

# Sovereign wealth funds and spending constraints in resource rich developing countries – the case of Uganda

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Abstract in Swedish:



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## Fondering och utgiftsbegränsningar i naturresursrika utvecklingsländer

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I denna artikel analyserar vi huruvida ett fattigt land som hittar en värdefull naturresurs bör skapa en nationell fond där vinsterna sätts in och koppla detta till en regel för hur många procent som får tas ut ur fonden per år (såsom i Norge). Fördelen med ett sådant system är att det minskar riskerna för politisk kortsiktighet. Nackdelen är dock att det begränsar möjligheten för ett fattigt land att satsa pengar på fattigdomsreduktion, nationell infrastruktur och kapitaluppbyggnad. Dessa två motstridiga aspekter skapar ett dilemma för politiker i fattiga länder. I tidigare forskning har båda dessa aspekter diskuterats separat men frågan är vilket av dom som överväger.

För att komma närmare ett svar analyserar vi kvantitativt förlusten för ett fattigt land av att försena användningen av olje-pengar. Analysen appliceras på Uganda som nyligen funnit stora mängder olja. Vi använder en makroekonomisk modell av Ugandas ekonomi som inkluderar aspekter så som kapitaluppbyggnad, teknisk utveckling, ekonomisk upphämtning gentemot andra länder och investeringsfriktioner till följd av korruption. I modellen kan man simulera hur ekonomin kommer utvecklas med och utan en oljefond. Vi finner att förlusten som en fond och utgiftsregel medför med all sannolikhet är väldigt små. Detta är delvis förvånansvärt men beror till stor del på att Ugandas befolkning förväntas växa i framtiden vilket gör att oljepengarna kan komma till god användning även senare. Baserat på dessa resultat drar vi slutsatsen att fondering av oljepengar är lämpligt i Uganda.

the risk of using more of the revenues for public spending in election years to boost the popularity of incumbent politicians. There is substantial evidence that government consumption in developing countries is pro-cyclical and that this increases business cycle volatility (Ilzetzki and Vegh, 2008). There are reasons to believe that this has negative effects on growth, in particular in developing countries with less developed financial markets.<sup>2</sup> A related issue is the selection of specific investment projects. Earlier research has documented that spending of resource revenues quite often goes toward projects with low returns, motivated by pleasing various political groups or electorates (Murphy, 1983; Gelb, ed, 1988; Little et al., 1993; Isham and Kaufmann, 1999). This is related to the time profile of spending as the absorption capacity is often insufficient in developing countries (van der Ploeg, 2012) which calls for postponing the domestic usage.

[4] Given these potential negative effects of spending, for a developing country such as Uganda, it may be important to either constrain the extraction of oil or the government's usage of the proceeds (see, e.g., Segura, 2006; Davis et al., 2003; Barnett and Ossowski, 2003).<sup>3</sup> However, this is of course inconsistent with the recommendation that a poor country should increase its current spending, as discussed above (van der Ploeg and Venables, 2011). This is naturally a dilemma for policy makers, and which of these two contradicting aspects should be prioritized is an open question. To take a step towards answering this question we analyze, quantitatively, the potential loss of limiting the resource income initially. This can be done in two ways: either by 1) postponing extraction or 2) by postponing the usage of the proceeds by investing the resource income in a sovereign wealth fund and utilizing a spending rule.

[5] The first option, of postponing extraction, will in most realistic circumstances reduce the total economic value of the oil. We analyze how large, quantitatively, the potential losses are of deviating from the profit maximizing extraction path. We find that

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<sup>2</sup>See Aghion et al. (2009) for evidence on a negative relation between real exchange rate volatility and growth.

<sup>3</sup>Even though part of the motivation for this recommendation tends to lie in the theoretical explanation forwarded by Friedman's permanent income hypothesis, the concern about negative political consequences is also cited as an important justification for constraining spending.

postponing extraction will generally entail large losses relative to the maximum value that can be obtained. Hence, this seems like an unattractive solution to the problem.

[6] The second option, to constrain government spending, can be done by investing the resource revenues in a sovereign wealth fund and then utilizing a simple and transparent rule for what share of the fund's total value that can be spent each year.<sup>4</sup> Clearly, such a construction implies an actual spending of oil revenues which is increasing over time and may therefore imply losses for a developing country. But how costly is this postponement of using the resource revenues? To answer this question, we build a macroeconomic model which is well suited for a quantitative analysis. It contains the intratemporal trade-off between public and private capital and the intertemporal tradeoff between capital and consumption. It further allows for population growth, investment frictions and technical change. The model is calibrated to the Ugandan economy. Perhaps surprisingly, we find that from a consumption smoothing perspective, a shift from a spend-as-you-go scheme to using an oil fund along with a fairly strict spending rule appears to entail only a marginal, if any, welfare loss. This implies that, considering the potential negative political and economic side effects of the spend-as-you-go scheme, the case for constructing a sovereign wealth fund along with a spending rule is rather strong.

[7] The next section presents an overview of the Ugandan economy and the size of the oil revenue. This is followed by analysis of how quickly to extract the oil (in Section 3). Section 4 uses a macroeconomic model to analyze different spending schemes. Section 5 concludes.

## **2 Some key characteristics of the Ugandan economy**

[8] Uganda is a developing landlocked country in east-central Africa. The GDP in

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<sup>4</sup>In Uganda, following the oil bill (EDP Bill, 2012), a sovereign wealth fund is supposed to be set up. However, the parliament decides how much of the oil revenues each year will be invested in it and how much will be spent right away. Likewise, the parliament decides how much will be taken out from the sovereign wealth fund. The beneficial democratic effect of this is obvious and it allows for using the sovereign wealth fund as a tool for mitigating business-cycle fluctuations, an issue we briefly discuss as well. However, it may also create the sort of problems discussed above. A spending rule, partly takes care of these problem.

2011 was \$16.8 billion (throughout, we use \$ to denote USD) at nominal exchange rates with a population of 35 million. This makes for a GDP per capita of \$487.<sup>5</sup> Using a purchasing power parity (PPP) adjustment to take a lower domestic price level into account, income is almost three times as high at a GDP per capita of \$1,345.<sup>6</sup>

[9] Like many other countries in Africa, growth in recent years has been higher than previously.<sup>7</sup> Figure 1 presents the growth rate of PPP-adjusted GDP per capita in constant prices. The solid line represents the average growth rate over the preceding ten years while the dotted line represents the yearly growth rate. As can be seen, the average growth rate was higher over the more recent period and also substantially less volatile. The average real per capita growth rate over the last 15 years in the sample was 3.0%. Over the last decades, the population growth rates were around 3%, implying an average total GDP growth rate of around 6%.

[10]

*Figure 1 here*

Government finances have been in deficits in recent years, but over the last decades, deficits have not been very large and the general government gross debt stands at 36% of GDP in the year 2012. However, the current account deficits have recently been deteriorating at an alarming rate, as can be seen in Figure 2.

[11]

*Figure 2 here*

## 2.1 TFP decomposition

[12] Let us now perform a simple decomposition of Ugandan growth per capita into the contribution of capital accumulation and productivity growth. This decomposition

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<sup>5</sup>GDP levels for 2011 are taken from the World Bank at <http://databank.worldbank.org>.

<sup>6</sup>Compared to its neighbors, Uganda has a GDP per capita that is slightly lower than those in Kenya and Tanzania, but substantially higher than those in South Sudan and the Democratic Republic of Congo.

<sup>7</sup>Note, however, that the data quality is likely to be quite low. There is, in fact, a suspicion that growth and GDP levels in sub-Saharan Africa are seriously underestimated; see, e.g., Young (2012). Needless to say, our quantitative analysis is conditional on the data being accurate.

will be used when calibrating the model we develop later. The approach is standard using a stylized production function of Cobb-Douglas type, i.e.,

$$y_t = z_t k_{g,t}^\gamma k_t^{1-\alpha-\gamma} l_t^\alpha \quad (1)$$

where  $y_t$  is real GDP,  $z_t$  total factor productivity (TFP),  $k_{g,t}$  the public capital stock,  $k_t$  the private capital stock, and  $l_t$  labor input, all in period  $t$ . The exponents  $\gamma$  and  $\alpha$  are time-invariant parameters. Using data on output growth and how the capital stocks and labor evolve over time, we back out how much output growth can be accounted for by growth in factor inputs. The remainder is then attributed to TFP growth. This procedure would be standard if one abstracted from government capital. The appendix outlines the procedure details.

**[13]** Figure 3 presents the yearly growth rate of TFP. As in the previous graph, we show the average over the preceding ten years. As can be seen, the TFP growth rate increased substantially between the 1980s and the 1990s – from negative numbers to levels between 2 and 3%. However, there is a clear sign of a productivity slowdown and over the last 15 years the average productivity growth rate has been a fairly low 0.65% annually.

**[14]**

*Figure 3 here*

**[15]** We can further conclude that productivity growth contributed to slightly more than half of the growth in per capita GDP from about the mid-1980s to the early 2000s. For example, over the period 1991–2000, the average yearly growth in per capita GDP was 3.9%, of which 2.4 percentage points are accounted for by productivity growth. Over the next decade, GDP per capita grew by 2.7% annually, of which only 0.1 percentage points are accounted for by productivity growth.

**[16]** The estimation procedure also allows for balanced growth – a situation where investment rates are constant while per-capita GDP and capital grow at the same rate. Such a balanced growth path is a key feature of the model presented in Section 4 since the

economy tends to converge to such a growth path whenever the productivity growth rate and other parameters of the economy are stable. In conclusion, GDP growth was close to balanced during the 1990s but unless productivity growth picks up and an important structural change occurs, one might worry that growth will fall. It is important to note that the oil discovery, however positive as a source of wealth, is in itself not an automatic source of structural change.

## 2.2 Oil resources

[17] There is substantial uncertainty regarding the amounts of recoverable oil in Uganda. Over one billion recoverable barrels have been discovered in the Lake Albert Rift Basin.<sup>8</sup> There is also potential for more discoveries. According to the organization Oil in Uganda, a reasonable estimate is 2.5 billion barrels.<sup>9</sup> Following a discussion with Tullow Oil during our field visit to Uganda, we use as a somewhat conservative benchmark assumption that 1.8 billion barrels can be recovered.

[18] Recovering and selling this oil is associated with costs in the form of exploration (around \$1/barrel), extraction (\$10-\$15/barrel) and transport (\$4-\$5/barrel).<sup>10</sup> This sums to roughly \$15-\$20/barrel of costs. This is not an exact calculation of costs but suffices for producing an estimate of the economic magnitude of the oil resources.

[19] The quality of the oil is somewhat low; it is estimated to generate a price of around \$10 below the Brent crude oil index. With the Brent price being around 110 US\$/barrel up until recently, these figures would mean revenues of \$100/barrel and profits of around \$80/barrel. At those prices and costs, the oil resource amounts to \$180 billion in revenues and \$144 billion in profits. With a population of 35 million, the latter means \$4,100 per capita. Note that this assumes all oil profits end up with the Ugandan government while the oil companies get none of the resource rents. This is obviously unrealistic as the

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<sup>8</sup>Stated on the web site of Tullow oil, <http://www.tulloil.com>, in February 2013.

<sup>9</sup>Stated on the website by Oil in Uganda, [www.oilinuganda.org](http://www.oilinuganda.org), in February 2013.

<sup>10</sup>This assumes that an efficient infrastructure for transportation is constructed in Uganda (e.g., a pipeline). Transportation by truck is likely to be substantially more costly at around \$23 per barrel (Henstridge and Page (2012)).

sharing agreement probably specifies some rents also to the oil companies. However, as the sharing agreements are not public and the government officials did not share them with us (we see the confidentiality as a problem in itself), we make this stark assumption here and treat the value of \$4100 as an upper bound. This is clearly a sizable amount as compared to a per-capita income of \$487 per year.<sup>11</sup> However, since GDP is a flow, it may be more reasonable to compare it to the income flow from oil. As a thought experiment, suppose that Uganda invested all oil profits in a sovereign wealth fund which yields a real rate of return of 4% per year. This would mean an added income flow of \$160 per year. That is, an increase amounting to 33% of current income could be sustained forever. Another perspective of the value of the oil resource is obtained by noting that with a growth rate of 3% per year, a 33% higher level of income is achieved after less than ten years. The purpose of this back-of-the-envelope calculation is to show that the value of the discovered oil is not large enough by itself to lead to a revolutionary change in the living conditions of the average Ugandan. However, wisely spent, the oil income can certainly make a difference.

### **3 When to extract**

[20] In the previous calculation of the total value of the oil resource, it was assumed that the oil could be extracted at once. Although it is useful as a first approximation, this assumption is of course unrealistic. In fact, it will take a long time to extract all the oil, even at the fastest pace possible. In conversations with Tullow oil, we have been shown their calculations of a reasonable extraction profile. The solid line in Figure 4 shows this profile measuring extraction in 1,000 barrels per day. We take it that Tullow has incentives to propose a high extraction speed; while there may be social reasons to slow down the extraction, it is hard to see such motives for a private international oil company. Thus, we

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<sup>11</sup>Another comparison is to the PPP-adjusted GDP of \$1,345. This level of GDP is computed using world market prices, i.e., not the actual valuations of the Ugandan economy. Thus, we prefer the comparison with local, market-valued GDP.

take the profile in Figure 4 to represent the quickest possible extraction – an upper bound of sorts. As the figure shows, the benchmark profile suggests a rather fast ramp-up to a maximum extraction phase of just above 200,000 barrels/day for a little less than a decade and then a slow decline.

[21] We will now calculate the present discounted value of oil at two different extraction profiles – the quick extraction path of Tullow and a path that is constant over the same 45-year period – and at two different oil price scenarios – a gradually increasing price and a constant price. By extracting 112,000 barrels per day, the same amount is produced over a 45-year period as under the Tullow plan (that is, 1.84 billion barrels). This extraction profile is represented by the dashed line in Figure 4.

[22]

*Figure 4 here*

[23] The present discounted value of the oil is given by the expression

$$W = \sum_{t=0}^T \frac{1}{R^t} (p_t E_t - C(E_t)).$$

It simply says the net profits (revenues net of extraction costs) in each period  $t$  should be discounted by the accumulated interest from today until that date ( $R^t$ ). Hence, to calculate the value of oil, we need to make assumptions about future oil prices, the accumulated interest, and the evolution of costs. We take as a benchmark that the (real) interest rate is 4% per year. We further assume that the costs are constant and examine different assumptions about the price path. A common assumption in theoretical growth models is the Hotelling rule (see Hotelling, 1931; Dasgupta and Heal, 1974). This theoretical result states that if resource owners of a finite resource are rational, the path of equilibrium aggregate supply should lead to growth of a resource price (minus extraction costs) at the same rate as alternative investment opportunities. The result stems from owners treating the resource as an asset. By not selling it the returns they get is in the form of price growth which has to equal the interest in order for returns on assets to equalize. Thus, one natural

scenario is that the oil price grows at the rate of the alternative investment opportunity, in our case 4% annually.<sup>12</sup>

[24] Under the assumption that oil price growth is equal to the discount rate and that extraction follows the Tullow profile, the present discounted value of oil revenues minus costs is \$132 billion. Instead, assuming a flat extraction profile, the value is \$136 billion, i.e., almost the same.<sup>13</sup> In fact, if we consider the assumptions underlying the Hotelling result, the timing of extraction has no effect on the value of the oil resource since the price then rises at the rate of interest. Under alternative assumptions, the value can be quite sensitive to the extraction path.

[25] To illustrate this, let us consider the value of the oil resource for the two extraction paths under an alternative oil price scenario – one where the oil price is constant in real terms. Clearly, in this case, delaying extraction is costly. But how costly? With a constant real oil price, the value of the Tullow extraction profile is \$76 billion, while the flat extraction profile gives a value of \$58 billion. Thus, the delayed extraction profile implies a loss of \$18 billion, or almost one fourth, relative to the Tullow profile. We should also note that the Tullow profile has a much lower value than the (unrealistic) immediate full extraction hypothesis. This suggests that under the assumption that oil prices are constant, any delay is rather costly. In fact, the cost of delaying the whole extraction profile by one year equals the discount rate times the total value when prices are assumed to be constant. That is, 4% of \$ 76 billion which equals more than \$ 3 billion. It is worth mentioning here that a delayed extraction profile also makes the value of the oil resource more sensitive to variations in future oil prices.

[26] A second consideration is that, under the realistic assumption that Uganda does not have perfect access to capital markets, domestic interest rates may differ from their world counterparts. Specifically, if Uganda is credit constrained, the implicit discount rate

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<sup>12</sup>While the oil price has been falling during most of the 20th century and price increases (such as during the oil crisis in the 1970:s) have been followed by subsequent price falls, there are reasons to believe that the increasing price trend of the last 15 years will continue. See, for instance, Hamilton (2009) and Spiro (2014) who analyze the long-run oil price.

<sup>13</sup>The fact that the flat profile gives a slightly higher value is due to the presence of extraction costs: since those are assumed not to grow, there is a (small) value of postponing extraction.

is higher than the 4% assumed to apply on the world market. In such a situation, there is a cost of delaying extraction also if the oil price grows at the world market interest rate. We therefore conclude that delaying extraction is a rather costly method of constraining the oil revenue use.

## **4 Macroeconomic dynamics and intertemporal trade-offs**

[27] This section provides a formal analysis, using a calibrated theoretical model, of the role of oil in the Ugandan economy. We take a growth perspective, since the main issue is the role of oil over time. Thus, the maintained time horizon is rather long – in the order of 100 years. With this long-run perspective, we take a stand on the development process and capture the sources of long-run growth and catch-up via a gradual, but slow, elimination of inefficiencies. This approach is consistent with the recent growth literature, as for example expounded and summarized by Jones (2013). The removal of inefficiencies implies direct benefits to output but also indirect benefits through induced capital accumulation. The model displays this process and how oil revenues arriving in different years affect it.

[28] We abstract from a number of issues. For instance, business-cycle fluctuations are not studied in the formal analysis but the concluding discussion in Section 5 below highlights their relevance. Moreover, the often-discussed Dutch disease problems arising from resource income shocks are formally absent in the model. Furthermore, we use a representative agent framework which implicitly abstracts from distributional issues (of oil and other income).

[29] We will begin by describing the basic features of the model and the main quantitative assumptions (on parameter values and the oil revenue). Then, we present a sequence of illustrations of the dynamic paths of major variables from the calibrated model and show the effect of oil revenues on these paths. The dynamics are illustrated for alternative scenarios of using the oil revenue and Uganda's access to the world capital market. We

conclude this section with a discussion on welfare under two alternative schemes of using the oil revenue: i) spending the revenues as they arrive and ii) a sovereign wealth fund coupled with a spending rule.

#### 4.1 Model description and assumptions

[30] We use an extension of the basic Cass-Koopmans model of optimal growth, the cornerstone of growth theory. This model focuses on a macroeconomic aggregate output which can be used for investment or consumption. The main model describes Uganda as a closed economy with no access to borrowing. While, in reality, Uganda is probably not completely credit constrained, it seems that such constraints are strong enough to motivate this as the main case. A version of the model – though not the baseline – describes Uganda as an open economy with access to borrowing and lending on international credit markets. When oil is included in the analysis, extracted oil is added to the aggregate income. In all versions of the model it is assumed that oil is traded internationally at competitive prices.

[31] The resource constraint is

$$c_t + i_t + i_{gt} = y_t + p_t o_t, \quad (2)$$

where  $c$  is aggregate consumption (government and private),  $i$  is private investment,  $i_g$  is government investment in infrastructure, and  $y$  is output from domestic production (manufacturing, services, and agriculture put together in one macroeconomic aggregate). The term  $p_t o_t$  refers to oil revenue, using a world price  $p_t$  and a quantity of barrels  $o_t$ . We thus distinguish the private from the public capital stock; the former is structures and equipment used in the private sector and the latter is various forms of infrastructure. Separately including government capital is important in an economy such as that of Uganda; the infrastructure necessary for private production is only partially in place, unlike in most developed economies where the main issue is infrastructure maintenance and improve-

ments, not basic build-up. The associated capital stocks evolve according to

$$k_{t+1} = (1 - \delta)k_t + (1 - \kappa_t)i_t \quad (3)$$

and

$$k_{g,t+1} = (1 - \delta_g)k_{gt} + (1 - \kappa_{gt})i_{gt}, \quad (4)$$

where  $\delta$  and  $\delta_g$  are the associated depreciation rates. Parameters  $\kappa$  and  $\kappa_g$  are time-varying measures of inefficiencies in the private and public investment sectors, respectively. Thus, we take the perspective here that when one unit of resources is invested, a fraction disappears. This is motivated by discussions with Ugandan officials and by recent research (van der Ploeg, 2012; van der Ploeg and Venables, 2012). The gradual elimination of these wedges will be a source of long-run growth in this economy as any unit invested will result in a higher eventual capital stock (and thus higher output) and also in higher returns from accumulating capital, potentially inducing more of this activity.

**[32]** Output is produced according to

$$y_t = z_t^{1-\alpha-\gamma} k_t^\alpha k_{gt}^\gamma.$$

We thus assume a Cobb-Douglas production function, giving constant shares to capital and labor income.<sup>14</sup> The labor input is suppressed (i.e., it can be viewed as set to 1 and to be inelastic). Population growth is not modeled here – an issue whose implication will be highlighted later on. Government capital, as modeled, displays complementarity with private capital: with a higher stock of government capital, the returns from investing in private capital go up. Importantly,  $z_t$  is a productivity parameter which both captures technical progress (making  $z$  high) and inefficiencies (making  $z$  low). Thus, temporarily low  $z$ 's are thought of as a source of underdevelopment and as the  $z$ 's grow and catch

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<sup>14</sup>We change notation slightly relative to Section 2 by defining total factor productivity as  $z_t^{1-\alpha-\gamma}$ . This change of variables implies that the growth rate of GDP is equal to that of  $z$  in balanced growth rather than  $(1 - \alpha - \gamma)^{-1}$  times the growth of  $z$  as in (6). This change is for convenience only and does not affect any part of the analysis.

up with those of the developed world, the country's economy catches up more generally in terms of capital accumulation and output since higher  $z$ 's induce endogenous capital accumulation. Thus, as with the lowering of the  $\kappa$ 's, improved efficiency has both direct and indirect benefits. Notice, finally, that we abstract from oil as an input here, since oil in this model is not of primary importance as a production input but rather as a source of extra revenue. This is in line with the approach taken in the literature on economic growth.

**[33]** In order to evaluate welfare for this economy, we assume a representative agent with preferences

$$\sum_{t=0}^T \beta^t u(c_t)$$

where  $u(c) = \frac{c^{1-\sigma}-1}{1-\sigma}$ . Here,  $\beta < 1$  represents discounting, which can be interpreted both as a weight on a given individual's own future utility flows and as a weight on the utility flows of future generations. The parameter  $\sigma$  is a measure of how costly fluctuations in consumption are perceived to be – the higher is  $\sigma$ , the more the individual wants to smooth consumption over time.  $T$  is finite but large enough for the economy to have converged to a balanced growth path. To find an optimal path, we thus maximize the above utility function under the restrictions implied by the macroeconomic resource constraint (2) and the capital accumulation equations (3 and 4).<sup>15</sup>

**[34]** In calibrating the model (see the appendix for details), we view the past as quite distorted both in the private and public investment sectors, though more in the latter. Based on discussion with Ugandan officials we set them to 25% and 50% respectively. However, these distortions, as described by the  $\kappa$ 's, are assumed to asymptotically vanish. We also regard past and current total-productivity growth as historically high – 4% per annum – to capture the growth experience in the last twenty years and then declining toward 2.5% per year – a rate consistent with the rest of the world – to account for catch-up effect.

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<sup>15</sup>We can implicitly define a government budget in the model, with  $i_{gt}$  (possibly plus a public part of consumption) defining spending and  $p_{to_t}$  defining revenues; the difference is made up by a lump-sum tax or transfer between the government and the private sector. Our focus here, however, will be that of the aggregate economy and not the government-private breakdown, since our aim is to take the perspective of the average Ugandan citizen.

Asymptotically, the closed economy will generate the same interest rate as in the rest of the world. For the parts of our baseline economy not having to do with oil, we mostly use standard parameter values in the macroeconomic literature.

[35] As for oil revenues, we consider the baseline scenario as the “maximum extraction path” obtained by Tullow oil (discussed earlier). This path implies 32,850,000 barrels extracted in an initial year of 2018 and then a rise to a maximum of 83,950,000 in just a few years (obtained in 2021), with a maintained high level of production for nine years and then a gradual tapering down with the last oil production occurring in 2062. We value oil by taking a current world price of \$100 per barrel as the baseline. We then assume a Hotelling price path, thus implying a growth of 4% per year in the oil price. An alternative assumption could, for example, maintain a constant oil price, and it is, of course, straightforward to alter these assumptions as one wishes. A more or less rapidly increasing price path would be interesting to consider but would likely not influence our main conclusions markedly aside from the remarks that were already made in our benchmark calculations in Section 2.2. We set the net revenue from oil to be barrel production times the world price per barrel minus costs estimated to be \$20 per barrel (see Section 2.2); we assume these costs to be constant over time in real terms.<sup>16</sup>

[36] A final feature of the calibration is the size of the oil revenue relative to (net-of-oil) GDP. In terms of the model, given any normalization of  $z_0$ , and with an initial oil price of 100, this size is obtained by selecting the barrel unit relative to total output appropriately. Relative to 2011 GDP, this gives 21.8%.<sup>17</sup> It should be noted that we use official GDP figures and a current exchange rate, as opposed to a PPP-adjusted measure. We deem the PPP adjustment inappropriate for the model analysis since it involves using a relative price between traded and non-traded goods which is not in line with the domestic evaluation of

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<sup>16</sup>As discussed in Section 2, the sharing agreements are non-public. Therefore, we assume that all the oil profits accrue to the government and abstract from the sharing of profits with the oil companies. This is, however, not likely to significantly affect the main macroeconomic dynamics as sharing the oil revenues would simply imply a proportionate income effect in all periods. The same of course holds if we lower the oil price proportionally in all periods.

<sup>17</sup>Uganda’s GDP in 2011 was measured at \$16.8 billion. Tullow’s estimate for 2018 of 32,850,000 produced barrels means a revenue of  $(100 \cdot 1.04^7 - 20) \cdot 32.85 \cdot 10^6$ , which equals \$3.666 billion.

these goods.<sup>18</sup> Thus, Ugandan GDP including oil would rise in the order of magnitude of 50% at the peak of the extraction path, whereas when using PPP-adjusted GDP, the level is in the order of 15–20%.

## 4.2 Dynamics

[37] We will now present a sequence of illustrations of the dynamic paths of major variables from the calibrated model, beginning with the case where Uganda proceeds without any oil income. This case is not interesting per se but it serves as a comparison and as a way of explaining the basic features of the economy.<sup>19</sup> Then, we look at how oil revenues affect outcomes if they accrue according to the Tullow scheme – one that can be regarded as a maximally fast extraction – and the economy is closed, i.e., where any revenue is consumed or invested immediately. Next, this case is compared to an open economy with unlimited access to borrowing and lending.<sup>20</sup> We also look at a case where although the oil revenue is extracted according to the Tullow scheme, it is not used up as it arrives but rather put in a fund from which only a limited amount is withdrawn for consumption or investment each year. Although our analysis could be amended to allow any intermediate schemes for extraction and use of the oil resources, we believe that these different cases bracket most of the remaining possibilities because they emphasize the possible advantages and disadvantages of different setups.

### 4.2.1 The case without oil

[38] Under the assumption that Uganda receives no oil revenue, the economy should be expected to converge rather smoothly to the balanced growth path, as TFP growth gradually slows down and as the investment wedges disappear. Figure 5 displays the

<sup>18</sup>The model here does not have the distinction between traded and non-traded goods.

<sup>19</sup>The solution technique relies on global, nonlinear solution methods and is not discussed here. The programs are available upon request.

<sup>20</sup>The economy that is open to international borrowing and lending has a resource constraint that reads  $c_t + a_{t+1} + i_t + i_{gt} = y_t + p_t o_t + (1 + r)a_t$ , where  $a$  denotes transformed international lending and  $r$  the net international real interest rate. The planning problem is thus to maximize utility subject to this constraint, with an additional choice of  $a_{t=0}$ , and the “no-Ponzi” condition.

paths for (logarithms of) the major variables.

[39]

*Figure 5 here*

We see that all variables roughly grow in parallel, with faster transition rates for the capital stocks. The government capital stock grows the fastest since the inefficiency wedge that is eliminated for this variable is assumed to be larger than for private-sector capital. The figure also illustrates the absence of business cycles: the future looks entirely smooth. We see that the transition path is somewhat nonsmooth at the outset, reflecting an initial boost to private investment at the expense of public investment due to the fact that the falls in the wedges are larger in percentage terms for private investment.<sup>21</sup> Thus, the initial opposite reactions of the capital stocks are somewhat surprising but logical given our setting. However, they are quantitatively unimportant in the comparison of the different setups for oil revenues that we look at below.

[40] The above paths reflect optimal transition dynamics for a closed economy. If the economy would be open and Uganda could borrow and lend freely at some international interest rate, the dynamics would become quite different. This case is interesting to consider not because it is the most realistic one – it is not – but because it indicates the direction in which borrowing and lending influence the economy. Figure 6 displays the results for output and consumption, in comparison with the closed-economy case. Several points are noteworthy here. First, while the balanced growth path for output will be the same,<sup>22</sup> the open-economy output would be above closed-economy output throughout but with a decreasing gap. The reason is that the internal interest rate in a closed-economy is higher during the transition and only gradually falls to 4%, so less capital is used when foreign borrowing cannot be used to (partly) finance investment. Second, consumption would be quite a bit higher in an open-economy for several decades. This is because Ugandan output is low at the outset compared to its future potential, given that the ineffi-

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<sup>21</sup>The reason is that these wedges do not accrue to the undepreciated part of capital, which is much larger for public capital, so the initial drops in the wedges work like a boost to private capital in relative terms.

<sup>22</sup>The model is calibrated so that the real interest rate will be the same.

ciencies are expected to go away over time, so it is optimal to borrow significantly right at the outset to boost consumption. The growth path for consumption in an open economy would therefore be less steep than in a closed economy. But eventually the paths cross, as loans need to be paid back. Third, welfare would be higher in an open-economy case both due to consumption smoothing and higher output.

[41]

*Figure 6 here*

#### **4.2.2 The case with oil**

[42] We now introduce oil into the economy and look at the dynamics of our key macroeconomic variables under three alternative scenarios: a closed economy with a spend-as-you-go (SAYG) scheme, a closed economy with a sovereign wealth fund and an open economy (with unlimited access to borrowing and saving). The objective is to examine how the oil revenue affects the macroeconomic dynamics under alternative scenarios.

[43] The maintained assumption in the SAYG scheme is that the oil revenues (i.e., the price obtained in the world market minus the costs) go straight into the domestic budget and that these resources are allocated optimally between consumption and investment. The paths for log consumption and output under this scheme are plotted in Figure 7.

*Figure 7 here*

We see that, anticipating the oil revenues to arrive later, consumption should be increased already at the beginning. However, facing borrowing constraints, the only way of achieving this is by reducing investments which in turn reduces output in the early years. But then output catches up around 10 years after the first oil revenue has arrived. Output is then permanently higher, though asymptotically the output paths with and without oil are identical.

[44] We now look at the case where a sovereign wealth fund is used. The following fund construction is adopted: (i) extraction according to the Tullow scheme is maintained and the profits are added to the fund as they accrue; and (ii) each year, 4% of the fund is withdrawn for consumption and domestic spending (the balance between which is determined endogenously) and the rest is invested in the world markets at 4% interest . Figure 8 displays the results for the fund scheme along with the SAYG scheme. As can be seen, the fund construction allows significantly less consumption smoothing than does the SAYG scheme at the same time as it keeps output up in the early years.

*Figure 8 here*

[45] If we consider an open economy with oil, the initial consumption response is quite strong: the added oil revenue allows consumption to react even more, since it is possible to borrow against all future oil revenues.

[46] Figure 9 summarizes the results. We compare the consumption and output paths in four economies. The figure displays the variables (i) without oil in an open economy, (ii) with oil in an open economy, (iii) with oil using the SAYG scheme, and (iv) with oil using the fund scheme. All variables are *relative to* the closed-economy without oil. The upper and lower panels present relative consumption and relative output, respectively.

[47] Under the assumption that Uganda is an open economy, two patterns are noteworthy. First, the oil discovery should have no effect on output. Thus, the output curve for the open economy without oil is the same as the one with oil. Second, consumption displays a permanent shift: the present value of the oil revenue is annuitized over the infinite future. Under the SAYG, output increases rapidly after the year 2020. This increase coincides with the rapid inflow of oil revenues as the extraction pace accelerates, and a significant part of the revenue is spent on domestic capital which, in turn, raises domestic (non-oil) production. Note also that despite the large amount of domestic spending under the SAYG, output in the SAYG never exceeds output in the open economy. Thus, the

domestic rate of return on capital under SAYG still remains below the international rate. Long run consumption is the highest under the fund because of the accumulated wealth resulting from the constraint on current spending. Finally, we see that since the fund scheme constrains domestic spending, capital accumulation is slower than under SAYG after the oil revenues start arriving. This means output is lower for many years under the fund.

[48]

*Figure 9 here*

### **4.3 Welfare implications: a fund or spend-as-you-go?**

[49] Given that our maintained hypothesis is continued growth and catch-up, with a successive elimination of inefficiencies in production and investment (particularly for government capital), there is a strong need for consumption smoothing. That is, the marginal utility of consumption is naturally initially very high and, given the future output increase, restrictions on consumption will lower welfare. The implications for oil revenue management are clear, at least on a qualitative level: the oil revenues will help smooth consumption and, foreseeing their arrival, consumption will, and should, rise already today. In a closed-economy context, this means that domestic output production is hurt since it lowers investment.

[50] Considering the case of a fund that holds back consumption, it is clear that the initial boost in consumption is less marked, as is the initial drop in output growth. The welfare under this scheme can thus be lower than under the SAYG scheme.

[51] How large are these effects, i.e., how large is the loss when keeping initial consumption relatively low under the fund scheme? Arguably not large. For example, in our calibration, the welfare loss from a shift to the fund scheme from the SAYG scheme, measured in terms of a reduction in the permanent consumption level, does not exceed 0.3 percent.

[52] The result that welfare loss from shifting to the fund scheme (from SAYG) is quite

robust to several alternative assumptions. We have assumed a fairly optimistic scenario about the path of Uganda's future productivity and catch-up. There is, of course, substantial uncertainty surrounding Uganda's future productivity. Thus, one may rather prefer to consider a more modest scenario. In that case, the welfare loss from constraining current consumption under the fund scheme would be even less pronounced. Our calibration also abstracts from population growth – a relevant factor for Uganda given that it has one of the fastest growing populations in the world. With an annual average growth rate of 3.3 percent, the population of Uganda has nearly doubled during the last two decades – from 17.5 million in the year 1990 to 33.4 million in 2010.<sup>23</sup> Uganda's population growth is also expected to continue at a rapid pace in the coming decades. According to forecasts provided by the UN, Uganda's population may reach 205 million by the end of the century – a sixfold increase as compared to the level in 2010.<sup>24</sup> A rapid population growth can have significant implications for the optimal utilization of the oil revenues. First, the revenues will have to be shared among more consumers in the future. Moreover, in an economy without international borrowing and lending, higher population growth, all else equal, implies a larger future labor force and hence, less capital stock per worker for the future generations. Both these factors call for a reduction in the consumption of the current generation. In fact, when we re-calibrate our model incorporating population growth, we find that using the fund scheme delivers a higher welfare than the SAYG scheme.<sup>25</sup> All in all this suggests that the potential losses of using a fund are rather small.

**[53]** We have presented the analysis for a fund scheme where 4% of the fund is spent

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<sup>23</sup>Source: Penn World Tables 7.1.

<sup>24</sup>The UN provides three variants of projections for population size: a low, a medium and a high variant. For Uganda, the low, medium and high variants of projections for the year 2100 are, 139, 205 and 292 million, respectively. Source: Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, World Population Prospects: The 2012 Revision, <http://esa.un.org/unpd/wpp/index.htm>. Accessed on July 29, 2014; 11:57:19 AM

<sup>25</sup>Population growth is incorporated using the standard approach in the Ramsey-Cass-Koopmans model with exogenous population. We take the population growth projections from the UN. With  $c$ ,  $y$ ,  $k_g$ ,  $i_g$  and  $i$  now denoting per capita values, we make the following three sets of modifications to the model. 1) The welfare function is defined as  $\sum \beta^t L_t u(c_t)$  with  $L_t$  denoting total population size: the welfare of each member within a generation has an equal weight while the welfare of the next-period generation is discounted by  $\beta$ . 2) The resource constraint becomes:  $c_t + i_t + i_{gt} = y_t + p_t o_t / L_t$ . 3) Capital stocks evolve according to  $k_{t+1} n_{t+1} = (1 - \delta)k_t + (1 - \kappa_t)i_t$  and  $k_{g,t+1} n_{t+1} = (1 - \delta_g)k_{gt} + (1 - \kappa_{gt})i_{gt}$ , where  $n_{t+1}$  is population growth in period  $t + 1$ .

annually. However, the relatively small welfare loss from shifting to the fund scheme does not particularly rely on choosing 4% as the spending share. In fact, given that 4% may not necessarily be the spending share that maximizes welfare, one could minimize the welfare loss further by choosing an alternative spending share with a higher welfare.

[54] Finally, the welfare loss from shifting to the fund scheme would still be small if we abstract from the investment wedges (i.e. the  $\kappa$ 's). The gradual elimination of inefficiencies in investment, as we have modeled it, has two implications. First, a higher level of inefficiency during the current periods calls for postponing investment to more efficient future periods. This speaks in favor of constraining current spending and adopting the fund scheme. On the other hand, the gradual elimination of the inefficiencies makes the future generation relatively richer and induces a motive for increasing current consumption. This latter effect favors the SAYG. The latter effect is, however, not large enough to offset the former one. Thus, the welfare loss from shifting to the fund would still be small – less than 0.3 percent – when we abstract from the  $\kappa$ 's.

## **5 Concluding discussion**

[55] In a developing economy, the merit of maximizing current spending from resource revenues is that it provides an opportunity to increase the consumption of the currently poor population. It also relaxes potential borrowing constraints and thereby enables increasing investment in domestic capital with high rates of return. Thus, constraining spending by utilizing a sovereign wealth fund with a restrictive spending rule may involve a welfare loss. Using Uganda as a case study, we analyze the size of this loss quantitatively and find, perhaps surprisingly, that it is most likely to be very small. Hence, given that having a sovereign wealth fund along with a simple spending constraint provides more transparency and decreases the potential negative political side effects associated with increased spending, adopting such a construction seems like a well motivated policy measure.

[56] In light of the pronounced volatility of the oil price and the substantial evidence that government consumption in developing countries is pro-cyclical (Ilzetki and Vegh, 2008), there is additional motivation for using a fund instead of spending revenues as they arrive. One possibility is to use two funds: one for constraining spending over the long run and one with the specific purpose of smoothing government budgets in the short and medium run. Such a construction has, for instance, been used in Ghana (van der Ploeg et al., 2012) and could prove useful in Uganda as well. While focusing on the long run costs and benefits of a sovereign wealth fund, we have abstracted from this possibility.

[57] The choice of Uganda for the quantitative analysis is primarily driven by our relative familiarity with the Ugandan context. Although the key assumptions we make regarding the long run development path are generally relevant to other developing countries as well, country-specific factors like the timing and quantity of the oil flow do influence our results. Thus, care should be taken in generalizing the results to a broader set of developing economies. Given the direct policy relevance of investigating the costs and benefits of a sovereign wealth fund, further research employing a similar analysis for other countries is well warranted to provide a more general picture on the relative merits of constraining spending.

## **Appendix A: TFP decomposition**

[58] The TFP decomposition uses the following model. Production is of the Cobb-Douglas as represented in equation 1 where  $y_t$  is real GDP,  $z_t$  total factor productivity (TFP),  $k_{g,t}$  the public capital stock,  $k_t$  the private capital stock and  $l_t$  labor input. The exponents  $\gamma$  and  $\alpha$  are parameters assumed to be constant over time. We use data from the Penn World Table for the period 1950 to 2010. Unfortunately, The Penn World Table does not contain data on capital stocks. However, it does have measures of gross investment, i.e., the sum of public and private capital. We can then use the relation

$$k_{t+1} = (1 - \delta)k_t + i_t(1 - \kappa_t)$$

to construct a series of capital stocks. Here,  $\delta$  is the average rate of depreciation,  $i_t$  is investment, and  $\kappa_t$  is a parameter between 0 and 1 intended to capture the assumption that some investment spending is wasted and not actually transformed into productive capital. Finally, assuming that the growth rates of public and private capital stocks are approximately equal, by differentiating the logarithm of 1 and rearranging we can construct the growth rate of  $z_t$ , denoted  $g_{z_t}$ , by noting that

$$g_{z_t} = g_{y_t} - (\alpha + \gamma) (g_{k_t} - g_{l_t}) \quad (5)$$

where  $g_{y_t}$  is the growth rate of real GDP per capita,  $g_{k_t}$  is the common growth rate of the two types of capital and  $g_{l_t}$  is the population growth rate. We set the depreciation rate

to 10% per year and  $\kappa_t$  to  $\frac{1}{3}$ .<sup>26</sup> Finally, we set  $\gamma = 1/6$  and  $\alpha = 1/3$  which are standard numbers in the macroeconomic literature.

[59] For now, we note that we can use (5) to calculate the relation between the productivity growth rate and the growth rate of GDP per capita along a balanced growth path. Using the fact that the growth rate of per capita GDP and the per-capita capital stocks are equal under balanced growth (i.e.,  $g_y = g_k = g_l$ ) in (5), we obtain

$$g_y = \frac{g_z}{1 - \alpha - \gamma} \quad (6)$$

[60] Under the previously made assumption that  $\alpha = 1/3$  and  $\gamma = 1/6$ , GDP per capita thus grows twice as fast as productivity under balanced growth.

## Appendix B: Parameter values and calibration details

- $\alpha = 1/3$ , representing a typical share of private capital of 1/3.
- $\gamma = 1/6$ , representing a cost share of government capital of 1/6, although this capital is not traded and hence, should be viewed as an externality from the perspective of the private sector.
- $\bar{\delta} = 0.1$ , depicting a wear-and-tear of structures and equipment of an average of 10% per year.
- $\bar{\delta}_g = 0.04$ , capturing a significantly lower depreciation rate on infrastructure than on private capital.

- $\frac{z_{t+1}}{z_t} = 1 + g + g_0 \rho_1$ , with  $g = 0.025$ ,  $g_0 = 0.015$ , and  $\rho_1 = 0.95$ . Thus, we take the initial growth situation to be one where total factor productivity grows relatively

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<sup>26</sup>The value of  $\kappa = 1/3$  implies that to attain a certain increase in capital, Uganda has to invest 50% more than other countries. This seems like a reasonable number after discussions with Ugandan officials. The results are quite insensitive to reasonable variations in the values of  $\bar{\delta}$  and  $\kappa$  as well as to the  $\alpha^t$ s. We also need to set the initial level of capital. However, the effect of the choice of the value for the initial capital stock vanishes fairly quickly and we report estimates of productivity only from 1975 and onwards.

fast, indicating a catch-up (relative to the rest of the world not explicitly modeled here). The long-run growth rate of  $z$ , and thus output, implied by these assumptions is 2.5%, which is still somewhat high relative to the average rate of developed countries but the idea here is that the catchup will continue beyond the horizon considered here and this process is reasonably approximated by assuming a long-run growth rate of 2.5%. The short-run growth rate is 4% which is in line with the recent growth history of Uganda reported above. The convergence in productivity is rather slow, with a persistence parameter of 0.95, thus implying that the gap away from the long-run growth rate closes by 5% per year.

- $\kappa_t = \kappa_0 \rho_2^t$ , with  $\kappa_0 = 0.25$  and  $\rho_2 = 0.95$ . Thus, the private-sector investment inefficiencies are 25% to start with and fall slowly over time (as for total-factor productivity, the convergence rate is 5% per year).
- $\kappa_{gt} = \kappa_{g0} \rho_2^t$ , with  $\kappa_{g0} = 0.5$ , indicating that the government sector has twice the amount of inefficiencies as the private sector. We obtained the number 50% from discussions with Ugandan officials and the estimate for the private sector is simply our best guess.
- $\hat{k}_0$  and  $\hat{k}_{g0}$  set at balanced-growth levels consistent with a  $z$  growth of 2.5 percentage points,  $\kappa = 0.25$ , and  $\kappa_g = 0.5$  at all past times.
- $\sigma = 1$ , representing an intermediate value of the intertemporal substitution elasticity, a value that is common in the growth literature.
- $r = 0.04$ , capturing a world interest rate of 4%; notice that this should be viewed as a return on capital and as a long-run average (the current low international rates being strongly influenced by the world-wide recession).
- $\beta$  such that  $\beta(1+r) = (1+g)^\sigma$ : the long-run discounting within the country will be consistent with balanced-growth behavior at the same interest rate as in the international economy.

## List of Figures

Figure 1: Real per capita growth in Uganda. Source: Penn World Tables 7.1.

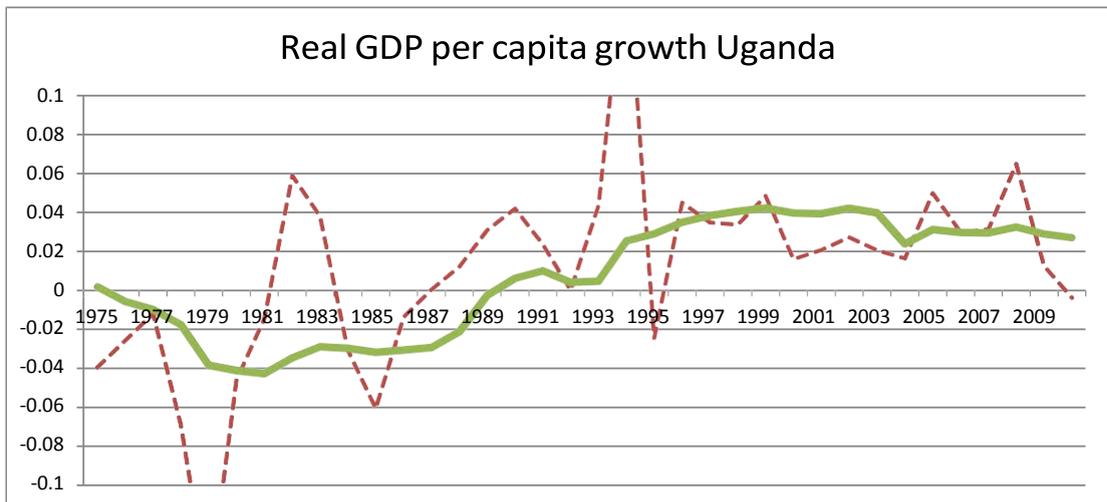


Figure 2: Current account (solid) and General government net lending (dashed) in percent of GDP. Sources: IMF World Economic Outlook, October 2012 Online edition.

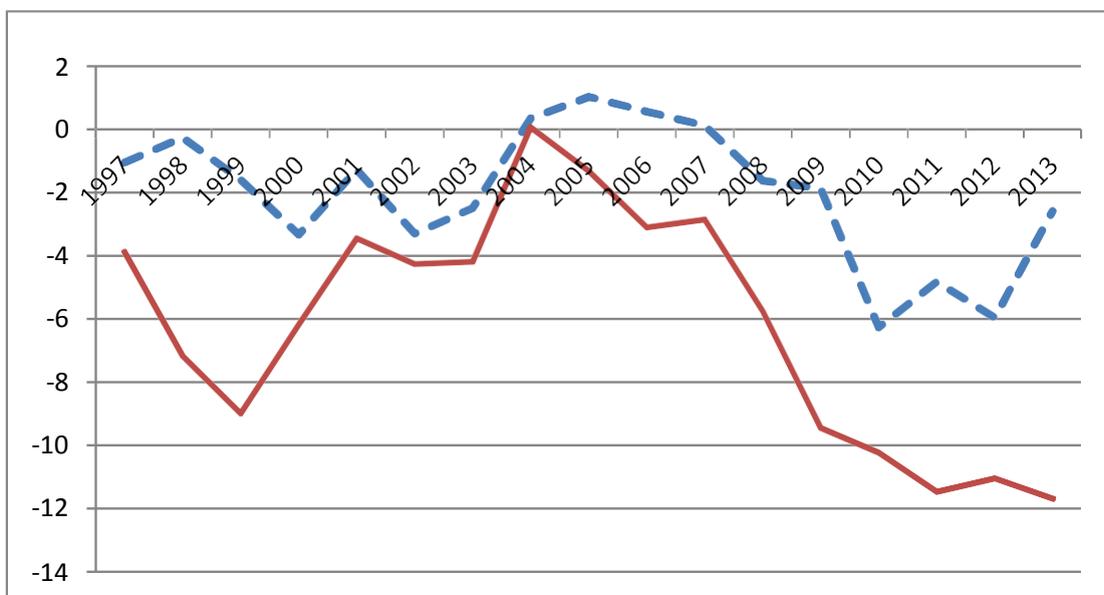


Figure 3: Ten year backward average of TFP growth in Uganda.

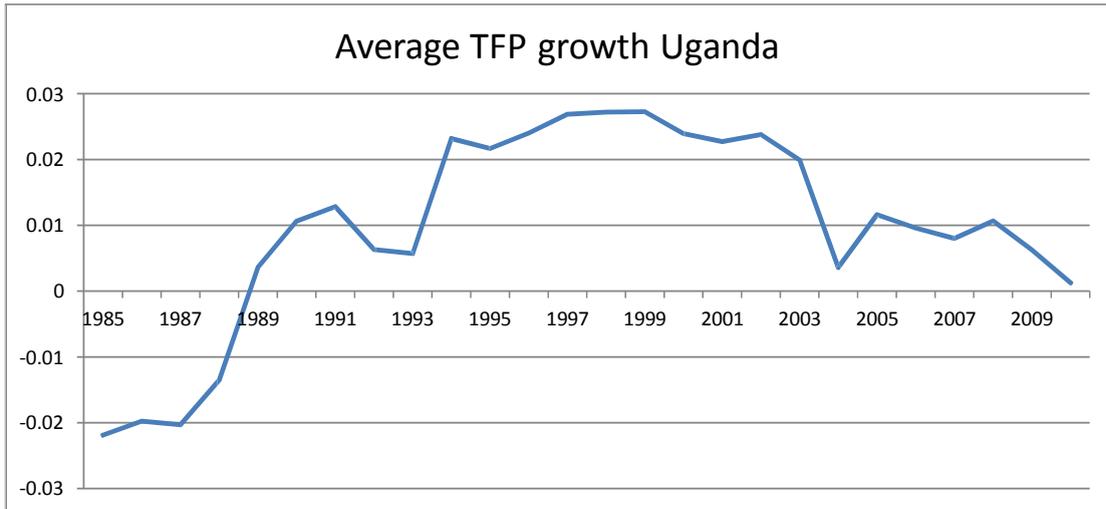


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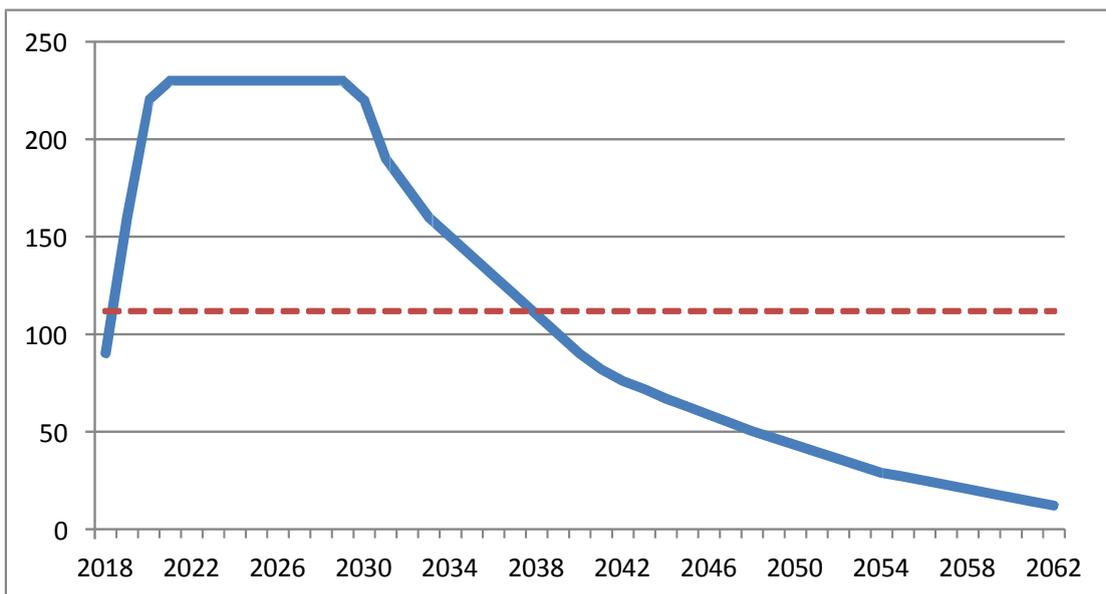


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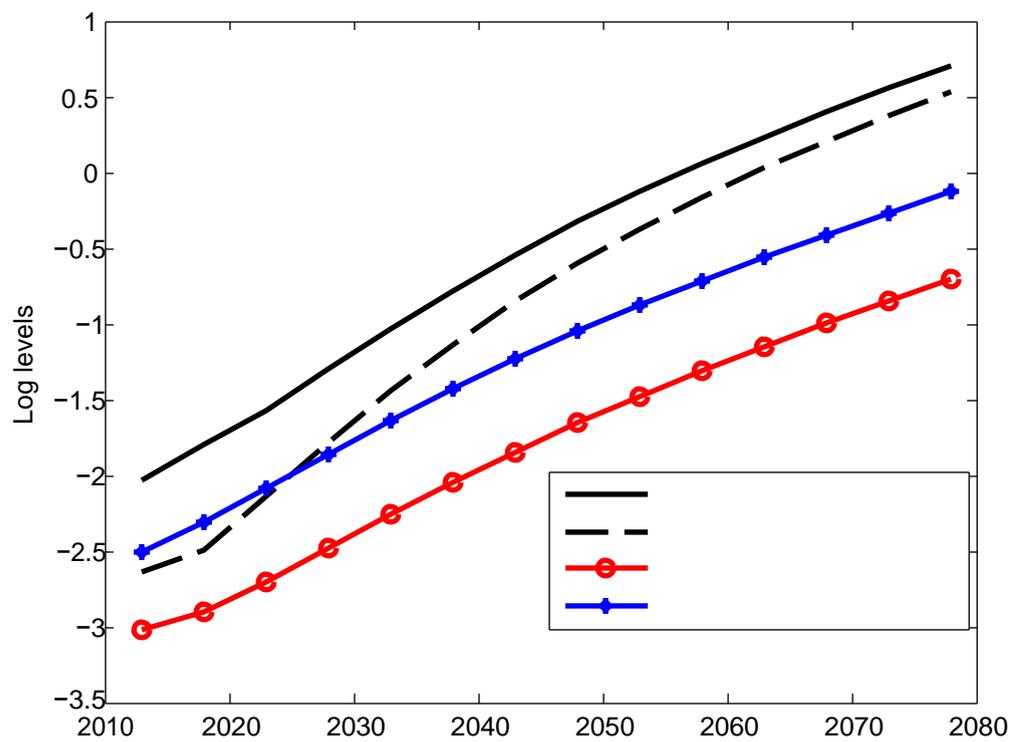


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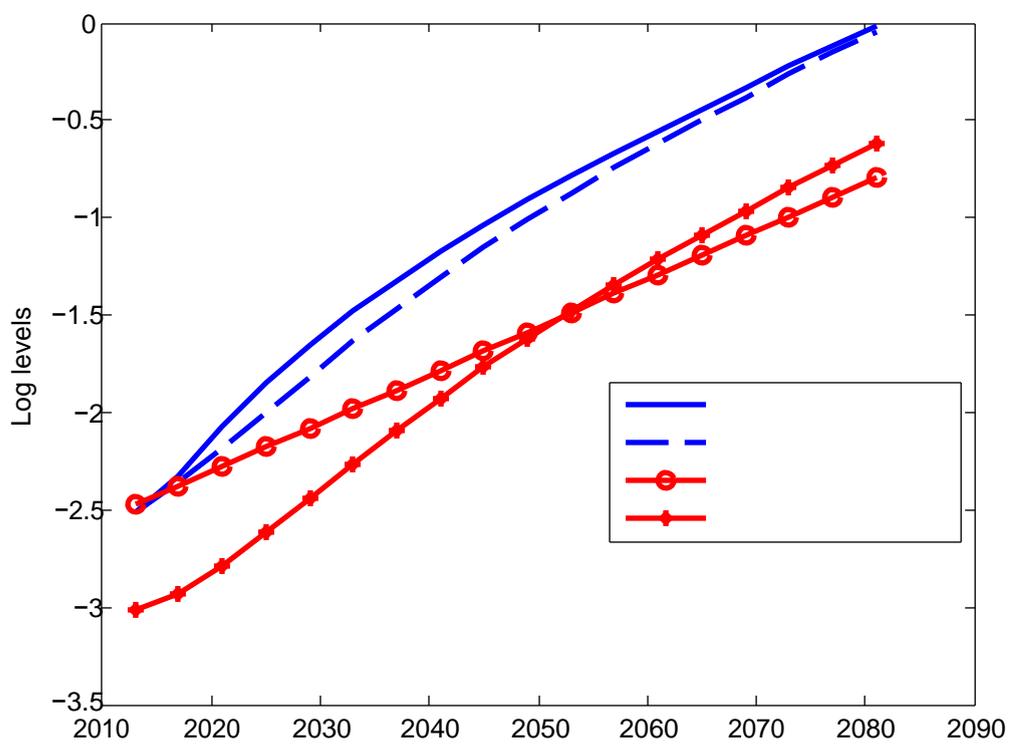


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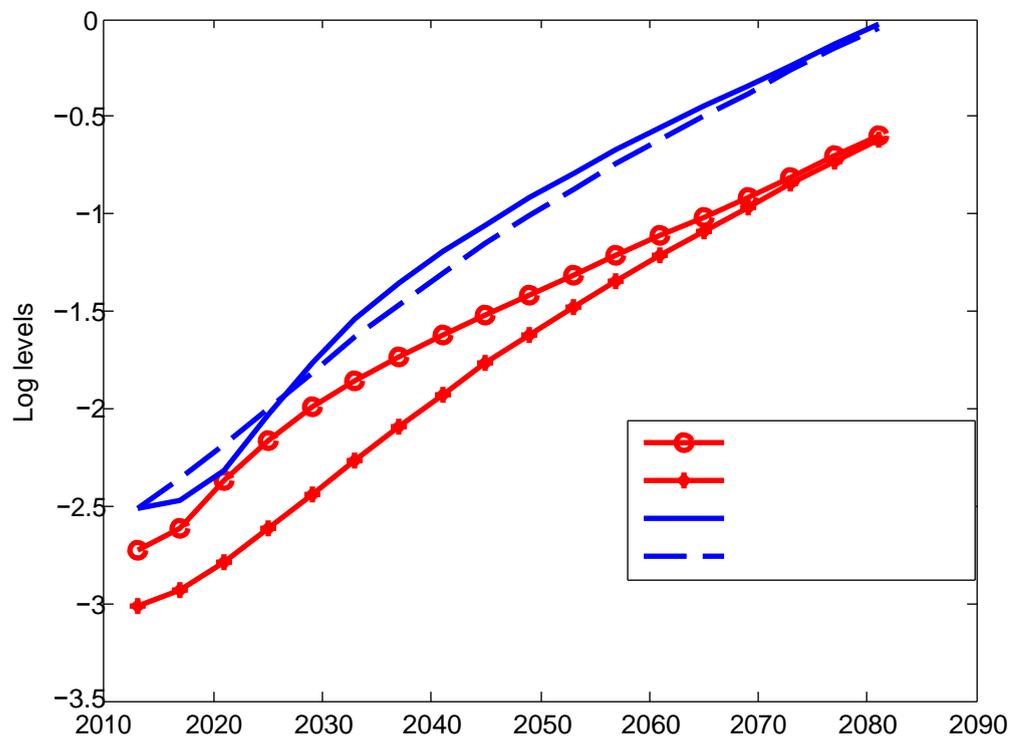


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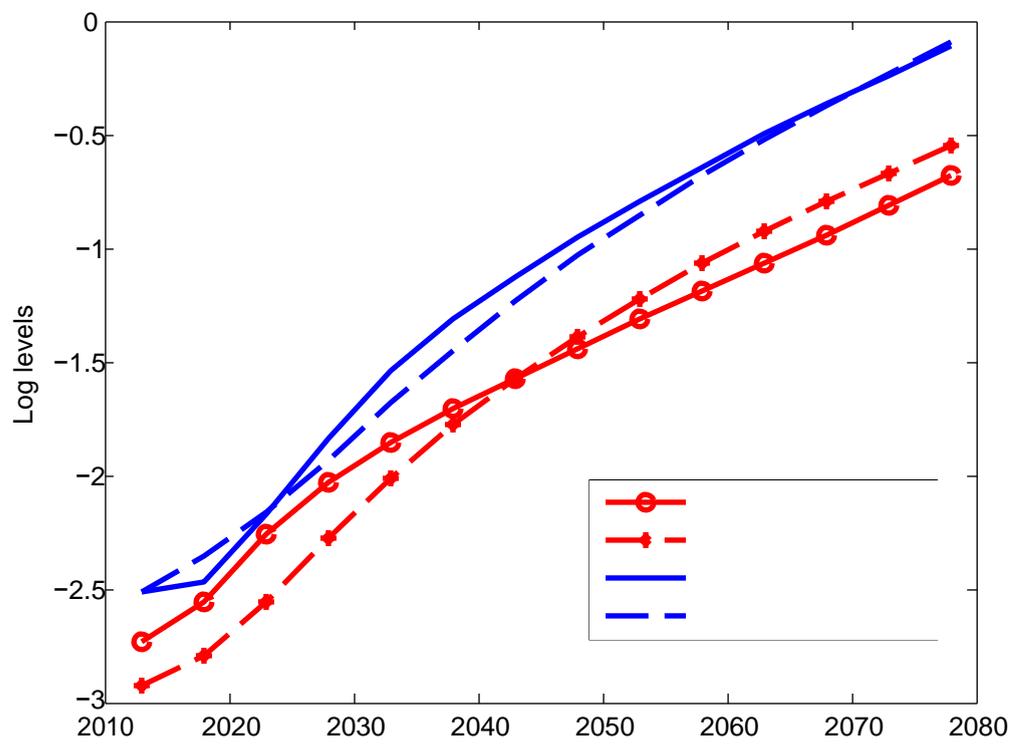
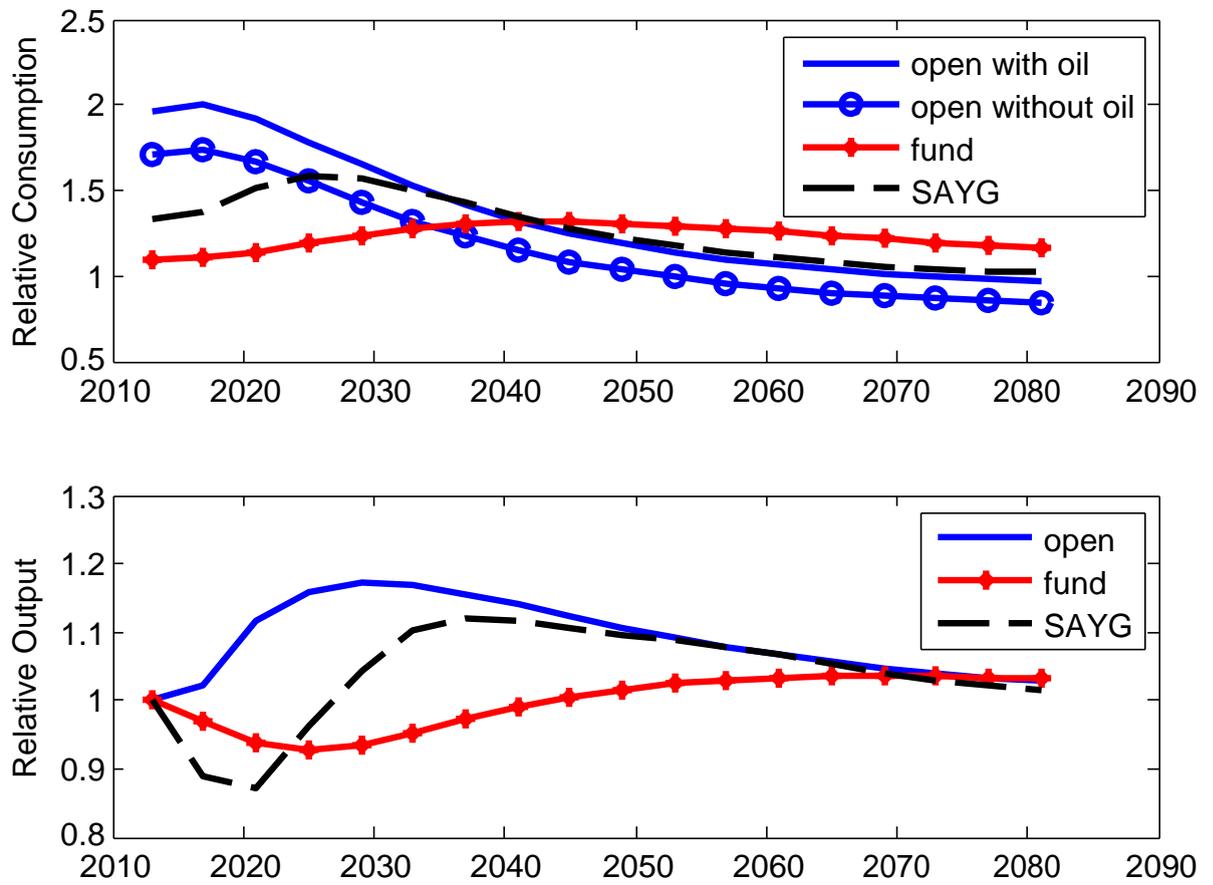


Figure 9: Consumption and output levels (relative to closed economy without oil).



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