfect competitive market. Thus, demand for labor and capital inputs are described in the following equations:

$$p_t (1 - \gamma) K_{Nt}^\gamma A_t (A_t L_{Nt})^{-\gamma} = w_t \quad (2.8)$$

$$p_t \gamma K_{Nt}^{\gamma-1} (A_t L_{Nt})^{1-\gamma} = R_{Nt} \quad (2.9)$$

where p is the price of non-traded goods, i.e., the real exchange rate. Given that labor is mobile across sectors, the wages paid in the both sectors are equal.

2.2.3 Households

The representative household is endowed with a fixed amount of labour (normalized to be one unit), which sells at the competitive wage, w . She also accumulates capital that rents to production firms, and may borrow internationally on a world capital market. Moreover, the entire income generated from oil extraction, O_t is distributed among households.

Accordingly, the households budget constraint is:

$$D_{t+1} - D_t = r_t D_t - w_t - R_{Nt} K_{Nt} - R_{Tt} K_{Tt} + P_t C_t + p_t I_t - O_t \quad (2.10)$$

where D is the total debt held by households, C is the consumption index of traded goods and non-traded goods and P is the consumption price index. Households take the

given oil revenue, O . To sustain an equilibrium of on-going growth, oil revenues must be tied to the scale of the economy

$$O_t = o_t Y_t$$

where Y is the total output², and o is the oil-output ratio, which is an exogenous, stochastic variable.

$$o_t = O\epsilon_t \tag{2.11}$$

where

$$\log(\epsilon_t) = \rho \log(\epsilon_{t-1}) + v_t \tag{2.12}$$

Thus, the typical household chooses, in the first stage, consumption level C and the rate of accumulation of capital, K_N and K_T , and debt D to maximize the intertemporal utility function,

$$U \equiv E_0 \sum_{t=0}^{\infty} \beta^t \log C_t$$

subject to the budget constraint (2.10) and capital accumulation constraints (2.1) and (2.2). Thus, household optimum is characterized by the following equations:

$$\frac{1}{C_t} = \lambda_t P_t \tag{2.13}$$

$$\lambda_t = \beta E_t[\lambda_{t+1}(1 + r_{t+1})] \tag{2.14}$$

$$\lambda_t p_t = \lambda_{Nt} \tag{2.15}$$

$$\lambda_{Tt} = \lambda_{Nt} \left(1 + \frac{hX_t}{K_{Nt}} \right) \tag{2.16}$$

²In the total output we include the production of oil, thus $Y = Y_T + pY_N + O$

$$\lambda_{Tt} = \beta E_t(\lambda_{Tt+1} + \lambda_{t+1}R_{Tt+1}) \quad (2.17)$$

$$\lambda_{Nt} = \beta E_t \left[\lambda_{Nt+1} \left(1 + \frac{hX_{t+1}^2}{2K_{Nt+1}^2} \right) + \lambda_{t+1}R_{Nt+1} \right] \quad (2.18)$$

along with capital accumulation (2.1)-(2.2), and the budget constraint (2.10). Where λ is the shadow value of wealth in the form of internationally traded bonds and, λ_N and λ_T are the shadow values of one unit of capital stock in the non-traded and traded sector respectively.

Equation (2.13) equates the marginal utility of consumption to the shadow value of wealth. Thus, the Lagrange multiplier measures the increase in household utility associated with one additional unit of real wealth. Equation (2.14) is a Euler equation that determines intertemporal allocation, it equates the intertemporal marginal rate of substitution in consumption to the real rate of returns to bonds. Combining equations (2.15) and (2.16), we obtain:

$$\frac{X_t}{K_{Nt}} = \frac{(q_t - p_t)}{p_t h} \quad (2.19)$$

where $p = \lambda_N/\lambda$ and $q \equiv \lambda_T/\lambda$ represent the market price of capital in terms of the foreign bond in the non-traded and traded sector respectively. Equation (2.17) determines the rate at which capital is transferred between the two sectors. There is a positive (negative) transfer from the non-traded sector to the traded sector when the market price of capital in the traded sector is above (below) the price of capital in the non-traded sector. There is no capital transfer across sectors when prices are equal in both sectors. Notice that in absence of adjustment cost, $h = 0$, the market price of capital must be equal in the non-traded and traded sector, $q = p$. Plugging equation (2.15) into equations (2.17) and (2.18), we obtain the following two equations:

$$q_t = E_t \left(\frac{q_{t+1}}{1 + r_{t+1}} + \frac{R_{Tt+1}}{1 + r_{t+1}} \right) \quad (2.20)$$

$$p_t = E_t \left[\frac{p_{t+1}}{1 + r_{t+1}} \left(1 + \frac{hX_{t+1}^2}{2K_{Nt+1}^2} \right) + \frac{R_{Nt+1}}{1 + r_{t+1}} \right] \quad (2.21)$$

Equations (2.20) and (2.21) state the pricing conditions for capital in the traded and the non-traded sectors, respectively. The revenue from selling one unit of capital today must be equal to the discounted value of renting the unit of capital for one period and then selling it, net of adjustment costs. It is straightforward to demonstrate that, in the absence of adjustment cost, the return on capital must be equal in the non-traded sector and the traded sector, $R_N = R_T$.

On the other hand, in the second stage, given total consumption index, households decide the share of non-traded and traded goods of their consumption basket. Consumption index is a Cobb-Douglas function of non-traded goods and traded goods, $C = C_T^\theta C_N^{1-\theta}$ with $\theta > 0$. Thus, the representative household faces the following maximization problem,

$$\text{Max} \quad C_T^\theta C_N^{1-\theta} \quad (2.22)$$

subject to

$$PC = C_T + pC_N \quad (2.23)$$

From the first order conditions, we obtain the optimal demand for traded and non-traded goods,

$$C_T = \theta PC \quad pC_N = (1 - \theta)PC \quad (2.24)$$

We can also rewrite the consumption-price index as a function of the price of the non-traded goods,

$$P = p^{1-\theta} \quad (2.25)$$

2.2.4 Current account

In this section, we derive the current account of the economy,

$$D_{t+1} - D_t = r_t D_t - Y_{Tt} + C_{Tt} - O_t \quad (2.26)$$

and thus, we prove that the Walras' law is satisfied. The starting point is the households budget constraint, equation (2.10),

$$D_{t+1} - D_t = r_t D_t - w_t(L_{Tt} + L_{Nt}) - R_{Nt}K_{Nt} - R_{Tt}K_{Tt} + P_t C_t + p_t I_t - O_t$$

Applying zero profit condition for firms and decomposing consumption expenditure, that is,

$$Y_{Tt} = R_{Tt}K_{Tt} + w_t L_{Tt}$$

$$pY_{Nt} = R_{Nt}K_{Nt} + w_t L_{Nt}$$

$$P_t C_t = C_{Tt} + p_t C_{Nt}$$

we obtain,

$$D_{t+1} - D_t = r_t D_t - p_t Y_{Nt} - Y_{Tt} + p_t C_{Nt} + C_{Tt} + p_t I_t - O_t$$

Finally, we apply the market clear condition in the non-traded sector, $pY_N = pC_N + pI$. In this way we obtain equation (2.24).

2.2.5 Learning by Doing (LBD) and borrowing premium

Following other models on the Dutch disease, we adopt the same LBD mechanism as Sachs and Warner (1995). Productivity growth is driven by the labor employed in the

traded sector, and benefits not only the traded sector but also the non-traded sector. Thus, the dynamics of productivity A are

$$\frac{A_{t+1} - A_t}{A_t} = a + bL_T t \quad (2.27)$$

where the parameter $b \geq 0$ measures the strength of the LBD effect, and a is the constant value of productivity growth. As in the earlier literature, the LBD effect is external to firms, the underlying assumption being that each firm is too small to take its own contribution to LBD into account.

On the other hand, we assume that the interest rate that households face is a function of the country's debt-output ratio³.

$$r_t = r_t^* + f(D_t/Y_t) \quad f' > 0 \quad (2.28)$$

where r^* is the exogenously given world interest rate. This assumption implies that capital markets assess an economy's ability to service debt costs and the associated default risk. The endogenized risk premium assumed in this model rules out the nonstationary behavior of consumption and the current account presented in unrestricted small open economy models. Other authors such as Turnovsky (1997) have previously adopted this assumption⁴.

2.3 Macroeconomic Equilibrium

The steady-state equilibrium has the characteristic that all real quantities grow at the same constant rate, g , and the relative prices of capital in the non-traded and traded sector, p and q , are constant. Thus, we express the dynamics of the system in terms of the following stationary variables, $k_T \equiv K_T/Y$, $k_N \equiv K_N/Y$, $c \equiv C/Y$, $d \equiv D/Y$, $x \equiv X/Y$ and, L_N , L_T , p and q .

³The functional specification of the upward sloping curve that we use is: $r = r^* + e^{zD/Y} - 1$. Thus, in case of a perfect world market, when $z = 0$, $r = r^*$, the world interest rate.

⁴Other methods used in the literature include finitely-lived households, transaction costs in foreign assets and endogenous discount factor, see for further discussions of these methods Schmitt-Grohe and Uribe (2002).

Thus, the equilibrium of the economy is a sequence of prices $\{\Pi_t\} = \{w_t, r_t, p_t, R_{Nt}, R_{Tt}\}$ and quantities $\{\Theta_t\} = \left\{ \{\Theta_t^h\}, \{\Theta_t^f\} \right\}$ with

$$\{\Theta_t^h\} = \{c_t, c_{Nt}, c_{Tt}, d_t, k_{Nt+1}, k_{Tt+1}, i_t, x_t\}$$

$$\{\Theta_t^f\} = \{L_{Nt}, L_{Tt}, k_{Nt}, k_{Tt}\}$$

such that:

(1) given a sequence of prices $\{\Pi_t\}$ and a sequence of shocks, $\{\Theta_t^h\}$ is a solution to the representative household's problem;

(2) given a sequence of prices $\{\Pi_t\}$ and a sequence of shocks, $\{\Theta_t^f\}$ is a solution to the problems of representative firms in both the non-traded and traded sector;

(3) given a sequence of quantities $\{\Theta_t\}$ and a sequence of shocks, $\{\Pi_t\}$ clears the market:

(i) Labor market:

$$L_{Tt} + L_{Nt} = 1 \tag{2.29}$$

(ii) Capital market:

$$K_{Nt}^S = K_{Nt}^D \quad K_{Tt}^S = K_{Tt}^D \tag{2.30}$$

(iii) Non-traded goods sector:

$$pY_{Nt} = pC_{Nt} + pI_{Nt} \tag{2.31}$$

(iv) Foreign loans market:

$$D_t^S = D_t^D \tag{2.32}$$

(v) Balance of payments:

$$D_{t+1} - D_t = r_t D_t - Y_{Tt} + C_{Tt} - O_t \tag{2.33}$$

2.4 Calibration

Due to the complexity of the model, we will employ numerical methods to examine the effects of oil shocks. We begin by calibrating a benchmark economy, selecting parameter values that are, as close as possible, consistent with the main features of a representative small open economy. The time unit is one quarter.

TABLE 2.1: Parameter Values

Parameter	Value	Description
α	0.35	capital share in traded sector
γ	0.25	capital share in non-traded sector
r^*	0.01	world interest rate
θ	0.5	consumption preference
o	0.15	oil-output ratio
z	0.04	risk borrowing premium
β	0.973	discount rate
h	30	adjustment cost
a	0.0025	constant value of growth
b	0.0125	learning-by-doing

The benchmark parameter choices of the model are described in Table 2.1, while Table 2.2 reports macroeconomic ratios implied by the theoretical model.

Our choice for the discount factor, β and the world interest rate, r^* , are standard in the literature. For the key parameters of the model, we follow Morshed and Turnovsky (2003). Thus, we set the share of the traded goods in the consumption portfolio, $\theta = 0.5$. We assume the standard assumption that the traded sector is more capital-intensive than the non-traded sector, and chose the value of the capital share in traded and non-traded sectors, α and γ , equal to 0.25 and 0.35 respectively. One of the key parameters of the model is adjustment cost, h . As Morshed and Turnovsky (2003) argue, adjustment cost in this model is different from the standard adjustment cost parameter in aggregate investment models. The cost of converting one existing form of capital into another is more costly than converting new output into capital. Thus, we also set $h = 30$ as the benchmark value for our dynamic analysis. However, we also analyse the dynamics for different values of h .

Another important parameter in the model is the one that establishes the benefits from learning-by-doing, b . In a study for Indonesian firms Blalock and Gertler (2004) find

strong evidence that firms experience an annual increase in productivity of about 2 to 5 percent immediately after the initiation of exports. Van Biesebroeck (2003) finds similar results in sub-Saharan Africa. Thus, we establish an annual increase in productivity of 5 percent for new workers in the traded sector, $b = 0.0125$. The other parameter $a = 0.0025$ is chosen to ensure a plausible growth rate.

The borrowing premium $a = 0.03$ is chosen to ensure a plausible national debt. Finally, we assume that oil production represents a 15% of total production in the economy, $o = 0.15$.

TABLE 2.2: Structure of the theoretical economy

Capital in traded sector/GDP	2.2872
Capital in non-traded sector/GDP	2.9615
External debt/GDP	62%
Consumption/GDP	83%
Investment in traded sector/GDP	2%
Investment in non-traded sector/GDP	4%
Employment in non-traded sector/Total Employment	64%
Employment in traded sector/Total Employment	36%
Oil/GDP	15%
Quarterly growth	0.7%

2.5 Steady State properties

2.5.1 No Growth

In the absence of learning-by-doing ($b=0$) and exogenous growth ($a=0$), all real quantities keep constant at the steady state. The steady state is thus described by firms cost minimization conditions, equations (2.5), (2.6), (2.8) and (2.9), household optimum conditions (2.13), (2.14), (2.19), (2.20), (2.21) and (2.24), the inelastic labor supply assumption (2.3), the current account equation (2.26), and the risk premium condition (2.27).

The steady state equilibrium has the characteristic of having no investment, and therefore, capital adjustment cost has no impact on steady state values. Consequently, from equation (2.19), the price of capital in the non-traded and traded sector are equal. Moreover, the return on capital, expressed in terms of the foreign bond, equals the interest

rate, $R_T/p = R_N/p = r$, equations (2.20)-(2.21). This result implies, from firms first order conditions, that the relative price and the capital-labor ratios can be expressed as a function of the interest rate ⁵,

$$p = p(\bar{r}) \quad K_N/L_N = K_N/L_N(\bar{r}) \quad K_T/L_T = K_T/L_T(\bar{r}) \quad w = w(\bar{r})$$

The first conclusion that we can take is that these variables are independent of oil booms. In the long-run, the relative price of non-traded goods and traded goods (real exchange rate) will not be affected by a permanent increase of oil revenue.

However, an oil boom raises households real income, and thus, the demand for traded and non-traded goods. From equation (2.24), we observe that a higher total demand leads to an increase in demand for all goods, including traded and non-traded goods.

$$C_T = C_T(\overset{+}{O}) \quad C_N = C_N(\overset{+}{O})$$

Given the market clear condition in the non-traded sector, the rise in the demand of non-traded goods leads to increase in the production of this type of goods. It is not possible to import non-traded goods; thus, when the real income of households increase, the economy must produce more of non-traded goods.

$$Y_N = Y_N(\overset{+}{O})$$

To increase the production of non-traded goods, firms of the non-traded sector need to employ more production factors, both capital and labor. Given that the labor supply is inelastic, the rise of the labor employed in the non-traded sector implies the decline of the labor employed in the traded sector.

$$L_N = L_N(\overset{+}{O}) \quad L_T = L_T(\bar{O})$$

Therefore, in the absence of learning-by-doing (and growth) an oil shock has no impact on the relative price of consumption goods. However, even without a price response,

⁵See Obstfeld and Rogoff (1996) for more detail.

the rise in the real income leads to a higher demand in both types of goods. In order to keep the market clear condition of the non-traded sector, a permanent oil shock causes a permanent decline (increase) of the traded sector (non-traded sector).

Table 2.3 shows the steady state response of one percent permanent oil shock. The left hand side of the table shows the effects on the main variables in absence of economic growth. As we have argued above, capital-labor ratios and households wages do not change after an oil shock. They are determined by the interest rate. Similarly, the relative price of non-traded and traded goods is pinned down by the interest rate, and therefore, an increase in oil revenue does not have an impact on the relative price (real exchange rate). However, a permanent oil shock will reallocate production factors across sectors. The higher demand in the non-traded sector implies the need to increase production, and thus, we observe that the labor employed in this sector rises around 0.16 percent. Consequently, we observe a decline in the traded sector. The labor employed in this sector decreases around 0.26 percent. Consumption of both traded and non-traded goods increases. However, given that the relative price does not vary, the relative consumption rate remains constant after the oil shock.

2.5.2 Growth

When the economy benefits from learning-by-doing ($b > 0$), the steady state equilibrium has the characteristic that all real quantities grow at the same constant rate g . The steady state is described by the same equations as in the previous section 2.5.1 plus capital accumulation equations, (2.1) and (2.2) and LBD equation (2.28). The main difference with respect to the non-growing economy is that a permanent oil shock has permanent effects on all variables of the economy. The right hand side of table 2.3 shows the steady state response of one percent oil shock in a growing economy.

The mechanism behind an oil shock is very similar to that mentioned in the previous section 2.5.1. A rise in oil revenue makes households richer. Higher income leads to an increase in demand for all goods, including non-traded and traded goods. As demand increases for both types of goods, production of non-traded goods must increase to clear the market of non-traded goods. In order to increase production in the non-traded sector, it is necessary for additional input of both capital and labor. Consequently, labor is transferred from the traded to the non-traded sector. Given that we assume

that the economy benefits from learning-by-doing which is acquired in the traded sector, the decline of the labor employed in the traded sector leads to lower economic growth. In contrast to the non-growing economy, a permanent oil shock affects the growth rate of the economy at the steady state, g .

$$g = g(\bar{O})$$

Table 2.3 shows that one percent permanent oil shock causes the rise of the labor employed in the non-traded sector of 0.16 percent, and the fall of the labor in traded sector of 0.27 percent. Thus, given the decline of labor employed in the traded sector, the growth rate of the economy at the steady state decreases from 2.80 percent to 2.79 percent.

On the other hand, a rise in oil revenue leads to a lower debt-output ratio. Under risk premium assumption, Equation (2.28), the interest rate is positively correlated with debt-output ratio. Thus, the decline of the debt output ratio implies a lower interest rate.

$$r = r(D^+/Y)$$

As in the non-growing economy, the relative price of non-traded goods and traded goods is pinned down by the interest rate at the steady state. A fall in the interest rate leads to a rise in the relative price. Table 2.3 shows that the relative price, p , increases around 0.03 percent. The rise in the relative price implies that the consumption of traded goods with respect to total consumption, increases. Although the consumption of both traded and non-traded goods increases after a positive oil shock, the consumption of traded goods increases relatively more due to the rise in the price of non-traded goods.

2.6 Simulation of a natural resource bonanza

In this section, we present results of simulation of the model after an exogenous oil shock. We do not distinguish between oil shocks stemming from a rise in oil price or a

rise in oil production. We show the response of the main variables of the model to one percentage increase in oil revenue.

2.6.1 Permanent oil shock in a non-growing economy

We analyse the effects of a permanent oil shock in a non-growing economy, that is, a economy that does not benefit from learning-by-doing ($a=0, b=0$). This case allows us to illustrate clearly the influence of capital adjustment cost on the model. Figure 2.1 shows response of the following variables to one percentage permanent increase in oil revenue: relative price of non-traded and traded goods (real exchange rate), labor employed in the traded sector, capital in the traded sector and household total consumption.

The dynamics of the real exchange rate depend highly on the assumption about capital adjustment cost. In contrast to the earlier models of the Dutch disease, we allow for intersectoral adjustment cost, that is, capital can not move freely across sectors. In the absence of capital adjustment cost, $h = 0$, the real exchange rate is devoid of any transitional dynamics; moreover, there is no response to oil shocks. The real exchange rate is determined by the interest rate not only at the steady state but also along the transitional path (it appreciates slightly in the short-run due to the decline in the debt-output ratio, and therefore, in the interest rate). It is unrealistic to consider that the real exchange rate does not react to a resource boom.

When we consider positive capital adjustment cost, $h = 30$, the dynamics of not only the real exchange rate but also the main variables of the model are more realistic. A rise in household income, stemming from the increased oil revenue, leads to an increase in demand for both traded and non-traded goods. As demand rises for both types of goods, production of non-traded goods must increase to restore home-market equilibrium. In contrast to the case where capital mobility is costless, capital can not be transferred instantaneously to the non-traded sector. To compensate the incapability of capital to adjust instantaneously to the oil shock, the real exchange rate and labor overreact. The price of non-traded goods rises (i.e., an appreciation of the real exchange rate) to restore home market equilibrium.

Given that labor moves freely across sectors, labor draws out of the traded sector into the non-traded sector. This makes it possible to increase production in the non-traded

sector. However this is not enough to compensate the rise of the demand of non-traded goods. Hence, we observe that the price of non-traded goods rises (i.e., an appreciation of the real exchange rate) to restore home-market equilibrium.

Capital speed adjustment to the new steady state depends on intersectoral adjustment cost. The higher the h is, the more time is required for that capital to reach the new steady state. As capital decreases (increases) in the traded sector (non-traded sector), labor moves back from the non-traded sector to the traded sector. Similarly, the real exchange rate is gradually restored back to its long-run equilibrium value.

2.6.2 Permanent oil shock in a growing economy

In this section, we analyse the consequences of a permanent oil shock in an economy, with intersectoral adjustment cost, which benefits from learning-by-doing. Figure 2.2 shows responses to one percentage increase in oil revenue. All variables are ratios with respect to GDP except real exchange rate and productivity growth. Their impulse responses are in deviation from the steady state values.

A positive oil shock leads to a conventional Dutch disease story. A permanent increase in oil revenue implies a permanent rise in households income, and consequently, the demand for traded and non-traded goods increases. As demand rises for both types of goods, the production of non-traded goods must increase to restore home-market equilibrium. However, due to capital adjustment cost, capital cannot move freely to the non-traded sector. Hence, in the short-run, labor employed in the non-traded sector overshoots its long-run equilibrium. Similarly, in contrast to earlier literature on the Dutch disease based on perfect mobility of capital, the relative price of non-traded goods (i.e., the real exchange rate) increases in the short-run to clear the market of non-traded goods.

As capital adjusts to its long-run equilibrium, production in the non-traded sector increases. Because of the rise in production, the relative price of non-traded goods fall. Similarly, as capital moves to the non-traded sector, there is a transfer of labor from the non-traded to the traded sector.

In the long-run, a permanent increase in oil revenue implies a permanent decline of the traded sector and a permanent rise in the non-traded sector. There is a transfer of production factors from the traded to the non-traded sector. Capital increases around

0.16 percent in the non-traded sector and decreases around 0.18 percent in the traded sector. Similarly, labor employed in the non-traded sector increases around 0.15 percent and decreases 0.3 percent in the traded sector.

A positive oil shock causes a rise in labor employed in the non-traded sector, and thus, the decline of labor employed in the traded sector. Based on previous models of the Dutch disease, we have assumed that productivity growth is acquired through learning-by-doing which is present in the traded sector. To be precise, productivity growth is a function of the labor employed in the traded sector. Therefore, the decline in labor employed in the traded sector, caused by the oil shock, implies a permanent decrease in productivity growth. The dynamics of productivity growth follow the path of labor employed in the traded sector.

We observe that there is a permanent consumption rise of almost 0.2 percent. The lower productivity growth is not enough to offset the higher household income due to the rise in oil revenue. The welfare of households increase with the permanent oil shock.

2.6.3 Temporal oil shock in a growing economy

In this section, we analyze the consequences of a temporal oil shock ($\rho = 0.7$) in an economy with intersectoral adjustment cost which benefits from learning-by-doing. Figure 2.3 shows responses to one percentage increase in oil revenue. All variables are ratios with respect to GDP except real exchange rate and productivity growth. Their impulse responses are in deviations from the steady state values.

As expected, a temporal oil shock causes temporal effects on the main variables of the model. After the oil shock there is a decline of the traded sector. A higher household income leads to a higher demand of both types of goods. To restore home-market equilibrium there is a transfer of production factors from the traded to the non-traded sector. Intersectoral adjustment cost causes an appreciation of the real exchange rate. As the shock diminishes, all variables return to their steady state equilibrium.

Therefore, the decline of the labor employed in the traded sector is temporal and consequently, the effects on productivity growth are also temporal. Households income is affected negatively by the lower productivity growth however, the increase in oil revenue

is high enough to cause a rise in the household total income. Hence, households enjoy higher consumption rates.

2.7 Conclusion

In this paper, we try to enrich previous models of the Dutch disease adopting a dynamic framework with intersectoral adjustment cost for capital. We analyze the consequences of positive oil shocks in an economy with and without adjustment cost for capital.

We show that by adding adjustment cost for capital to the model, the dynamics of the main macroeconomic variables are more realistic. After an oil shock, the higher demand for non-traded goods causes the appreciation of the real exchange rate and, consequently, the decline of the traded sector. When we consider that economic growth is driven by learning-by-doing acquired in the traded sector, the decline of the traded sector after an oil shock implies lower growth rates for the future.

2.8 References

Auty, R.M. (2001a). The political economy of resource-driven growth, *European Economic Review*, 46, 839-846.

Blalock, G. and P.J. Gertler (2004), Learning from Exporting Revisited in a Less Developed Setting", *Journal of Development Economics*, Vol. 75, pp.397-416.

Bruno, M. and J. Sachs (1982), "Energy and Resource Allocation: A Dynamic Model of the Dutch Disease", *The Review of Economic Studies*, 49(5), pp. 845-59.

Corden, M. (1984), "Booming Sector and Dutch Disease Economics: Survey and Consolidation", *Oxford Economic Papers*, 36(3), pp. 359-80.

Corden, M. and P. Neary (1982), "Booming Sector and De-Industrialisation in a Small Open Economy", *The Economic Journal*, 92 (368), pp. 825-48.

Devereux, M., P. Lane, and J. Xu (2004), "Exchange Rate and Monetary Policy in Emerging Market Economies",

Fernandes, A. and A. Isgut, Learning by doing, learning by exporting, and productivity: Evidence from Columbia, Wesleyan University and World Bank, Mimeo (2005).

Morshed, M. and S. Turnovsky (2003), "Sectoral Adjustment Cost and Real Exchange Rate Dynamics in a Two-Sector Dependent Economy"

Sachs, J. and A. Warner (1995), "Natural resource abundance and economic growth", NBER Working Paper no. 5398.

Schmitt-Groh, S. and M. Uribe (2002), "Closing Small Open Economy Models", *Journal of International Economics*, vol.1, 1-23.

Torvik, R. (2001), "Learning by doing and the Dutch Disease", *European Economic Review*, 45, 285-306.

Van Wijnbergen, S. (1984), "The Dutch Disease: A Disease After All?", *The Economic Journal*, vol. 94, no. 373, pp.41-55.

Van Biesebroeck, J., 2005, Exporting Raises Productivity in Sub-Saharan African Manufacturing Firms, *Journal of International Economics*, Vol. 67, No. 2, pp. 373-91.

TABLE 2.3: Steady State Response to a permanent oil shocks

	No Growth (a=0,b=0)		Growth (h=30)	
	o=0.15	o=0.1515	o=0.15	o=0.1515
K_T/L_T	30.2827	30.2827	-	-
K_N/L_N	18.7464	18.7464	-	-
w	2.1445	2.1445	-	-
p	1.3742	1.3742	1.2608	1.2612
D/Y	0.4398	0.4398	0.6160	0.6157
C_T/C	0.5861	0.5861	0.5614	0.5615
C_N/C	0.4265	0.4265	0.4453	0.4452
Y_T/Y	0.3561	0.3546	0.3346	0.3332
Y_N/Y	0.3594	0.3594	0.4088	0.4086
L_T	0.3846	0.3836	0.3601	0.3591
L_N	0.6154	0.6164	0.6399	0.6409
g	-	-	2.8004%	2.7959%

FIGURE 2.1: Temporary 1% increase in oil-output ratio. No growth (no LBD)

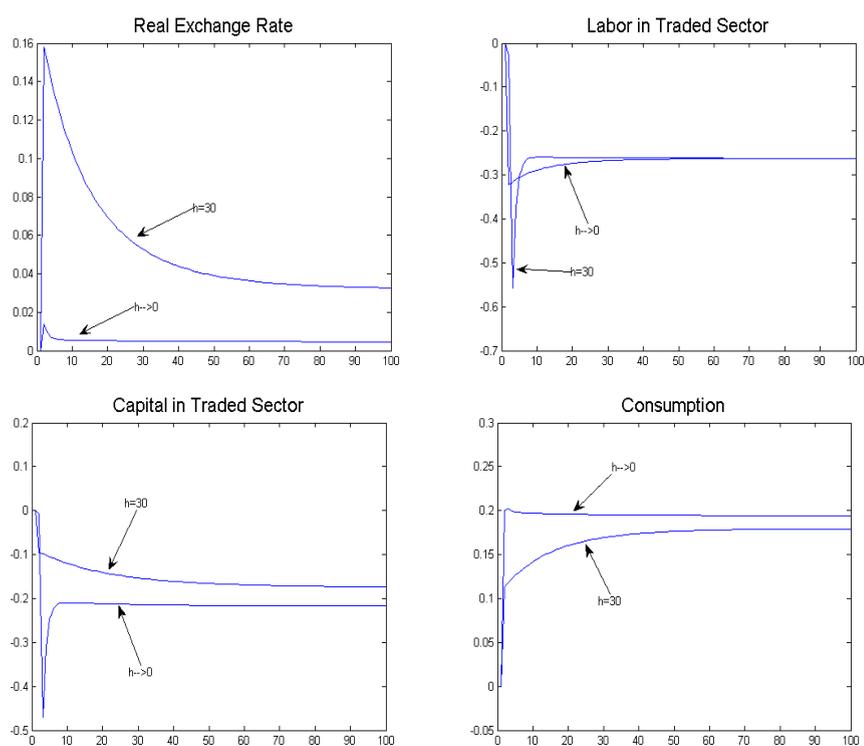


FIGURE 2.2: Temporary 1% increase in oil-output ratio. With LBD

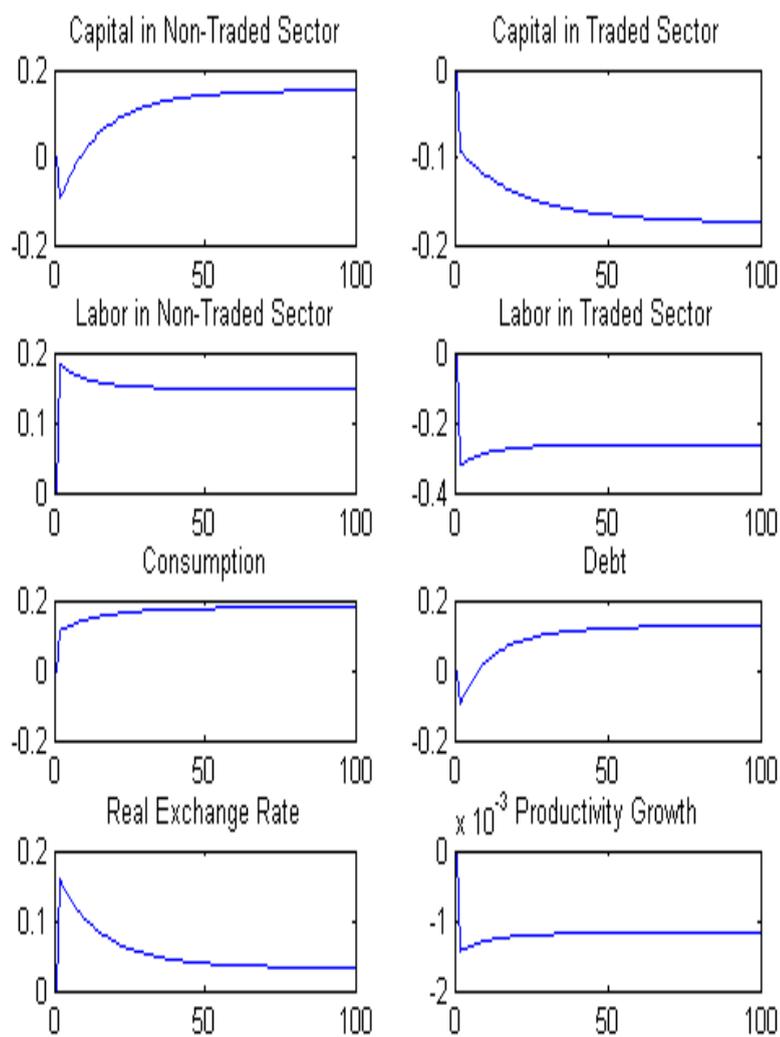
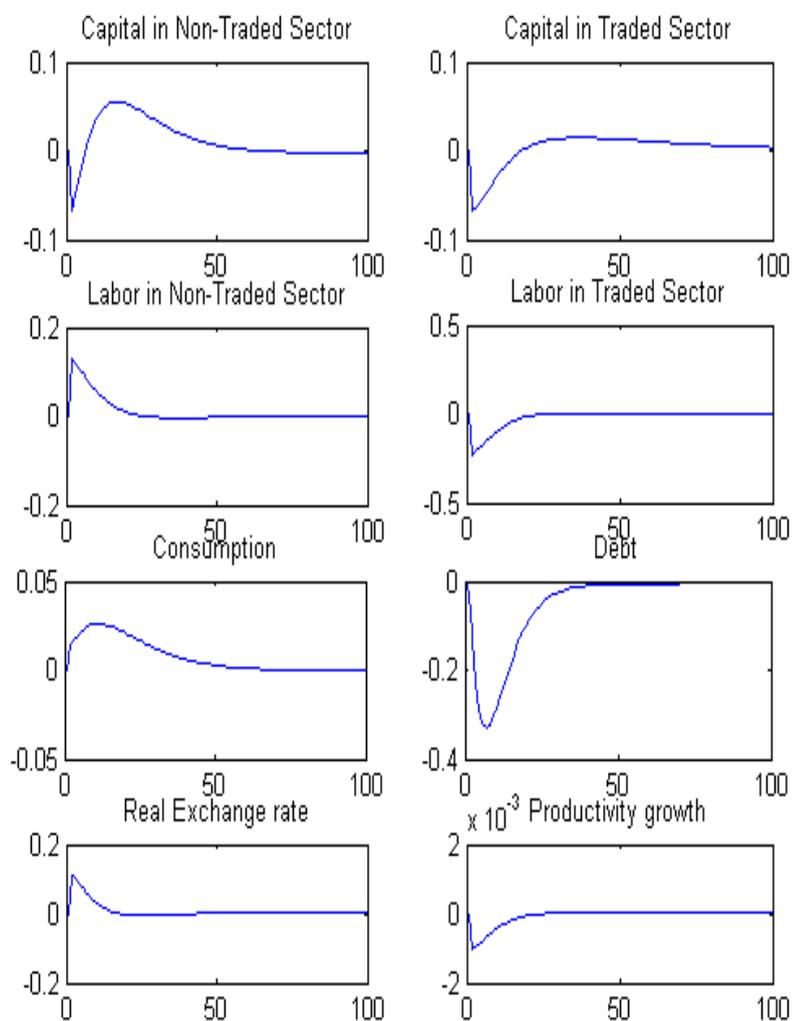


FIGURE 2.3: Permanent 1% increase in oil-output ratio. With LBD



Chapter 3

Macroeconomic Aspects of Stabilization Funds in Resource-rich Countries

The economic performance of resource-rich countries has been very unequal in the last few decades. While some economies have benefited from the extra wealth stemming from natural resources, others have suffered the so-called resource curse. Previous literature highlights the process of de-industrialization caused by the appreciation of the real exchange rate as an explanation of the natural resource curse. Others attribute the poor economic performance to the volatility generated by natural resource revenue. One of the measures adopted in some countries to avoid the resource curse has been the creation of stabilization funds. We develop a two-sector small open economy DSGE model to study the effects of resource booms under different fiscal strategies. We show that stabilization funds can help to moderate both real exchange rate appreciations and macroeconomic volatility caused by resource booms.

3.1 Introduction

Although there are resource-rich countries that benefit from their natural wealth, the economic performance of many other resource-rich countries has been very poor in the last few decades. Oil exporting countries such as Nigeria and Venezuela have experienced lower growth rates than less oil-dependent developing countries. This paradox has been the theme in many empirical analyses. For example, Sachs and Warner (1995) shows that resource-rich countries grow on average about one percentage point less during 1970-89¹.

There have been several approaches in earlier literature to account for the resource curse. The most important one is associated with the notion of the Dutch disease². The idea behind the Dutch disease is that the extra wealth generated by the sale of natural resources induces an appreciation of the real exchange rate and a corresponding contraction of the traded sector. If we consider that most of the economic growth is caused by technological progress acquired through learning-by-doing which is mainly present in the traded sector, a temporary decline in that sector may lower growth.

Other authors claim that the adverse effects of natural resources on the economy may also result from sensitivity to volatility of commodity prices in the world market. Natural resource revenues tend to be very volatile, because the supply of natural resources exhibits low price elasticity. It is well known that volatility is bad for growth, investment and income distribution (e.g., Ramey and Ramey, 1995; Aizenman and Marion, 1999).

3

Natural resources are the largest source of government revenue in many countries. Most of them are highly dependent on this revenue, hence the economic performance of these countries depend on the way their natural resources are managed. Previous literature has focused on explaining why resource wealth may have a negative impact on the economy. Little attention has been given to the question of how the government should respond to resource booms. This chapter tries to explain how different policies lead to different outcomes.

¹Other articles in the literature that provide empirical evidence about this fact are Sachs and Warner, 2001; Bravo-Ortega and De Gregorio, 2005; Leite and Weidmann, 1999; Gylfason et. al., 1999; Busby et al., 2002

²See for instance Corden and Neary, 1982; Sachs and Warner, 1995; Torvik, 2001

³Other approaches to the resource curse have to do with the rent-seeking activities.

Oil sector is a very important source of revenue for the governments of countries such as Norway, Mexico, Venezuela, Indonesia, etc. For instance, in Mexico and Norway, the oil sector contributes around 30 percent of the total government revenue. This means that oil price shocks have important consequences for the economies of these countries. However, these two countries have managed oil revenue in very different ways. Figure 3.1 shows how government expenditure has responded to changes in oil revenues in Norway and Mexico. While Norway has managed to isolate government expending from oil revenue, Mexico's figure shows a high correlation between these two variables.

Unlike Mexico, Norway adopted a stabilization fund in 1990 (State Petroleum Fund) to shield the economy from oil price fluctuations. According to the Fund policy, all Fund assets are invested in a range of foreign financial assets and only the return from the Fund can be used for government purchases. Consequently, temporary oil booms had not direct effects on the economy, most of the money is put into the Fund, and the economy benefits from permanent higher returns from the Fund.

The State of Alaska provides a different example in managing oil revenue. Like Norway, a stabilization fund (Alaska Permanent Fund) was created in 1978 to deal with the volatility of oil revenues. In contrast to Norway, the returns generated by the Fund are not transferred to the government but to the households (The Permanent Dividend Program). Thus, since 1982, every Alaskan receives a transfer from the Fund returns.

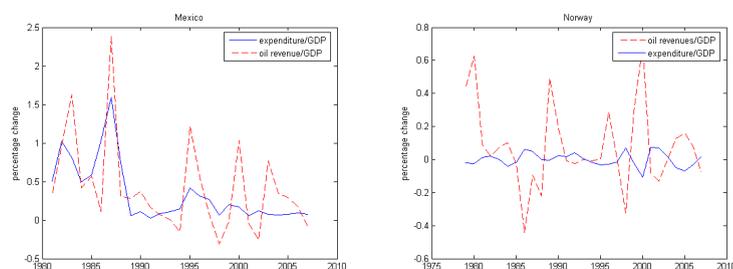
In order to illustrate the consequences of oil booms under different fiscal regimes, we construct a two sector small open economy DSGE model. We assume that production of oil requires no factor inputs, and all its production is exported at an exogenous world price. This model makes no distinction between resource booms that occur because of oil discovery or because of price increase. Both the traded and non-traded sectors require labor and capital for production.

We assume that oil revenue is appropriated by the government and analyze three different policies/cases. In the first case, government uses oil revenue to increase its consumption. In the second case, a Fund is created and only the returns on the Fund are used for government consumption. In the last case, a Fund is created and the returns on the Fund are transferred to households. The purpose is to evaluate the impact of an oil shock in these three scenarios, especially to observe how the real exchange rate and the traded sector are affected. We show that under a stabilization Fund, the effects of oil

shocks are smoothed. In the short-run, the real exchange rate appreciates less and the decline of the traded sector is lower. Furthermore, the impact on the traded sector is permanent. This implies that a stabilization fund, like the one adopted in Norway and in the State of Alaska, diminishes the effects related to the Dutch disease.

The rest of the chapter is organized as follows: Section 3.2 presents the model. Section 3.3 discusses the implications of three different fiscal policies. Section 3.4 concludes.

FIGURE 3.1: Oil revenue and government expenditure in Mexico and Norway



3.2 The model

We construct a two-sector model of a small open economy. Three goods are produced: a non-traded good, a traded good and oil. We assume that production of oil requires no factor inputs, and all its production is exported at an exogenous world price. Our model assumes competitive markets in the non-traded and traded sector. The price of the traded good is fixed in the world markets, and normalized to one.

Production of traded and non-traded goods requires labor and capital. Labor is supplied by the households inelastically, and can move instantaneously between sectors within the economy. Labor mobility implies that workers earn the same wage in either sector. Capital is accumulated by households and rented to firms. Capital accumulation is subject to adjustment cost.

3.2.1 Households

Households consume both traded and non-traded goods. Total consumption is specified by the following Cobb-Douglas function

$$C_t = C_{Tt}^\theta C_{Nt}^{1-\theta} \quad 0 < \theta < 1 \quad (3.1)$$

where C_{Tt} and C_{Nt} are consumption of traded and non-traded goods respectively. The parameter θ measures the share of traded goods in total consumption. Households will choose non-traded and traded goods to minimise expenditure. Demand for non-traded and traded goods is then

$$C_{Nt} = (1 - \theta) \frac{P_t}{p_t} C_t \quad (3.2)$$

$$C_{Tt} = \theta P_t C_t \quad (3.3)$$

where, $P_t = p_t^{1-\theta}$, is the implied consumer price index, and p_t is the price of non-traded goods (the price of traded goods is normalized to one)⁴.

The representative household consumes the aggregate consumption, C , yielding utility over an infinite horizon represented by the utility function

$$U \equiv E_0 \sum_{t=0}^{\infty} \beta^t \frac{C_t^{1-\sigma} - 1}{1-\sigma} \quad \sigma > 0, \quad 0 < \beta < 1 \quad (3.4)$$

where β is the discount factor and $1/\sigma$ is the intertemporal elasticity of substitution. The representative consumer also accumulates physical capital which is rented to traded and non-traded firms. Capital investment implies adjustment costs specified by the quadratic convex function

$$\Psi(I_N, K_N) = I_N + h \frac{I_N^2}{2K_N}$$

$$\Psi(I_T, K_T) = I_T + h \frac{I_T^2}{2K_T}$$

Capital stock depreciates at the rate, δ , so that its net rate of accumulation is

⁴See Obstfeld and Rogoff (1996) for more detail.

$$K_{i,t+1} = I_{i,t} + (1 - \delta)K_{i,t} \quad i = N, T \quad (3.5)$$

Investment in new capital requires traded and non-traded goods in the same mix as household's consumption basket. Thus, the price of a unit of investment, in either sector, is P_t .

Households also have access to the world capital market, allowing them to borrow internationally. We assume that the world capital market assesses the economy's ability to service its debt costs, and views the country's debt-output ratio as an indicator of its default risk. Thus, the borrowing rate is of the form:

$$r(D/Y) = r^* + f(D/Y) \quad f' > 0 \quad (3.6)$$

where r^* is the exogenously given world interest rate, D is the total foreign debt in the economy and $f(D/Y)$ is the country-specific borrowing premium that increases with the country's debt-output ratio⁵. The endogenized risk premium assumed in this model rules out the nonstationary behavior of consumption and the current account presented in such unrestricted small open economy models⁶.

The representative consumer chooses consumption, and the rates of capital and debt accumulation, to maximize intertemporal utility, equation (3.4), subject to the capital accumulation, equation (3.5), and the budget constraint

$$D_{t+1} - D_t = r_t D_t - w_t - R_{Tt} K_{Tt} - R_{Nt} K_{Nt} + P_t C_t + P_t \Psi(I_T, K_T) + P_t \Psi(I_N, K_N) + T_t \quad (3.7)$$

where D is the stock of debt of the representative consumer, w is the wage, R_i $i = T, N$ represent the return on capital in the traded and non-traded sector and T denotes lump-sum taxes. In performing this optimization, the agent takes the borrowing rate, r , as given.

⁵Since we are focusing on debtor nations, we assume $D > 0$. However, it is possible for $D < 0$ in which case the households accumulates credit by lending abroad

⁶Other methods used in the literature include finitely-lived households, transaction costs in foreign assets and endogenous discount factor, see for further discussions of these methods Schmitt-Grohe and Uribe (2002).

Thus, household optimum is characterized by the following equations:

$$C_t^{-\sigma} = \lambda_t P_t \quad (3.8)$$

$$\lambda_t = \beta E_t[\lambda_{t+1}(1 + r_{t+1})] \quad (3.9)$$

$$\lambda_{Tt} = \lambda_t P_t \left(1 + h \frac{I_{Tt}}{K_{Tt}} \right) \quad (3.10)$$

$$\lambda_{Nt} = \lambda_t P_t \left(1 + h \frac{I_{Nt}}{K_{Nt}} \right) \quad (3.11)$$

$$\lambda_{Tt} = \beta E_t \left[\lambda_{t+1} \left(R_{Tt+1} + P_t \frac{h I_{Tt+1}^2}{2 K_{Tt+1}^2} \right) + \lambda_{Tt+1} (1 - \delta) \right] \quad (3.12)$$

$$\lambda_{Nt} = \beta E_t \left[\lambda_{t+1} \left(R_{Nt+1} + P_t \frac{h I_{Nt+1}^2}{2 K_{Nt+1}^2} \right) + \lambda_{Nt+1} (1 - \delta) \right] \quad (3.13)$$

along with capital accumulation (3.5), and the budget constraint (3.7). Where λ is the shadow value of wealth in the form of internationally traded bonds and, λ_N and λ_T are the shadow value of one unit of non-traded and traded capital stock.

Equation (3.8) equates the marginal utility of consumption to the shadow value of wealth. Thus, the Lagrange multiplier measures the increase in household utility associated with one additional unit of real wealth. Equation (3.9) is a Euler equation that determines intertemporal allocation, it equates the intertemporal marginal rate of substitution in consumption to the real rate of returns to bonds. We redefine equations (3.10) and (3.11) to obtain

$$q_{Tt} = P_t \left(1 + h \frac{I_{Tt}}{K_{Tt}} \right) \quad (3.14)$$

$$q_{Nt} = P_t \left(1 + h \frac{I_{Nt}}{K_{Nt}} \right) \quad (3.15)$$

where $q_T \equiv \lambda_T/\lambda$ and $q_N \equiv \lambda_N/\lambda$ represent the market price of capital in terms of foreign bonds in the traded and non-traded sector respectively. Notice that, in the absence of adjustment cost, the price of one unit of capital is equal in both sectors. Moreover, it equals the price of one unit of consumption.

Making use of equation (3.9), we rearrange equations (3.12) and (3.13) to obtain

$$q_{Tt} = E_t \left[(1 - \delta) \frac{q_{Tt+1}}{1 + r_{t+1}} + \frac{1}{1 + r_{t+1}} \left(R_{Tt+1} + P_t \frac{hI_{Tt+1}^2}{2K_{Tt+1}^2} \right) \right] \quad (3.16)$$

$$q_{Nt} = E_t \left[(1 - \delta) \frac{q_{Nt+1}}{1 + r_{t+1}} + \frac{1}{1 + r_{t+1}} \left(R_{Nt+1} + P_t \frac{hI_{Nt+1}^2}{2K_{Nt+1}^2} \right) \right] \quad (3.17)$$

Equations (3.16) and (3.17) state the pricing condition for physical capital in the traded and non-traded sector respectively. They equate the revenue from selling one unit of capital today ($q_{i,t}$), to the discounted value of renting the unit of capital for one period, and then selling it, net of depreciation and adjustment costs. It is straightforward to demonstrate that, in the absence of adjustment cost, the return on capital must be equal in the non-traded sector and the traded sector, $R_N = R_T$.

3.2.2 Firms

3.2.2.1 Firms producing tradables

The representative firm in the traded sector uses capital and labor in a Cobb-Douglas production function in order to produce the traded good

$$Y_{Tt} = A_T K_{Tt}^\alpha L_{Tt}^{1-\alpha} \quad (3.18)$$

where A_T is a time invariant technology parameter. Firms in the traded sector operate under perfect competition. Their decision is to choose capital and labor allocation K_T and L_T to maximize the firms profits in units of tradables. Costs minimization behavior implies the following equations:

$$(1 - \alpha) A_T K_{Tt}^\alpha L_{Tt}^{-\alpha} = w_t \quad (3.19)$$

$$\alpha A_T K_{Tt}^{\alpha-1} L_{Tt}^{1-\alpha} \equiv R_{Tt} \quad (3.20)$$

where the price of traded goods is normalized to one, and R_T represents the return on capital used in the traded sector. Equation (3.19) and (3.20) describe the demand for labor and capital inputs in the traded sector.

3.2.2.2 Firms producing non-tradables

The representative firm in the non-traded sector also uses capital and labor in a Cobb-Douglas production function in order to produce non-traded goods.

$$Y_{Nt} = A_N K_{Nt}^\gamma L_{Nt}^{1-\gamma} \quad (3.21)$$

where A_T is a time invariant technology parameter. The firms decision is to choose capital and labor allocation K_N and L_N , to minimize the cost, under a perfect competitive market. Thus, demand for labor and capital inputs are described in the following equations:

$$p_t (1 - \gamma) A_N K_{Nt}^\gamma L_{Nt}^{-\gamma} = w_t \quad (3.22)$$

$$p_t \gamma A_N K_{Nt}^{\gamma-1} L_{Nt}^{1-\gamma} \equiv R_{Nt} \quad (3.23)$$

where p is the price of non-traded goods, i.e the real exchange rate.

3.2.3 Fiscal Policy

Government income is made up of lump-sum taxes, T_t , and oil revenue, O_t . Oil income is an exogenous stochastic variable:

$$O_t = O\epsilon_t \quad (3.24)$$

where

$$\log(\epsilon_t) = \rho \log(\epsilon_{t-1}) + v_t \quad (3.25)$$

Government purchases are assumed to have no direct effect on the utility of households. The fiscal authority consumes the final good, C_t^g , using the same aggregator as households. Thus government demand for traded and non-traded goods is the following:

$$C_{Nt}^g = (1 - \theta) \frac{P_t}{p_t} C_t^g \quad (3.26)$$

$$C_{Tt}^g = \theta P_t C_t^g \quad (3.27)$$

In this chapter, we focus on three fiscal strategies that can be implemented by the government in response to a positive oil shock.

3.2.3.1 Increase in government spending

The government may use oil revenue to increase its spending. Oil windfall is employed to increase consumption of both traded and non-traded goods. Thus, government budget constraint is the following:

$$\bar{T}_t + O_t = P_t C_t^g \quad (3.28)$$

where lump-sum taxes are constant. A positive oil shock implies higher government consumption.

3.2.3.2 Stabilization Fund

An alternative fiscal policy is to create a Stabilization Fund similar to the one implemented in Norway. The oil windfall is deposited in a Fund and the government receives

the return on the Fund. The extra wealth that the government receives is used to increase government consumption. Consequently, government budget constraint is the following:

$$\bar{T}_t + r^* F_t = P_t C_t^g \quad (3.29)$$

and

$$F_{t+1} - F_t = O_t \quad (3.30)$$

where r^* is world interest rate and F_t is the Fund value. The return on the Fund is used to increase government consumption, keeping lump-sum taxes constant.

3.2.3.3 Dividend Program

The third fiscal strategy that government may carry out is the Dividend Program adopted by Alaskan authorities. As Norwegian Stabilization Fund, the oil windfall is deposited in a Fund. However, the return on the Fund is not used to increase government consumption, but to cut lump-sum taxes. That is, oil revenues is transferred to households. Thus, government budget constraint is the following:

$$T_t + r^* F_t = \overline{P_t C_t^g} \quad (3.31)$$

and

$$F_{t+1} - F_t = O_t \quad (3.32)$$

In this case, the return on the Fund is used to cut lump-sum taxes, keeping government consumption constant.

3.2.4 Market clearing

In each period, the non-traded goods market must clear. Thus, we have

$$Y_{Nt} = (1 - \theta) \frac{P_t}{p_t} \left(C_t + C_t^g + I_{Tt} + h \frac{I_{Tt}^2}{2K_{Tt}} + I_{Nt} + h \frac{I_{Nt}^2}{2K_{Nt}} \right) \quad (3.33)$$

Equation (3.33) indicates that demand for non-traded goods comes from household consumption, government consumption, investment in the traded and non-traded sector and the adjustment cost.

Additionally, the labor market conditions must be satisfied:

$$L_{Tt} + L_{Nt} = 1 \quad (3.34)$$

3.2.5 Calibration

Due to the complexity of the model, we will employ numerical methods to examine the effects of oil shocks. We begin by calibrating a benchmark economy, selecting parameter values that are, as close as possible, consistent with the main features of a representative small open economy. The time unit is meant to be one quarter.

The benchmark parameter choices of the model are described in Table 3.1, while Table 3.2 reports macroeconomic ratios implied by the theoretical model.

We defined one period as a quarter, and thus, set the discount factor, β , to 0.975, which implies a steady state interest rate of $r = 0.0256$. We set the quarterly world interest rate to $r^* = 0.01$ so that country premium is 1.56 percent. We set the risk premium parameter $a = 0.04$ so that the debt-output rate of the economy is 55 percent.

We assumed the standard assumption that the traded sector is more capital-intensive than the non-traded sector, and chose the value of the capital share in traded and non-traded sectors, α and γ , equal to 0.65 and 0.25 respectively. We set the depreciation rate, δ , at 10 percent per annum, standard value in the business cycle literature. The value of the adjustment cost parameter, h , is set at 10.

Finally, we set the intertemporal elasticity of substitution, σ , to one, implying a log-utility consumption function. The share of traded goods in the consumption portfolio is assumed to be 0.5. The steady state value of oil income, O , is set to 15 percent to GDP.

TABLE 3.1: Parameter Values

Parameter	Value	Description
α	0.65	capital share in traded sector
γ	0.25	capital share in non-traded sector
r^*	0.01	world interest rate
δ	0.025	capital depreciaton rate
σ	1	inverse of intertemporal elasticity of substitution
θ	0.5	share of traded goods in total consumption
a	0.04	risk borrowing premium
β	0.975	discount rate
h	10	adjustment cost

TABLE 3.2: Structure of the theoretical economy

Capital in traded sector/GDP	2.1733
Capital in non-traded sector/GDP	3.7380
External debt/GDP	55%
Consumption/GDP	88%
Investment in traded sector/GDP	5.4%
Investment in non-traded sector/GDP	9.3%
Employment in non-traded sector/Total Employment	74%
Employment in traded sector/Total Employment	26%
Oil/GDP	15%

3.3 Consequences of a temporary oil shock

In this section we analyze the impact of a one percent temporary increase in oil revenue under three different fiscal strategies. In the first case, government benefits from the oil shock and increases public expenditure (Increase in Government spending). In the second case, oil revenue is deposited in a Fund, and government only receives the return on the Fund (Stabilization Fund). In the third case, oil revenue is deposited in a Fund, and the return on the Fund is transferred to households (Dividend Program).

3.3.1 Increase in Government spending

Firstly, we consider that the government employs the extra-oil revenue to raise public expenditure. Figure 3.2 shows impulse responses to one percentage increase in oil revenue. All figures are expressed in percentage terms of the steady state value.

In the short-run we have the conventional story of a reaction to a positive demand shock. One percentage increase in oil revenue causes a 0.6 percentage increase in government spending. A rise in government expenditure implies a higher demand for traded and non-traded goods. Domestic market equilibrium implies that the non-traded goods market must clear each period. Therefore, production of non-traded goods should increase. In order to increase production of non-traded goods, labor is transferred from the traded to the non-traded sector. However, capital adjustment cost hampers the reallocation of capital in the short-run; hence, the relative price of non-traded goods (i.e., the real exchange rate) increases. When extra-oil revenue is employed to increase government consumption, real exchange rate appreciates a 0.075 per cent.

We observe that in the short-run, the rise in government consumption has two effects on the economy. On the one hand, the real exchange rate appreciates and, on the other hand, the production in the traded sector declines. There is a transfer of labor and capital from the traded to the non-traded sector. This is the conventional Dutch disease story. An oil boom causes the appreciation of the real exchange rate and the decline of the traded sector. If we had assumed that economic growth is caused by technological progress acquired through learning-by-doing in the traded sector, the oil shock would have reduced economic growth.

Even if extra-oil revenue is employed to increase government consumption, households are also affected by the oil shock. The rise in the relative price of non-traded goods leads to a higher marginal product of labor in the non-traded sector, and consequently, pushes up wages. The increase in wages raises consumers income. As a result, consumption rises and the demand for traded and non-traded increases even more.

In the long-run, the effects of the temporary oil shock disappear. As oil revenue returns to its initial value government spending declines, and thus, the demand for non-traded goods declines. This implies that the relative price of non-traded goods decreases. To restore home market equilibrium, production of non-traded goods declines.

Therefore, when the government employs the extra-oil revenue to raise public expenditure, the effects of the oil shock are temporary. Consumption of both government and households increase; however, the benefits are temporary. The positive effects on households are longer. The rise in households income, stemming from higher wages,

is employed to increase consumption and reduce debt. Hence, households can prolong consumption several periods.

3.3.2 Stabilization Fund

In this section, we consider the case where the extra-oil revenue is deposited in a Fund, and the government receives the return on the Fund to increase government consumption. We set an initial value of the Fund-GDP ratio of 60%. Figure 3.3 illustrates impulse responses to one percentage temporary increase in oil revenue.

In this scenario, the first effect of the oil boom is an increase in the Fund. The extra-oil revenue is deposited in the Fund; hence, we observe that the value of the Fund increases until the boom is over. One percentage temporary increase in oil revenue causes a 0.75 percentage permanent increase in the value of the Fund. A higher value of the Fund implies a higher return for the government. Thus, a temporary oil boom has permanent effects on government income.

The government employs extra-income to increase the demand for traded and non-traded goods. As we have seen above, production of non-traded goods should increase to satisfy domestic market equilibrium. In order to increase production of non-traded goods, labor is transferred from the traded to the non-traded sector. However, capital can not move instantaneously to the new steady state because of the costly adjustment cost. Consequently, the relative price of the non-traded good (real exchange rate) rises in the short-run. As capital reaches the new steady state the relative price goes back to its initial value. Notice that, in this model, permanent demand shocks have a temporary effect on the relative price. This is because long-run relative price behavior is determined by changes in productivity between the traded and non-traded sector⁷.

The temporary rise in the relative price of non-traded goods makes the marginal product of labor increase, and thus wages rise. Households benefit from the temporary higher income and demand more of traded and non-traded goods. In contrast to government income, the positive effects on households income are temporary. When relative prices adjust to the long-run equilibrium, wages decline.

⁷In order to generate permanent changes in the relative price, Rebelo and Vegh (1995), include an specific factor (land) in the production of non-traded goods.

We observe that the effects of an oil shock on an economy are softened with a Stabilization Fund. In this case, the government consumption increase is lower than in the previous case. Under a Stabilization Fund, one percentage temporary increase in oil revenue causes a 0.02 percentage increase in government consumption. Moreover, in contrast to the previous case, the effects on the economy are permanent. Thus, high volatility caused by oil-shocks are avoided.

The real exchange rate appreciation (i.e., a rise in the relative price of non-traded goods) is also lower than in the previous case. Consequently the effects on the traded sector are smaller. We observe that the production of the traded sector declines after the oil-shock, however the decrease of 0.008% is lower than in the previous case, 0.1%. Thus, it has avoided the Dutch disease effects.

We argue that the adoption of a stabilization Fund, like the one created in Norway, is a good measure to avoid volatility and the Dutch disease effects.

3.3.3 Dividend program

In this section, we consider the case where the extra-oil revenue is deposited in a Fund, and the return on the Fund is transferred to the households. We set an initial value of the Fund-GDP ratio of 60%. Figure 3.4 illustrate impulse responses to one percentage temporary increase in oil revenue.

After the oil shock, we observe that the value of the Fund increases until the boom is over. One percentage temporary increase in oil revenue causes a 0.75 percentage permanent increase in the value of the Fund. In contrast to the stabilization Fund policy, government is not affected by the oil shock. The return on the Fund is transferred to households.

Households face a permanent increase in their income; hence, they increase the demand of traded and non-traded goods. Given that the share of traded and non-traded goods in the consumption basket of households and government is the same, we obtain similar results as in the previous case.

The higher demand of non-traded goods leads to increased production. Capital cannot adjust instantaneously to the shock, thus the real exchange rate appreciates in the short-run. As capital reaches the new steady state the relative price returns to its initial value.

The appreciation of the real exchange rate raises wages due to a higher marginal product of labor.

Similar to the Stabilization Fund policy, the effects of an oil shock are softened with a dividend program. Real exchange rate appreciation is very low, 0.0016%, hence, the traded sector does not decline so much, 0.008%. The effects on the economy are permanent, avoiding high volatility which characterize economies with oil revenues.

3.4 Conclusion

Oil is the largest source of government revenue in many countries. Most of them are highly dependent on this revenue; hence, the economic performance of these countries depend on the way that oil revenue is managed.

In this chapter, we analyse from a theoretical point of view, the consequences of adopting different fiscal policies. Particularly, we analyse three different fiscal policies. In the first case, oil revenue is employed to increase government consumption. In the second case, oil revenue is deposited in a Fund and government consumes only the returns on the Fund. In the third case, oil revenue is deposited in a Fund and the return on the Fund is transferred to households.

We observe that Stabilization Funds, like the ones adopted in Norway and Alaska (the second and third cases), help to soften the effects of an oil boom. There are two positive consequences of adopting a Stabilization Fund. First, it reduces volatility of the main macroeconomic variables in the economy. Second, the decline of the traded sector is lower, and thus, Dutch disease effects are avoided.

3.5 References

Auty, R.M. (2001a), "The political economy of resource-driven growth", *European Economic Review*, 46, 839-846.

Blanchard, O. and R. Perotti (2002), "An Empirical Characterization of the Dynamic Effects of Changes in Government Spending and Taxes on Output", *Quarterly Journal of Economics*, 117, 1329-1368.

Blalock, G. and P.J. Gertler (2004), "Learning from Exporting Revisited in a Less Developed Setting", *Journal of Development Economics*, Vol. 75, pp.397-416.

Bravo-Ortega, C. and J. De Gregorio (2005). "The relative richness of the poor? Natural resources, human capital, and economic growth", Policy Research Working Paper No. 3484, The World Bank, Washington D.C.

Bruno, M. and J. Sachs (1982), "Energy and Resource Allocation: A Dynamic Model of the Dutch Disease", *The Review of Economic Studies*, 49(5), pp. 845-59.

Busby, G., J. Isham, L. Pritchett and M. Woolcock (2002), "The varieties of rentier experience: how natural resource export structures affect the political economy of economic growth", mimeo, World Bank, Washington D.C.

Corden, M. (1984), "Booming Sector and Dutch Disease Economics: Survey and Consolidation", *Oxford Economic Papers*, 36(3), pp. 359-80.

Corden, M. and P. Neary (1982), "Booming Sector and De-Industrialisation in a Small Open Economy", *The Economic Journal*, 92 (368), pp. 825-48.

Devereux, M., P. Lane, and J. Xu (2004), "Exchange Rate and Monetary Policy in Emerging Market Economies",

Fernandes, A. and A. Isgut (2005), "Learning by doing, learning by exporting, and productivity: Evidence from Columbia", Wesleyan University and World Bank, Mimeo (2005).

Fatas, A. and I. Mihov (2001), "The Effects of Fiscal Policy on Consumption and Employment: Theory and Evidence", Working paper, INSEAD.

Gali, J., J. D. Lopez-Salido and J. Valles (2005), "Understanding the Effects of Government Spending on Consumption", NBER Working paper series, No. 11578, Cambridge, MA.

Gelb, A. (1988), "Windfall Gains: Blessing or Curse?", Oxford University Press, Oxford.

Gylfason, T., T. T. Hebertsson and G. Zoega (199), "A mixed blessing: natural resources and economic growth", *Macroeconomic Dynamics*, 3, 204-225.

Hausmann, R. and R. Ribogon (2002), "An alternative interpretation of the resource curse: theory and policy implications", Working Paper 9424, NBER, Cambridge, Mass.

Lane, P. R. and A. Tornell (1996), "Power, growth and the voracity effect", *Journal of Economic Growth*, 1(2), 213-241.

Leite, C. and M. Weidmann (1999), "Does Mother Nature Corrupt? Natural resources, corruption and economic growth", WP/99/85, IMF, Washington D.C.

Morshed, M. and S. Turnovsky (2003), "Sectoral Adjustment Cost and Real Exchange Rate Dynamics in a Two-Sector Dependent Economy"

Rebelo, S. and C. A. Vegh (1995), "Real effects of exchange rate-based stabilization: An analysis of competing theories", NBER working papers, National Bureau of Economic Research.

Sachs, J. and A. Warner (1995), "Natural resource abundance and economic growth", NBER Working Paper no. 5398.

Sachs, J. and A. Warner (2001), "The curse of national resources", *European Economic Review*, 45, 827-838.

Schmitt-Grohe, S. and M. Uribe (2002), "Closing Small Open Economy Models", *Journal of International Economics*, vol.1, 1-23.

Talvi, E. and C. Vegh (2005), "Tax base variability and procyclical fiscal policy in developing countries", *Journal of Development Economics*, 78, 156-190.

Torvik, R. (2001), "Learning by doing and the Dutch Disease", *European Economic Review*, 45, 285-306.

Van der Ploeg, F. (2006), "Challenges and opportunities for resource rich economies".

Van Wijnbergen, S. (1984), "The Dutch Disease: A Disease After All?", *The Economic Journal*, vol. 94, no. 373, pp.41-55.

FIGURE 3.2: Increase in Government spending

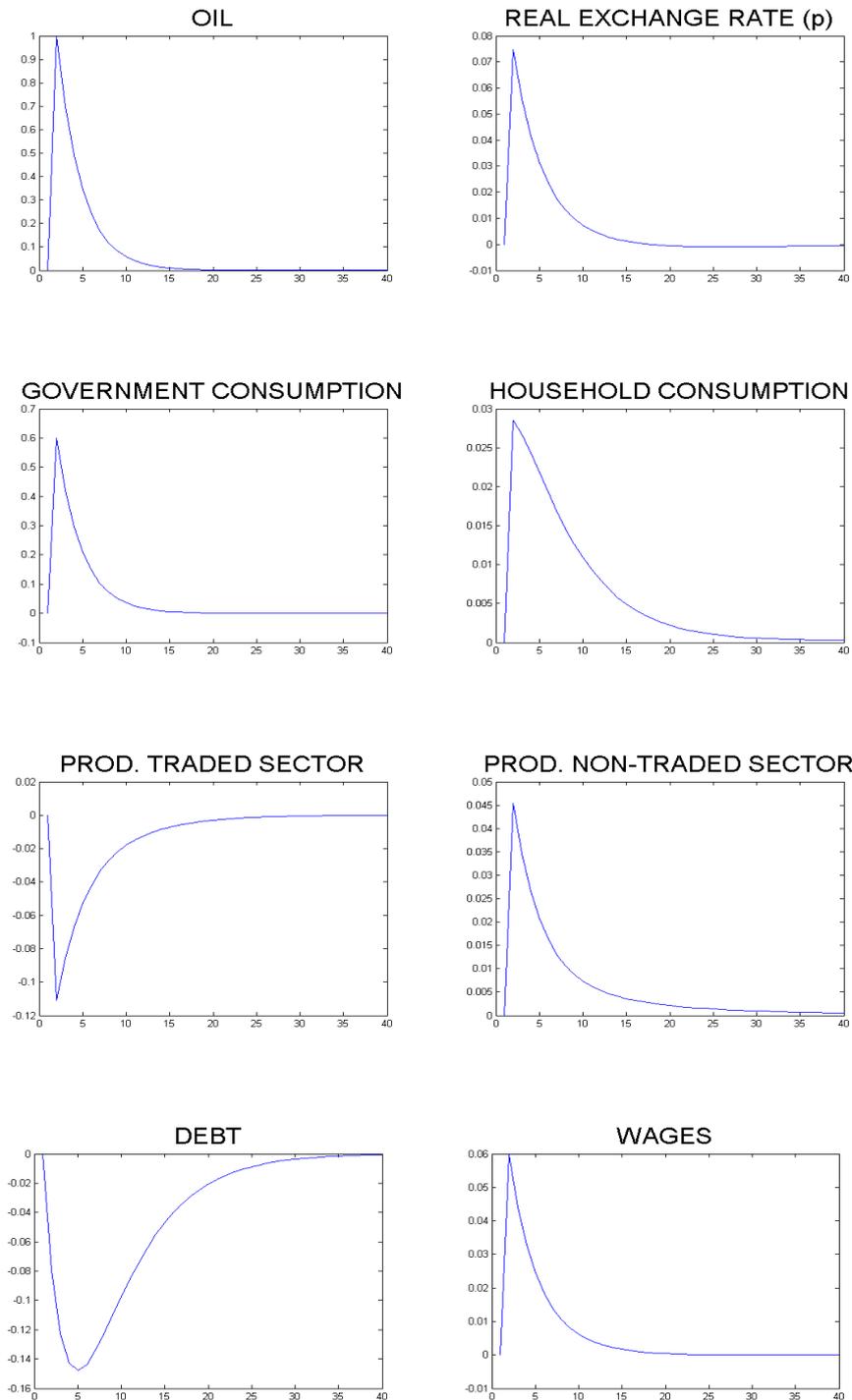


FIGURE 3.3: Stabilization Fund

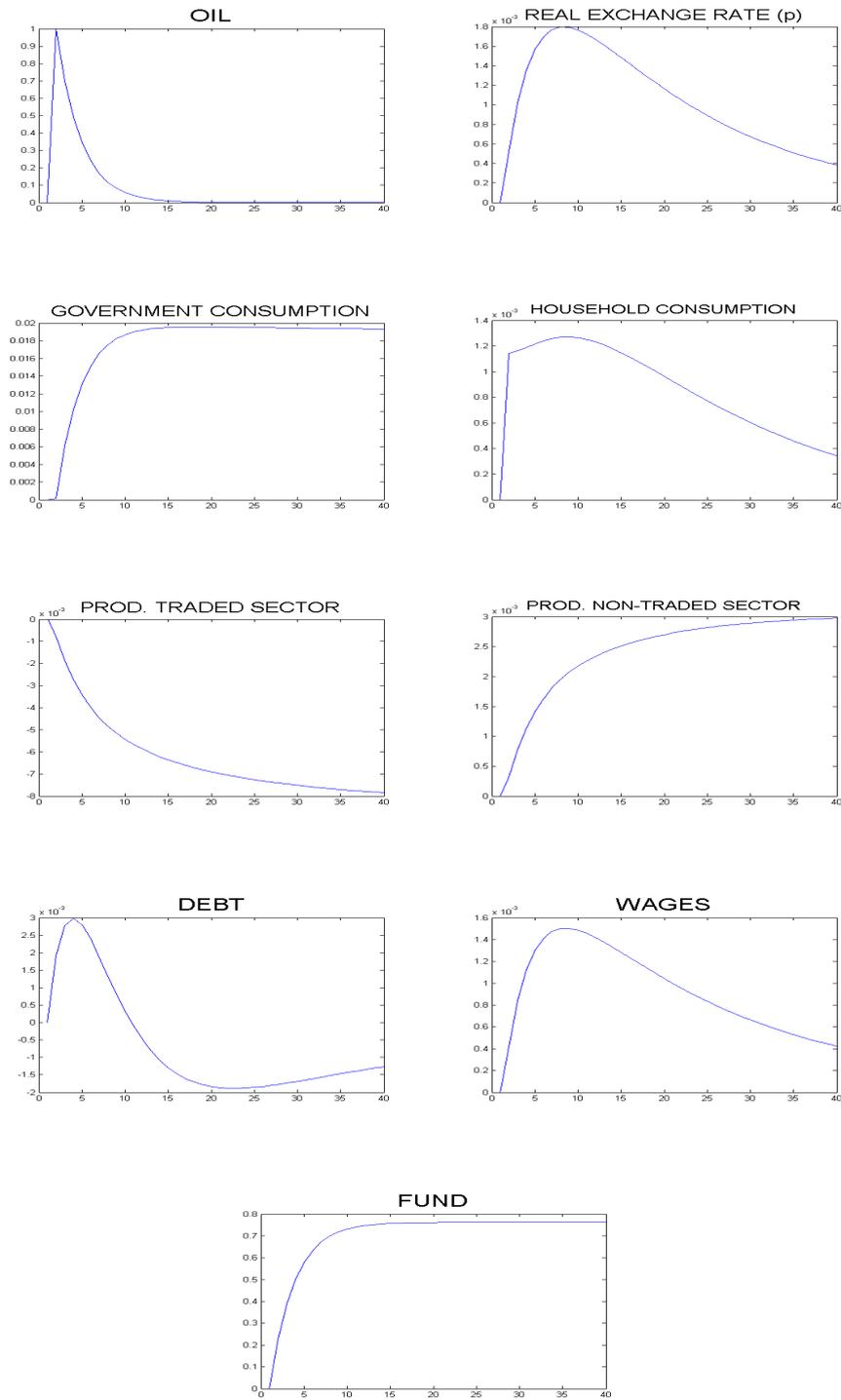
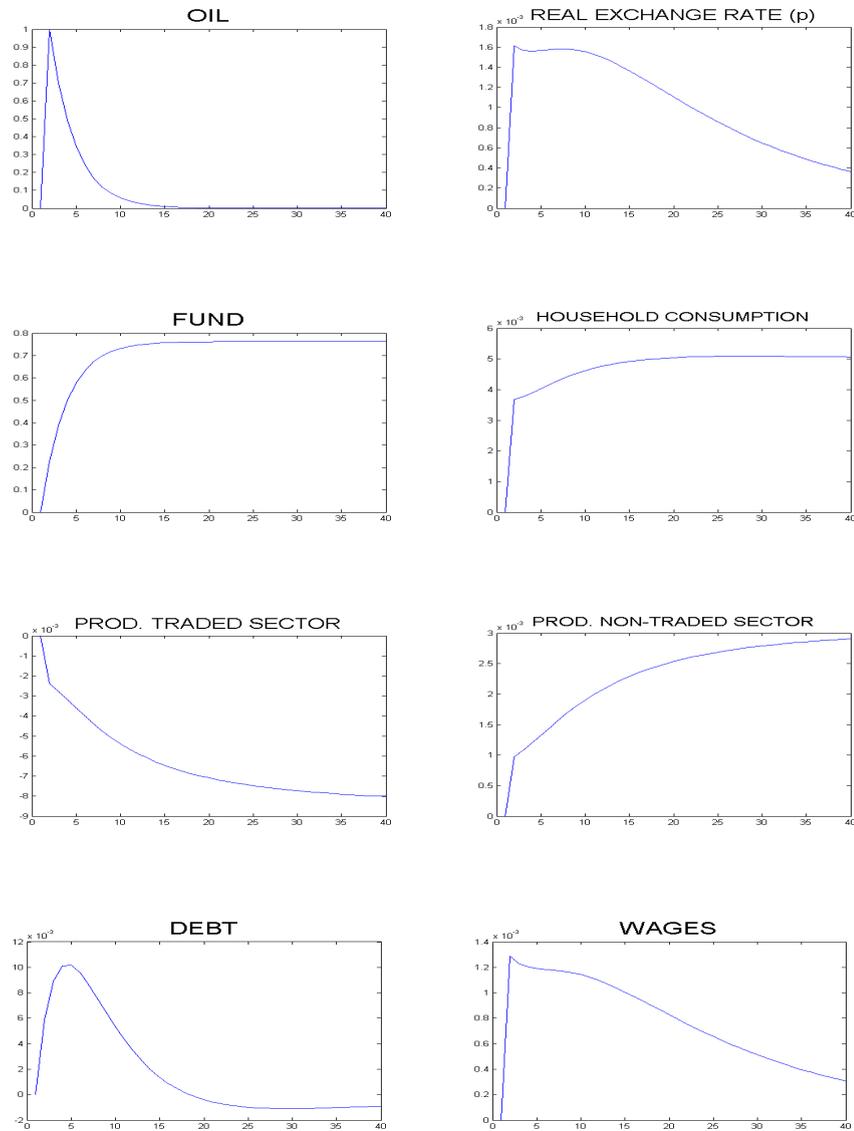


FIGURE 3.4: Dividend Program



Chapter 4

Natural-Resource Depletion and Optimal Fiscal Policy: Lessons from Mexico

In a number of oil-exporting countries, oil revenue represents an important share of government revenue. These countries face a challenge from the fact that oil revenue is exhaustible. In this context, fiscal policy represents a key instrument for an optimal wealth distribution between current and future generations. Models based on Friedman's (1957) permanent-income hypothesis (PIH) provide a possible path to ensure a fair intergenerational use of resource wealth. However, although the main insights of these models are sound, they ignore essential features of resource-rich countries. In this chapter further reality is added by including productive government spending and Dutch disease effects. We find that a higher share of oil revenue should be spent upfront when government spending effects overcome Dutch disease effects. This approach is applied to Mexico.

4.1 Introduction

Oil-exporting countries face the challenge that oil revenue is exhaustible. For many governments of these countries, oil revenue represents the most important source of revenue. In this context, it is essential to assess whether oil revenue is managed properly. A priori it seems optimal that oil-exporting countries should save a share of their current oil revenue so that future generations can benefit from oil wealth. But, how much should be saved?

Empirical evidence suggests that governments with a large share of oil revenue in their budget show overall fiscal surpluses. This is especially true in periods when oil prices are high. In 2005, the governments of countries such as Algeria, Nigeria and Saudi Arabia showed overall surpluses above 10% of GDP (Table 1). However, given that oil revenue is not forever, a fiscal assessment based on the overall fiscal balance can be misleading. It looks more adequate to assess fiscal stance by evaluating their non-oil balance. Apart from Norway, most of the oil-producing countries show high non-oil deficits. That is, when we do not count oil revenue, government spending is considerably above their revenue. If new oil reserves are not found, in countries such as Mexico, Ecuador and Algeria, the current reserves will deplete in the near future. The question is whether these countries will be able to keep non-oil deficits when oil reserves deplete.

The large reliance on oil revenue and the exhaustible nature of oil reserves obligate oil-producing countries to be particularly prudent in their designs of fiscal policies and to take a long-term view. If oil reserves were limitless, governments could simply consume oil revenues directly. Given that oil reserves are exhaustible, governments should take a long-run view. A forward-looking fiscal strategy is necessary, so that governments do not need to adjust drastically their consumption when oil reserves deplete.

The literature on optimal fiscal policy in countries endowed with exhaustible natural resources has typically been based on Friedman's (1957) permanent-income hypothesis. Within this framework, government consumption should be limited to the permanent income¹. Thus, given that oil is exhaustible, government should accumulate enough assets to finance the non-oil deficit once oil revenue dries up. Decisions on the non-oil deficit should be based on assessments of government wealth (including oil wealth),

¹See, for instance, Davids et al. (2002), Barnett and Ossowski (2003), Segura (2006), Leigh and Olters (2006), Basdevant (2008)

rather than merely on current oil income. Although the main insights of these models are sound, they ignore essential problems of resource rich countries.

TABLE 4.1: Data from governments in oil-exporting countries (2005)

	Oil rev /Total rev	Overall balance /GDP	Non-oil balance /GDP	Depletion ² (years)
Norway	31%	16%	-1%	8
Mexico	37%	-1%	-7%	10
Algeria	76%	12%	-19%	15
Ecuador	24%	2%	-5%	23
Nigeria	85%	11%	-22%	40
Saudi Arabia	91%	18%	-25%	68
Venezuela	58%	2%	-18%	78

The aim of this chapter is to enrich previous models by adding features particular to resource-rich countries. To be precise, we include productive government spending and Dutch disease effects. We assume that government consumption not only yields utility but also increases productivity. Thus, non-oil GDP will be positively affected by higher government spending. This interpretation of government spending is consistent with the broadly shared view that government spending on social (e.g., health and education) and physical infrastructure raises productivity³. This is also the basis for the claim by the governments in resource-rich developing countries that they should spend more of the resource endowment upfront, when the marginal benefit of government spending is likely to be higher than the return from external financial assets.

On the other hand, we also consider Dutch disease effects. The idea behind the Dutch disease is that the exploitation of natural resources shifts production factors from the traded to the non-traded sector. If we consider that most of economic growth is caused by technological progress acquired through learning-by-doing (LBD) which is mainly present in the traded sector, a decline in that sector may lower growth. This has been the most widespread argument for the poor economic performance of resource rich countries⁴. Thus, the literature based on the Dutch disease argues that the optimal share of national wealth consumed in each period should be adjusted downwards.

²Keeping current oil production, the number of years before oil depletes, if new oil reserves are not found

³Evidence of a growth-enhancing effect of government spending can be found in Cashin (1995), Miller and Tsoukis (2001), Gupta, et al. (2002), and Kneller, Bleaney and Gemmel (2000).

⁴See, for instance, van Wijnbergen (1984), Sachs and Warner (1995) and Gylfason et. al. (1999)

To analyze the optimal fiscal policy in a resource-rich country with productive government spending and Dutch disease effects, we follow a similar framework developed by Matsen and Torvik (2005). We consider a small open economy that produces traded, non-traded and public goods. In contrast to Matsen and Torvik (2005), we consider that the dynamics of productivity are not only driven by the traded sector (Dutch disease effects) but also by public goods. The government is the only agent in the economy that has access to capital markets. Therefore, only the government can move resources over time. The government's objective is to maximize households' utility, yielded by traded, non-traded and public goods, subject to national wealth (oil and non-oil wealth).

The present model is relevant for a current debate on the need for fiscal rules in resource-rich countries. There is a general agreement on the desirability of accumulating funds to avoid sharp declines in government consumption. Including endogenous effects on productivity growth, our model prescribes a different spending path from what the permanent income hypothesis would imply. On the one hand, productive government spending induces higher spending in the first periods, so households can benefit from higher productivity in the future. On the other hand, Dutch disease effects lead to postpone the use of oil revenue, and thus, avoid the decline of the traded sector. Therefore, we find that the optimal spending path will depend on which of these two effects is stronger.

We apply the model to Mexican economy, where oil revenue is an important share of government revenue. In the last few years, oil revenue has accounted for around 35 percent of total government revenue. Thanks to high oil prices, the primary balance of Mexican government reached a surplus of 2 percent of GDP in 2007. However, the non-oil primary balance (the primary balance minus oil revenue) showed a deficit of 3 percent. Given that, if new reserves are not found, oil reserves are to run out in 20 years, is the non-oil deficit sustainable in the long-run? We show that under the permanent-income hypothesis Mexican government should cut the non-oil deficit to around 0.6 percent of non-oil GDP. However, when we analyze Mexican economy in a model with endogenous growth we draw different conclusions. If we consider that LBD is specially present in the Mexican traded sector and public goods are not an important mean for productivity growth, non-oil deficit should be cut more sharply. On the other hand, if there are no LBD differences between the traded and non-traded sector and public goods boost productivity growth, the current non-oil deficit is optimal.

The outline of the chapter is as follows: Section 4.2 presents the main features of Mexican oil sector. Section 4.3 presents the benchmark model based on the standard permanent income hypothesis. Section 4.4 enriches previous analysis including endogenous productivity growth, where government consumption and the traded sector drive productivity growth. Section 4.5 calibrates the model for Mexican economy and presents the results. Section 4.6 concludes.

4.2 Oil sector in Mexico

Oil sector is crucial for Mexican economy. Oil revenue generates over 10 percent of Mexico's export earnings and accounts for 35 percent of government revenue. Mexico is the sixth largest oil producer in the world and the tenth largest in terms of net exports. However, oil production has declined in the last few years. During 2007 oil production averaged 3.08 million barrels per day, 5 percent less than the average production recorded in 2006. The decline is driven mainly by the depletion of proven reserves.

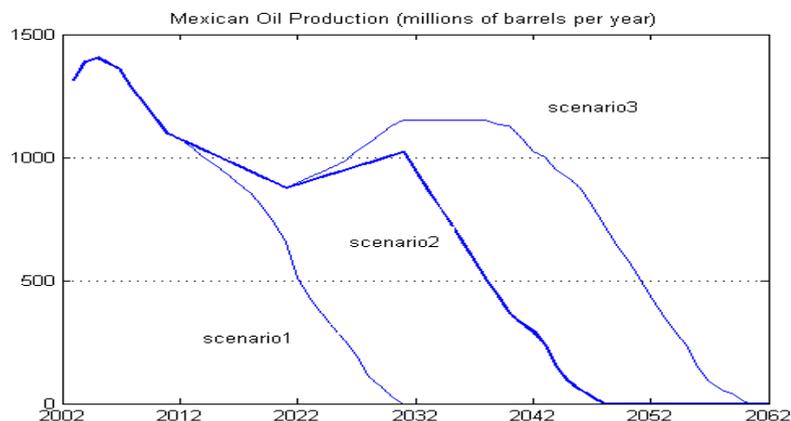
Pemex, the state-owned oil company, estimates proven reserves of 14.717 billion barrels of oil. This means that, given current oil production, oil reserves would deplete in 10 years. This would provoke a downturn in government revenue which depends highly on oil revenue. Hence, it is highly important to analyze whether current government spending path is both sustainable and optimal in the long-run.

Pemex faces a variety of challenges in its efforts to stem Mexico's oil production decline. Pemex sends a large share of its revenues to the government, making it difficult to increase spending on further exploration and production. In September 2007, Mexico's Congress approved some reforms, including a reduction in the tax rate levied on Pemex, which will allow Pemex increase resources for deepwater exploration. However, even if new oil fields are discovered, oil production would not recover until 2025.

Figure 4.1 shows three different scenarios for oil production depending on oil reserves. The source is Pemex's annual statistics 2008⁵, which, based on Securities and Exchange Commission (SEC), divides oil reserves in three categories. In the first scenario only proven reserves are included (14717.2 million barrels). In the second scenario oil fields with a probability of at least 50 percent are added (29861.6 million barrels). In the

⁵Oil reserves statistics can be found on the website www.pemex.com

FIGURE 4.1: Oil Production in Mexico



last scenario less probable reserves are included (44482.8 million barrels). Production path is based on EIA's *International Energy Outlook 2008*, which estimates a decline of oil production until 2025, thereafter, there is a production recovery if new reserves are discovered.

Even if new reserves are discovered and oil production can be prolonged for another 50 years, given the importance of oil revenue in Mexican economy, it is crucial to analyze how oil revenue should be managed.

4.3 Benchmark: A Model of Permanent Income

Following Barnett and Ossowski (2003), we construct a model where the government chooses the optimal size of the primary deficit (the problem is expressed solely in terms of spending, treating the tax rate as exogenous). Government maximizes a social welfare function, subject to an intertemporal budget constraint and a transversality condition. The government's problem can thus be written as follows:

$$\max_{G_t} \sum_{s=t}^{\infty} \left(\frac{1}{1+\delta} \right)^{s-t} U(G_s) \quad (4.1)$$

$$\text{s.t.} \quad B_t = RB_{t-1} + G_t - T_t - Z_t \quad (4.2)$$

$$\lim_{s \rightarrow \infty} B_{t+s} = 0 \quad (4.3)$$

where B is government debt, $R = 1 + r$, with r being the long-run interest rate (assumed to be constant) and G_t government expenditure. Non-oil revenue is denoted by T_t and oil revenue by Z_t . The parameter δ is the discount factor. It is assumed that there is no uncertainty about the future.

The first order condition of the government's problem yields the following Euler equation:

$$U'(G_t) = \left(\frac{1+r}{1+\delta} \right) U'(G_{t+1}) \quad (4.4)$$

where $U'(G)$ denotes the marginal utility of government consumption. Assuming that $\delta = r$, it follows that $U'(G_t) = U'(G_{t+1})$. This implies that government spending is constant over time: $G_t = G_{t+1} = G$. Combining equation (4.4) with equations (4.2) and (4.3) yields the optimal level of government spending:

$$G = T + \frac{r}{R} \sum_{s=t}^N \left(\frac{1}{R} \right)^{s-t} Z_s - r B_{t-1} \quad (4.5)$$

where N is the date at which oil revenue is exhausted. Equation (4.5) implies that the optimal policy is to smoothen government consumption over time. While oil production is active, government saves a share of oil revenue. Thus, it is possible to keep government consumption constant when oil reserves run out.

4.4 A model of productive government consumption and Dutch disease effects

4.4.1 Production

We consider a small open economy that produces four types of goods: non-traded (C_N) and traded (C_T) consumption goods, public goods (G) and oil (O). Oil production requires no inputs, and total oil revenue (Z) is appropriated by the government. The production of consumption and public goods only requires labor, which is inelastically

supplied by households and normalized to unity. Thus, the production function of the three goods is given by

$$X_{Nt} = H_t(1 - \eta_t - \lambda_t) \quad (4.6)$$

$$X_{Tt} = H_t\eta_t \quad (4.7)$$

$$X_{Gt} = H_t\lambda_t \quad (4.8)$$

where X_{Nt} , X_{Tt} and X_{Gt} represent production of non-traded, traded and public goods, respectively. H_t denotes productivity which is equal in all sectors and, η_t and λ_t are the share of labor employed in the traded and public sector, respectively. The equal productivity in all sectors implies a relative price equal to 1. Adding up equations (4.6), (4.7) and (4.8) we obtain total production (non-oil GDP):

$$X_t = X_{Nt} + X_{Tt} + X_{Gt} = H_t \quad (4.9)$$

The most important assumption in this model concerns what drives productivity growth. Following other models of the Dutch disease as Sachs and Warner (1995), we assume that the labor force employed in the traded sector positively affects productivity. However, we add a second parameter to productivity growth. We consider that public spending also has positive effects on productivity. Thus, the dynamics of productivity H are

$$\frac{H_{t+1} - H_t}{H_t} = \alpha\eta_t + \chi\frac{G_t}{H_t} \quad (4.10)$$

where the parameters $\alpha, \chi \geq 0$ measure the effect of traded and public sector on productivity.

4.4.2 Households

The representative household has not access to the capital market, so she consumes all her income. She can neither lend nor borrow. Household's income (Y_t) is composed of after tax labor income and government transfer (R_t),

$$Y_t = (1 - \tau) H_t + R_t = C_t \quad (4.11)$$

where $C_t = C_{Nt} + C_{Tt}$ is total household consumption which includes non-traded C_N and traded goods C_T . The representative household allocates spending on non-traded and traded goods according to a Cobb-Douglas utility function. Let $\gamma \in (0, 1)$ be the weight on traded goods in the utility function. The demand for non-traded goods is

$$C_{Nt} = (1 - \gamma) Y_t = X_{Nt} \quad (4.12)$$

The last equality shows that in equilibrium domestic demand of non-traded goods matches domestic production of such goods.

4.4.3 Government

The government is the only agent in the economy that has access to the international capital market, so foreign debt B corresponds to public debt. Consequently, the economy's current account matches government budget constraint

$$\begin{aligned} CA_t &= B_{t+1} - B_t = rB_t - X_{Gt} + G_t - X_{Tt} + C_{Tt} - X_{Nt} + C_{Nt} - Z_t \\ &= rB_t - H_t + G_t + C_t - Z_t = rB_t - \tau H_t + G_t - Z_t + R_t \end{aligned} \quad (4.13)$$

where r is a constant exogenous real interest rate. The first equality in the second row follows from using (4.9), and the last equality is obtained using (4.11). Notice that the last equality is the government budget constraint. Government finances public goods (G_t) and transfers (R_t) through income taxes (τ), oil revenue (Z_t) and debt.

The governments role in the economy is to allocate public goods and lump-sum transfers over time. We assume a benevolent government, whose horizon is M periods. When

government takes a decision, it considers the effects on future productivity. The objective is to maximize the following households' utility function

$$\max_{G_t, R_t} \sum_{t=1}^M \left(\frac{1}{1+\delta} \right)^{t-1} (\Psi \log G_t + \log C_t) \quad (4.14)$$

subject to the economy's current account (4.13) and the dynamics of productivity (4.10), where the parameter, $\Psi \geq 0$, measures the relative importance of both public and consumption goods.

Following Matsen and Torvik (2005), the problem is more easily analyzed by merging (4.10) and (4.13) into one constraint, describing the dynamics of national wealth. At the start of period $t + 1$, the national wealth NW is

$$NW_{t+1} = -(1+r)B_{t+1} + \sum_{s=t+1}^M \left(\frac{1}{1+r} \right)^{s-(t+1)} H_s + \sum_{s=t+1}^M \left(\frac{1}{1+r} \right)^{s-(t+1)} Z_s \quad (4.15)$$

It includes debt B accumulated through period t plus the present value of current and future income, both non-oil GDP and oil wealth. For later use, we rewrite (4.15) as

$$\begin{aligned} NW_{t+1} = & -(1+r)[(1+r)B_t + G_t + C_t - H_t - Z_t] + (1+r) \sum_{s=t}^M \left(\frac{1}{1+r} \right)^{s-t} H_s - (1+r)H_t \\ & + (1+r) \sum_{s=t}^M \left(\frac{1}{1+r} \right)^{s-t} Z_s - (1+r)Z_t = (1+r)(NW_t - G_t - C_t) \end{aligned} \quad (4.16)$$

In choosing the optimal path, the government takes into account that the labor employed in the traded and public sector affects future productivity. Using (4.6), (4.11) and (4.12), we find that the traded sector employment is given by

$$\eta_t = 1 - (1-\gamma)(1-\tau) - (1-\gamma) \frac{R_t}{H_t} - \frac{G_t}{H_t} \quad (4.17)$$

We assume that the public good is non-tradable, so production equals consumption $X_{Gt} = G_t$. Thus, plugging equation (4.17) into (4.10), the dynamics of productivity can be written as follows

$$H_{t+1} = aH_t - bR_t + cG_t \quad (4.18)$$

where

$$a = 1 + \alpha [1 - (1 - \gamma)(1 - \tau)]; \quad b = \alpha(1 - \gamma); \quad c = \chi - \alpha$$

Equation (4.18) shows the effects of both government spending and transfers on productivity. On the one hand, government transfers to households have a negative impact on productivity. This is one of the effects associated with the Dutch disease. When households enjoy higher income, they raise consumption of traded and non-traded goods. In order to increase the production of non-traded goods, labor must shift from the traded to the non-traded sector. Employment in the traded sector is reduced, and thus, productivity growth. The stronger the effect, the more important are the non-traded goods in consumers' preference. On the other hand, government spending has an ambiguous effect on productivity. There is a positive effect due to an increase in public spending, and thus, productivity growth. However, this also implies lower employment in the traded sector, and therefore, lower productivity growth. The effect of government spending on productivity will depend on which of these two effects is stronger.

Iterating equation (4.18), we can write non-oil GDP (or productivity) in period $s > t$ as

$$H_s = a^{s-t}H_t - b \sum_{i=t}^{s-1} a^{s-i-1}R_i + c \sum_{i=t}^{s-1} a^{s-i-1}G_i \quad (4.19)$$

Combining equations (4.15) and (4.19), we can express national wealth in period $t + 1$ as

$$\begin{aligned} NW_{t+1} = & -(1+r) [(1+r)B_t + G_t + R_t - \tau H_t - Z_t] + aH_t \sum_{s=t+1}^M \left(\frac{a}{1+r}\right)^{s-(t+1)} \\ & - b \sum_{s=t+1}^M \left(\frac{1}{1+r}\right)^{s-(t+1)} \left[a^{s-(t+1)}R_t + \sum_{i=t+1}^{s-1} a^{s-i-1}R_i \right] \\ & + c \sum_{s=t+1}^M \left(\frac{1}{1+r}\right)^{s-(t+1)} \left[a^{s-(t+1)}G_t + \sum_{i=t+1}^{s-1} a^{s-i-1}G_i \right] \\ & + \sum_{s=t+1}^M \left(\frac{1}{1+r}\right)^{s-(t+1)} Z_s \end{aligned} \quad (4.20)$$

This equation replaces the two constraints (4.10) and (4.13) in the government's maximization problem. Notice that government transfers in period t have two effects on

national wealth. On the one hand, there is the ordinary effect of lower future wealth; on the other hand, there is a negative effect on future income through lower productivity growth. Similarly, government spending in period t has two effects on national wealth. First, government spending lowers wealth in the next period. Second, there is a positive effect on future wealth through higher productivity growth.

4.4.4 Optimal government consumption

In this section, we present the optimal solution for the government problem. The government chooses the amount of public good (G_t) and transfer (R_t) to maximize the utility of the representative household (4.14) subject to the wealth constraint (4.20).

Proposition 4.1. *Let*

$$J(NW_t) = \max_{G_t, R_t} \sum_{t=1}^M \left(\frac{1}{1+\delta} \right)^{t-1} [\Psi \log G_t + \log((1-\tau)H_t + R_t)]$$

Subject to (4.20) and the terminal condition $B_{M+1} = 0$. Then,

$$J(NW_t) = \phi_t + \Theta_t \log NW_t$$

where

$$\Theta_t = (1 + \Psi) \left(\frac{1 + \delta}{\delta} \right) \left(1 - \left(\frac{1}{1 + \delta} \right)^{M-t+1} \right)$$

and ϕ_t is an inessential function of only time. Optimal government and household consumption is

$$G_t = q_t C_t \qquad C_t = h_t NW_t \qquad (4.21)$$

where

$$q_t = \Psi \frac{1 + \frac{b}{a-(1+r)} \left[\left(\frac{a}{1+r} \right)^{M-t} - 1 \right]}{1 - \frac{c}{a-(1+r)} \left[\left(\frac{a}{1+r} \right)^{M-t} - 1 \right]} \quad (4.22)$$

$$h_t = \frac{1}{1 + q_t + (\Theta_t - 1 - \Psi) \left[1 + \frac{b}{a-(1+r)} \left(\left(\frac{a}{1+r} \right)^{M-t} - 1 \right) \right]} \quad (4.23)$$

Proof. See Appendix □

Equation (4.21) relates to consumption and public goods. We observe that the ratio of consumption and public goods is determined by several parameters. Most of them have an ambiguous effect on this ratio. However, two parameters have a positive effect on public goods with respect to consumption goods. First, the relative importance of consumption and public goods in the utility function, Ψ . It is clear that when the public goods has more weight in the utility function (i.e., higher Ψ), it will be optimal to consume more public goods. Second, the effect of public spending on productivity, χ . When the public goods have a stronger effect on future productivity (i.e. higher χ and therefore higher c), it will be optimal to consume more public goods with respect to consumption goods.

Combining equations (4.16) and (4.21) it is straightforward to demonstrate that aggregate consumption grows according to

$$\frac{C_{t+1}}{C_t} = (1 + r) h_{t+1} \left(\frac{1}{h_t} - 1 - q_t \right) \quad (4.24)$$

in optimum. The optimal consumption growth is time-varying.

Corollary 4.2. *When the government has an infinite time horizon, $M \rightarrow \infty$, and in absence of endogenous growth, $\alpha, \chi = 0$, the optimal consumption growth equals the one of the PIH model, $\frac{C_{t+1}}{C_t} = \frac{1+r}{1+\delta}$.*

Proof. For $\alpha, \chi = 0$ it is straightforward to demonstrate that $q_t = \Psi$. When $M \rightarrow \infty$, $\Theta_t = (1 + \Psi) \left(\frac{1+\delta}{\delta} \right)$, and thus, h_t is given by

$$h_t = \frac{\delta}{(1 + \Psi)(1 + \delta)} \quad (4.25)$$

which is a constant. Plugging this value into equation (24), and simplifying gives

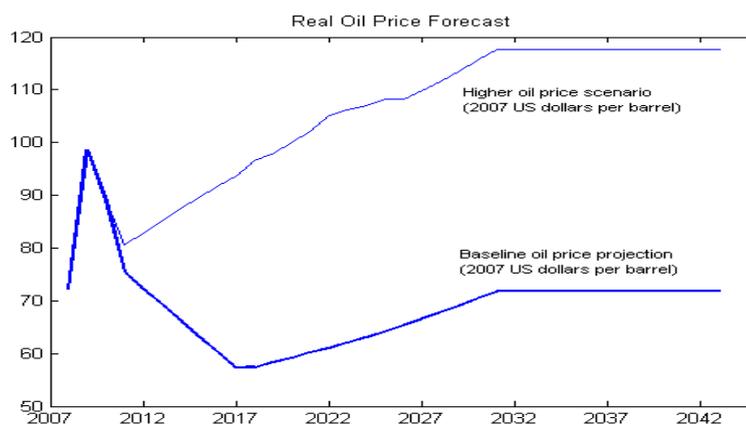
$$\frac{C_{t+1}}{C_t} = \frac{1+r}{1+\delta} \quad (4.26)$$

□

4.5 Model Calibration and Results

To simulate the optimal government spending path, we calibrate the model to fit the relevant features of Mexican economy. To establish the baseline projection for future real oil revenue, projections for the real oil prices and the volumes of oil production are required. The projection for oil prices is based on U.S. Energy Information Administration's (EIA) *Annual Energy Outlook 2008* (AEO), which presents two scenarios. In the reference case, real oil price⁶ is expected to decline until 2020, thereafter, to increase to 71.7 US dollars per barrel by 2030. In the high price scenario, real oil price is expected to increase continuously, reaching 117.7 US dollars per barrel by 2030 (Figure 4.2).

FIGURE 4.2: Real oil price forecast



For future oil output, we consider the three scenarios explained in section 4.2. We take the second scenario as the reference case. The second scenario includes proven reserves and oil fields with a probability of at least 50 percent recoverable.

⁶An inflation rate of 2 percent per year is used to convert the oil prices into real terms

Real oil GDP is obtained by multiplying the predicted production volumes and the real price path, net of intermediate consumption (which is assumed to remain constant at the level of 22 percent of oil production, which is the average for the period 2000-07⁷). These calculations include a discount for Mexican crude oil relative to the WTI crude price, which is also to remain constant at 23 percent (equivalent to discount factor averaged in the period 2000-2007). Exchange rate forecasts are based on the Economists outlook for Mexico, which foresees a rate of 12.45 pesos per US dollar in 2008 and 13.14 in 2009; afterwards, the exchange rate is held constant at 13.14 pesos per US dollar. Fiscal oil revenue is based on the Pemex's new tax regime, which estimates a tax rate of around 79 percent of oil GDP⁸.

The real interest rate, r , and the discount factor, δ , are set at a standard value of 3 percent. The non-oil tax rate, τ , is kept constant at the 2007 level of 17 percent. The parameter Ψ is set at 0.15. This implies that, in absence of endogenous growth, households' consumption is around 6.5 times government consumption, which matches the observed values in Mexican economy. Similarly, we set γ at 0.46, which corresponds to the share of non-traded goods in consumption expenditures in the Mexican CPI basket.

Finally, each time period is one year and the government has a planning horizon of 100 years, i.e., $M = 100$.

4.5.1 Results

In this section, we simulate the optimal path under different growth scenarios. We analyze how government decisions are influenced by the growth parameters α and χ . We observe that high values of α lead to postpone the use of national wealth, in order to avoid the Dutch disease. On the other hand, high values of χ lead to make use of national wealth upfront, and thus, benefit from the productive government spending.

⁷Intermediate consumption level is obtained from INEGI's *El Sector Energetico en Mexico 2007*

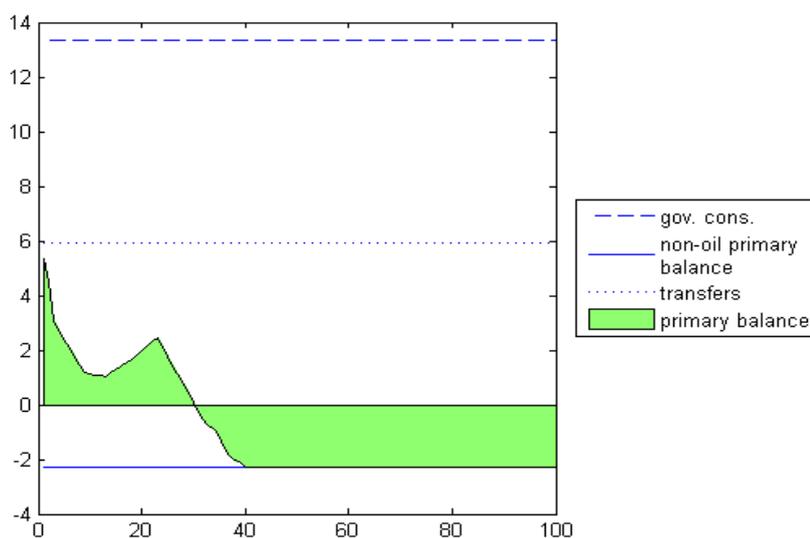
⁸For a complete analysis of the new tax regime, see www.pemex.com

4.5.1.1 Without Growth

To put the results into perspective, we display the optimal paths in a non-growing economy ($\alpha, \chi = 0$) as in Figure 4.3. As we have demonstrated above, the optimal paths in a non-growing economy corresponds to the optimal paths under the PIH. Without growth, government distributes national wealth homogeneously over time. Consequently, a share of oil revenue has to be saved while oil production is active. Under the baseline parameters and oil projections, this implies that in the next 30 years Mexican government should obtain surpluses around 2% of non-oil GDP. The financial wealth accumulated during these years makes it possible to run a permanent non-oil deficit of around 2% of non-oil GDP. The depletion of oil reserves in 40 years would not pose a problem for the Mexican government. They could keep government consumption and transfers permanently constant, thanks to the wealth accumulated during the first years.

Without endogenous growth, the consumption of public goods has no effects on productivity. Therefore, the choice between consumption and public goods depends solely on the marginal utility of both goods. The optimal share of consumption and public goods is; thus, determined by the parameter Ψ . Government decides to consume around 13% of non-oil GDP and transfer to households 6% of non-oil GDP.

FIGURE 4.3: Optimal paths without growth (percent of non-oil GDP)



4.5.1.2 Only one source of growth

We now analyze the optimal paths when productivity growth is driven by either public sector or traded sector. The first case implies $\alpha = 0$ and $\chi = 0.5\%$, and it is showed in Figure 4.4. The second case implies $\alpha = 0.5\%$ and $\chi = 0$, and it is showed in Figure 4.5.

When government spending has a positive effect on productivity growth, the government has incentives to spend national wealth upfront (Figure 4.4). In this case, there are no negative consequences from a smaller traded sector, since this does not affect productivity. The government raises spending in public goods in the first periods, and thus, households benefit from higher productivity in the future. The increase in public goods leads to a rise in transfers. In order to keep equal the marginal utility of consumption and public goods (Equation 4.21), the government transfers a share of the national wealth to households, so that they can raise consumption.

The implications for the non-oil primary balance are straightforward. The economy shows large deficits in the first periods, which are repaid in the last periods, when productivity is higher. Oil revenue is spent immediately, and nothing is saved for future generations. Although households do not benefit from oil wealth in the future, they enjoy higher productivity.

FIGURE 4.4: Optimal path with productive public goods (percent of non-oil GDP)

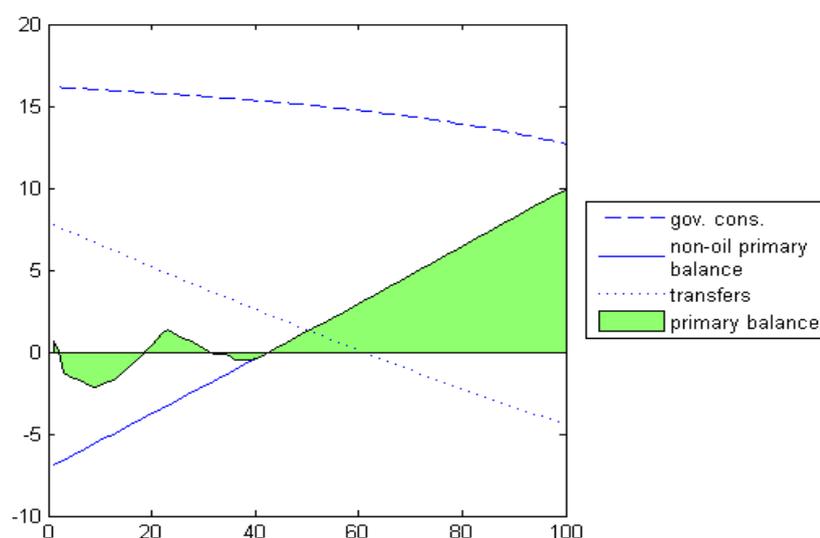
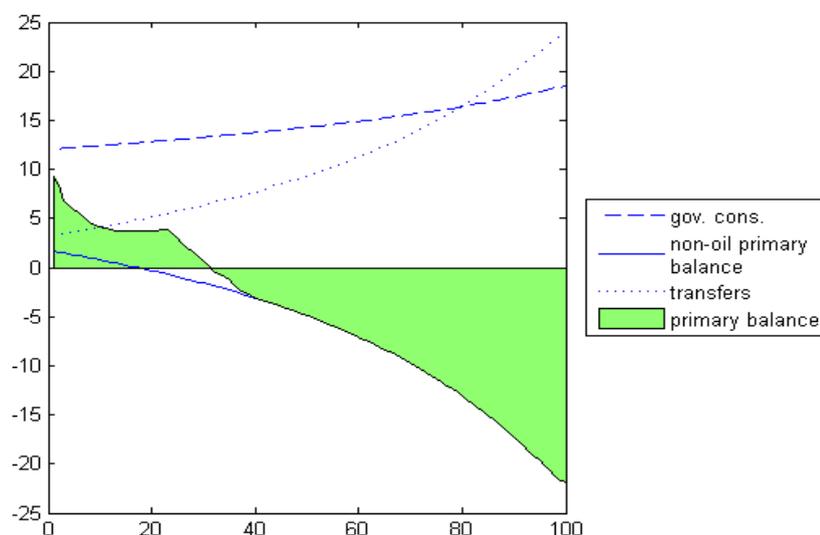


Figure 4.5 displays the case where productivity growth is only driven by the traded sector. Under this scenario, the government has incentives to reduce both government spending and transfers in the first periods. As we have explained above, government transfers to households lead to higher demand of the non-traded goods, and thus, a decline of the traded sector (Dutch disease effect). Similarly, government spending moves employment from the traded to the public sector. In order to avoid a decline of the traded sector in the first periods, and therefore, lower productivity levels in the future, government saves a large share of national wealth, and spends it in the last periods, when the effect on productivity is lesser.

The consequence is that the optimal non-oil budget is balanced in the first 20 periods, that is, oil revenue is saved completely. The largest share of national wealth is spent in the last periods, when there is shorter impact on productivity. The economy would reach a deficit of 20 percent of non-oil GDP in the last period.

FIGURE 4.5: Optimal path with Dutch disease effects (percent of non-oil GDP)

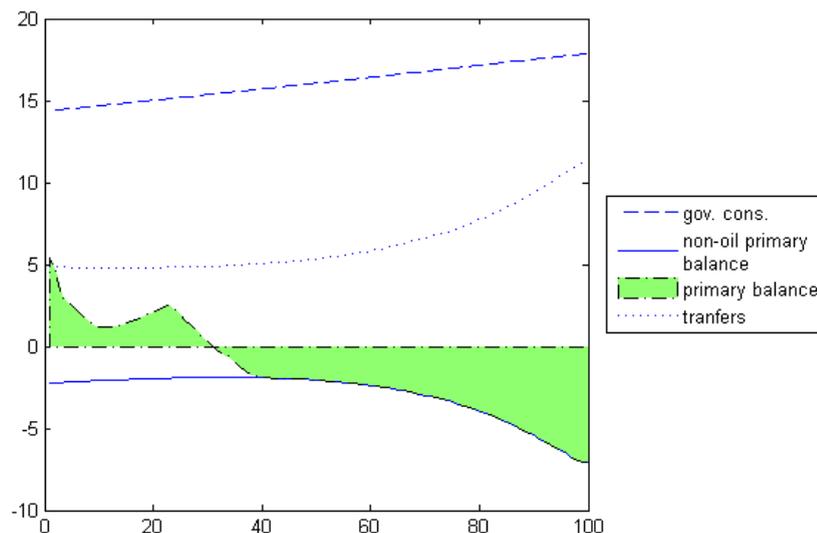


4.5.1.3 Two sources of growth

Figure 4.6 shows the optimal path of government spending, transfers and the non-oil primary balance, when there are two sources of growth ($\alpha, \chi = 0.5\%$). Simulating the

optimal path, three main results emerge.

FIGURE 4.6: Optimal paths with two sources of growth (percent of non-oil GDP)



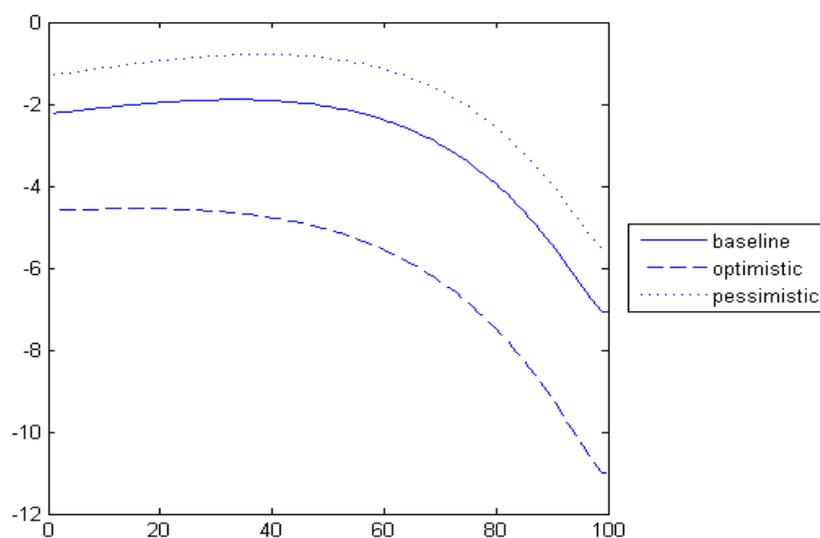
First, government transfers to households grow over time, particularly in the last periods. It is optimal to transfer part of the resource wealth to households; however, this is lower in the first periods. This result is the optimal response to the Dutch disease. Government transfers imply higher demand (and supply) of non-traded goods, and thus, a movement of labor from the traded to the non-traded sector. In order to avoid large productivity falls due to a smaller traded sector, transfers are kept low in the first periods. The negative impact of transfers on future productivity is lower over time, hence, we observe an increase of transfers in the last periods.

Second, government spending grows over time. Given that government spending positively affects productivity growth, we could expect higher spending upfront, so households would benefit from higher productivity in the future. However, government spending also has a negative effect, it lowers employment in the traded sector, and thus, productivity growth. Under the given values of α and χ these two effects counteract. Equation (4.18) shows the dynamics of productivity growth. When the parameters α and χ have the same value, the effect of government spending on productivity is null.

Third, given the baseline parameters and oil projections, Mexican economy can afford non-oil primary deficits in the next 100 years. It is optimal to spend relatively little of the resource wealth while oil production is active, and thus, accumulate enough foreign assets to keep the non-oil deficit once oil revenue dries up. Given that government spending has no effect on productivity, it is optimal to save a share of the resource wealth for the future, and thus avoid the Dutch disease.

4.5.1.4 Sensitivity analysis

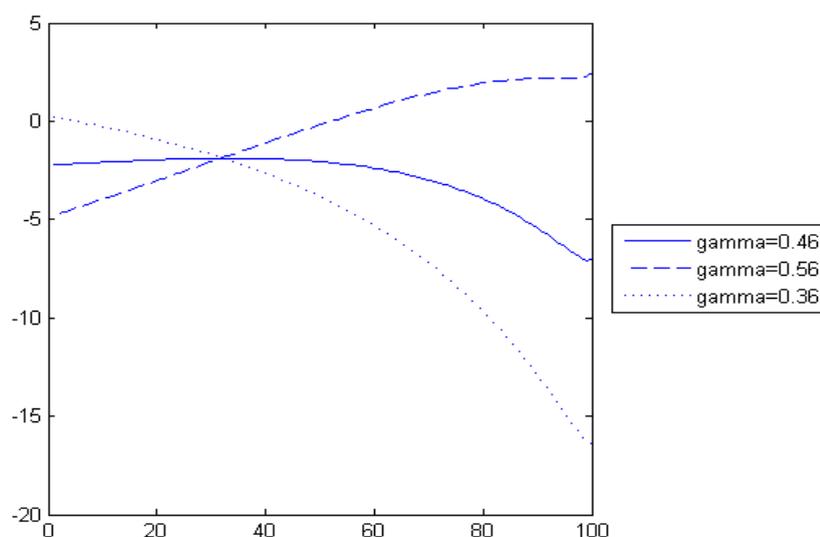
FIGURE 4.7: Non-oil balance optimal paths for different scenarios



We now analyze how the path of the non-oil primary balance is affected by changes in our baseline values. Figure 4.7 displays the paths of the non-oil primary balance for different scenarios of oil price and oil production. In the optimistic scenario, we assume the high oil price projection and scenario 3 for oil production, that is, oil fields with a probability of less than 50 percent recoverable, are included. In the pessimistic scenario, we assume the baseline oil price projection, and scenario 1 for oil production, that is, new oil reserves are not discovered. The rest of the values are the same as in the previous section with two sources of growth.

We observe that oil revenue has no effects on the shape of the non-oil primary balance path. A large share of oil revenue is saved in the first periods and it is transferred to households as we approach period M . As we have explained in the previous section, postponing transfers, the government avoids the decline of the traded sector and therefore lower growth rates. The effects of the oil revenue are quantitative. Under the optimistic scenario Mexican government could afford a non-oil deficit above 4% of non-oil GDP in the first periods, and it would reach 11% in the last periods. Very different results are obtained under the pessimistic scenario. In this case, non-oil deficit should be reduced to around 1% of non-oil GDP, and in the last 30 periods it would increase until it reaches 5% of non-oil GDP in the last period.

FIGURE 4.8: Non-oil balance optimal paths for different values of γ

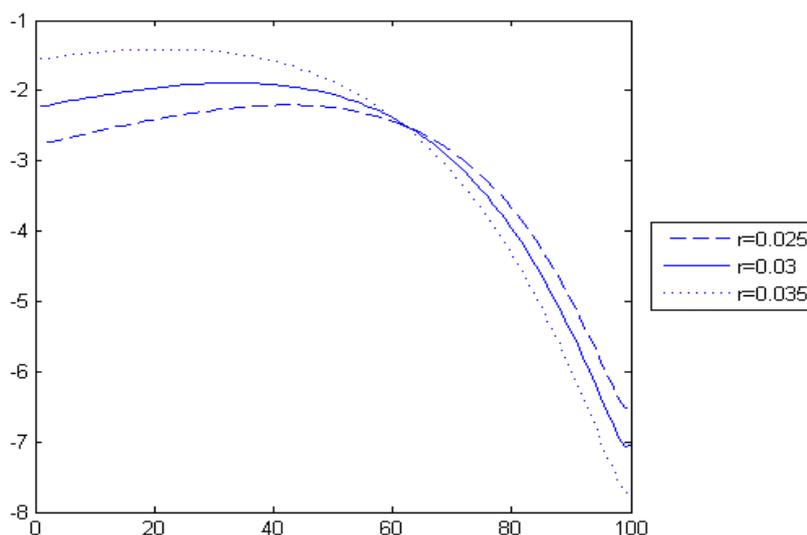


Turning to the effect of the traded goods expenditure share γ , we observe in Figure 4.8 that different values can have important effects on the solution. High values of γ give a positive sloped optimal non-oil balance. The opposite slopes of the non-oil balance paths reflect a fundamental trade-off that the government faces in our model: on the one hand, output growth generally implies that the early generations should receive a larger share of oil revenue, but on the other hand, spending should be postponed because of its negative effect on future productivity. This result implies that Dutch disease effects are less important for high values of γ . The intuition behind this result is that a large

expenditure share on traded goods implies a large traded sector, and thus, a high growth potential for any given level of total demand. For high values of γ , government transfers have lower effects on the demand of non-traded goods, and the labor employed in the traded sector is hardly reduced. Therefore, there is little gain in future productivity from postponing spending. However, for low values of γ , the employment in the traded sector is strongly affected when households income increases, and therefore there are incentives to postpone government transfers.

The effect on the non-oil balance path from a higher interest rate is the expected. A higher interest rate provides incentives to increase savings in the first periods. The optimal non-oil balance shows a deficit below 2% of non-oil GDP in the first periods, and increases until 8% of non-oil GDP in the last period. Similarly, lower interest rates imply lower optimal savings in the first periods.

FIGURE 4.9: Non-oil balance optimal paths for different values of r



4.6 Conclusion

The literature on the optimal use of exhaustible resources is mainly based on the permanent-income hypothesis. Little attention has been drawn to two important aspects of resource-rich countries. First, the fact that resource abundance may shift factors of

production away from sector generating learning by doing (Dutch disease). Second, the claim that government spending enhances productivity growth, particularly in developing countries, so that a larger share of the resource endowment could be spent upfront. In this chapter, we have included these two aspects to add more reality to the normative analysis. In contrast to the previous models based on the permanent-income hypothesis, we find that a constant government spending rule is not always optimal. When public goods are the main factor which drives productivity growth, we find that the optimal spending path decreases over time. In opposition of PIH models, a higher share of natural wealth should be used in the first periods, and thus, households would benefit from higher productivity in the future. On the other hand, when the traded sector is the main factor which drives productivity growth, the optimal spending path grows over time. In order to avoid a large shift of production away from the traded sector, government saves a higher share of natural wealth in the first periods.

Analyzing the Mexican economy under a model with endogenous growth, different conclusions are drawn with respect to the PIH model. Currently, Mexico can afford a non-oil deficit higher than the level prescribed by the PIH, when we consider that government spending is the main factor driving productivity growth. Mexico should spend a large share of its oil revenue, and consequently do not save it for future generations, since they will benefit from higher productivity. We reach opposite results when we consider that the traded sector is the main factor driving productivity growth. A higher share of oil revenue should be saved for future generations not only to benefit them from current oil revenue but also to avoid a decline in productivity. Therefore, in order to draw a final conclusion about the optimal non-oil balance path in Mexico, it would be necessary to know the real impact of the public and the traded sector on the Mexican economy.

In assessing the optimal fiscal policy we have focused on the fact that oil revenue is exhaustible. We have not taken into consideration an important feature of oil revenue, volatility. Uncertainty about future income would imply higher savings, known as precautionary saving. We could consider two sources of uncertainty, oil reserves and prices. One avenue for future research would involve considering this feature.

Bibliography

- [1] Auty, R. M. (2001a), “The political economy of resource-driven growth”, *European Economic Review*, 46, 839-846.
- [2] Barnett, S. and R. Ossowski (2003), “Operational Aspects of Fiscal Policy in Oil-Producing Countries”, in *Fiscal Policy Formulation and Implementation in Oil-Producing Countries* ed. by J. Davis, R. Ossowsky and A. Fedelino, Washington: International Monetary Fund, pp.45-81.
- [3] Basevant, O. (2008), “Are diamonds forever? Using the permanent income hypothesis to analyze Botswana’s reliance on diamond revenue”, Working Paper No. 08/80, International Monetary Fund, Washington D.C.
- [4] Campbell, J. and J. Cochrane (1999), “By Force of Habit: A Consumption Based Explanation of Aggregate Stock Market Behavior”, *Journal of Political Economy*, 107(2), pp. 205-251.
- [5] Constantinides, G. (1990), “Habit Formation: A Resolution of the Equity Premium Puzzle”, *Journal of Political Economy*, Vol. 9, pp. 519-543.
- [6] Cashin, P. (1995), “Government Spending, Taxes, and Economic Growth”, *IMF Staff Papers*, Vol. 42(2), pp. 237-269.
- [7] Corden, W.M., J.P. Neary (1982), “Booming Sector and de-industrialisation in a small open economy”, *Economic Journal* 92, 825-848.
- [8] Davis, J., R. Ossowski, J., Daniel and S. Barnett (2002), “Stabilization and Saving Funds for Non-Renewable Resources: Experience and Fiscal Policy Implications”, *IMF Occasional Paper No. 205*, International Monetary Fund, Washington D.C.

- [9] Friedman, M. (1957), "A Theory of the Consumption Function", Princeton University Press.
- [10] Gupta, S., B. Clements, E. Baldacci and C. Mulas-Granados (2002), "Expenditure Composition, Fiscal Adjustment, and Growth in Low-Income Countries", IMF Working Paper No. 02/77, International Monetary Fund, Washington D.C.
- [11] Gylfason, T. (2001), "Natural resources, education, and economic development", *European Economic Review* 45, 847-859.
- [12] Gylfason, T., T. T. Hebertsson and G. Zoega (1999), "A mixed blessing: natural resources and economic growth", *Macroeconomic Dynamics*, 3, 204-225.
- [13] Hartwick, J. (1977), "Intergenerational equity and the investing of rents from exhaustible resources", *American Economic Review* 67, 972-991.
- [14] Kneller, R., M. Bleaney and N. Gemmell (1999), "Fiscal Policy and Growth: Evidence from OECD Countries", *Journal of Public Economics*, Vol. 74, pp. 171-190.
- [15] Leigh, D. and J. Olters (2006), "Natural resource depletion, habit formation, and sustainable fiscal policy: lessons from Gabon", IMF Working Paper WP/06/193, International Monetary Fund, Washington D.C.
- [16] Matsen, E. and Torvik (2005), "Optimal Dutch Disease", *Journal of Development Economics*, 78, 494-515.
- [17] Miller, N.J. and C. Tsoukis (2001), "On the Optimality of Public Capital for Long-run Economic Growth: Evidence from Panel Data", *Applied Economics*, Vol. 33, pp. 1117-1129.
- [18] Obstfeld, M., and K. Rogoff (1996), "Foundations of International Macroeconomics" MIT Press, Cambridge, MA.
- [19] Sachs, J. and A. Warner (1995), "Natural resource abundance and economic growth", NBER Working Paper no. 5398.

- [20] Sachs, J. and A. Warner (2001), “The curse of national resources”, *European Economic Review*, 45, 827-838.
- [21] Segura, A. (2006), “Management of oil wealth under the permanent income hypothesis: the case of Sao Tom and Principe”, Working Paper No. 06/183, International Monetary Fund, Washington D.C.
- [22] Takizawa, H., E. Gardner and K. Ueda (2004), “Are Developing Countries Better Off Spending Their Oil Wealth Upfront?” IMF Working Paper 04/141, International Monetary Fund, Washington D.C.
- [23] Van Wijnbergen, S. (1984), “The Dutch Disease: A Disease After All?”, *The Economic Journal*, vol. 94, no. 373, pp.41-55.

4.7 Appendix

Proof. For the proposed value function J_t , the Bellman optimality equation is

$$\phi_t + \Theta_t \log NW_t = \max_{G_t, R_t} \left[\log((1 - \tau) H_t + R_t) + \Psi \log G_t + \frac{1}{1 + \delta} (\phi_{t+1} + \Theta_{t+1} \log NW_{t+1}) \right] \quad (4.27)$$

subject to (4.20). The first-order conditions can be written as

$$R_t : \quad C_t^{-1} = \frac{\Theta_{t+1}}{1 + \delta} \left[(1 + r) + b \sum_{s=t+1}^M \left(\frac{a}{1 + r} \right)^{s-(t+1)} \right] NW_{t+1}^{-1} \quad (4.28)$$

$$G_t : \quad \Psi G_t^{-1} = \frac{\Theta_{t+1}}{1 + \delta} \left[(1 + r) - c \sum_{s=t+1}^M \left(\frac{a}{1 + r} \right)^{s-(t+1)} \right] NW_{t+1}^{-1} \quad (4.29)$$

Dividing equation (4.28) by (4.29), we obtain the optimal ratio of consumption and public goods

$$\frac{G_t}{C_t} = \Psi \frac{(1+r) + b \sum_{s=t+1}^M \left(\frac{a}{1+r}\right)^{s-(t+1)}}{(1+r) - c \sum_{s=t+1}^M \left(\frac{a}{1+r}\right)^{s-(t+1)}} = \Psi \frac{1 + \frac{b}{a-(1+r)} \left[\left(\frac{a}{1+r}\right)^{M-t} - 1 \right]}{1 - \frac{c}{a-(1+r)} \left[\left(\frac{a}{1+r}\right)^{M-t} - 1 \right]} \equiv q_t \quad (4.30)$$

Making use of this expression and substituting for NW_{t+1} from equation (4.16), we rewrite equation (4.28) as

$$C_t = \frac{1}{1 + q_t + (\Theta_t - 1 - \Psi) \left[1 + \frac{b}{a-(1+r)} \left(\left(\frac{a}{1+r}\right)^{M-t} - 1 \right) \right]} NW_t \equiv h_t NW_t \quad (4.31)$$

Substituting for C and G in (4.27) gives

$$\begin{aligned} \phi_t + \Theta_t \log NW_t &= \\ \log(h_t NW_t) + \Psi \log(q_t h_t NW_t) + \frac{1}{1+\delta} \{ \phi_{t+1} + \Theta_{t+1} \log[(1+r)(1-h_t-h_t q_t) NW_t] \} \\ &= \left(1 + \Psi + \frac{\Theta_{t+1}}{1+\delta} \right) \log NW_t + \log h_t + \Psi \log(q_t h_t) + \frac{\phi_{t+1}}{1+\delta} \\ &\quad + \frac{\Theta_{t+1}}{1+\delta} \log[(1+r)(1-h_t-h_t q_t)] \end{aligned} \quad (4.32)$$

Thus, the values for Θ_t and ϕ of the proposed value function are

$$\Theta_t = 1 + \Psi + \frac{\Theta_{t+1}}{1+\delta} \quad (4.33)$$

and

$$\phi_t = \log h_t + \Psi \log(q_t h_t) + \frac{\phi_{t+1}}{1+\delta} + \frac{\Theta_{t+1}}{1+\delta} \log[(1+r)(1-h_t-h_t q_t)]$$

A general value for Θ can be obtained observing that $\Theta_{M+1} = 0$. Thus, $\Theta_M = 1 + \Psi$, $\Theta_{M-1} = 1 + \Psi + \frac{\Theta_M}{1+\delta}$, etc. Iterating equation (4.33) we obtain

$$\Theta_t = (1 + \Psi) \left(\frac{1 + \delta}{\delta} \right) \left(1 - \left(\frac{1}{1 + \delta} \right)^{M-t+1} \right) \quad (4.34)$$

Therefore, we obtain an equation for C_t as a function of NW_t ,

$$C_t = \frac{1}{1 + q_t + (\Theta_t - 1 - \Psi) \left[1 + \frac{b}{a-(1+r)} \left(\left(\frac{a}{1+r} \right)^{M-t} - 1 \right) \right]} NW_t \quad (4.35)$$

where

$$\Theta_t = (1 + \Psi) \left(\frac{1 + \delta}{\delta} \right) \left(1 - \left(\frac{1}{1 + \delta} \right)^{M-t+1} \right) \quad (4.36)$$

□

Chapter 5

Conclusion

Economic performance of many resource-rich countries has not been as good as it may be expected. Various literature have been trying to explain this phenomenon for many years. In this thesis, we wanted to contribute to this strand.

The most popular explanation for natural resource curse has been based on the notion of the Dutch disease. We enrich previous models of the Dutch disease by adopting a dynamic framework with costly sectoral reallocation of capital between non-traded and traded sector. Therefore, it is more costly to transform one form of existing capital into another. This way capital becomes a specific factor for each sector in the short-run and mobile across sectors in the long-run. Thus, real exchange rate is no longer fully determined by the supply side and does not adjust instantaneously.

In our model, we follow Sachs and Warner (1995), and assume endogenous economic growth. Productivity is a function of the labor employed in the traded sector. We observe that an increase in natural resource revenues induces lower growth rates.

When an economy benefits from an oil boom, households' income rises and the demand for both traded and non-traded goods increases. Given that it is not possible to import non-traded goods, production of this type of goods must increase. Hence, we observe a transfer of production factors from the traded to the non-traded sector. However, unlike labor, capital cannot move freely across sectors. Consequently, there is a relative increase in the price of the non-traded good with respect to the price of the traded goods. In other words, there is a real exchange appreciation. Thus, we observe that an increase

in natural resource revenues induces a real exchange appreciation and a decline in the traded sector.

The decline in the traded sector is the appropriate market response to an increase in natural resource revenues, and it should not cause any problem in the economy. However, under the assumption that productivity is positively affected by the labor employed in the traded sector, a decline in the traded sector implies lower growth rates.

In this way, we can explain why some resource-rich countries may experience lower growth rates.

However, the economic performance of some resource-rich countries has been more successful. Not all the countries have performed badly. Hence, we analyze the tools that may help resource rich-countries to avoid the resource curse. More precisely we study the effects of adopting stabilization funds. Oil-exporting countries such as Norway and the state of Alaska decided to establish a stabilization fund to isolate their economy from oil price volatility. Although, there exists differences between their stabilization funds, the main mechanisms are very similar. According to the fund policy, oil revenue is deposited in the fund and invested in a range of foreign financial assets. Only the return from the assets can be used for government purchases or transferred to households.

In our analysis, we observe large benefits of adopting a stabilization fund, particularly, two positive consequences. First, it reduces volatility of the main macroeconomic variables in the economy. Second, the decline of the traded sector after an oil boom is lower, and thus, Dutch disease effects are avoided.

Finally, we explore the optimal use of natural resources given that they are exhaustible. Our benchmark model is based on the permanent-income hypothesis. We find that resource rich countries should distribute resource wealth over time. Consequently, a share of resource revenue should be saved while production is active.

However, the models based on the permanent-income hypothesis do not consider important aspects of resource-rich countries. First, resource abundance may shift factors of production away from sectors generating learning-by-doing (Dutch disease). Second, government spending may enhance productivity growth, particularly in developing countries. Hence, we include these two aspects in our model.

We observe that these two aspects have opposite effects on the way resource wealth should be managed. Dutch disease effects induce to postpone wealth consumption in order to avoid the decline of the traded sector. However, a higher consumption of public goods upfront raises productivity for future generations.

Therefore, the optimal management of natural resource wealth is not straightforward. On the one hand, when we consider that public goods are the main factor that drives productivity growth, we find that the optimal spending path of natural resources decreases. On the other hand, when the traded sector is the main factor which drives productivity growth, the optimal spending path grows over time.