Natural Resource Extraction and *Dutch Disease:* Application to Papua New Guinea

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Abstract

Natural resource booms are often thought to be an impediment to economic development due to Dutch disease effects. This paper uses DSGE simulations to investigate the transmission mechanisms behind these effects and policy options to mitigate them. The transmission mechanism is driven by increased spending on non-tradables financed by natural resource inflows. Dutch disease effects can be mitigated by concentrating spending on tradables and public investment as well as smoothing the spending profile through use of a Sovereign Wealth Fund. Monetary policy alone is not effective in mitigating Dutch disease effects, at least not without causing a significant crowding out of the private sector.

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Contents

1 Introduction

This paper is the result of two modelling workshops, held in July 2011 and May 2012, to introduce staff at the Bank of Papua New Guinea (BPNG) and the PNG Department of Treasury to various macroeconomic modelling tools developed by the IMF for assessing the macroeconomic effects of natural re- source inflows. Specifically, the workshops focused on a medium-term Dynamic Stochastic General Equilibrium (DSGE) model with a natural resource sector. The model has its origins in a model developed by Andy Berg and his colleagues Rafael Portillo and Felipe Zanna for analyzing the macroeconomic effects of the scaling up of aid. It was augmented with a natural resource sector and sovereign wealth fund (SWF) by Susan Yang[1]

The objective of the workshop series was to practically demonstrate the use of these models for analyzing the macroeconomic effects of natural resource inflows and assessing the available fiscal and monetary policy options. The focus throughout the paper is on the economic and policy implications of the model simulations, with an attempt to distil lessons that can be shared with policymakers without recourse to the underlying model.

The first workshop focused on fiscal and monetary policy issues, summarised in Section 2 of this document[2]. Besides the basic economic transmission mechanism of an increase in natural resource revenues, this workshop covered the role of the composition of fiscal spending, the time profile of spending, the ability of monetary policy to constrain the degree of real appreciation, and the effect of introducing an SWF.

The second workshop focused on *Dutch disease* effects, which are at the centre of Sections 3 and 4 of this paper. Section 3 starts out with a discussion on whether there is actually a disease if *Dutch disease* effects are narrowly defined to consist only of a real appreciation and shrinkage of tradable sector production, consistent with the setup in Section 2. Arguably, these effects can be understood as an equilibrium response of the economy to natural resource inflows and do not constitute a disease per se.

Alternatively, Section 3 considers a broader definition of *Dutch disease* where a long-term negative effect arises due to the tradable sector being a special source for economic development (in particular through industrialization), implying that a

[1] We would like to thank Susan Yang, who is the main developer of the model used in this paper, for making her model code available to us and for her continued technical support and other contributions to this project. We would also like to thank Scott Roger and Yongzeng Yang for their support and many insightful comments.
We also acknowledge the Bank of PNG for its continued support for our research, including the organization of two workshops where we could share results and methodologies more broadly among our colleagues at the Bank. Specifically we would like to thank Dr. Gae Kauzi, who was instrumental in seeing our project through and our colleagues at the Bank in general, who provided us with valuable feedback and comments. The remaining errors are ours.

[2] The results of this workshop were also published in a separate working paper, [Basu et al, 2013], and are largely reproduced here. This sister paper also includes a detailed discussion of the model used here, which this paper does not reproduce for the sake of brevity

shrinkage of the tradable sector will retard development and impose a long-term economic cost on the economy. This broader definition of *Dutch disease* effects is implemented in the model via strong learning-by-doing externalities in the tradable sector. Given the uncertainty on whether such learning-by-doing externalities are relevant for PNG, the subsequent simulation results should be seen as representing a worst case scenario for PNG. Section 4 repeats the policy simulations of Section 2 in the model with strong learning-by-doing externalities and assesses how the efficacy of various policy measures changes under this broad definition. Section 5 provides a short summary.

2 Policy Simulations under a Narrow Definition of *Dutch Disease* Effects

Using the model for PNG set up by [Basu et al, 2013], we run a suite of policy simulations that assume only weak learning-by-doing effects, thereby fitting the narrow definition of *Dutch disease* effects discussed above. The policy scenarios were chosen to simulate realistic policy responses to the resource inflows, as well as for their ability to demonstrate the pros and cons of certain policy choices. We center the discussion around one central question: should the Government spend or save the resource revenues? Each option is analyzed further, with the spending choice broken down into temporal and sectoral considerations, and the saving option broken down into reserve accumulation versus investment in a sovereign wealth fund.

2.1 Spending

In this section, we concentrate on scenarios in which the Government spends the entirety of the revenue inflows. For monetary policy, we assume that the central bank allows the exchange rate to adjust flexibly by abstaining from re- serve accumulation - that is, all foreign exchange inflows associated with natural resource revenue inflows are sold in the foreign exchange market; with respect to domestic monetary policy, the central bank implements interest rate targeting via a standard Taylor rule.

2.1.1 The Baseline Scenario

This scenario will act as a benchmark for all subsequent simulations. It is constructed to reflect a policy mix that often prevails in the event of resource revenue inflows. We use the parameterization that the Government spends 90 percent of the inflows on consumption, and the remainder on investment. Of that which is consumed, 70 percent is spent on non-tradables ($v_g = 0.7$). This specification is meant to highlight the macroeconomic effects of government consumption; in contrast, spending increases on public investment would likely have a lower share of spending on non-tradables and therefore a smaller macroeconomic impact, as will be shown in the first policy scenario, plus public investment would raise overall GDP in the medium term relative to our consumption scenario by building up the public capital stock.

We model the revenue inflows in the form of an oil price shock. The increase in oil prices leads to a surge in oil revenues to the government. The results are presented in Figure 1.[3] The macroeconomic impacts of the surge in oil revenue inflows is driven by government spending, which increases in line with the oil revenue inflows, given that we assume here that the government spends the entirety of revenue inflows. As a direct consequence of the government spending profile, demand for non-tradables increases. Since this sector is characterized by monopolistic competition, the demand shock translates in the short-run into increases into both prices and production in this sector. The latter requires increases in factors of production, which occurs through labor migration from the tradable sector as well as increased investment in non-tradables.[4] Given the upward pressure on non-tradable prices resulting from the shift in demand from non-tradables to tradables, non-tradable prices increase relative to tradable prices, which implies that the real exchange rate appreciates.[5] In the absence of interventionalist central bank policy, this appreciation does manifest. As a result, profitability in the domestic tradable sector declines, facilitating an outward migration of capital and labor.

[3] Only the key macroeconomic variables are shown here. The plots are annual impulse responses as measured as a percentage deviation from steady state.
[4] It should be noted that investment is a slower process than labor migration, and hence embodies a longer-term strategy for increasing production.
[5] We measure the real exchange rate in two ways, namely in form of the nominal exchange rate deflated by CPI and/or the non-tradable/tradable price ratio

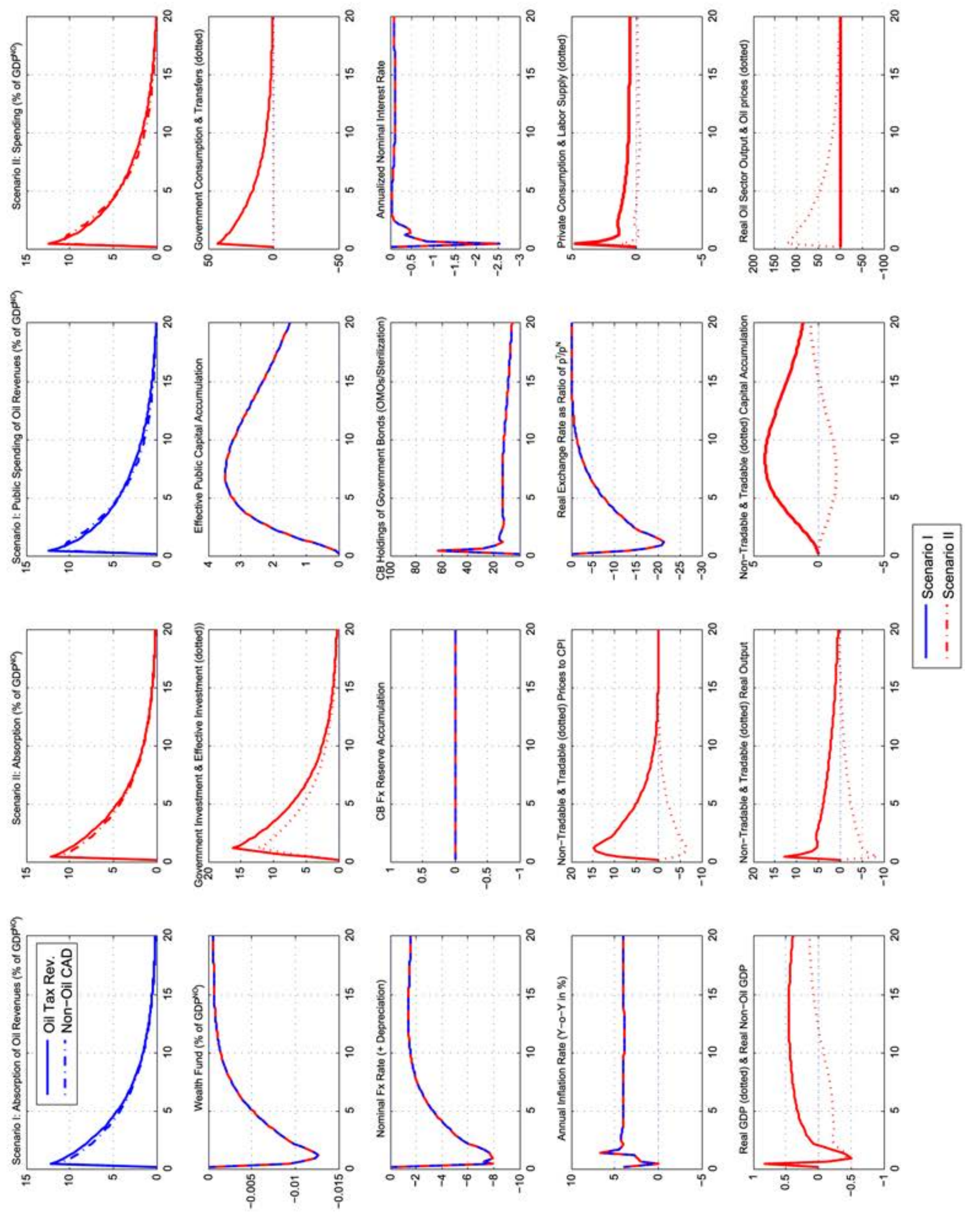

Figure 1: Baseline Scenario

The real appreciation causes a widening of the current account deficit, for two reasons.[6] First, the real appreciation makes tradables relatively cheaper, causing overall demand for tradables, and hence imports, to increase. Second, owing to the shrinking domestic tradable sector, a greater portion of that demand must be met through imports. Finally, owing to the persistence of the exchange rate appreciation, overall inflation falls, triggering a moderate loosening of monetary policy (a decrease in the real interest rate) in the short-run.

To summarize, the macroeconomic effects of resource inflows are driven largely by fiscal spending, in particular on non-tradables. More specifically, the macroeconomic effects occur as a result of the economy needing to restructure to meet the government demand for non-tradables.

Before turning to the policy simulations, it is useful to outline how we are going to judge whether a given policy setting improves macroeconomic outcomes relative to the baseline or not. One intuitive option would have been to focus on the output response, as measured by the real non-oil GDP response in our figures, with a higher medium-term output response pointing to a more preferable macroeconomic outcome. We do not follow this path because the medium-term output response depends mostly on the degree to which the government uses oil revenue inflows to increase public investment and to what degree the resulting public capital accumulation is sustainable. Given that this issue is discussed comprehensively in [Berg et al., 2013] we focus instead on the macroeconomic effects of government consumption, as noted above in the specification of the baseline scenario. Taking into account that the oil price shocks in our simulations are temporary and that using oil revenues mostly for consumption will not build up the public capital stock in any sustainable manner, in the medium term all our macroeconomic variables can be expected to revert to their baseline value, which corresponds to the zero line in our figures. Hence, measuring the medium term response will tell us little about the relative desirability of the macroeconomic outcomes.

Rather, the benchmark for judging whether a given policy setting improves macroeconomic outcomes will be the degree of macroeconomic volatility generated by the different scenarios, with lower volatility being more desirable. We use the term macroeconomic volatility loosely and measure it informally by observing how much the macroeconomic variables fluctuate around their baseline values in our simulations, i.e., in the graphical presentation of our simulation results we focus on how large and frequent deviations of the depicted impulse response functions are

[6] This is shown in the chart through the increase in absorption, which corresponds to a widening of the current account deficit.

from the zero line.[7] Given that we do not claim that our model can generate reliable quantitative projections, this qualitative approach is sufficient for our purpose.

Finally, before moving on it is worth asking why do we care about macroeconomic volatility? At a general level, macroeconomic stability is a widely accepted objective of fiscal and monetary policies, so aiming for low macroeconomic volatility makes a natural benchmark. A related argument, which we discuss in more detail in the scenario with front-loaded spending, is that mobilizing production factors and reallocating them among sectors is not costless, which implies that *temporarily* ramping up non-tradable production is inherently wasteful, especially so if the production increase is short lived. Hence, the economy is likely to be better off with gradual, sustained adjustment processes.

2.1.2 Inter-Sectoral Spending Profile: Tradable vs Non-Tradables

The results of the baseline scenario suggest that macroeconomic volatility depends on the profile of government spending. This profile can vary both inter-temporally and inter-sectorally, i.e. how fast government spends the inflows, and in which sectors. The current simulation will vary the sectoral spending profile with respect to its spending on tradables versus non-tradables. In particular, government will now devote 80 percent of spending on tradables ($v_g = 0.2$).

The remainder of the assumptions are as per the baseline.

Figure 2 shows the results of the simulation. Now, the increase in non-tradable demand is much smaller, thus resulting in smaller increases in non-tradable prices and output and hence a smaller migration of labor and capital to this sector. Concurrently, the tradable sector retains a greater proportion of overall demand, experiencing a smaller price drop and hence retains its profitability.[8]

The current account widens as per the baseline, this time through direct government spending on imports. The overall inflationary pressure is identical to that in the baseline. This is because the smaller nominal appreciation – which constitutes a disinflationary pressure - is directly offset by the smaller increase in non-tradable prices.

This simulation proves that it is not the resource inflows per se that cause the macroeconomic volatility, but rather government spending on non-tradables. The key issue is that the supply of non-tradables is limited by domestic production

[7] An alternative would have been to measure macroeconomic volatility more formally by computing the standard deviations of key variables such as real non-oil GDP or the real exchange rate, but this would have lengthened our paper without generating much additional information, given that the graphical results depict very clearly which scenarios are more volatile than others.

[8] Both measures of the real exchange rate, i.e the nominal CPI-deflated exchange rate and the non-tradable/tradable price ratio, demonstrate a smaller appreciation than in the baseline scenario.

whereas supply for tradables is unlimited, as demand which is not met domestically can be met through imports. Hence, spending on tradables has limited macroeconomic effects, whereas spending on non-tradables, through the limited supply response, generates large macroeconomic effects.

2.1.3 Inter-Temporal Spending Profile

The previous scenario altered the inter-sectoral spending profile of government. This simulation will vary the speed of spending and compare a scenario with front-loaded fiscal spending to an alternative scenario with a smooth spending profile. The most relevant situation for a front-loaded fiscal spending scenario is the occurrence of a temporary oil price shock. In the previous simulations, the oil price shock was fairly persistent, which we need to modify here by short- ening the period over which oil prices are elevated in order to make the oil price shock more temporary - more than 90% of the oil price shock dissipates now after three years, compared to approximately ten years under the previous specification - and reduce the size of the shock accordingly.

Beginning with the specification of the front-loaded fiscal spending scenario, in this scenario government spends all of the oil revenues as they come in, which implies a large ramping up of expenditures as oil prices surge initially, followed by a fairly rapid reduction in spending as oil prices fall again. Apart from the modified path for oil prices, the settings for the front-loaded spending scenario are identical to those of the baseline.

The alternative scenario implements a smoother spending profile. The section on Sovereign Wealth Funds (SWF) will consider a case where a temporary increase in oil revenues is transformed into a small but permanent increase in spending, which could be considered as the ultimate smoothing of the spending profile. In this section we are going to consider an intermediate case where spending of the temporary rise in oil receipts is spread relatively evenly over five years.

To implement this limited form of smoothing, it is necessary for the government

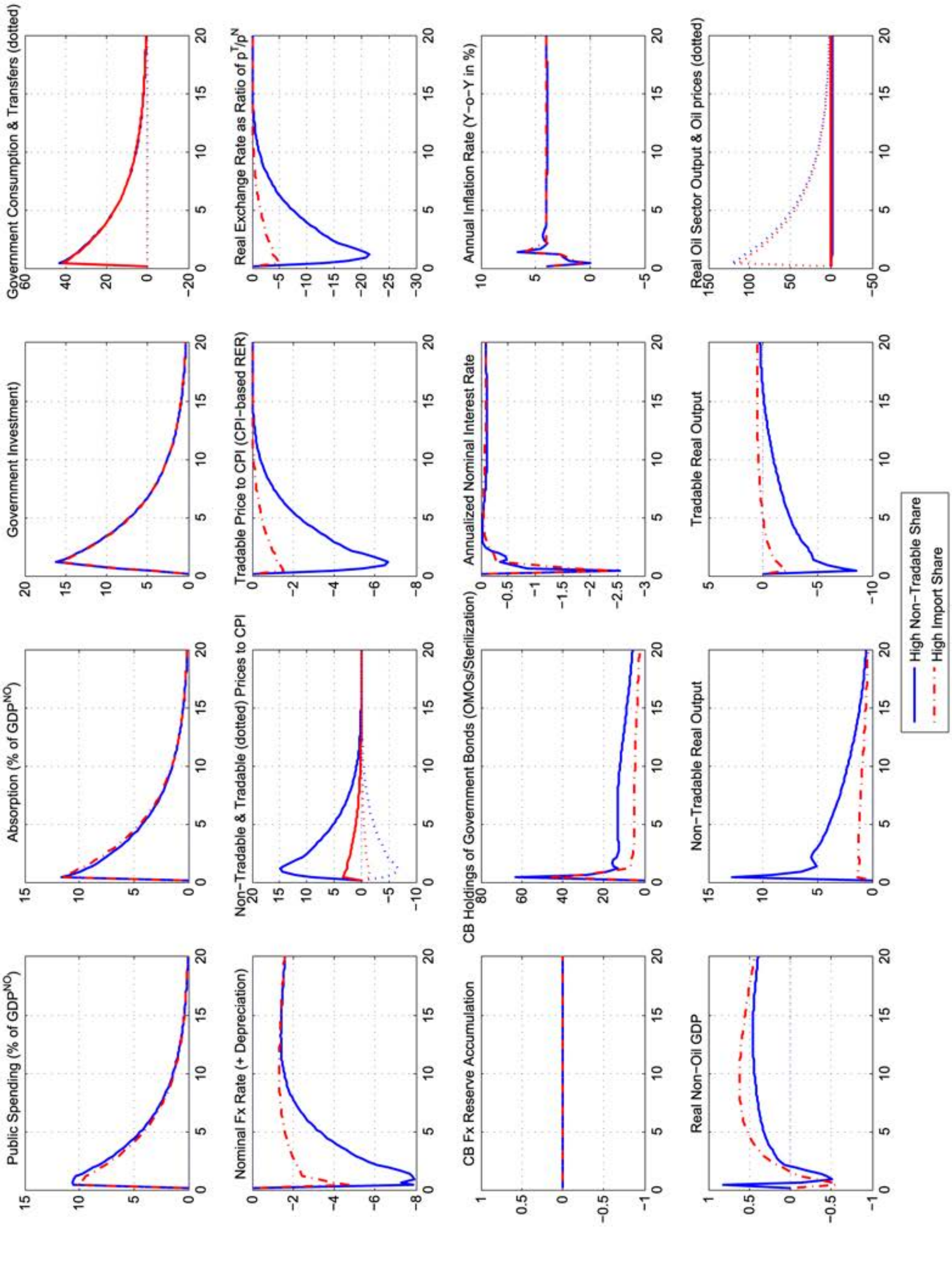

Figure 2: Intersectoral spending

to save parts of the temporary oil revenues that are not initially spent and draw on these savings when spending exceeds the level of oil revenue inflows; we implement this in the model simulation by transferring initial fiscal surpluses into the government deposit with the central bank, followed by a draw down in later years to finance budget deficits that arise when oil revenues have receded and spending is still elevated.

We also modify the foreign exchange management by the central bank for the smoothing scenario: instead of selling all foreign exchange inflows, we assume that the central bank will sell an amount of foreign exchange that matches the amount of government spending financed out of the additional oil revenues. As a result, the buildup of government deposits in the early years when the government saves part of the temporary oil revenue inflows is matched with a corresponding buildup of foreign exchange reserves, which leaves the overall money supply broadly unchanged. Likewise, when the government draws down its government deposits to finance fiscal deficits, the stock of central bank foreign exchange reserves will fall as well. Hence, smoothing in this scenario applies both to fiscal spending and foreign exchange management, which has the effect of aligning economy-wide absorption (i.e., the path of the non-oil current account deficit) with the path of the fiscal deficit. This is a key characteristic of the baseline scenario where fiscal spending and foreign exchange management are aligned as well through spending of *all* oil revenue inflows by the government and sale of *all* foreign exchange inflows by the government. Technically, the smoothing of foreign exchange sales is implemented by making the nominal exchange rate somewhat sticky.

The results for the two scenarios are shown in Figure 3. In essence, the evolution of the macroeconomy occurs through a more sustained, gradual process in the scenario with smooth spending compared to the front-loaded spending scenario. The contrast highlights the undesirable consequences of front-loading spending, which fall into two categories:

1. *Macroeconomic volatility.* Strong macroeconomic pressures emerge during front-loaded spending, all of which subside as spending slows down, allowing variables to return to steady state. The result is significant macroeconomic volatility. For example, the real exchange rate appreciates by about 6.5 percent at its peak under the front-loaded spending scenario, whereas in the smooth spending alternative, the

appreciation peaks at only about 2.5 percent. The same difference in volatility is visible for inflation, nominal interest rates, and output variables.

2. *Costs.* Front-loaded spending results in economic costs that cannot be captured in the model predictions. These stem from the massive real-location of labor to the non-tradable sector when spending surges, and subsequent re-allocation to tradables once spending recedes. The model assumes frictionless labor migration. However, in reality, such movements will undoubtedly be accompanied by periods of unemployment, itself costly to both individuals and the broader economy, and possibly periods of low productivity in the non-tradable sector, as newly arriving workers require retraining to acquire the necessary skills. The model also assumes that the tradable sector merely "hibernates" during the spending spree. In reality, some firms in the tradable sector that were shuttered during the spending surge in the front-loaded spending scenario would have been unable to restart their business when spending recedes, leading to permanent output losses.

In summary, front-loading spending should be avoided because of macroeconomic volatility and economic costs caused by these policies.[9] The costs of front-loaded expenditures would be even more pronounced if there are bottlenecks to effective public spending, also known as absorptive capacity constraints.[10]

2.1.4 Monetary Policy

We have seen how rapid government spending on non-tradables can result in Dutch disease effects in the form of a real appreciation and reduction in tradable sector output, which leads to the question "Can monetary policy be used to mitigate the effects of *Dutch Disease*?". So far, the simulations assumed that the central bank would sell all of the foreign exchange inflows stemming from the increase in oil revenues; this is a key factor for the nominal appreciation under the baseline and by extension for the real appreciation. Hence, if the central bank wants to prevent a

[9] Of course, an alternative is to mitigate the macroeconomic effects of a frontloaded spending profile by aiming for a high import content of spending and raising public investment; provided the buildup of public capital is sustainable, the last will raise output permanently and thereby boost the supply response of the economy.

[10] The topic of absorbtive capacity constraints is explored in more detail in the sister paper, [Basu et al, 2013].

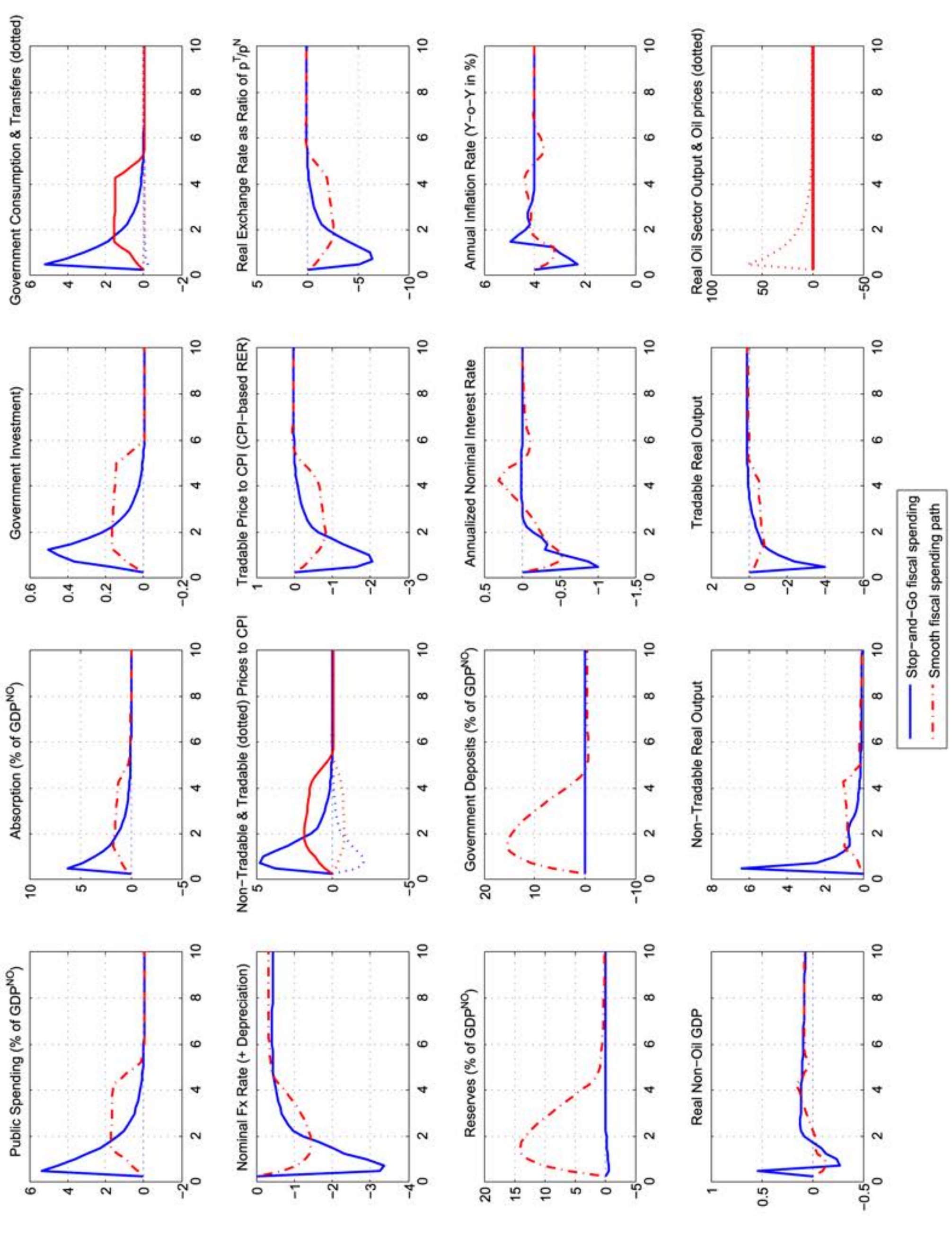

Figure 3: Intertemporal spending

real appreciation, a first step would be to start accumulating the foreign exchange inflows as reserves instead of selling them. However, this would result in a large expansion in money supply that would fuel inflation and lead to a real appreciation through the inflation differential to other countries. Moreover, the inflationary pressures could become large enough to risk unhinging inflation expectations. Hence, this policy would have to be accompanied by a sterilization of the increase in money supply in order to contain inflation. That is, the monetary policy stance would need to be very tight. Both types of policies reserve accumulation and sterilization - will be implemented in this alternative scenario.

The central bank now retains 70 percent of the foreign exchange it acquires through the resource inflows as foreign reserves ($\omega_o = 0.7$). In order to offset the effect of this accumulation on domestic money, the central bank needs to issue public debt to sterilize the reserve accumulation. To accomplish this, we change the interest rate targeting regime to be much stricter in response to inflation. Finally, we revert to imposing a persistent oil price shock as under the original baseline specification.

Figure 4 shows the results of the simulation. The reserve accumulation policy is effective in mitigating the sizable nominal exchange rate appreciation seen in the baseline, which in turn keeps the real appreciation to a limit. As a result, the tradable sector remains largely competitive, with production dropping by far less than under the baseline. In this regard, monetary policy has been successful in protecting the tradable sector from a real appreciation and subsequent loss of competitiveness. Furthermore, from a fiscal perspective, reserve accumulation does not significantly affect the demand for non-tradables, and the economy still generates the necessary supply response to front-loaded spending. Hence, it would appear this alternative Pareto-dominates the previous alternatives. However, it is instructive to compare how the demand for non-tradables is met in this scenario. In the baseline, non-tradable demand is met through factor migration which itself is facilitated through a real appreciation. In Scenario 2.1.2 where the government concentrates spending on tradables, government demand is met through imports. However, these avenues are both blocked in this setting, the first by the central banks reserve management, and the second because of the government’s spending profile. Instead, the sterilization that accompanies the reserve accumulation constitutes a monetary tightening, i.e. real interest rates increase dramatically. This causes a crowding-out of the private sector, i.e., private sector demand falls, thereby freeing

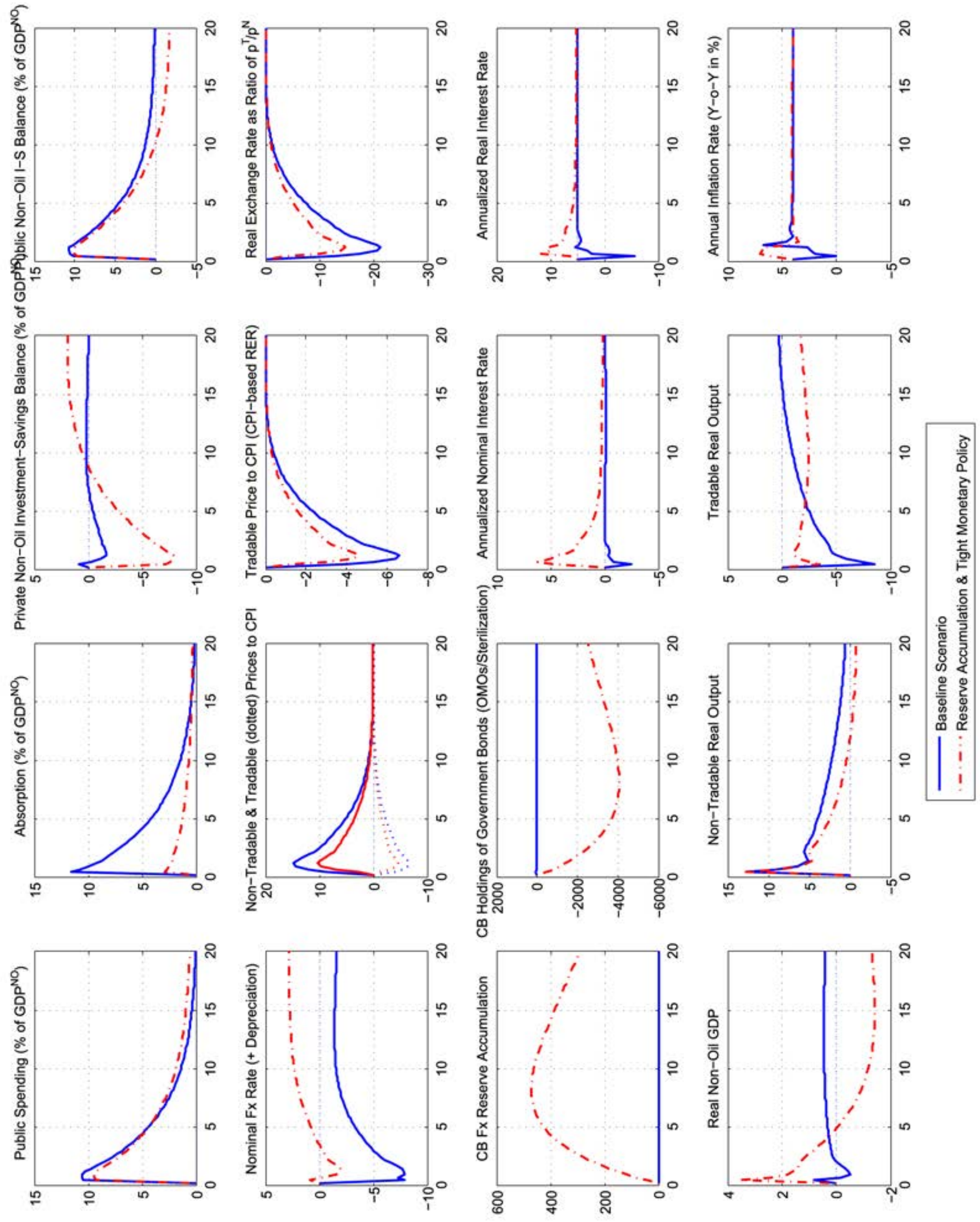

Figure 4: Monetary policy

up supply capacity of the economy that can be used to meet expanding government demand. Thus, whilst the first two scenarios exhibit a change in the profile of private sector demand, this scenario yields a drop in overall private demand.[11] Essentially, the process is identical to an orthodox debt financed fiscal expansion, since the central bank absorbs the foreign impact and issues public debt to the same amount, and as such, the ensuing crowding-out is inevitable. As a side effect of the reduction in private sector consumption, households increase their labor supply, which accounts for the larger short-run increase in GDP under this scenario and the significant rise in non-tradable production.

In conclusion, there is no simple dichotomy between fiscal and monetary policy, whereby monetary policy can costlessly neutralize the effects of front-loaded government spending on non-tradables, insofar as the resultant private sector crowding-out is undesirable.

2.2 Saving through a Sovereign Wealth Fund

When the Government spends the resource revenues, we have seen how macroeconomic volatility ensues, in particular from front-loaded spending, and how monetary policy cannot offset this volatility without cost. We turn now to scenarios in which the Government chooses to save a portion of the resource inflows. We already considered the effects of savings in the form of limited smoothing of spending over time in Scenario 2.1.3. Here, we extend this idea to a more sophisticated mechanism where the government can now build up a permanent stock of savings that enables it to perfectly smooth its spending profile over time. To do so, the government now saves a portion of the resource revenues in an offshore SWF that accrues interest at an exogenous rate. Dividend payments are made in the form of transfers.[12]

We specify the operation of the SWF as follows: government saves a proportion of the revenue inflows (in the simulation, the share of natural resource inflows that is saved in the SWF is approximately 75 percent), thereby enabling the fund to reach a permanently higher level in the detrended equilibrium, and divides the remainder between consumption and investment as per the baseline ($\varphi^{gc} = 0.9$, $\varphi^{gi} = 0.1$). All other assumptions are as per the baseline scenario.

Figure 5 shows the results. The intertemporal smoothing of spending results in much reduced macroeconomic volatility, similar to Scenario 2.1.3. Further- more,

[11] This is indicated through two channels. First, the current account deficit expands by less. Second, the reduction in private sector investment reduces the long-run level of output.

[12] This setup follows the bird-in-hand rule.

as a result of less overall front-loaded spending, the reduced spending on non-tradables lowers macroeconomic volatility even more, as discussed in Scenario 2.1.2. In effect, the SWF transforms a temporary increase in oil revenues into a permanent, if smaller, revenue stream fed by interest earnings on SWF balances. Hence, fiscal spending under the SWF scenario is sustainable, and the public capital stock will not wither away as it does under the baseline. Monetary policy challenges are much reduced. Given that most of the oil revenue inflows are saved in an offshore fund, and given the limited macroeconomic pressures from the moderate increase in spending, there would not be much of a rationale for accumulating the remaining foreign exchange inflows as reserves and for pursuing a very tight monetary policy. Hence, monetary and fiscal policy objectives are consistent with each other and the fiscal expansion can take place without triggering a monetary policy response that would lead to a crowding out of the private sector.

In summary, smoothing fiscal spending through an SWF arrangement can support a fiscal strategy that contributes to development through a sustained buildup of human and physical capital, makes it possible to calibrate the level of spending such that *Dutch disease* effects do not undermine the growth strategy, and avoids macroeconomic pressures that would put monetary policy objectives at risk

2.3 Further Issues

There are a couple of issues that require singling out. Whilst it would have been entirely possible to discuss them within each scenario, they are of both sufficient complexity and importance to warrant separate discussion.

2.3.1 Current Account

In both the baseline scenario and the scenario with higher government imports, the current account deficit widens by the same amount.[13] Furthermore, this amount matches the oil revenue inflows precisely, i.e. in both cases, full ab- sorption occurs. It may be intuitive to assume absorption is greater in the case with higher government import, whereas the simulations suggest this is not the case, i.e., the degree of absorption is identical in both scenarios. To understand why, we must break the absorption process into two phases. First, government must fully spend the revenue inflows, which happens in both cases. Second,

[13] Though out the paper, we use the terms “current account” and “non-oil current account” Interchangeably.

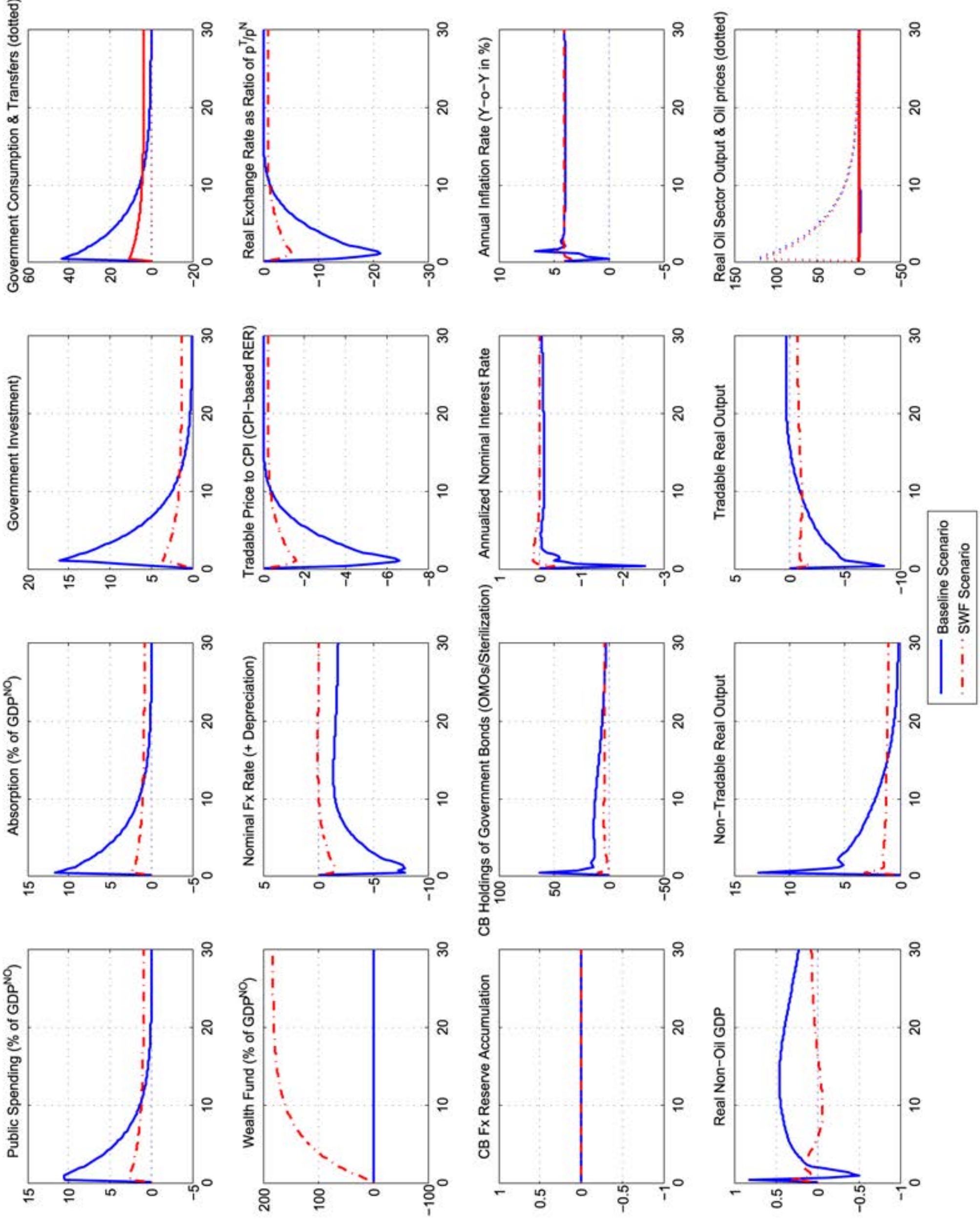

Figure 5: Sovereign Wealth Fund

the increase in fiscal spending needs to be 'converted' into an increase of the non-oil current account deficit. This means all spending is ultimately converted into imports. In the scenario with a high import share, this happens automatically as the government spends directly on imports. In the baseline, it happens via a two-fold effect of the real appreciation: the appreciation makes imports relatively cheaper, thus increasing demand for tradables, whilst the loss of competitiveness in the domestic tradable sector sees a decline in domestic tradable production. Hence, the increased demand must be met through imports.

However, in Scenario 2.1.4, monetary policy blocks both channels, thereby making it impossible for the non-oil current account deficit to rise. Under the baseline, the increase in the non-oil current account deficit allows an equivalent increase in economy-wide absorption (i.e. consumption and investment), which means government consumption and investment can rise without crowding out private sector consumption and investment. In the alternative scenario, monetary policy does not allow economy-wide absorption to increase (because it blocks the channels for an increase in the non-oil current account deficit) and consequently an increase in government consumption and investment necessarily results in an equivalent reduction in private sector consumption and investment. This is yet another way of interpreting the existence of private sector crowding-out in this scenario.

2.3.2 Real versus Nominal Exchange Rate

It is important to make a distinction between the real and nominal exchange rates, what factors determine and affect them and the role they play in the transmission mechanism. The nominal rate is set in the foreign exchange market, and as such is controlled by the central bank's reserve management policy. The real rate is controlled by both fiscal and monetary policy, in the following sense. An expansionary fiscal policy will tend to lead to a real appreciation that can happen either through a nominal appreciation or through inflation. Whilst the nominal appreciation can be prevented through reserve accumulation by the central bank, to prevent a real appreciation, monetary policy (as distinct from reserve management policy) must also be invoked, which can choose to sterilize the impact of the reserve build-up on money supply. This constitutes a tightening of the monetary policy stance. In a sense, the decision whether to allow the nominal exchange rate to appreciate or not is a nominal decision that in itself has little implication for the real exchange rate; the latter depends on whether monetary policy tightens or not, which is a real decision. Reserve management policy alone does not determine the path of the real exchange rate; rather, it is the combination of reserve management policy and monetary policy (sterilization) that matters for the real exchange rate.

3 A Closer Examination of *Dutch Disease* Effects

Dutch disease effects are often considered as a major impediment to economic development in natural resource rich countries. The term *Dutch disease* originates with the fear of de-industrialization in the Netherlands, following the discovery and exploitation of natural gas fields in the North Sea around 1960.[14]
The natural-gas export boom led to a sharp appreciation of the Dutch currency, reducing the profitability of Dutch manufacturing industries and causing exports of products other than natural gas to fall substantially, bringing about a decline in the overall exports-to-GDP ratio. This led to the fear that the natural gas boom would eventually de-industrialize the Netherlands.[15] Before we analyse *Dutch disease* effects on the economy, it is worth taking a moment to outline two different approaches to defining *Dutch disease*. We begin with a narrow definition, and follow this with a broader one.

3.1 Narrow Definition

A narrow definition would hold that *Dutch disease* effects refer to the real appreciation in response to natural resource inflows and the subsequent shrinkage of the tradable sector as the real appreciation shifts production factors from the tradable to the non-tradable sector.[16] Associated with these effects are a noticeable rise in government spending and larger non-natural resource current account deficits.[17] These dual phenomena were key features of the simulations in the preceding chapter, and as such, the macroeconomic effects associated with this narrow definition of *Dutch disease* effects have already been extensively analyzed. What has not yet been explicitly discussed is to what degree such effects constitute a *disease*. The results presented in the preceding chapter have two major implications:

1. The previous simulations suggest that the shrinkage in tradable sector production is not a disease at all, but rather a desirable structural change. In

[14] See [Gylfason, 2008].
[15] This was a fear that failed to materialize; from the late 1960s onward, the exports-to-GDP ratio recovered from roughly 40 percent to more than 70 percent, suggesting that Dutch manufacturing regained its strength.
[16] See [van der Ploeg, 2011].
[17] See [Frankel, 2010].

particular, it frees up the production factors that are needed to meet the demand in the non-traded sector. Without this transfer of factors towards the non-tradable sector, the attempts of the government to increase the delivery of non-traded public services would be futile; under such circumstances, higher government spending on non-tradables, financed by natural resource inflows, would lead only to a change in prices and wages, rather than an improvement in service delivery. More technically, the shrinkage of the tradable sector, combined with the real appreciation, are equilibrium responses of the economy to an increase in government demand for non-tradables, financed out of natural resource revenue in-flows.[18]

2. Even under this equilibrium view, volatility in natural resource revenues and associated government spending poses a challenge for macroeconomic management. However, this issue is not directly captured in the model used here, because the model assumes that transferring production factors from one sector to the other is costless whereas this is un- likely to be the case in the real world. First, shifting production factors out from the tradable sector will cause firms to close. Shifting factors back into the tradable sector in the model is easy as these firms just would reopen but in reality, it is likely that these firms will remain closed, given that their export markets and firm-specific expertise have both been lost. Second, the skills required in the non-tradable sector are likely to be different from those acquired in the tradable sector, forcing the non-tradable sector to invest sizeable resources into the training of labor hired from the tradable sector. If the output expansion in the non-tradable sector is temporary, the newly trained workers will leave after a short while, wasting all the resources that went into their training. Moreover, these newly unemployed workers will find it difficult to find employment in the tradable sector because many firms previously active in this sector remain closed. So, whilst the model effortlessly restructures the economy, in reality the shifts involved come at great costs. This is of real concern for natural resource rich countries; low supply elasticites render commodity prices, and hence inflows, highly volatile.

[18] This last qualifier is important. If the increase in government demand for non-tradables was financed domestically, the foreign exchange would not be available to redirect this demand towards imports through both the real appreciation and the shrinkage of the tradable sector. This would ultimately cause the private sector crowding-out necessary to free up resources to satisfy the increase in government demand.

3.2 Broad Definition

A broader definition of *Dutch disease* effects would consider not only the real appreciation and shrinkage of the tradable sector, but also a negative long-term development effect, due to the privileged role played by the tradable sector in supporting economic growth.[19] Typically, this privileged role is associated with positive externalities, in particular learning-by-doing effects that depend on the size of the tradable sector. The remainder of this paper will investigate the implications of long-term negative effects in more detail.

The model allows for externalities in the tradable sector, but these were de-facto switched off. To understand how these externalities work, it is necessary to revisit the production function of the tradable sector:

$$y_t^T = z_t^T (k_{t-1}^T)^{1-\alpha^T} (l_t^T)^{\alpha^T} (K_{t-1}^G)^{\alpha_G} \tag{1}$$

Here, y_t^T represents production in the tradable sector, z_t^T determines the productivity level in the tradable sector, and k_t^T , l_t^T , and K_t^G are private capital, labor, and public capital inputs into the production of tradables. This is essentially a standard neoclassical production function, which has exactly the same structure for non-tradable production. The special role of tradables is introduced by the specification of the productivity process for the tradable sector that captures the role of externalities by making the level of productivity dependent on the size of the tradable sector:

$$ln(z_t^T) = \rho_{z^T} ln(z_{t-1}^T) + dln(y_{t-1}^T) \tag{2}$$

The larger the level of production in the tradable sector, y_t^T, is, the higher will be the level of productivity in this sector, z_t^T. The extent of this effect depends on the parameters d and $_{z^T}$. The parameter d governs the direct effect of the size of the tradable sector on its productivity whereas $_{z^T}$ determines the persistence of this effect. For the tradable sector to play a special role for economic development, it is critical to assume that learning-by-doing effects are not present in the non-tradable sector. Typically, learning-by-doing effects are thought to be characteristic for the production process of the manufacturing sector, i.e., they are specific to the tradable sector.

[19] There is no agreement regarding whether these long-term negative effects should be associated with *Dutch disease* effects or with the broader phenomenon of the 'natural resource curse'. For instance, [Gylfason, 2008] would classify these as *Dutch disease* effects, whereas [van der Ploeg, 2011] and [Frankel, 2010] would not.

Regarding the economic rationale for learning-by-doing effects, assume that an individual firm faces a steep learning curve, i.e., the firm will become more efficient in producing a new good after it has already been in production and the firm worked out kinks in the production process. In addition, externalities can arise when the knowledge learned during this process becomes available to other firms, for example, through the hiring of already skilled workers. These scale effects at individual firms causes the tradable sector to become more knowledgeable and productive the larger it is. Vice versa, when a real appreciation reduces the size of the tradable sector, such knowledge will be harder to come by, and the productivity level in this sector will be lower. This loss in tradable sector productivity imposes an economic cost that is not present in the non-tradable sector. The economic cost has the potential to transform *Dutch disease* effects from a beneficial equilibrium response of the economy into a hindrance for economic development.

Before discussing what policy options are available to mitigate *Dutch disease* effects, it is useful to illustrate how learning-by-doing externalities can lead to adverse long-run economic outcomes in the model used presently. To make these simulations relevant for PNG, we are going to focus in the remainder of this chapter on a scaling up of oil production levels through FDI inflows. This captures the notion that concerns in PNG relate mostly to the effects of an increase in natural resource inflows as LNG exports commence, that is, the issue in PNG is related to production levels and not commodity price fluctuations. Such an increase in production levels leads to a different profile for natural resource inflows compared to commodity price shocks, in that the build-up of natural resource inflows is more gradual but also more persistent, creating long-lasting economic effects.

Turning now to the specification of learning-by-doing externalities, these were excluded in the baseline simulation by setting the direct impact parameter d and the persistence parameter ρ_{z^T} to values near zero (0.1, to be exact). In the specification with learning-by-doing (LBD) externalities these were set to the maximum values that are economically plausible. This meant setting d = 0.3, and ρ_{z^T} = 0.6.[20] Introducing LBD externalities has the following effects, as shown in Figure 6:

1. Tradable sector production declines permanently and by much more than is the case under the baseline. This reflects the negative impact of LBD externalities on traded sector productivity. The high persistence parameter in the LBD externality specification has the effect of making these productivity losses semi-permanent.

2. Real non-oil output declines substantially and semi-permanently in the scenario with LBD externalities, illustrating the large potential costs to the economy of *Dutch disease* effects in the presence of externalities.

3. The extent of the real appreciation under the scenario with LBD externalities is smaller, with the real exchange rate even depreciating in the medium term. This result stems from the fact that the decline in tradable sector production due to LBD externalities is so large that in the medium term a real depreciation is necessary to prevent further drops in output.[20]

4. The demand impact of the scenario with LBD externalities is contractionary, as illustrated by the steep fall in private sector consumption; dis- inflation due to the large nominal exchange rate appreciation and fall in wage inflation; and an easing of the monetary policy stance as measured by the reduction in nominal and real interest rates. The driving force behind this contractionary impact is that households realize that LBD externalities will lower the production potential of the economy, leading to lower expected future consumption levels; consumption smoothing by house- holds implies that they lower their consumption levels immediately, thereby reducing overall demand and contributing to the disinflation. Monetary policy eases to lean against disinflation.

It needs to be stressed that this paper does not take a strong view whether learning-by-doing effects are relevant for PNG - assessing this is outside its scope. This leaves it up to the reader to weigh the role of industrialization for economic development in general versus the currently small role of the manufacturing sector in PNG and the potential for PNG to take a development path that does not rely on industrialization. If the reader does not see a special role of the tradable sector for PNGs economic development, the policy simulations in Section 2 are sufficient and those in Section 4 will not be of interest. If, however, the reader sees a special role for the tradable sector and finds the specification of learning-by-doing externalities in the extended model adequate to capture this role, the policy simulations in Section 4 should be of interest.

[20] A primary role of the real appreciation is to shift production factors from the tradable sector to the non-tradable sector. The existence of LBD externalities facilitates this process, thereby easing real appreciation pressures.

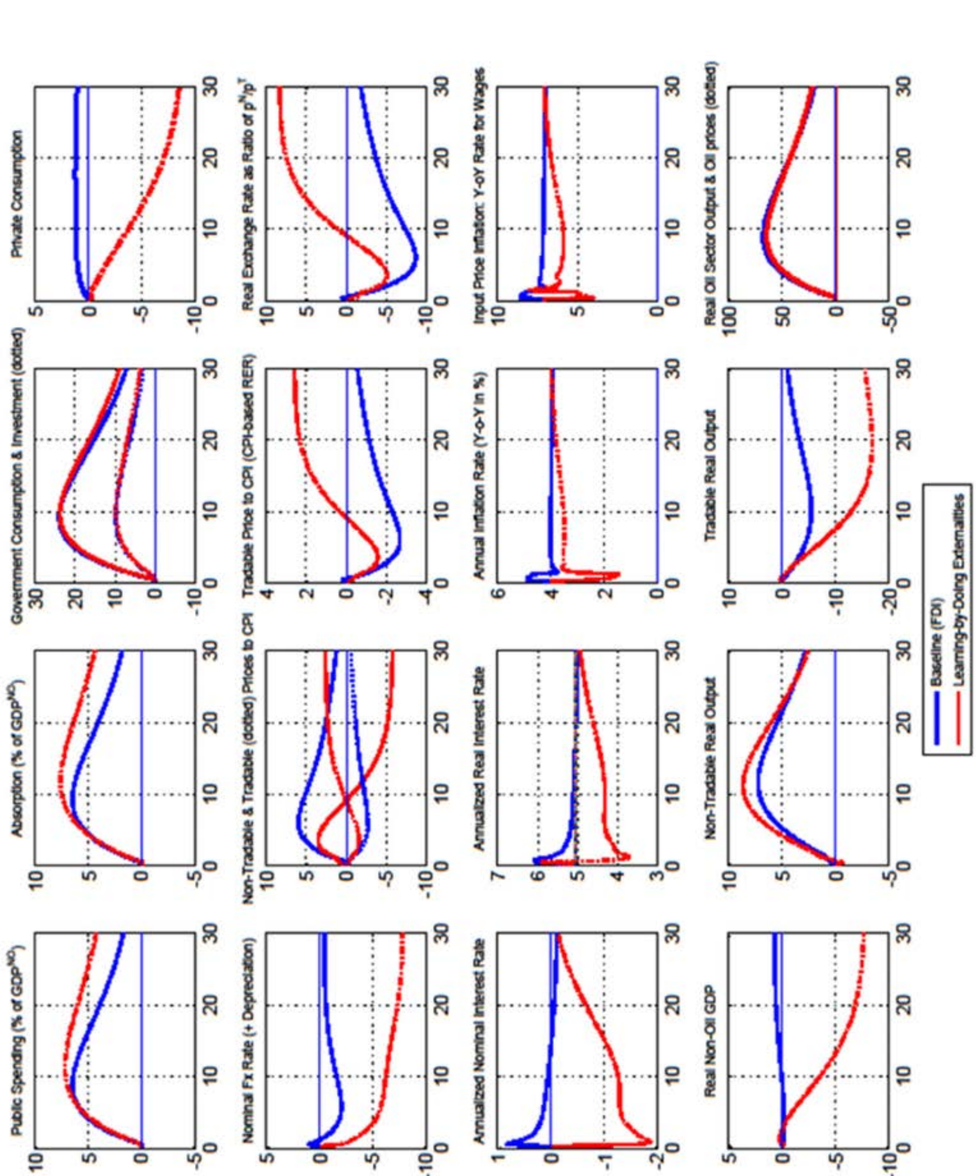

Figure 6: Impact of Learning-by-Doing Externalities

4 Policy Simulations under a Broad Definition of *Dutch Disease* Effects

We now investigate several policy options that are available to mitigate *Dutch disease* effects when strong learning-by-doing externalities are present. The focus is primarily on fiscal policy options, but we will also consider whether monetary policy can prevent *Dutch disease* effects in response to high fiscal spending. The policy simulations are going to be compared to the baseline simulation with strong learning-by-doing externalities introduced in the preceding section. To recapitulate, below are the main assumptions for this scenario:

1. FDI Shock in Oil Sector
   - Shock to FDI in oil sector such that oil production increases by approximately two-thirds, but the increase in production is gradual, requiring about 8 years to reach peak production levels. After about 10 years, production slowly tappers off.
   - Oil is entirely exported.
   - No increase in oil prices; shock represents purely an increase in the volume of oil production.

2. Fiscal Policy
   - Government saves nothing, spends everything.
   - Mainly spends on consumption, small investment expenditure.
   - 70 percent public spending devoted to non-tradable sector.

3. Monetary Policy
   - Government gives foreign exchange receipts from tax revenues and dividends to central bank, in exchange for kina.
   - Central bank holds none of this additional foreign exchange in re-serves; passes it all on into the foreign exchange market.

Comparing these assumptions with those for the baseline in the preceding chapter, the only difference is the source of the increase in oil revenues that is now due to an increase in the volume of oil production rather than prices.

4.1 Inter-Sectoral Spending Profile: Tradables vs Non-Tradables

This scenario maintains full fiscal spending of all oil revenues but asks whether a variation in the composition of fiscal spending with respect to tradables and non-tradables could prevent strong Dutch disease effects from occurring. That is, this scenario is similar to the variation in the inter-sectoral spending profile discussed in Section 2 (2.1.2) but is now repeated under strong learning-by-doing externalities. In Section 2.1.2, reducing the share of spending on non-tradables had the effect of reducing the macroeconomic effects of fiscal spending considerably, including the real exchange rate impact and the decline in tradable sector production. This section is going to follow the same approach, maintaining all assumptions of the baseline scenario outlined above with the exception that similar to Section 2.1.2 the share of public spending directed towards non- tradables is reduced from 70 percent to only 20 percent, which implies that 80 percent of all spending in this scenario goes towards tradables.

In line with Section 2.1.2, directing government spending towards tradables is very effective in mitigating the macroeconomic impact of the fiscal expansion financed by oil revenues (see Figure 7). Specifically, this policy option avoids a large reduction in tradable sector production, which means learning-by-doing externalities play practically no role in this scenario because they are tied to the size of the tradable sector. This also implies that real non-oil GDP remains effectively unchanged. Hence, the potential costs of a fiscal expansion in the presence of learning-by-doing externalities are almost entirely avoided.

The underlying transmission mechanism has been discussed in detail in Section 2.1.2, so a short summary suffices here: by directing spending towards tradables, it is possible to draw on imports to meet the demand generated by increased government spending. This removes almost all supply constraints - after all, the supply potential of imports is practically infinite from the viewpoint of a small country such as PNG. Hence, the need for the real exchange rate to appreciate in order to channel production factors from the tradable to the non-tradable sector is substantially avoided. Viewed from the perspective of the non-tradable sector, a low degree of spending on non-tradables means that demand pressures in this sector are limited and the increase in production in this sector remains moderate.

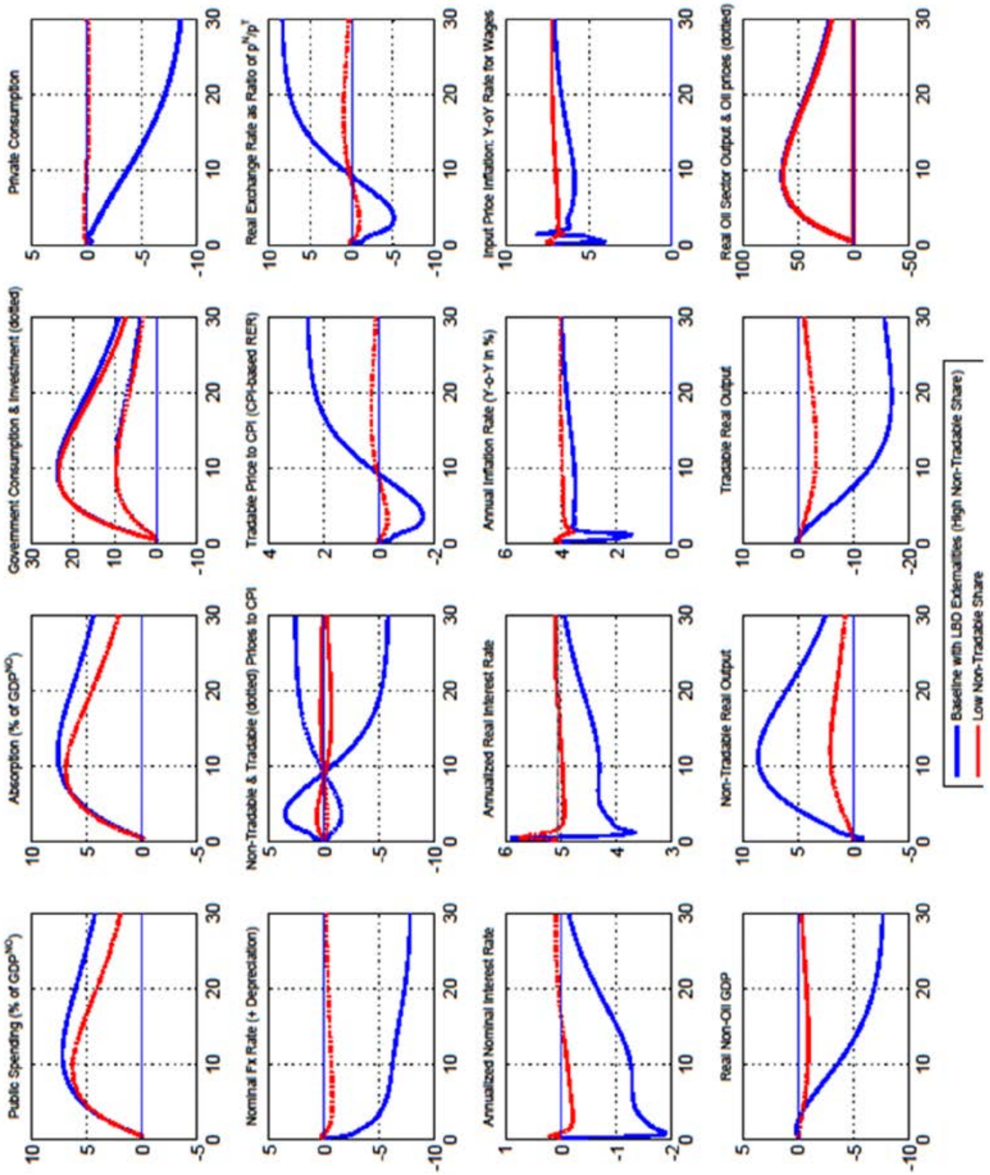

Figure 7: Preventing Dutch disease effects, spending on tradables.

4.2 Inter-Sectoral Spending Profile: Consumption vs Investment

This scenario also maintains full spending of all oil revenues but now redirects government spending towards public investment.[21] Otherwise all assumptions are the same as in the baseline scenario above. Regarding the share of public investment spending, this rises from 10 percent in the baseline to 80 percent in the scenario considered here. The remainder of spending goes towards public consumption.

This scenario shows that focusing spending on public investment is effective in the long term in mitigating Dutch disease effects (Figure 8). In the short and medium term, however, tradable sector production declines in this scenario approximately in line with the baseline. Still, eventually the effect of public in- vestment makes itself felt and raises tradable sector production above the level in the baseline scenario. In the long term, tradable sector production even exceeds its steady state value. The reason public sector investment is able to compensate Dutch disease effects is that public capital enters into the production function of both the tradable and non-tradable sector, which means a build up of public capital raises productivity, thereby offsetting the loss of productivity through learning-by-doing effects in the tradable sector. If the build up of public capital is large enough, which is the case in the long run in the simulation, the learning-by-doing productivity losses are more than compensated for and traded sector production levels rise above their steady state and even exceed levels attained in the scenario without learning-by-doing externalities. The same holds for real non-oil GDP, which means public investment of natural resource inflows makes in the long run a positive contribution to economic development. The simulation suggests that it can take considerable time for this scenario to be effective in countering Dutch disease effects. The reason is that building up the public capital stock is a slow process; this reflects mostly the pace of public investment, which increases only gradually in line with the natural resource inflows. Another contributing factor is that the model takes into account that there are typically delays between public investment spending and the actual creation of public capital, thereby adding to the time required to build up a large public capital stock.

[21] This scenario has not been discussed in Section 2 because [Berg et al., 2013] discusses it extensively.

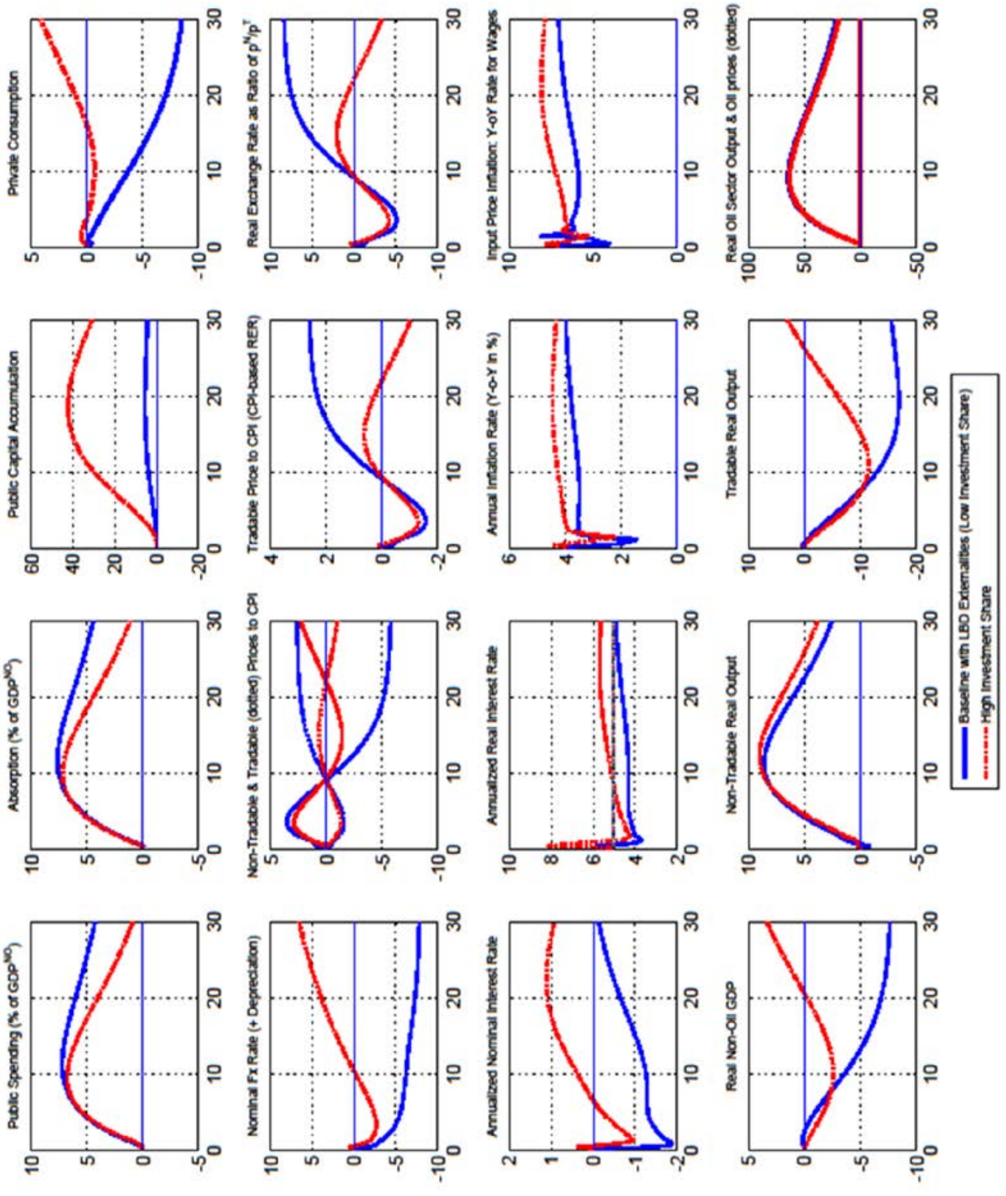

Figure 8: Preventing *Dutch disease* effects, public investment.

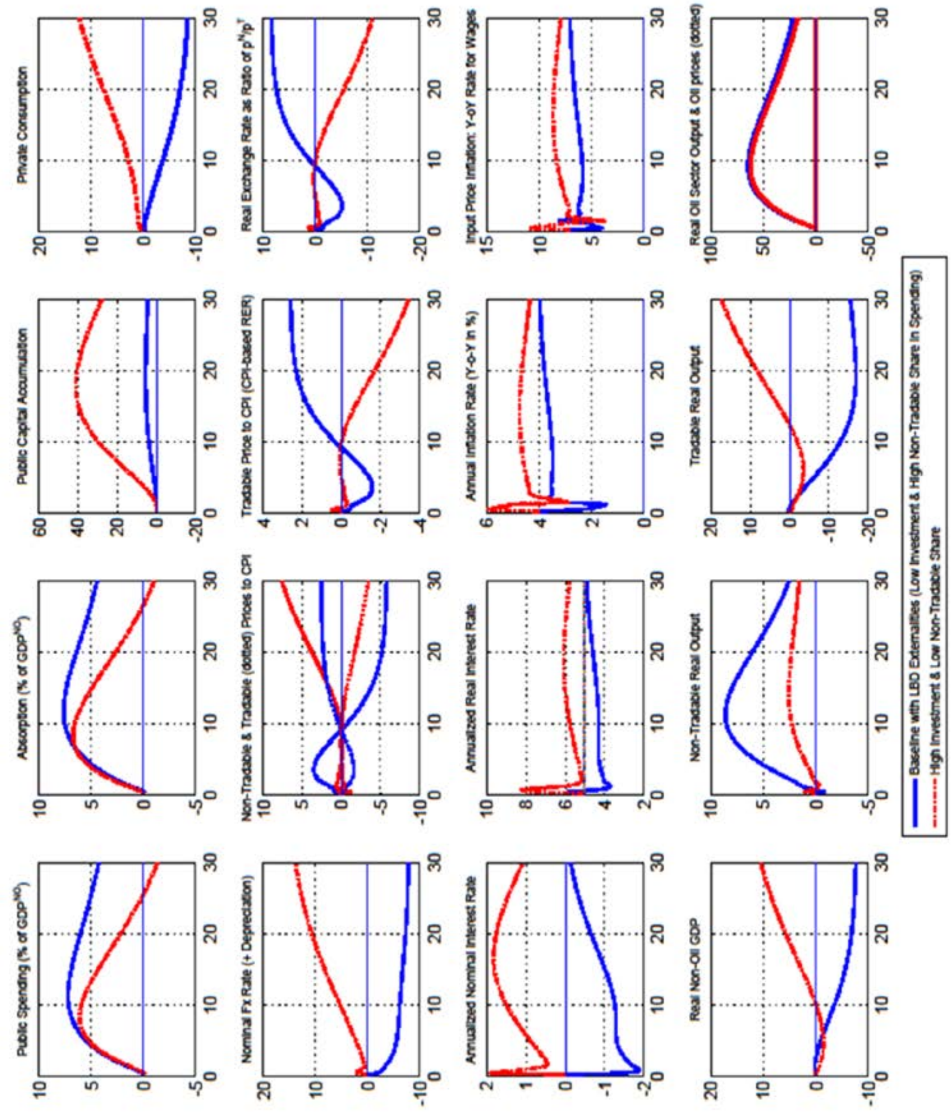

Figure 9: Preventing *Dutch disease* effects, public investment and spending on tradables.

Overall macroeconomic conditions in this scenario are less contractionary even in the short and medium term before the build up of public capital has been completed. This is visible in a smaller degree of disinflation, wage inflation falls by less, and the nominal appreciation is also less pronounced; as a result, monetary policy pursues a more neutral course as measured by the path of the real interest rate. The reason for less contractionary demand conditions lies again in the forward looking behaviour of households: they recognize that public capital accumulation will eventually boost the production potential of the tradable sector and the economy at large, thereby raising consumption relative to the scenario with strong learning-by - doing externalities and fiscal spending that focuses on government consumption.

Combining high investment with a low share of non-tradables in spending has the potential to make a strong positive contribution to economic development even in the presence of learning-by-doing externalities (see Figure 9). This scenario avoids the initial decline of tradable sector production due to the low share of non-tradables spending while in the medium to long term the build up of public capital boosts economic development. In fact, the presence of learning- by-doing externalities now works in the favor of the economy: as tradable sector production exceeds its steady state value in the medium term, productivity levels in the tradable sector rise because learning-by-doing externalities are now positive. Not surprisingly, demand conditions in the short and medium term are now much stronger than in the baseline or the other two scenarios considered so far.

4.3 Monetary Policy

The final scenario asks whether monetary policy is able to prevent Dutch dis- ease effects on its own, thereby countering the adverse long-run effects that emerge when fiscal policy spends most of the oil revenue inflows on public consumption and non-tradables. In Section 2.1.4, monetary policy was able to prevent to a significant degree the decline in tradable sector production through the accumulation of reserves and pursuing a tight, anti-inflationary monetary policy stance. Here we are going to implement the same policies, by adopting the same assumptions as per Section 2.1.4, but of course retaining the FDI shock.

Similar to Section 2.1.4, this monetary policy combination is able to prevent a decline in tradable sector production in the short and medium term, thereby preventing learning-by-doing externalities from having an adverse impact (Figure 10). However, in the longer term tradable sector production does decline, leading to productivity losses as learning-by-doing externalities assert themselves, and tradable sector production converges to that of the baseline simulation. The same holds for real non-oil GDP. Hence, beyond the short and medium term monetary policy is unable here to stem Dutch disease effects and counter the adverse effects of fiscal policy.

The reason monetary policy is unable to prevent Dutch disease effects from occurring in the long run is that even though monetary policy eases in the short term, private investment still declines significantly below its steady state value in the long term. The last reflects (i) the large decline of private investment in the baseline scenario with strong learning-by-doing effects and (ii) the tightening of monetary policy over the medium term compared to aforementioned base- line. This weakening in private sector investment spending is critical, because the resulting reduction in the private sector capital stock in the tradable sector leads to the decline in tradable sector output and thereby to productivity losses through learning-by-doing externalities.

Monetary policy is effective in the short and medium term to prevent tradable sector production from declining because real interest rates initially fall and boost private sector investment activity, so that crowding out of investment spending materializes only over the medium and long term. The short-term easing of the monetary policy stance as measured by the initial decline in the real interest reflects the response of monetary policy to the disinflation that takes place in the short term as a result of the nominal appreciation and wage disinflation; given that the monetary policy reaction function is programmed to respond strongly to inflation in this scenario, the initial disinflation triggers a strong monetary policy easing in the short term.

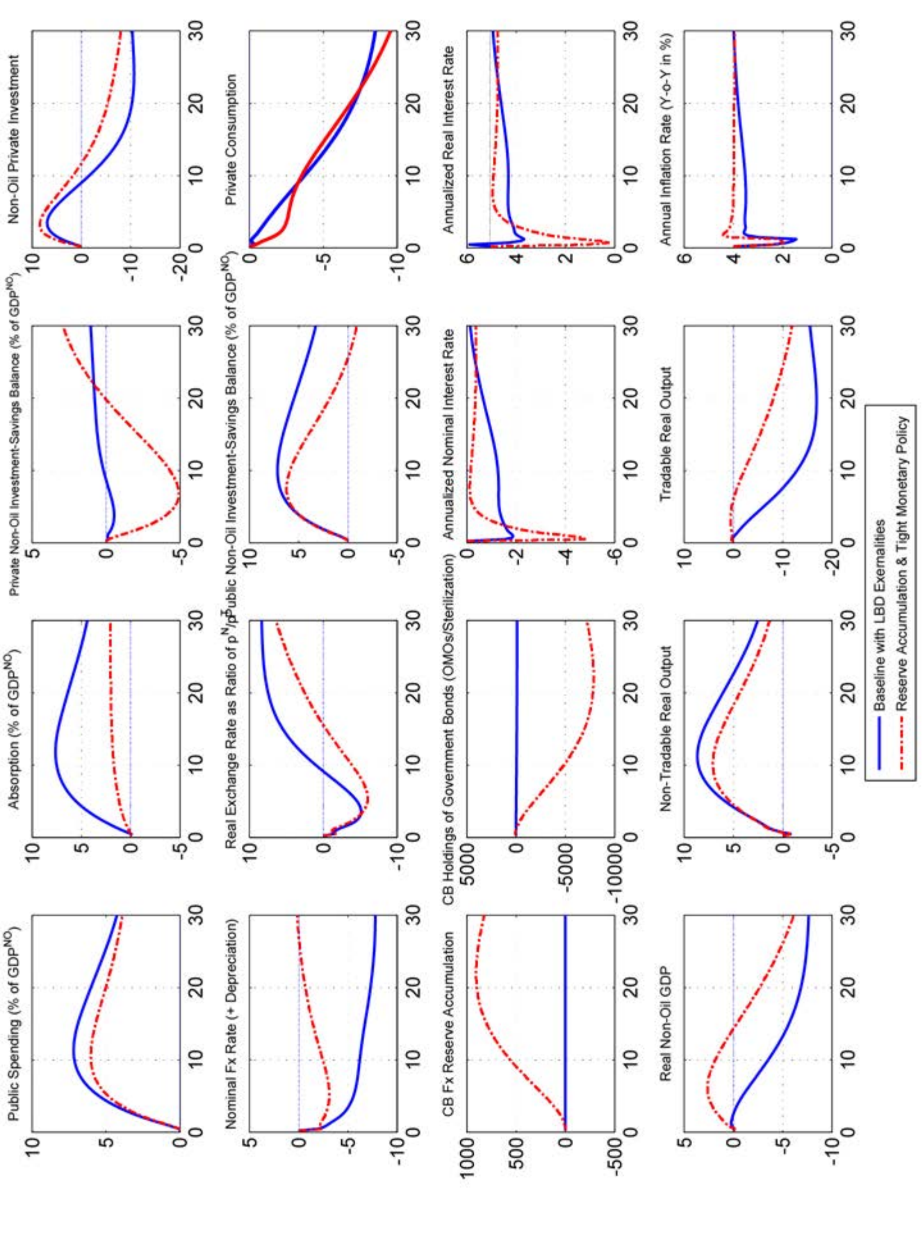

Figure 10: Preventing *Dutch disease* effects, monetary policy.

4.4 Saving through a Sovereign Wealth Fund

This scenario introduces expenditure smoothing via saving through a sovereign wealth fund (SWF). The setup here is almost identical to that in Section 2.2: approximately 75 percent of all natural resource inflows are saved in the SWF, while the remainder - plus dividends from the SWF remitted to the budget are spent equally on public consumption and investment. This policy option is effective in mitigating Dutch disease effects because it limits the amount of spending at any one time, thereby reducing demand pressures, the need for the currency to appreciate in real terms, and the decline in tradable sector production (Figure 11). The last reduces the adverse impact of learning-by-doing externalities. Still, given that expenditures increase to some extent, the impact of learning-by-doing externalities is not entirely eliminated; this is visible in a moderate reduction in tradable production and a small permanent decline in real non-oil GDP.

5 Conclusion

The purpose of this paper was to calibrate a dynamic micro-founded model and use it to analyze the macroeconomic implications of a surge in resource revenues in Papua New Guinea by running a suite of policy simulations that could aid policy-makers in determining the most appropriate policy mix. These scenarios were centered around the central question of whether the fiscal authorities should spend or save the revenues accrued from the resource boom. In short, the conclusions of the simulations may be summarized as follows:

- Fiscal spending on non-tradables is what drives the macroeconomic effects. Vice versa, concentrating spending on tradables minimizes *Dutch disease* effects.

- Front-loading of expenditures is both disruptive and costly, especially if there are bottlenecks in the economy.

- Monetary policy cannot undo the effects of fiscal policy without cost; attempting to do so through reserve accumulation by the central bank in order to stem appreciation pressures will crowd-out private sector investment due to the need to pursue a tight monetary stance for containing inflationary pressures.

- Smoothing of the spending profile over time by saving a significant part of natural resource inflows in a Sovereign Wealth Fund is very effective in avoiding *Dutch disease* effects.

- If strong learning-by-doing externalities are present in the tradable sector, concentrating spending on public investment can be effective in the long run in mitigating *Dutch disease* effects.

Of course, the model and the scenarios profess to being neither perfect nor exhaustive. Specifically, the model entails several shortcomings that should be kept in mind when applying its conclusions to PNG:

- A key shortcoming is that by assuming frictionless labor mobility, the model fails to realistically model labor migration: in a country such as PNG where education and skill levels are relatively low, labor cannot instantaneously move between sectors, or workers immediately acquire the requisite skills for their new professions.

- Another DSGE-specific shortcoming is that simulations in a DSGE model will by construction always return to a pre-defined steady state. As a result, it is impossible to simulate any large and permanent disruptions that might emerge in the real world as the economy adjusts to *Dutch disease* effects and profoundly change PNG's development path. Consequently, the smooth adjustment process depicted in the simulations is inherent to DSGE modelling and provides no guarantee that the real-world adjustments may not be considerably more messy.

- The lack of the commercial banking system in the model is another drawback, because in PNG the majority of government deposits are held in commercial banks, rather than the central bank. Indeed, this structural characteristic of the PNG monetary economy has been at the center of a major policy challenge for the Bank of PNG that cannot be addressed by the model used here: even though the fiscal authorities have been saving a sizable part of the resource revenues accrued during the commodity price boom over the last decade or so, these deposits have been placed at commercial banks and have therefore had a significant impact on the domestic money supply. The Bank of PNG subsequently issued significant volumes of Central Bank Bills (CBBs) in order to sterilize this build-up of excess liquidity, which contradicts the model prediction that sterilization should be unnecessary if natural resource revenue inflows are saved.

- Finally, it needs to be stressed that this model should be used only for qualitative analysis, not quantitative forecasts. This reflects the abovementioned shortcomings as well as uncertainty regarding the parameter calibration; estimating the model is not an option because the data required to do so simply does not exist.

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