Managing depleting gold revenues in Mali: An assessment of policy options

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Preliminary version. Please do not quote.

Abstract

This paper analyzes the impact of medium term policy options in the context of gold resources depletion in Mali. Using a recursive-dynamic computable general equilibrium (CGE) model calibrated to a 2006 Malian SAM, we assess the impact of two policy options in the context of gold resources depletion in Mali: the adoption of the permanent income hypothesis and a “borrow and invest” scenario consisting at boosting public investment by 5 percentage points of GDP. The depletion of gold resources in Mali would cause a substantial fall in GDP growth, and lead to unsustainable fiscal path if the government were to keep its current pattern of spending. Adopting either the “borrow and invest” fiscal approach or the permanent income hypothesis is likely to generate higher growth and a more sustainable fiscal framework compared to the status quo.

Keywords: Mali, gold revenues, macro-policy, permanent income, CGE

JEL classification codes: Q30, E60, C68, H50

1. Introduction

The issue of natural resources depletion management has much been debated since the early work of Hotelling (1931). Related to the issue of the optimal rate of extraction, another side of the literature has focused on how to manage the windfall gains in the so-called Dutch disease tradition (Corden and Neary, 1982; van Wijnbergen, 1984). More recently a growing literature has emerged, attempting to design some policy options for the post-resource period.

For many years, the debate was focused on how the permanent income hypothesis (PIH) should guide countries' efforts to achieve fiscal sustainability. The expenditure level defined by the PIH should be adopted by governments as a final target, to avoid sharp cuts in public spending if a resource is depleted. In the case of gold, this approach would imply that the net present value of future public expenditures should be set equal to the net present value of all future gold revenues (Barnett and Ossowski, 2003). The government would then define an optimal path of public expenditure (consumption) which respects this intertemporal budget constraint.
The PIH generally requires that the country set up a sovereign wealth fund and transferring all new revenues to that fund. Then post-resource consumption expenditures would be financed by the interest from this SWF (the permanent income stream). Thus, the revenue flow would be perpetual and benefit future generations. However it assumes that the country has good access to world financial markets.
Recently, a growing literature has emerged criticizing this approach to using the revenues from mineral resources. Starting with Van der Ploeg and Venables (2009) but also Collier al. (2010) as well as the IMF (Baunsgaard et al. 2012), this literature focuses on the role of market failures and the low capital stock in many developing countries. A country that lacks ready access to capital markets and where capital is scarce may well benefit from immediately devoting resource revenues to high-return investments, rather than saving these revenues in the interest of smoothing consumption over time. Thus, this new framework suggests a more flexible fiscal framework for the government and an investment level higher than the one suggested by the PIH.

Using a theoretical model, van der Ploeg and Venables (2009) show that, in a capital scarce country which faces an interest rate above the world interest rate, full consumption smoothing as suggested by the PIH is no longer optimal, in particular when the windfalls are small relative to the government initial debt level. The country can gain more (more rapidly reach a long-term consumption level) by devoting more resources to investment than would be suggested by attempting to smooth consumption over time. In a similar application to the oil sector in Cameroon, Djiofack and Omgba (2011), found that attempting to smooth consumption according to the PIH could lead to lower growth and welfare for households.

The issue of how to deal with the decline of gold revenues is paramount for Mali, the third largest gold producer in Africa and the ninth largest in the world (43 tons in 2010). The gold sector represented 8% of GDP in 2008. From 1992 to 2002, gold production increased tenfold, but has been declining since 2006. Receipts from gold represent 80% of total exports and, in 2007, 17.6% of government revenue (Thomas 2010).

In this paper we build on the above mentioned theoretical literature to analyze the macroeconomic impact of alternative policy options available to the Malian government to address the issue of declining gold revenues. Our analysis is based on a recursive dynamic general equilibrium model, which is calibrated to a 2006 social accounting matrix to produce forecasts through 2030. We treat the gold sector in a specific way by using “decline curves” (Arps, 1945) to project future gold production. The baseline scenario (business as usual) assumes that gold production and public expenditure remain at their 2006 levels. We then build three scenarios reflecting the depletion of gold resources by using decline curves. The first scenario assumes that government expenditures remain fixed at the 2006 ratio to GDP, the second that government expenditures are based on the permanent income hypothesis, and the third (referred to as “borrow and invest”) that public investment is increased by 5 percentage points of GDP, leading to a 30% growth in productivity.

The results suggest that the depletion of gold resources will lead to lower growth in the near future. Consumption smoothing reflecting the permanent income hypothesis yields better results than the constant spending scenario, particularly when it comes to the government balance and the debt ratio. However, the best scenario in terms of growth is reached with the “borrow and invest” scenario.

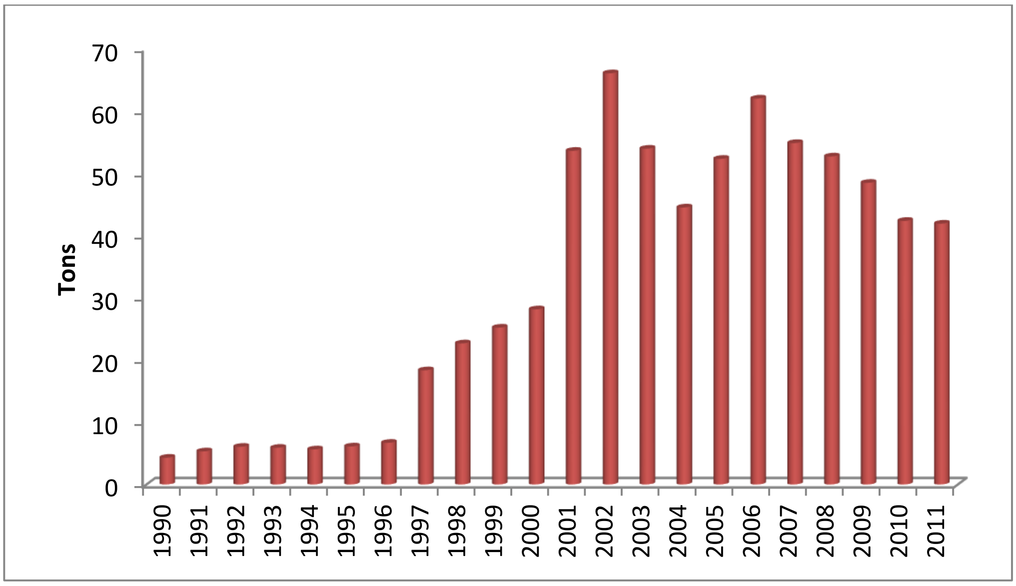
The remainder of this paper is organized as follows: Section 2 reviews the economy’s dependence on gold; Section 3 presents the CGE model while Section 4 describe the data and the calibration procedure; Section 5 discusses the empirical results and their policy implications and Section 6 concludes.

2. The Malian gold sector

2.1. Contribution to GDP and exports

Gold production and exploitation in Mali goes back to the 12th century[1] when Malian emperors (like King Mansa Mussa who went to Cairo with more than 800 kilos of gold) discovered large gold fields in southern Mali. Since then, the country has experienced episodes of booms and busts in production. During the French colonization, gold production declined in favor of cotton, which was more useful for France's industrial needs. However, people did continue extracting gold in the artisanal sector, which is still active.[2]

Figure 1: Gold production in Mali (1990-2011)



Source: BCEAO and Banque de France

Mali is now Africa's third largest gold producer (just behind South Africa and Ghana) and the ninth largest in the world, with 43 tons in 2010. Gold mining represented 7% of GDP in 2007 (IMF, 2011) and 8% in 2008. Figure 1 gives the evolution of industrial gold production in Mali since 1990. The recent boom started in the late nineties, with a peak of production of 66 tons in 2002. Over the 1992-2002 decade, gold production increased tenfold. However, since 2006 production has been declining, no new mines have been discovered, and only 500 tons of reserves have been identified (Jul-Larsen et al., 2006).

[1] The Kingdom of Mali at that time

[2] This sector is declining and represented less than 5% of total production in 2001 (Keita, 2001).

The huge increase in production since the early nineties is essentially due to investment by foreign companies (Anglogold Ashanti, Randgold Resources and Iamgold) operating in four main mines: Sadiola, Yatela, Morila and Syama. The boom in foreign direct investment is related to the low operating costs in Malian mines, coupled with high world prices. The operating cost in Mali is half the world average cost (Hatcher 2004, Jul-Larsen et al., 2006). Moreover, the world price of gold has more than doubled since 2006, due to a high demand for industrial purposes and as a safe haven during the market turbulence experienced since the onset of the global financial crisis.

Almost all of Mali's gold production is exported (fig. 2a), and export receipts from gold exceeded $1 billion a year from 2006 to 2011. From 49% in 2000, gold exports now account for 80% of total exports. This rising trend in gold exports (and a concomitant fall in the share of cotton in exports) has been the main feature of the Malian economy over the current decade.

Figure 2a: Gold exports in volume (2000-2010)

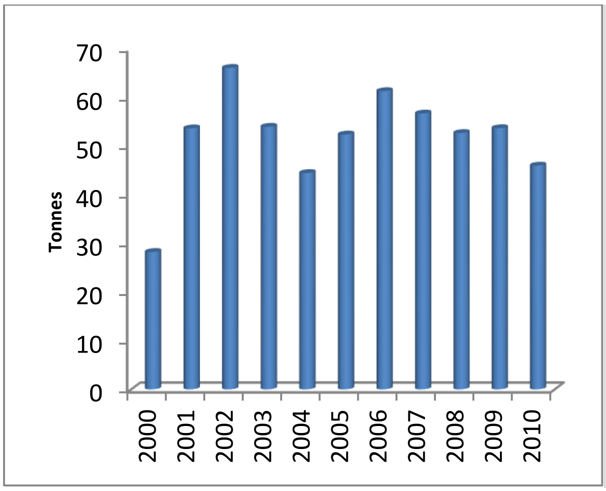
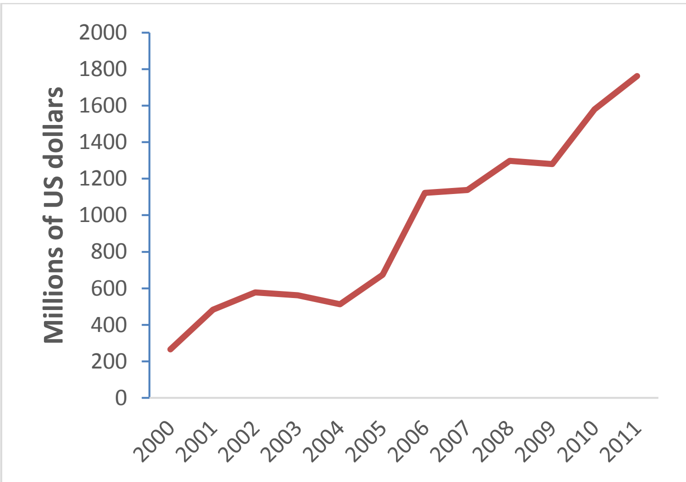
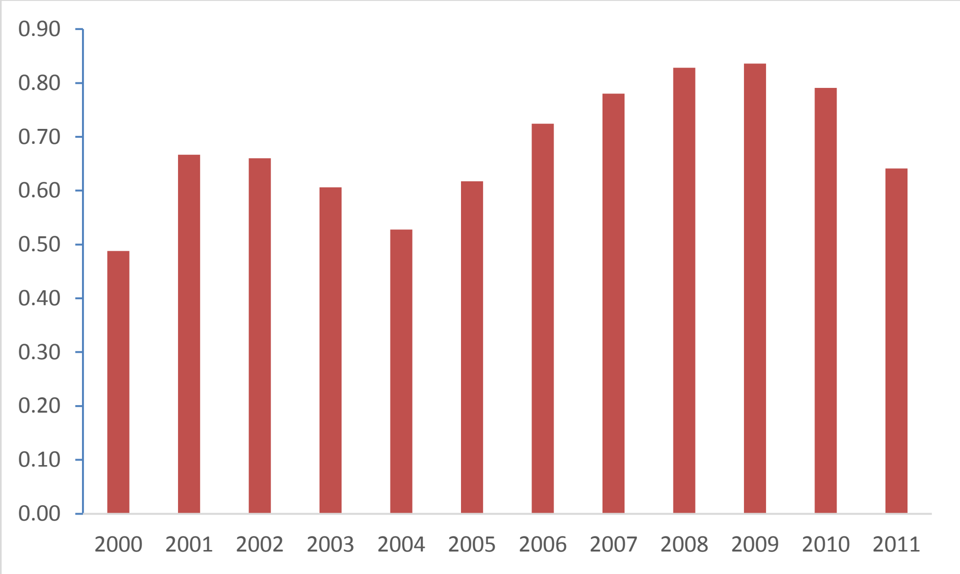


Figure 2b: Gold exports in value (2000-2011)



Source: BCEAO, AFRISTAT and INSTAT

Figure 3: share of gold exports in total exports (2000-2011)



Source: BCEAO and AFRISTAT

2.2. Contribution to gouvernement revenue

Given the outward orientation of the gold sector in Mali (repatriation of profits by foreign companies, high level of imports of petroleum and capital goods, low level of employment, weak backward linkages…), the main impact on the whole economy is through the fiscal channel (Thomas, 2010). The Malian government receives its revenues from the gold sector directly via the dividends it earns as a shareholder in some companies and indirectly via taxes, customs and royalties. All these contributions are regulated by the mining code introduced in 1991 and revised in 1999, which is the legal framework under which all the companies operate. The code aims at attracting foreign investors by a series of tax exemptions at each stage of the process. At the exploration stage, firms are exempted from all duties and taxes (including VAT) either on the domestic market or on the import side, with the exception of petroleum products (WTO, 2010). At the production phase, new mining firms face a 35% corporate income tax, a 12.5% to 18% dividend tax, and a 3% royalty. The exemption from import duties which was effective under the 1991 code was lifted in 1999. However, gold companies are still exempted from value added tax for the first three years of production.

Table 1: Contribution of Mining Sector to Government Revenues 2004–13 (CFAF billions)

	2004	2005	2006	2007	2010	2011	2012	2013
Direct taxes	14.3	15.9	24.8	76.5	84.6	83.7	105.0	71.0
Indirect & related taxes	13	17.8	27.8	23.4	41.7	48.9	65.6	55.3
Nontax revenue	2.3	0.5	0.3	0.6	29.6	22.8	31.4	17.4
Total revenues	**29.6**	**34.2**	**52.9**	**100.5**	**155.9**	**155.4**	**202.0**	**143.6**
% of GDP	1.1	1.2	1.7	3.0	3.3	3.1	3.9	2.7
% of total revenue	6.5	6.8	9.5	17.6	21.5	20.4	24.8	17.0

Source: IMF (2013)

Table 2: Composition of the contribution of Mining Sector to Government Revenues 2004–07 (CFAF billions)

	2004	2005	2006	2007
Royalties	7.5	10.5	15.9	12.3
Dividends	2.3	0.5	0.3	0.6
Profit taxes	6.3	6.7	13.5	63.5
Payroll taxes	8.0	9.2	11.3	13.0
Other taxes	5.5	7.3	11.9	11.1
Total revenues	29.6	34.2	52.9	100.5
Percent of GDP	1.1	1.2	1.7	3.0
Percent of total revenue	6.5	6.8	9.5	17.6

Source: Thomas (2010)

In terms of contribution to public finances, from 2004 to 2013 the Malian government received on average per year CFAF 109 billion (USD 218.5 million) and CFAF 874.1 billion (USD 1.7 billion) in total from the gold sector (Table 2). The revenue from the mining operations represented 24.8% of total government revenue in 2012 and 3.9% of GDP, which is quite substantial. Those revenues come from royalties, dividends, profit and payroll taxes. Given that most of the firms were operating under the 1991 code, these revenues are expected to increase over time with the new mining code which became effective in 2003. This can be seen starting in 2006 despite the decline in production. However with the huge decline in production, the main question is to what extent these tax flows will be maintained. One can notice that starting in 2012, total revenues are now clearly downward trending.

3. The CGE model

To assess the impact of the depletion of gold revenues on the Malian economy, we use a recursive dynamic general equilibrium model, building upon the World Bank - Linkage – model (Van der Mensbrugghe, 2005). The recursive dynamic approach consists of solving sequentially the model (one period at a time) with the main macroeconomic variables updated in every period. Since the model is similar to standard CGE models in the literature (Derviş, De Melo and Robinson (1982), Shoven and Whalley (1984), De Melo and Tarr (1992), Francois and Reinhert (1997)), we will highlight here only the specificities/changes made to fit the Malian case, in particular the gold sector. We first present the static module and then introduce the dynamic module.

3.1. Static module

Production and trade block

The production in all sectors takes place under constant returns to scale and perfect competition. Producers are assumed to maximize their profit by minimizing their cost of production. The production technology consists of a nested sequence of constant elasticity of substitution (CES). At the top level, output is specified by a Leontief technology of the value added and the intermediate aggregates. The aggregate intermediate input is a Leontief function of the primary inputs. Value added is a CES function of an aggregated factor: the "capital/skilled labor aggregate" and the "unskilled labor". The SAM distinguishes two types of labor distinguished by skill: unskilled labor and skilled labor and two types of capital: agricultural and non-agricultural capital. The "capital/skilled labor aggregate" factor is itself obtained by a CES function of capital and skilled labor.

We assume perfect competition and mobility of labor across the different sectors. Equilibrium is reached via a flexible wage rate, uniform across all sectors. However, we assume that capital is specific to each sector. Hence each activity pays an activity-specific remuneration for capital.

Imports are modeled using the Armington (1969) assumption, which states that demand for commodities is a function of their origin. Hence a CES aggregation function is used to take into account imperfect substitutability between imports and commodities sold domestically. The export side is treated in a symmetric fashion. Domestic output is allocated between domestic markets and exports via a constant elasticity of transformation (CET) function.

Specific issues for the gold sector

The gold sector, like the rest of the economy, operates under perfect competition and constant returns to scale. It maximizes profit by using in addition to labor and physical capital, a non-renewable or natural capital. Hence unlike physical capital, the natural resources is a non-renewable stock the depletion of which will yield that of gold. In this sector, the two types of capital are combined to give a « capital aggregate» using a Leontieff technology, so that a decrease in natural capital will yield a proportional decrease in gold production**.** For all the simulated scenarios, the depletion of gold is achieved through the yearly exogenous decrease of natural capital.

Institutions block

Household's income and consumption

Households receive income from factors of production and transfers from other institutions (enterprises, the government and the rest of the world). However, they do not receive any direct payment from the gold companies since the government is the sole agent owning a share of the capital in this sector. Transfers from the rest of the world are fixed in foreign currency.

Households use their income to pay direct taxes, save, consume and make transfers to other institutions. The share of savings and direct taxes in household income is held constant.

Households' consumption of the composite commodity is determined by a linear expenditure system (LES) demand function, derived from maximization of a Stone-Geary (1954) utility function.

The government Macroclosures

Macroeconomic closures determine how macro balances are restored after a shock. Specifically, these closures specify how the model achieves (i) balanced government accounts, (ii) the macro equilibrium of the capital account, i.e. the investment and savings balance, and (iii) the macro equilibrium of the accounts with the rest of the world. The closure rules adopted in the Malian model are as follows:

The government earns revenue through production taxes, export taxes, import tariffs, sales taxes, and income (direct) taxes. All tax rates, unless otherwise stated, are fixed at base year levels. The volumes of government current and investment spending are also fixed as shares of real GDP. This implies that government savings (primary balance) is endogenous and adjusts to clear the government balance. The gap between government investment demand and public saving is satisfied through foreign and domestic borrowing. The composition of public borrowing (i.e., the ratio of foreign borrowing to domestic borrowing) is fixed at the base year value. Alternative government closures would be considered for the simulations of management of gold resources.

For the savings-investment balance, we assume a savings-driven closure that fixes the savings rates of all nongovernmental agents (households and firms). Aggregate investment—which together with an exogenous rate of depreciation determines the next period's capital stock—is flexible to ensure that the investment cost will be equal to the savings value. The volume of available savings is determined by an exogenous level of foreign saving, endogenous government saving, and households, who save a fixed share of their post-tax income. In this context, an increase in government revenue as the result of a tax hike would be reflected in augmented saving, therefore stimulating current investment and future growth.

For the external balance, closure is achieved through adjustment of the real exchange rate, while the current account is fixed by the available quantity of foreign saving. To maintain the current account constant while maintaining fixed international prices (price taker assumption), a variation in the real exchange rate adjusts domestic prices so as to generate appropriate changes in the volumes of imports and exports demanded. The main implication of this closure in the context of Mali is that an increase in gold exports, for example, would generate an appreciation of real exchange rate, penalizing the competitiveness of non-gold sector. This is the manifestation of the classic "Dutch disease". Decreased gold exports would have the opposite effect.

3.2. Dynamic Module

The model has a recursive dynamic structure. This approach is adopted for computational convenience. Hence, the model is solved as a sequence of static equilibria in each period. Economic growth results from productive capital accumulation, exogenous labor supply growth and productivity changes.

The capital stock in each period is endogenous, given by the sum of depreciated capital stock inherited from the previous period and gross (new) investment as follows:

$$K_{i,t+1} = K_{i,t}(1-\delta) + \chi_i INVTOT_t$$

where δ is the annual depreciation rate of the capital, $INVTOT_t$ is the total investment in the current period (t), and χ_i is the share of each sector in total capital in the initial year. The allocation of capital among sectors depends on the return to capital in each sector in the previous period.

The labor stock available in each period grows exogenously at the growth rate of the working age population (ages 15-64), obtained from United Nations Population Division forecasts. This rate for Mali is estimated at 3.17% on average annually.

$$LS_{t+1} = LS_t(1 + p)$$

Regarding productivity changes, the model assumes technical progress specific to sector and production factors. The change in productivity is derived by a combination of factors, but is also partially judgmental. First, agricultural productivity is assumed to be factor-neutral and exogenous, and is set to estimates from empirical studies (for example Martin and Mitra 2001). Productivity in manufacturing and services is labor-augmenting, and a constant wedge is imposed between productivity growth in the two broad sectors with the assumption that productivity growth is higher in manufacturing than in services.

4. Data and calibration

4.1. The social accounting Matrix

We rely on a 2006 social accounting matrix. The original SAM consists of 16 sectors, which we decided to aggregate into 10 sectors. The matrix is square: each activity produces a single commodity and each commodity is produced by only one sector. There are four factors of production: unskilled labor, skilled labor and agricultural and non-agricultural capital. However, in the gold sector, in addition to the four factors we have "natural capital" or natural resources, the depletion of which yields gold production.

Five household groups are present in the SAM. They are split according to the main activity of the household head instead of a geographical basis. Households' income comes mainly from labor (both unskilled and skilled). The remaining income comes from capital and from transfers (from government as well as from other institutions). The SAM includes some inter-households transfers which remain constant during the simulations. A large part of those transfers correspond to the remittances urban households give to rural ones (Table 3).

Table 3: Households' sources of income

	Unskilled labor	Skilled labor	Non agricultural capital	Agricultural capital	Others (Transfers)
Salaried Households	4.14	40.75	11.21	12.97	30.93

Agricultural households	22.80	4.27	25.72	25.08	22.13
Store keeping households	9.10	6.10	35.10	36.60	13.10
Craftsmen households	16.34	23.05	18.48	24.14	17.98
Non-working households	21.00	12.04	24.26	8.58	34.12

Source: SAM

The SAM also gives a snapshot of government's accounts. From Table 4 below, one can notice that transfers from the rest of the world represent more than 40% of government income, followed by domestic sales taxes and direct taxes. Import tariffs represent only 13% of total income. There is therefore a huge dependence of the government on foreign aid.

Table 4: Government sources of income

	Direct taxes	Domestic sales taxes	Import taxes	Transfers from the ROW
Share in total revenue	0.18	0.28	0.13	0.41

Source: SAM

4.2. Gold production projections

In order to get projections for gold production in Mali one needs a lot of data. In other fields such as oil production, several institutes make such projections. However when it comes to gold and particularly for Mali, there are not enough data available. The only thing one can do is to model future trends in a consistent framework. To do so, we will use projection models which have proved to be successful in the literature.

There are many projection models one can use to project gold production forward, drawing mainly on the literature related to oil depletion. These models usually refer to what is called "decline curves". In this framework, one assumes that the production peak is known, and then production rates decline as a function of time. Since the seminal work of Arps (1945) who first gave a set of empirical functions modeling declines in production, researchers have extensively used those functions (Porges, 2006, Guo et al. 2007). The curves proposed by Arps rely on three parameters: the initial production rate or the production rate at the peak ($Q(t_0)$), the slope of the curve (β) which is a shape parameter, and the decline rate (λ). The general formulation is given by:

$$Q(t) = \frac{Q(t_0)}{\left(1 + \lambda\beta(t - t_0)\right)^{1/\beta}}$$

This specification corresponds to what is called “hyperbolic decline” in the literature. Depending on the value of beta, we have the following features:

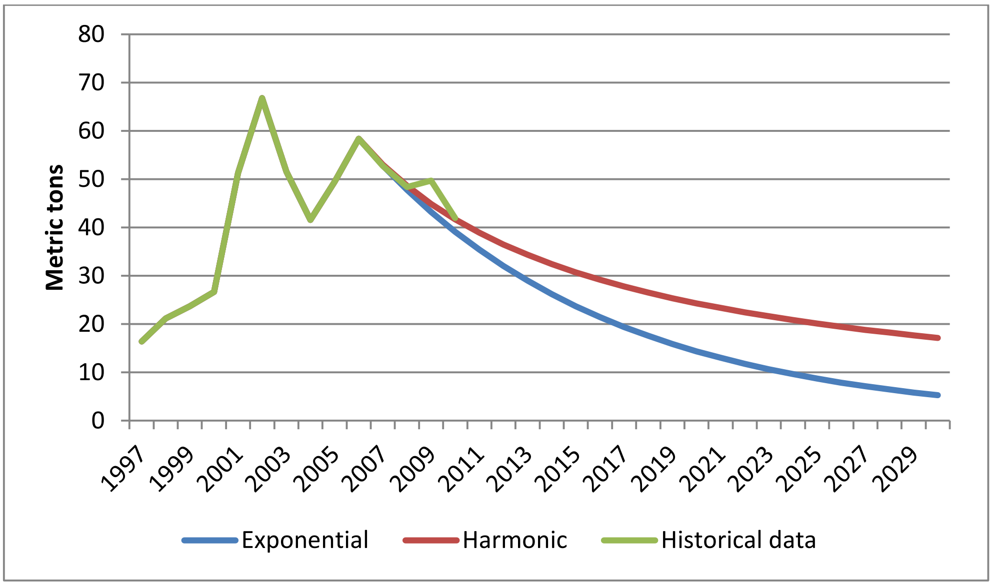
<u>Table 5</u>: functional forms

β	Function	Type of decline
$0 < \beta < 1$	$Q(t) = \frac{Q(t_0)}{\left(1 + \lambda\beta(t - t_0)\right)^{1/\beta}}$	Hyperbolic decline
$\beta = 0$	$Q(t) = Q(t_0)e^{-\lambda(t-t_0)}$	Exponential decline
$\beta = 1$	$Q(t) = \frac{Q(t_0)}{1 + \lambda(t - t_0)}$	Harmonic decline

We apply this framework to gold production in Mali. We start our analysis by fixing at 2006, the second peak of production, the beginning of the decline period (t_0). We use a decline rate of 10% with both the exponential and the harmonic specifications. Figure 4 below shows the pattern of gold production under these specifications by 2030[3].

[3] On can of course run a sensitivity analysis by varying the depletion rate.

<u>Figure 4</u>: gold production projections (Decline curves)



Source: BCEAO for the historical data and author's calculations for the projections

According to the exponential function, Gold resources might be depleted by 2030 in Mali. The harmonic function leads to a slight different pattern. We use these projections in the dynamic general equilibrium model.

5. Simulations and results

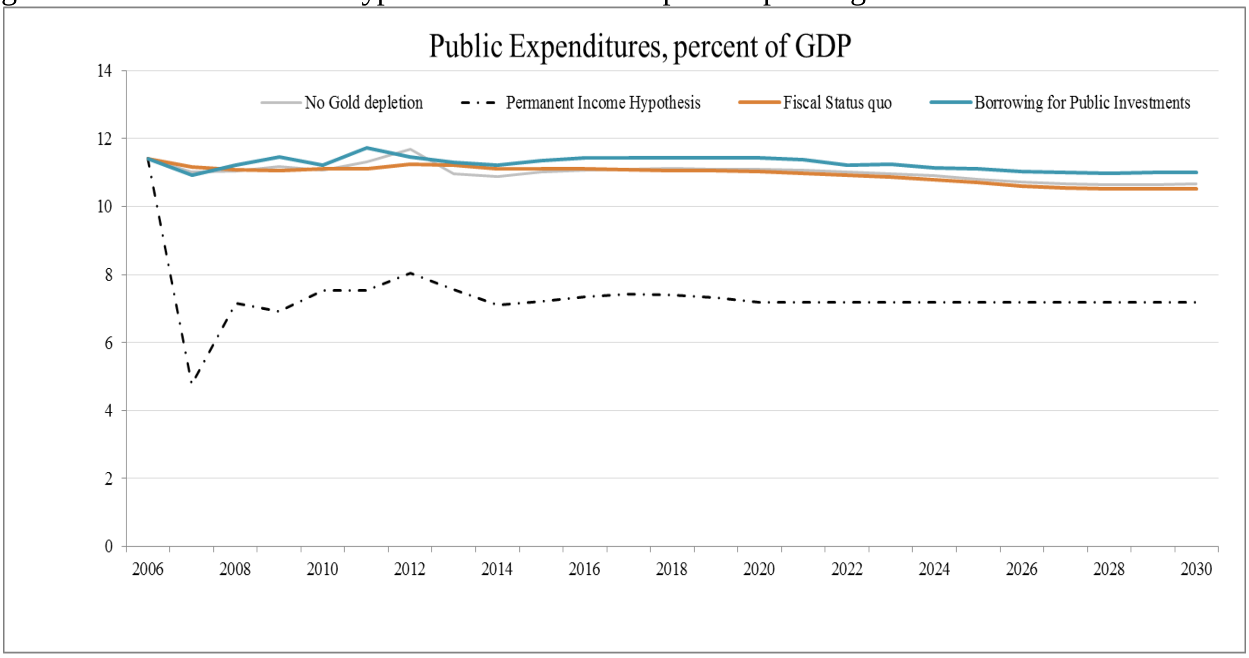
5.1. Definition of scenarios

In addition to Business as usual (BAU), we simulate three scenarios among which two different policy options. In the BAU, we keep constant the ratio of public expenditure to GDP at its level of 2006, the base year of the model. Furthermore, we assume no gold depletion across the model time horizon in the BAU.

The first scenario (scenario 1) assumes that gold is depleted by 2030 (see above) and that public expenditures remain fixed at the 2006 ratio to GDP.

Scenario 2 assumes the same rate of depletion of gold resources as scenario 1, but the ratio of government expenditures to GDP is based on the inter-temporal optimization of welfare reflecting the permanent income hypothesis. We rely on the "habit" PIH framework developed by Leigh and Olters (2006). Figure 5 shows actual government spending and the spending target obtained through the PIH framework.

Figure. 5 Permanent income hypothesis: evolution of public spending

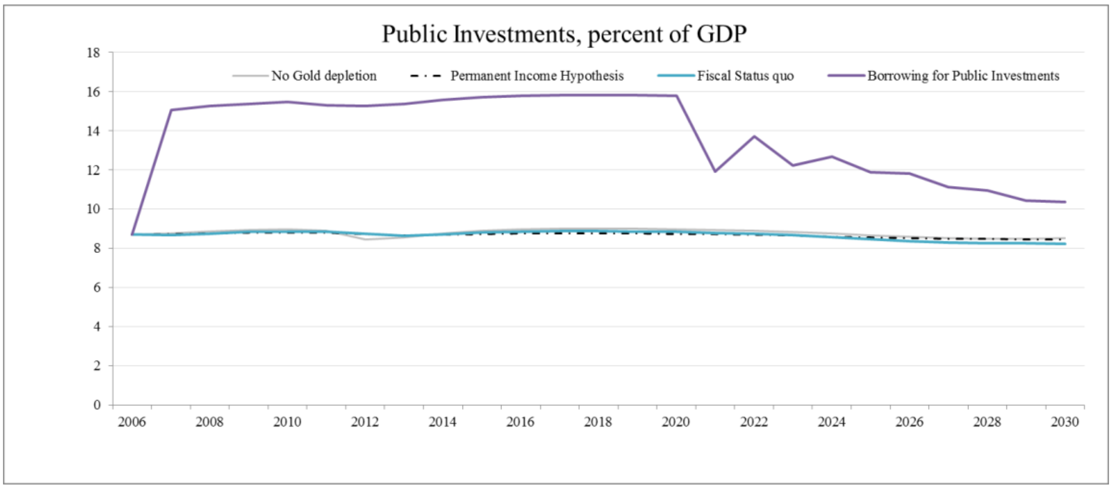


Source: Authors' estimates

The public spending to GDP ratio determined through the PIH is around 7%, significantly lower than the government's actual (observed) target of around 11%. This result suggests that the current fiscal pattern followed by the Malian authorities might be very far from an optimal, and sustainable fiscal objective.

Scenario 3 assumes the "borrow and invest" fiscal approach, where the government borrows and invest an additional 5% of GDP in short run (from 2006 to 2020) and pays back the debt in the medium term (over the 2020-2030 period) (see figure 6). Public investment is assumed to be allocated to development of human capital and key infrastructure that generate a 30% increase in productivity over the entire period (see World Bank, 2013).

Figure.6 Borrow and invest scenario: evolution of public investments



Source. Authors' construction

For all three scenarios, we consider that the gold depletion follow the exponential trend defined in section 4[4] .

5.2. Results of the simulations

5.2.1. Effect of gold depletion in Mali

The decline in Malian gold production started in 2002, and so far no significant discovery has been made that could reverse this trend. Table 6 reports the average levels of national income account and fiscal variables over 2015-30 in the gold depletion (scenario 1) and policy scenarios for mitigating its effects (scenarios 2 and 3). Each variable is expressed as an index, where the corresponding variable in the BAU is set equal to 100. Thus a value above 100 indicates an increase compared to the BAU, while a value under 100 indicates a decrease.

[4] As sensitivity analysis, we also present in annex all results considering that the gold depletion would follow an harmonic trend.

Scenario 1 shows that with no change in the fiscal policy rule, the depletion of gold would reduce Mali's GDP by 16 percentage points over the period 2015-2030. The decline in GDP is due to many factors, with the main channel the 22% fall in government revenues (see table 6). As we assume that government spending is fixed in relation to GDP, the decline in revenues leads to a rise in the government deficit to GDP ratio, by 3 percentage points over 2015-2030 compared to the BAU (without gold depletion). The widening of the deficit hampers total saving in the economy, leading to a fall of total investment by around 22%. This result strongly argues for changing the fiscal rule in light of the prospect of gold depletion.

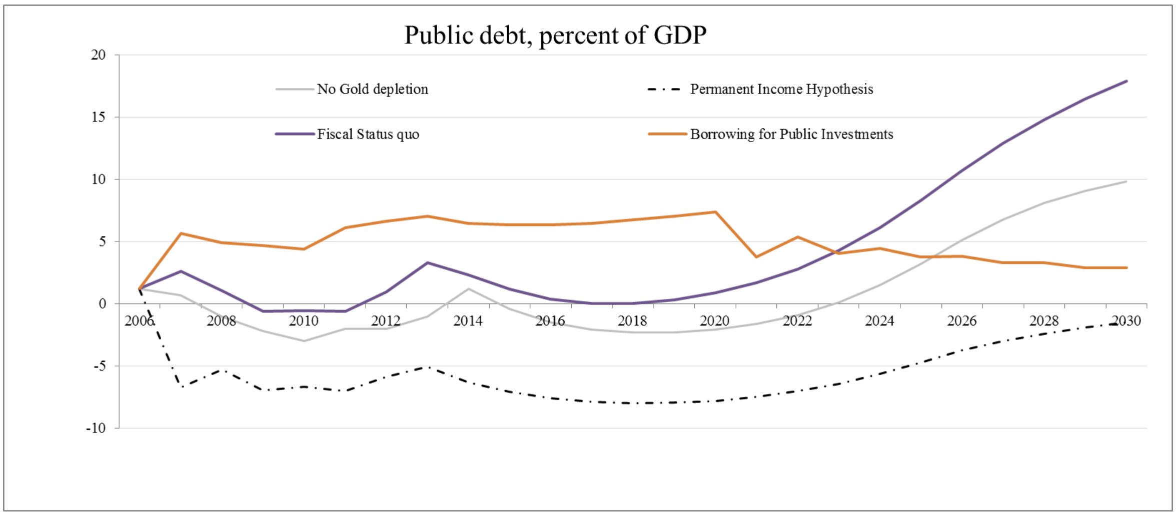
Table. 6 Gold resources depletion: Effect on GDP and public finance

	No Gold Depletion (BAU)	Status quo Fiscal	Permanent Income Hypothesis	Borrowing for Public Infrastructures
	BAU	Scenario 1	Scenario 2	Scenario 3
National accounts				
GDP at constant prices	100	84.0	97.3	120.1
Private consumption	100	92.9	97.8	103.6
Public consumption	100	83.2	48.5	115.4
Investment	100	83.2	104.8	123.0
Exports	100	53.5	92.1	171.0
Imports	100	78.0	92.9	131.4
Public finance				
Overall balance	100	102.8	77.5	42.4
Government revenue	100	78.6	96.3	131.1
Total expenditure	100	96.1	82.7	67.1
Recurrent expenditure	100	104.4	73.8	74.5
Capital expenditure	100	83.2	96.5	55.7

Source. Authors' estimates

The decline in GDP and the increase in the deficit result in an unsustainable fiscal path in scenario 1 (figure 7). Public debt increases from less than 5 percent of the GDP in 2010 to nearly 18 percent of GDP in 2030. In comparison, public debt would be at 10 percent of GDP in 2030 in the BAU (Figure 7).

Figure. 7 Gold resources depletion: effect on public debt



Source. Authors' estimates

Sectoral impact of gold depletion

The exhaustion of gold also has differentiated effects at the sectoral level. At least two factors determine the sectoral effect of gold depletion in this model. First, sectors that supplied the intermediate consumption needs of the gold sector suffer from demand shortages, while sectors using gold as an intermediate input suffer from price increases of key inputs. However, our results (table 7) points to an overall modest effect of gold depletion across sectors. This reflects the specific nature of the gold sector in Mali, which is very disconnected from the rest of the economy. For example, the "other manufacturing" (than textile and oil) is the only sector to use the production of the gold sector as intermediate consumption. This sector declines the most in scenario 1 (0.8 percentage points lower than in the business as usual--no gold depletion scenario). Other sectors with ties to gold (as suppliers), including tradable services (finance, telecommunications and transports) and non-tradable services, also decline slightly (see table 7).

Table 7. Sectoral production effect of gold depletion average yearly change over 2015-30

	Weight in total production (2006, base year)	BAU (1)	Scenario 1 (gold depletion) (2)	Change (2)-(1)
Crop	16.9	2.0	2.1	0.1
Exporting agriculture	3.0	2.1	1.4	-0.7
Gold	7.2	0.0	-6.0	-6.0
Textile	2.1	3.5	3.1	-0.4
refined Oil	14.1	4.7	4.4	-0.2
Other manufacturing	4.9	1.3	0.5	-0.8
Energy	7.5	4.2	3.7	-0.5
Non tradable services	11.7	4.7	4.5	-0.2
Tradable services	23.0	4.8	4.5	-0.3
Public services	9.6	3.8	3.3	-0.5

Source: Authors' estimates

Another factor determining the sectoral effect is government demand. As government consumption is set as a fixed share of GDP, gold depletion leads to an average annual decline of 0.5 percentage points in government consumption over 2015-2030.

5.2.1. *Fiscal options to mitigate gold resources depletion*

Various fiscal approaches have been considered in the literature to mitigate the effect of the depletion of natural resources on public finances and growth (see World Bank, 2013). As underlined above, we considered two approaches in this study: i) the adoption of consumption smoothing according to the permanent income hypothesis (scenario 2), and ii) the "borrowing and invest" approach (scenario 3). Table 6 reports simulations results for both scenarios.

The adoption of the PIH would greatly reduce the negative impact of the depletion of gold resources. GDP would fall by only about 3 percentage points over the 2015-30 period, a substantial improvement compared to 16 percentage point fall in scenario 1 (where expenditures remained fixed at the base year ratio to GDP). This outcome reflects immediate reductions in expenditures, allowing for more saving for future investments (see table 6)

As capital accumulation, a key factor for the growth, in our model is endogenous and determined by investment, the adoption of the PIH would contribute to higher long run growth. This suggests that adopting a PIH framework for determining public expenditures could substantially reduce the loss in GDP owing to the depletion of gold resources over the long run. The adoption of the PIH will also clearly provide a more sustainable fiscal position. In this scenario, public debt declines to zero, compared to 10% of GDP in the BAU scenario, and 18% in scenario 1 (gold depletion combined with a fixed ratio for government spending to GDP).

The adoption of the "borrow and invest" approach (scenario 3) would generate even higher growth. An increase in public investment by 5 percent of GDP (in the context of gold depletion) would lead to a 20 percentage point increase in GDP compared to the BAU scenario (in the absence of gold depletion). However, this outcome is very optimistic and related to the strong assumption that additional public investment would be properly used and would result in a 30 percent increase in total factor productivity.

6. Conclusion

The aim of this paper was to assess the impact that the depletion of gold resources would have on the Malian economy using a recursive dynamic general equilibrium model. It also studied alternative policy options to deal with that depletion. We found that the depletion will cause a substantial fall in government revenue and in GDP growth. In the face of the depletion of gold resources, determining government expenditures based on the permanent income hypothesis leads to sounder public finances compared to the current fiscal path and the "borrow and invest" scenario. However the borrow and invest scenario yields better results in terms of growth.

This study highlights the points raised by Van der Ploeg and Venables (2009), showing that basing public expenditures on permanent income may lead to better fiscal management but not necessarily to better growth and other indicators in countries where capital is scarce. Thus government expenditure rules should take into account country development needs and its characteristics. The main message from this study is that the PIH cannot be the only framework through which one should manage natural resources.

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Appendix: Sensitivity analysis with harmonic decline curves

Fig. 9: Effect of oil depletion on growth

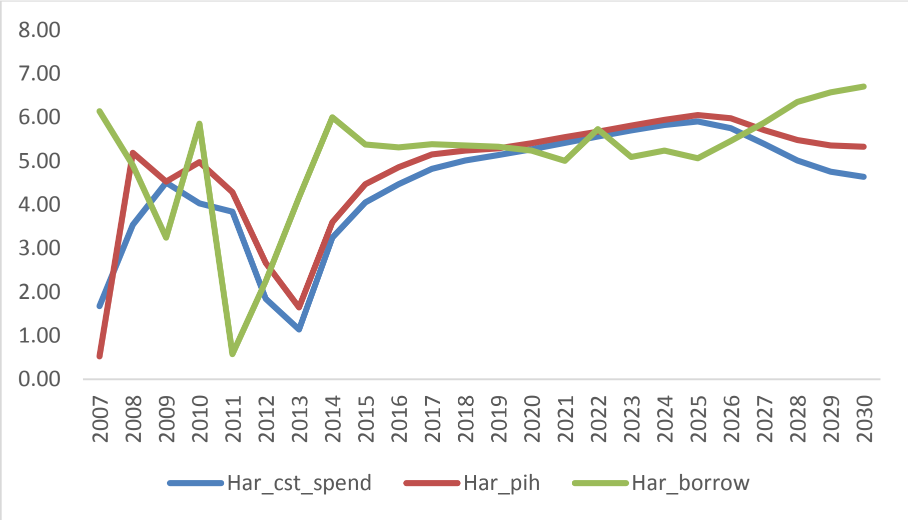

Fig. 10: Evolution of GDP per capita

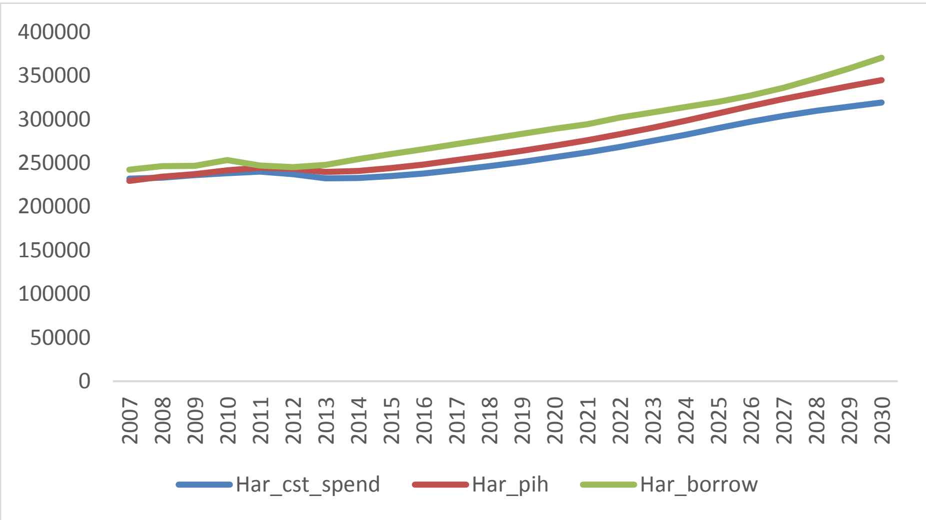

Fig. 11: Government overall balance in % of GDP