

**ESTIMATING THE OPTIMAL ROYALTY TAX IN THE GOLD MINING SECTOR OF
GHANA**

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DECLARATION

I hereby declare that this thesis is as a result of research undertaken by me towards the award of Master of Philosophy (MPHIL) degree in Economics in the Department of Economics, University of Ghana under the supervision of the undersigned lecturers.

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ABSTRACT

Gold is the most important mineral resource in Ghana. It has over the years contributed to Ghana's foreign exchange earnings, Gross Domestic Product, employment and government revenue through taxes. However, mining of gold brings great destruction to Ghana's forests and its habitats. These costs are usually not considered in the design of fiscal policies. The question that arises is, what is the optimal royalty tax rate that would internalize the environmental cost of mining, more specifically forest degradation? This study seeks to determine the optimal royalty tax rate that would internalize the environmental cost of forest degradation resulting from gold mining. Specifically, a dynamic optimization model is estimated where the objective functions of both the miner and social planner are optimized given their sets of constraints using the current value Hamiltonian. The results permitted the deduction of the optimal royalty tax rate that would internalize forest degradation resulting from gold mining. The optimal tax rate depended on the shadow price of forest resources, interest rate, time, corporate income tax, gold yield per acre of deforested land and the world market price of gold. Comparative static analysis carried out showed that the optimal royalty tax rate is negatively related to the world market price of gold, positively related to interest rate and increases with time. It recommend that policy makers take these relationships into consideration in designing a royalty tax for the gold mining sector.

DEDICATION

I wish to dedicate this study to my parents, Mr. and Mrs. Alfred Ablordeppey, and to my brothers, Nathaniel Ablordeppey, Edwin Ablordeppey and Kelvin Ablordeppey for their immeasurable support throughout my educational career.

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Although I received divers help, support and guidance from several individuals and colleagues throughout this study, I hereby emphatically declare that any errors (omission and commission), misrepresentations and misinterpretations that may be found in this study are solely mine.

Michael Ablordeppey

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ABBREVIATIONS

ACO	Alliance Compliance Order
BGL	Bogosso Gold Limited
BOG	Bank of Ghana
CGT	Capital Gain Tax
CSR	Corporate Social Responsibility
DSGE	Dynamic Stochastic General Equilibrium
EPA	Environmental Protection Agency
ERP	Economic Reform Program
ETR	Effective Tax Rate
FAO	Food and Agriculture Organization
FDI	Foreign Direct Investment
FOE	Friends of Earth
GAG	Ghana Australian Gold Ltd
GDP	Gross Domestic Product
GFMS	Goldfields Mineral Services Limited
GH	Ghana
GHEITI	Ghana Extractive Industry Transparency Initiative
GoG	Government of Ghana
GRA	Ghana Revenue Authority
IFC	International Finance Corporation
IMF	International Monetary Fund
JCI	Junior Chamber International
MESTI	Ministry of Environment, Science, Technology and Innovation
MoF	Ministry of Finance
MSSP	Mining Sector Support Program

NPV	Net Present Value
OECD	Organization for Economic Cooperation and Development
PAYE	Pay As You Earn
PNDCL	Provisional National Defense Council Law
PV	Present Value
RBM	Reducing Balance Method
SAP	Structural Adjustment Program
UK	United Kingdom
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
US	United States
USGS	United States Geological Survey

CHAPTER ONE

INTRODUCTION

1.0 Background of the study

Mining is simply digging into the crust of the earth to unveil a metal or mineral. According to Down and Stocks (1977), mining is the second most critical sector in the world behind agriculture. Ghana possesses a relatively rich and varied natural resource base – mainly of gold, diamond, bauxite and manganese ore. Recently in December 2010, Ghana began to produce oil in commercial quantities. Since these resources are non-renewable once depleted, monitoring as well as exploration activities are being enhanced to keep track of current extraction as well as to discover new mines. In the early 1990s, the Mining Sector Support Program (MSSP) was executed with donor support from the European Union (EU). This program was to ensure that selected fields were being monitored with geological mapping to generate an up to date data on mining activities in the country.

The historical significance of resource extraction to the growth and development of Ghana is outstanding and well recognized, with the country's colonial name Gold Coast reiterating the vast importance of gold production to the nation (Agbesinyale, 2003; Akabzaa, 2000). Ghana is the second largest producer of gold in Africa behind South Africa and also the third largest African producer of aluminum metal and manganese ore and a major producer of diamond and bauxite (Coakley, 1996). The total share of mineral export to total merchandise export averaged about 40%

from 2005 to 2014. The gold sector however made the greatest input to total export. From 2006 to 2015, gold exports contribution to total mineral exports has been an average of about 96.6%. In the year 2015 however, the mining sub-sector recorded a negative growth of -2.9% due to the intensive electricity rationing and low prices of crude oil and other mineral products.

Ghana boasts two types of gold mines. There are small scale mines which are largely controlled by locals as well as illegal miners known as *galamsey*¹ and there are large scale mines which are controlled mainly by foreign companies. Although small scale mines employ far more than large scale mines, the impact the large scale mines have on the national economy is substantial.

The expenses government incurs on the provision of health, infrastructure and education seem to outweigh the revenue government accrues hence the pressing subject has been how government could commendably and proficiently mobilize revenues using various tax devices. Due to lack of skills and low level of education, large scale mining companies make restricted use of labour from the indigenous towns and communities where they are mostly established (Akabzaa and Darimani, 2001). Gold mining companies employ highly educated and skilled workers who are brought into the rural communities and they do little to help these indigenous areas and propel a secondary economy (Garvin *et al.*, 2009). Taxation therefore remains the most viable way Ghana can benefit from its mineral resources.

World Bank (1988) defines taxation as ‘compulsory, unrequired payments made to the government by individuals, businesses and institutions’. A tax is a financial charge or levy enforced on an individual or legal entity by a state or the functional representative of a state for generation of revenues to support government programs (McLure, 1979, 2015). The tax system in a country is a

¹ *Galamsey (in the local parlance) means gathering and selling*

key index of other major macroeconomic indicators. The level of a country's economic development is strongly linked to its tax base (Hinricks, 1966; Musgrav, 1969). Taxation is an important revenue generation tool available to any nation. A good tax structure would greatly enhance Ghana's ability to generate more revenue from industry, cooperate bodies and individuals.

Optimal taxation theory is that branch of the study of economics where great consideration is given to the structure of the tax so as to result in the least possible deadweight costs or to ensure the best possible outcome is achieved in terms of social welfare. The theory involves the appropriate design and implementation of a tax that reduces inefficiency and distortions in the market under given economic constraints (Slemrod, 1989). A neutral tax according to Rothbard (1970), is a theoretical tax which circumvents distortion and inefficiency absolutely. Economists usually argue that taxes distort behavior in that, all other things being equal, for instance a tax payer, given between two mutually exclusive projects with same pre-tax risks and returns to choose from, would most rationally opt for the one with the lower or one with a tax exemption (Simkovic, 2015).

During the post-independence era prior to the Structural Adjustment Programme (SAP) particularly between 1957 and 1983, Ghana went through a nationalization campaign and many mines converted to state-owned. Thus, the mineral sector experienced a number of production, technical and financial limitations which come with many state-owned enterprises and institutions. Output in the sector went down and the state-owned companies became internationally less competitive (Akabzaa and Darimani, 2001; Aryee, 2001; Dumett, 1998; Sweeting and Clark, 2000).

A host of reasons necessitated the World Bank and the International Monetary Fund (IMF) funded Structural Adjustment Program beginning 1983. These included major economic shocks related to the El-Nino weather phenomenon and the sharply increased world market prices for crude oil after

the October 1973 Arab-Israeli war which led to the Arab oil embargo among others (Anaman, 2006).

Toye (1994), showed that, growth of real GDP fell from 6.4% in 1965-1973 to 3.2 % in 1973-1980, and further declined to 0.7% in 1982. It reached a record low of 0.2% in 1983, and was complemented by declines in average income per capita, formal sector employment, and per-capita food consumption (Hilson, 2004). By the 1980s, some sub-Saharan African countries were on the brink of economic breakdown (Konadu-Agyemang, 2001). In Ghana, a socially destructive inflation averaging 50% per year during 1976-1981 impoverished and demoralized the populace and the civil service (Kraus, 1991). Ghana was described by *The Economist* (a journal) at the time as “an extreme case even in Africa”.

The military coup by Flight Lieutenant Jerry Rawlings on 31st December, 1981 coupled with the drought in 1982/3 which led to water shortages in the Akosombo Dam bringing about power rationing and stifling of business and industry compounded the problem. The drought brought with it massive food shortages. Other economic shocks in the early 1980s included large repatriation of Ghanaians from Nigeria which was in response to the Alliance Compliance Order (ACO) of November 1969 enacted by the government of Dr. K. A. Busia which immediately led to increased population of Ghana (Aremu and Ajayi, 2014).

Ghana was thus the first sub-Saharan African nation to go through Structural Adjustments as a result of these economic and external shocks. The standard IMF structural adjustment reform package known as the Economic Recovery Program (ERP) as announced by the government of Ghana included maxi-devaluation, fiscal austerity measures, tight monetary controls and liberalization of trade (Kraev, 2004). The policy reforms came with them large financial inflows mostly from multilateral and bilateral financiers (Bird, 1996). During the program, the government

aimed at diligently improving the investment climate by encouraging more foreign investments which was viewed as the panacea for revitalizing the economy.

The mining industry featured prominently in the program's planning. Hilson (2005) observed that, there had been considerable improvements in the mineral sector since the inception of the policy reform making the sector more attractive to foreign investors. The country saw increases in the outputs of various mineral resources. Although large gains were chalked, literature shows that the associated growth have been detrimental to indigenous communities with these communities not gaining any real improvements in economic welfare.

Specifically, perpetual expansion of mining and exploration activities have displaced several local settings as well as destroying the culture of the indigenous people (Hilson, 2005). Also, the environmental effects of mining have been extensive with excessive land degradation and contamination and chemical pollution of water bodies. Research has established that the increase in mineral output has largely benefited multinationals the most and little has gone to the local communities.

During the 1960s, Ghana had acquired all equity stocks of mines on the brink of close down and had subsequently established Ghana State Mining Corporation and obtained shares in the largest gold mine at the time (Appiah, 2013). By 1981, all mines with the exception of those based in Obuasi and Konongo had been state-owned although these mines were nationalized in later years (Hilson, 2002). The government however unable to revive these mines began to explore other options under the auspices of the Brenton Wood Institutions, for privatizing existing large-scale mine operations and developing schemes to promote mineral exploration. The mining sector reforms that came with the SAP brought about increase economic growth in Ghana but as

explained earlier, these came at substantial environmental costs and other costs borne by the mining communities.

Prior to the IMF and World Bank intervention, the mineral economy of sub-Saharan Africa was characterized by relatively large state controls. Foreign investors were viewed with suspicion (Morgan-Foster, 2002). Bretton Wood officials pushed for the passage of legislation barring governments from directly involving themselves in large-scale mining ventures (Coakley, 2001). Eventually, state-owned mining enterprises and national assets were heavily privatized and sold to foreign investors. In 1983, there were about 235 state-owned enterprises in Ghana of which the government had a direct majority holding in 181 (Donkor, 1997). A central aim of the SAP was to privatize many of these companies, which the policy administrators of the nation believed would stimulate economic growth.

Critics of the SAP are of the view that, despite the macroeconomic achievements as a result of the reforms, the relatively large underprivileged and marginalized have been hit negatively (Banchirigah, 2006; Hilson and Potter, 2005; Hilson, 2004). Dordunoo and Sackey (1997), Panford (1997), Weissman (1990) also explain that, in the Ashanti Region the elite minority of cocoa farmers had increased incomes with a whopping majority of farmers still receiving very low incomes. Again, the researchers explain that, about 82% of households who were into cocoa farming had reduced revenues after the initiation of the program in the 1990s. Further, about 80,000 jobs were lost at the grassroots because of organizational changes that were implemented in the resource sector.

The mineral economy of the developing world was opened up to foreign investors and this coupled with other specific sectoral adjustments helped many Sub-Saharan African countries including Ghana to revive their economies through increasing growth. Critics again suggest that the benefits

from the reform were to say the least short-lived. Campbell (2003) expounds that international organizations presently operational in sub-Saharan African countries were enticed by inducements that included reduced royalty rates, tax exclusions and grants to maintain a large share of their foreign exchange proceeds in foreign accounts at the detriment of developing nations.

The launch of the ERP coincided with actions undertaken to build a more conducive investment atmosphere in the country's resource sector which necessitated a thorough evaluation and modification of some 78 acts, ordinances, decrees, codes and laws regulating the sector (Hilson, 2004). In order to address this challenge, the government first appointed the Committee on Gold Mining to identify the reasons behind the decline in national production. The committee made the following recommendations as elucidated by Tsikata, 1997 and Addy, 1998.

1. To establish an investment code and create a favorable investment climate in the country;
2. To review existing mineral laws to make it less stressful for prospective investors to acquire mineral franchises to explore and extract gold for up to 30 years;
3. To review taxation laws to make the taxes payable by companies comparable to those in other gold producing countries;
4. To review the remittance quota for expatriates in the industry to allow them at least 40% of net salary after tax; and
5. To legalize small-scale mining.

These recommendations served as the basis of a strategy aimed at revitalizing the mining sector and incorporated within the context of the ERP with accompanying financial support from the program used to fund each of the recommendations (Tsikata, 1997).

This study concentrates on the gold sector mainly because, it contributes over 95% to total mineral revenue. In 2014 and 2015, total gold revenue was over 97% of total mineral revenue (The Ghana Chamber of Mines, 2016).

1.1 Research Problem

The negative externalities that mining gold in Ghana brings about has often been underestimated (Schueler, *et al.*, 2011). The social and environmental costs of mining to Ghana have not been valued and often ignored in the formation of a tax policy. Agriculture and mining (including oil and gas) are the most important contributors to human development. These key sectors must be harnessed properly to ensure sustainable development. Surface mining however, continues to destroy the agriculture potential of the country because some mineral deposits are situated in areas with rich natural environments (fertile forest lands with water resources usually easily available) which will require a trade off between the rich natural environment and the mineral resource (Akpalu and Parks, 2007).

Climate change is a major concern of the world today. Deforestation significantly reduces the sequestration of carbon dioxide in the atmosphere increasing the amount of greenhouse gases in the environment. Reforestation and restoration of forest lands help the course to fight against climate change (Silver *et al.*, 2000). The extension of the United Nations Framework Convention on Climate Change (UNFCCC), the Kyoto Protocol of which Ghana is a signatory aims at improving capacity to control the emissions of anthropogenic greenhouse gases. Immense destruction of forest regions in Ghana for mining reduces the capacity of the nation to reduce greenhouse gases.

If the goals of the Kyoto Protocol are to be met, it requires that developing countries especially should adopt more stringent measures to reduce the emissions of harmful gases (Houghton, 2005). In studying the optimal royalty tax for mining tax policy formulation, the tax should be viewed as a corrective measure to at least reduce the destruction levels of the land (Bohm, 1997). Thus, the more the land is destroyed the higher the taxes paid for the destruction.

Data from the Ghana Statistical Service (GSS) shows that since 1990, the sector has contributed less than 5% of (Gross Domestic Product (GDP) although the sector receives a chunk (more than half) of the Foreign Direct Investment flows (FDI) The sector also generates more than one-third of all export revenues and is the largest tax paying sector and makes a significant contribution to GDP and employment (The Ghana Chamber of Mines, 2015). The mining and quarrying sector also recently (2014) contributed about 6% to GDP.

In another light, Ghana, given its rich haven of sub-soil resources is still faced with the problem of borrowing to finance her developmental projects. In the political arena for instance, there has been increasing debate about the rising debt of the nation with some describing the nation as a High Debt Distress country. Government debt to GDP continues to increase and in December 2014, the ratio hit the 70% threshold although it reduced to 69.12% in September 2015 (Ministry of Finance, MoF, 2015). Government raises monies through taxation and mineral exports. For instance, the percentage share of mineral exports to total merchandise exports increased from 27.8% in 1883 to about 42% in the year 2012 and thus, mineral exports are the main foreign exchange earners to the government of Ghana (Twerefou *et al.*, 2015).

Mining taxation is a key way by which government is able to maximize its revenue. The debt situation is worrying and rather than aggravating the situation, Ghana's policy makers should look at how they can more efficiently generate more from the nation's resources. In 2014 for instance,

the minerals and mining sub sector contributed 1.24 billion Ghana Cedis (GHC) representing 16.2% of total direct tax although in 2013 its share to total direct tax was 18.7% (Ghana Revenue Authority, 2015). Given the mineral contribution to the economy, the rising debt of the nation can be curtailed if the mineral sector is well placed to benefit the country the more.

Unfortunately the mining industry has few linkages with other segments of the Ghanaian economy. Thus, the multiplier benefit of minerals is accrued outside the country in light that processing of mineral output is not done internally (Mines and Communities, 2003). The country has little or nothing to show for the free gift that nature has presented although these gifts are increasingly diminishing (Aryee, 2001).

This study extensively concentrates on the gold sector. Gold alone has over the years contributed over 90% of the total mineral revenue to government. Again, the gold sector contributed over 30% of all merchandise exports which was higher than for crude oil (19%) and cocoa beans (17.3%) in 2015 (MoF, 2016). The importance of this precious metal to the Ghanaian economy cannot be overstated. Again, for the purpose of this research, optimal taxation or tax represents the optimal royalty taxation or tax.

This leads to the main questions this research hopes to answer;

1. What has been the tax reforms in the mining sector?
2. What is the optimal royalty tax for gold?
3. What is the optimal path of the optimal royalty tax?
4. What are the lessons to help policy makers of Ghana?

1.2 Objectives of the Study

McMahon and Berrios (1991) indicate that optimal taxation issues arise from the inability of the current tax structure as a tool to achieve the tax objective of revenue mobilization. A good tax system must achieve the objectives of revenue adequacy, economic efficiency, equity and simplicity. In ensuring an optimal tax as a corrective measure for economic inefficiencies, the relationship between the optimal tax rate and key variables in the resource sector is determined and explained. This is done basically using dynamic optimization modelling to optimize an expression for the royalty tax and then assessing the relationship with key economic variables using comparative static analysis.

In ensuring reduced forest destruction the study aims at modeling the objective functions of both the government and the mining firm and including forest destruction into the model. Thus for an optimal position to be reached, both the miner and the government will be satisfied with both the resource output and revenue on one hand and the reduced destruction of the forest on the other hand.

The main concern of this study however is to determine the nature of an optimal royalty tax that is the path of the optimal royalty tax. An optimal royal tax would enhance Ghana's benefit in the resource sector. Consequently, this study furnishes policy makers with information on how this optimal royalty tax should look like. Simulation results are carried out to determine what happens to the path of the optimal royalty tax if the key parameters change.

This optimal royalty tax would also help reduce unnecessary distortions and inefficiencies that crowd the mining sector. Also, looking at the relationship between the possible optimal royalty tax rate and other key economic variables and outlining possible reasons for their relationships can

enhance the quality of the tax system in ensuring revenue mobilization. With this, the revenue that would be mobilized in the long run period would be colossal and would help government with the funds it needs to supplement its budget to support its development and stabilization activities.

This study identifies the reforms of the mining sector from the 1980's Economic Recovery Program (ERP) and discusses them in relation to the new mining codes that came up as a result of the program. Prior to the 1980s, Ghana was plagued with serious economic challenges and the government had to enter into a recovery program with the IMF. This program brought about several reforms in the mining sector which led to substantial improvements in the sector. This study hence discusses some of these reforms as per the Ghana Minerals and Mining Act, 2006.

The overall objective of the study therefore is to simulate the optimal royalty tax of the gold sector and the specific objectives are to assess the tax reforms of the mining sector and to estimate the historical optimal royalty tax for the gold sector.

1.3 Justification of the Study

Environmental issues are a burden to both the developed and the developing world. All individuals are affected one way or the other be it through global warming, food insecurity, loss of culture and others when the forest is destroyed (Silver *et al.*, 2000; Fearnside, 2005). This study is significant firstly because it considers a key environmental issue in its modeling of an optimal royalty tax structure, the destruction of forest and the benefits that are lost. Such a tax policy will compensate the nation for the loss of its forests due to mining activities. Therefore, the optimal royalty tax structure will curtail the destruction of forests if not however, it will ensure that enough revenue is generated to compensate the nation for the loss of forest resources and their numerous benefits.

Based on the sustainability theory developed by Solow (1986), this generation must aim at providing productive capacities for the future generation to explore and benefit from since the non-renewable resources available to this generation will not be available in the future in large quantities. With an optimal royalty tax, government will be able to better enhance the living conditions and standards over time. In ensuring sustainable development, the environment is a key component that cannot be overlooked (Giddings *et al.*, 2002; Smit and Pilifosova, 2003 and Hopwood *et al.*, 2005). This study importantly includes the destruction of the environment (forest) in the analysis and so to some extent it is in line with sustainable development theories.

Taxation, especially in the gold sector, has been immensely beneficial to the revenue mobilization activities of the government of Ghana (Aryee, 2001). An optimal royalty tax is important for optimal exploration of mineral resources, maximizing of rents accruing from mining activities, maintaining high environmental standards and concurrently providing enough incentives for reinvesting of mineral profits from mining activities (Sarma, and Naresh, 2001). In consequence, this study provides invaluable insight to mining fiscal policy makers on important factors to consider in drawing a tax policy for the mining sector of Ghana to enhance mining tax revenue while also encouraging investment and also maintaining the physical environment.

Palmer *et al.*, (2010) point out that, the damage to the ecosystem and the growing threat to the very lives of humans and the lack of proper extenuation tools as a result of mining activities immediately requires improved and more vigorous legislations in the sector. This study will thus support a quest for an improved legislation in the mining sector by providing policy makers a good foundation for such a legislation.

Several recommendations for further studies are made at the end of this research. These recommendations can benefit the nation and the world at large if these recommended studies are

carried out. This study adds up to the literature on optimal taxation in the mining sector which has limited number of empirical studies.

1.6 Organization of the Study.

This study is carried out in six chapters carefully laid out in the following manner.

Chapter one clearly presents an introduction to the study and gives a background of mining in Ghana and then highlights the ERP of the 1980s. It states the problem and the questions that the research aims to answer. Chapter two presents an overview of the study which gives a synopsis of mining activities in Ghana as well as the various taxes that exist in the sector. It also among others highlights the revenue performance, investment, and output of mining in Ghana. Chapter three provides an analysis of the theoretical and empirical literature on the concept of optimal taxation, revenue mobilization and other related concepts. The methodology adopted by the study is presented in Chapter four and it looks at the theoretical and the analytical framework using mathematical modelling. Chapter five describes the analysis of the data and interpretations of the estimations and findings. A summary of the whole study and the recommendations for policy are presented in the concluding chapter, Chapter 6.

CHAPTER TWO

OVERVIEW OF THE MINING SECTOR IN GHANA

2.0 Introduction

In the overview of this study, important issues pertaining to the mining sector of Ghana are discussed. Some of the reforms of the tax system as a result of the ERP are highlighted, paying special emphasis to taxes in the mineral sector. Lastly, Foreign Direct Inflows (FDIs), output, revenue, exports from the mining sector are examined.

2.1 Mining in Ghana

Surface mining brings about major destruction of the forest and its benefits (both timber and non-timber benefits). Many indigenous people in the country rely on the forest for food such as palm fruit, coconut, snails, game and other wild foods. Forests serve the nation with bamboo sticks used for building, clothes especially for the indigenes, musical instruments and the like as well as providing a source of recreation for tourism purposes. This and many other benefits both economic and social of forests are lost through surface mining of Ghana's gold resource.

Thus, the major way the mining sector can benefit Ghana as a nation will be through the revenue that government is able to mobilize from the taxes it collects from the sector. The country can also benefit when these firms fulfill their corporate social responsibilities (CSR) such as building of infrastructure like roads, schools, health centers and others. But this is at the discretion of a mining

firm and the social planner cannot influence such social responsibilities. The revenue from the tax can however be adjusted to meet the objectives of the social planner which is mainly increasing revenue which an optimal royalty tax will achieve especially in the long-run.

Small scale mining as well as open pit mining brings about major damages to rainforests with private agents being the major cause of this damage (Contreras-Hermosilla, 2000). As a consequence these private owned firms may not act in the best interest of the environment once profit making is their major motive. The government of Ghana (GoG) will need to adopt stricter environmental policies through the Environmental Protection Agency (EPA) and the Ministry of Environment, Science, Technology and Innovation (MESTI) to monitor activities of these miners. Creating of pathways in the forest to mineral deposits also leads to the destruction of the forest. Again, social planners must infuse the cost of the loss of the forest in the setting up of a tax policy.

Ghana falls within the Precambrian rock shield of West Africa that traditionally hosts most of the mineral resources of the continent. The standard United Nations' (UN) definition of a resource economy is that country gaining at least 10% of its GDP from mining and at least 40% of its foreign exchange earnings from the export of minerals (United Nations, 1998). Ghana's mineral sector contributed about 6% to GDP in 2014 and 34% to total merchandise exports (Ghana Chamber of Mines, 2015).

The resource sector of the country was however able to account for not less than 40% of gross foreign exchange proceeds and among others contributed some 5.7% to GDP in the late 90s (Aryee, 2001). For four decades prior to the 1980s, no new mine was setup in the country because of numerous challenges encountered by investors and prospective investors as a result of the complexities in the many economic, financial, institutional and legal structure that the sector finds itself in (Aryee, 2001; Addy, 1998).

2.2 Mining sector reforms

In the early 1980s, as part of the structural adjustment program, the mineral sector benefited from large monetary and technical support from the World Bank, the IMF, and governments of major intermediate mining companies. Ashanti Goldfields, for instance which then had 55% Ghanaian share, received in the region of US\$260 million financed by a consortium of banks led by the IFC during the periods 1985 to 1995 (Hilson, 2005).

The ERP in the 1980s led to tremendous growth of the mining sector (Aryee, 2001; Aryee and Aboagye, 1997). The aim of the government was to encourage investment into export potential sectors to help revamp the stagnant Ghanaian economy with the ERP. As a result of this, over the period, 1983-1998, there was about US\$4 billion private capital injection into the sector for new mine exploration, formation of new mines, and the enlargement and recuperation of dwindling mines (Aryee, 2001).

The program included the introduction of open pit mining and also the introduction of bulk cyanide heap leaching operations and the provision of pollution abating technology including the installation of biooxidation plant for the treatment of sulphide rich gold ore (Bempah *et al.*, 2013). 237 companies were exploring for gold while 23 of them earned mining leases as at 1998 (Minerals Commission, 1999). Also related to the 7 mines that were in operation at the start of the programme, 14 mines were in operation at the close of the year 1998 (Aryee, 2001).

Gold Fields Ltd of South Africa held a whopping 71.1% stake in the Tarkwa and the Damang gold mines in a joint venture with Toronto-based IAMGOLD Corp (18.9%) and the Government of Ghana (10%) (US Securities and Exchange Commission, 2005 and Bermudez-Lugo, 2012). AngloGold Ashanti Ltd also of South Africa ran the Bibiani and the Iduapriem open pit gold mines

and the Obuasi underground gold mine. The Obuasi and the Bibiani mines were completely possessed by AngloGold Ashanti and the Iduapriem mine was about 80% owned by AngloGold Ashanti and about 20% by the International Finance Corporation (AngloGold Ashanti, 2006).

Golden Star Resources Ltd boasted a share of 90% in the Bogoso Prestea mine as well as the Wassa open pit mines and a 90% share in the idled Prestea underground mine (Hilson & Yakovleva, 2007). Newmont Mining Corporation of the United States (US) held the entire share of the Ahafo gold property and an 85% stake in the Akyem gold property. Ghana currently boasts of 10 registered large-scale mineral firms engaged in commercial production of gold, bauxite, diamond and manganese, with 5 companies engaged in exploration activities and 4 companies engaged in contract mining activities (The Ghana Chamber of Mines, 2016).

The under listed are major mining companies which are members of the Ghana Chamber of Mines as listed by the Ghana Chamber of Mines

- a. Adamus Resources Limited
- b. AngloGold Ashanti Iduapriem Limited
- c. AngloGold Ashanti Limited, Obuasi mine
- d. Chirano Gold Mines
- e. Ghana Manganese Company Limited
- f. Goldfields Ghana Limited, Tarkwa
- g. Goldfields Ghana Limited, Damang
- h. Golden Star Bogoso/Prestea Limited
- i. Golden Star Wassa Limited
- j. Newmont Ghana Gold Limited, Ahafo Mine

- k. Newmont Golden Ridge Limited, Akyem Mine
- l. Perseus Mining (Ghana) Limited
- m. Precious Mineral Marketing Company (Gold and Diamond)
- n. Asanko Gold Ghana Limited

Companies which are into the exploration of gold in Ghana include, Azumah Resources Ltd., Birim Goldfields Ltd., Mensin Gold Bibiani Ltd. and Pelangio Ahafo.

The question however remains, have these investments translated into massive wealth for the nation? What has been the effects of these investments on employment in the country? Awudi, (2002) in one of his studies writes; “The massive investment has not been translated into significant increase in employment. Labor-intensive underground gold mines have been replaced by surface mining, which is capital intensive and employs relatively few people. As a result of the high level of skill required in these large scale capital intensive mines, the labor required will have to display a certain level of skill to meet such standards”.

The benefits that mining investments have had on the national economy have come at great environmental, health and social cost to many local communities which has led to a public outcry against the mining companies in the country (Hilson and Nyame, 2006). Numerous communities have been displaced as a result of expansion of mining activities. Hilson and Nyame (2006) further assert that, the mining companies perform poorly on the social and ecological front.

When the forest is destroyed, the shelter belts of rivers are lost and endangered species of animals are also threatened the more. For instance, mining activities at Supuma forest, Opon Mansi Forest, Tano Suraw and Ajenjua forest reserve threaten the life of the Rivers Pra, Afosu, Adenkyesesu,

Akrawasu, Tano, Kyinso, Opon and others as well as 3 monkey species (Hilson and Nyame, 2006). Garvin, *et al.* (2009) indicate that the negative impacts of mining around the world to the environment have become serious.

In light of these, whether or not the sector is the beacon of hope for the Ghanaian economy remains to be seen in respect of the environmental implications that come with mining of minerals. An environmental organization in Ghana, Friends of the Earth-Ghana (FOE-Ghana) has challenged the mining sector as the holder of the key to a sustainable Ghanaian economy and have claimed that the sector is only providing short-term gains but long-term destructive impacts on the ecosystem.

2.2.1 Mining Sector Regulatory Framework

In response to the cry of investors with respect to the regulation of the mining sector by pieces of legislative and cumbersome procedures not to talk of concerns by the international world in revitalizing the industry, a number of new legislative instruments were promulgated and passed starting in 1983 (Twerefou *et al.*, 2007).

The mining industry was privy to priority consideration unsurpassed by any other sector of the economy under the Economic Reform Program (Akabzaa and Darimani, 2001). Specific sector policy reforms were put in place to enhance investor confidence in the mineral sector. A new Mineral and Mining Law (Provisional National Defense Council Law, PNDCL 153) of 1986 entrusts all the mineral resources of the nation be it in, under or upon ground in Ghana, rivers, streams water courses across the length and breadth of the country, the exclusive economic zone or an area covered by the territorial sea to the President who holds them on behalf of the citizens

of the country. In 1985, there was an Additional Profit tax law (PNDCL 122) and in 1987 there was a Minerals (Royalties) Regulation (LI 1349).

Another law, Small Scale Mining Law (PNDCL 218) was enacted in 1989 in order to give legal backing to small-scale artisanal mining in the country. Again, another legislation recognized and gave power to the Minerals Commission as an overseeing institution to monitor and enhance mining sector investment (Campbell, 2009). These laws carried with them numerous tax enticements for foreign investors including tax breaks, flexible labor policy, unregulated repatriation of profits and cheap transfers of assets.

A program was put in place to develop the mining sector and support institutions. This was aimed primarily to:

- Improve the ability of the sector institutions to empower them to better regulate investment in an environmentally welcoming method.
- Develop tools to provide productivity and financial viability and
- Institute measures to reduce the environmental impacts of small scale mining operations (Minerals Commission, 1995).

To regulate the activities of the mining firms, other legislative instruments such as PNDCL 219 – Precious Minerals Marketing Corporation law, 1989, PNDCL 154 – Minerals Commission Act, 1986, L.I 1652 – Environmental Assessment Regulation Act, 1994 were introduced (Appiah, 2013).

Corporate income tax on profit of the firm was for instance reduced to 45% in 1987 from the initial 55% and further to 35% in 1994 where as royalty rate, which stood at between 6% of total value of mineral won in 1975, came down to between 3-12% in 1987 and to between 3-6% with the

amendment of the Act 703 in 2006. Other duties like the Mineral duty 5%, import duty and Foreign Exchange Tax that stood at between 33-75% and added immensely to government revenue until the inception of the reform were removed.

Again, companies in the sector were excused from the payment of customs import duties on plant, machinery and equipment used in extractive activities. Their employees were also excused from the payment of income tax related to supplied accommodation at the mine site. An additional profit tax to capture windfall profits in times where there were mineral price hikes introduced in 1986 was scrapped in 2006.

In the PNDCL 153 1986, the depreciation allowance which was previously 20% in the first year of investment and 15% for successive years was increased to 75% in the first year and 50% in successive years. This was again revised upwards to 80% for the first year and 50% for successive years in the requirements of the Internal Revenue Act (Act 592) of 2000 (Minerals and Mining Acts, 2006). Again, government equity participation which was between 55-100% in 1975 and 1981 saw a reduction to 10% in 1986 and the same was maintained in the 2006 Mining Act.

Besides these, a holder of a mining lease may be permitted by the Bank of Ghana (BoG) to retain a minimum of 25% of the operator's foreign exchange earnings in an external account in order to be able to acquire equipment, spare parts, and other necessary mining materials and for the payment of dividends as well as remittance especially with the case of goods for expatriate personnel, and others (Campbell, 2003). The state-owned gold mining companies as well as the mineral sector were privatized (Awudi, 2002). These and more incentives attracted significant FDI especially with the gold sector which has brought in the highest investment.

2.3 Taxation

Taxes constitute the mainstay of Ghana's domestic revenue yet the country which is endowed with extractive resources which have attracted substantial Direct Investment has not succeeded in mobilizing substantial tax revenue from the extractive resources sector (Akabzaa, 2009). The quantum of revenue that Ghana can exact from the mining sector will be dependent on institutional and policy efficiencies. Fiscal regimes define the quantum of taxes and tax incentives for the mining sector (Appiah, 2013).

A tax which is from the Latin word *taxo* is a fiscal charge or levy enacted upon a taxpayer (an individual or entity) by a state or its financial representative to enable the state with these resources undertake its mandate of governance (McLure, 1979). Failure to fulfill tax obligations, or evasion of or resistance to taxation is illegal and punishable by law. Taxes are also levied by many administrative divisions. A few countries like Brunei, Darussalam, Saudi Arabia and United Arab Emirates impose no taxes at all. In assessing the economic viability of a project, tax constitutes a key cost and hence, issues with respect to tax obligations and incentives are critical during negotiations (Artist, 2009).

The main taxes that apply to the extractive sector in Ghana include, the Royalty tax, the corporate profit tax, the Dividend to government, the Withholding tax, the Windfall profit tax, the Pay-As-You-Earn, Ground rents and the Capital Gains tax. In the next section these taxes are discussed.

2.3.1 Mineral Royalties

A mineral royalty is a payment to the holder of resource right for the privilege of extracting the mineral from the ground based on a lease agreement. It is a payment to the owner of a resource for

the right to use their property. The payment of this royalty is dependent on a percentage of earnings from the extraction and may vary depending on the mineral type and the conditions prevailing in the market.

This tax is levied on the basis of Article 25 of the Minerals and Mining Act, 2006 which points out that; “A holder of a mining lease, restricted mining lease or small scale mining license shall pay royalty that may be prescribed in respect of minerals obtained from its mining operations to the Republic, except that the rate of royalty shall not be more than 6% or less than 3% of the total revenue of minerals obtained by the holder”. The percentage used (3-6%) depends on how profitable the holder is in the extraction. In 2004, all the mining companies paid a royalty rate of 3%. Currently, the royalty rate is set at a fixed rate of 5% of gross revenue. However, mining companies who have a stability agreement with the government pay between 3-5% of gross revenue.

2.3.2 Corporate income tax

Corporate income tax is the income of a company which is subject to tax. Generally this tax is levied based on the net profit of the company. In 2001, the rate was 32.5% and declined to 25% in 2006. As of 2010, mineral companies listed on the Ghana Stock Exchange paid on their chargeable income a rate of 22% while those that were not listed paid 25%. In addition, the government in 2010 introduced a uniform regime for capital allowance for five years at a rate of 20% for all mining companies.

Based on MoF (2012), there was a provision where losses that have been made with regards to a mining site will no longer be balanced by profits amassed from another mining site that belongs

to the same firm when the corporate income tax is being determined as it was the case previously. This restriction is known as “ring fencing”. The government thus suggested an increase in the corporate income tax rate from 25% to 35%. Thus, corporate profit tax currently charged is 35% of profit of the mining firm.

2.3.3 Windfall or Additional Profit tax

A windfall profit tax is a tax levied by governments that enable them to take advantage of abnormal or extra profits raked in by companies as a result of improvements in the economic environment. These allow governments to charge rent on windfall profits made by mining companies as a result of high international mineral prices or the discovery of high quality mineral deposits. The additional profit tax provision in the Mining code of 1986 was scrapped in the 2006 code. In the 2012 budget statement of MoF, government introduced a 10% windfall profit tax to take advantage of excess profit of mining companies but there has been some difficulty with regards to implementing this tax because the main players which is the mining companies have not accepted to pay this tax.

With this tax, Ghana could have raised huge revenues from the mining sector as the world market prices of some of these mineral resources like gold increased consistently in the 2000s.

2.3.4 Withholding tax

A withholding tax is an obligation by government for the payer of an item of income to reserve or subtract tax from the payment and pay that tax to the government. In many set ups, withholding

tax applies to employment income (Osumanu, 2016). Many other institutions also require withholding tax on payments of interest or dividends to shareholders.

This tax is levied usually on non-taxpayers in a given set up and payments are made directly by the mineral organization to the fiscal authorities or government representative. The tax law specifies a percentage between 8 and 15 of withholding tax on dividends that are paid to shareholders, fees for hired consultants as well as on loan interests.

2.3.5 Pay-As-You-Earn (PAYE)

PAYE is a system of withholding income tax from payments that are due workers. Under this tax system, the mineral company deducts the tax at source on the taxable income of the employee and pays it to the Ghana Revenue Authority (GRA) before the 15th day of the month after the month in which the deduction was made (PriceWaterHouse Coopers, 2015).

This tax is not exclusive to mining. It is also an important source of government funds from the mineral industry since employees in this sector earn a relatively higher amount of income. As part of Ghana's very generous mining agreements, expatriates are exempt from this tax thus Ghanaian employees in this sector are the main contributors to this and based on their level of income, the rate charged ranges from between 0% to 25%.

2.3.6 Capital Gains Tax

A capital gains tax (CGT) is a tax on gains from the sale of capital. Thus, the profit accrued from the disposing of this non-inventory stock which was acquired at a cost lower than the returns from the sale is taxed. Common to this type of tax includes profits on stocks, bonds, precious metals and property. Capital gains tax is payable at the rate of 15% from the realization of a chargeable asset owned by a person (PriceWaterHouse Coopers, 2015). They apply to mining plants and equipment as well as mineral properties that have been sold above their stipulated book value.

2.3.7 Ground Rent

These are payments made by mining companies and other institutions as a result of their operations on stool lands. Payments are made to the district offices administration of stool lands and then sent to the regional offices for distributions to the related communities. Currently, the rate for ground rent is set at GH¢15 per acre. Before the review which was in 2014, the rate was set at GH¢0.50 per km².

2.4 Fiscal Regime and Commercial Regulation

The government of Ghana is entitled to a 10% free stake in any mining activity in the country with an option for an added 20% share at a fair price. A resource lease bearer is also mandated to pay an annual rent based on prescriptions in the legislations (law). Taxes in the sector may be reduced as a result of the enlisted capital allowance privileges;

1. 75% depreciation in the first year of the life of the investment and 50% in succeeding years using the reducing balance method (RBM).
2. An Investment allowance of 5% in the initial year only
3. Losses for a financial year that does not exceed the value of capital replacement for that year can be carried forward into another year. All pre-production expenses that have received approval from the fiscal authorities at the beginning of the development of the mine can be capitalized.

The bearer of a mining lease may also be liable to the following privileges;

1. Staff of foreign origin are exempted from the payment of income tax in respect of accommodation of the mine;
2. Expatriate workers benefit from immigration quota hence are immune to any tax from the government when they want to transfer foreign currency out of the country;
3. The bearer of the lease is also exempt from the selective alien employment under the selective alien employment decree.

There have been some other additions to the nation's commercial law and according to the Ghana's Minerals and Mining Act 2006, Act 703, these additions include;

1. In line with the provision for tax relief under the regulated amortization provision, expenses on exploration and development may be capitalized;
2. A percentage of revenue can be retained in a foreign account which would be used in the acquisition of the needed equipment and plant in addition to spare parts for the smooth operation of the mine; and
3. The lease holder also has immunity from import duties on imported plant and equipment.

2.5 Foreign Direct Investment

An important factor that determines investment decision of a mine is the geological prospect of a site, but this is countered by the fiscal and socio-political environment which includes the tax rates, the stability of the tax system and the political economy that is at play (Mitchell, 2009). According to the Ghana Chamber of Mines, relatively new mining exploration into the country has declined drastically over the years. Among the factors accounting for this is the overburdened pre-exploration taxes that these mining companies have to pay.

According to Tsikata (1997), the country was positioned as the third most attractive for mining investment in Africa behind Botswana and Zimbabwe. This was largely due to the country's very rich geological data and a conducive investment environment. The decade after the ERP showed the keen interest investors had in the mining and resource sector. The development of mining up to the late 1990s intensified investor confidence in the sector as compared to other major economic sectors (Aryee, 2001).

In order to sustain the growth and the output levels in the mining sector, there is no doubt that there is the need to create an enabling environment for investment. It is therefore eminent that, to sustain the nation's mining industry, the country needs a pipeline of investments in exploration, development and production. There is competition for the limited investors in other African countries. To continue to remain competitive to attract investors in the sector, it is necessary that Ghana repositions the mining sector not least the gold sector to be able to maintain its enviable position as second on the continent.

Between the mid-1980s and 2005, investment into the mining sector totaled more than US\$5 billion with an average inflow of over US\$200 million per year. The non-mining sector recorded

accumulated net flows of a little over US\$1.6 billion between 1980 and 2005 (Appiah, 2013). Again, over the period between 1995 and 2012, total percentage share of investment in the mineral sector was 33% (Twerefou, *et al.*, 2015). Prior to the discovery of oil at the Cape 3 point in the Western Region of Ghana, Investment in the mining sector per total share was about 40% annually. Despite Ghana having a somewhat sound economic and business environment, the major issues that currently hunt down the mining sector are economic and the most serious is the government's fiscal policy (KPMG, 2012). In order to address the budget deficit in 2012, the government increased taxes and reduced subsidies thereby increasing the cost of doing business. This coupled with pressures on the wage front as well as high inflation rate would make investment in the sector more costly.

Indeed many international companies own these mines and exploration activities are usually carried out by their junior partners, mostly from Canada, Australia and South Africa with other coming from the US, UK, China and Norway. Exploration licenses have been issued to many local and foreign firms numbering to the tune of over 230 mainly for exploration of gold. Leading among these companies include BHP Minerals, Golden Star Resources, International Gold Resources, Gencor, Cluff Mining, Ashanti Exploration, Resolute, Anglo-American, Kenor and JCI (Awudi, 2002). Cumulatively, investment inflow into the mining sector from 2000 to 2010 stood at approximately USD 6.4 billion (Appiah, 2013).

Foreign multinational companies coming from a wide range of national settings which include Australia, Canada, South Africa, The UK and The US bear ownership to Ghana's mines and control about 70% of the shares with the government of Ghana holding a meagre 10% free stake in each mine. Also, some of the mineral firms in the country have their investments endorsed, guaranteed and secured by the World Bank (Awudi, 2002). For example, the IFC has provided

funds for companies engaged in large-scale mining among others, Ashanti Goldfields Company expansion, Bogosso Gold Limited (BGL) and Ghana Australian Gold Ltd. (GAG).

Despite the huge investments in the mining sector especially within the periods after the economic reform, the sector contributed less than 2% to GDP in the 1990s in the same period that the agriculture sector was contributing over 30% to GDP (Awudi, 2002). The gold that is exported is in its raw form thus the country does not benefit from the value added and employment increases. The lack of linkages in the mining sector is the main reason for the inability of the sector to contribute immensely to the nation's development.

Mining operations in Ghana has numerous implications for both the external and the real sectors of the economy. But the main macroeconomic impact is through the fiscal channel. In more developed economies, there are usually sound structural links because there exists opportunities for the local industry to provide inputs into mineral projects for their own production of output. In Ghana however, there exists no such linkages. There exists little or no direct economic association between the resource sector and other sectors of the Ghanaian economy (Awudi, 2002).

2.6 Mineral Output

Ghana has featured in the top ten producers of gold in the world since 2007 although Ghana has been mostly ranked 10th throughout the period (United States Geological Survey, USGS, 2015). China however remains the largest world producer of gold with an output of 450 metric tonnes with Ghana at 91 metric tonnes in 2015 (USGS, 2016). The ranking of the top 10 gold extracting nations all through the 10-year period to 2015 has featured almost the same countries throughout. If the current production levels in Ghana is anything to go by and given the current stock of gold

resources, all things being equal, Ghana's gold stock will be exhausted in not more than 14 years' time (USGS, 2016).

The output of the country's mineral sector was relatively low in 2014. According to (Goldfields Mining Service, GFMS) Gold Survey, the output of the predominant mineral, Gold, expanded from 107.4 tonnes in 2013 to 108.2 tonnes in 2014, a marginal lift of 0.7 percent. Despite the slow growth from the previous year, the mineral sector added significantly to the overall economic progress of the country in 2014.

Mining and quarrying subsector's contribution to GDP went up in 2012 from 9.5% in 2011 to 9.8% mainly as a result of the increasing production in the oil sector. Conversely, growth in the mining sector slowed down in 2013 from the previous year's 16.4% to 11.7% (GFMS gold survey, 2013).

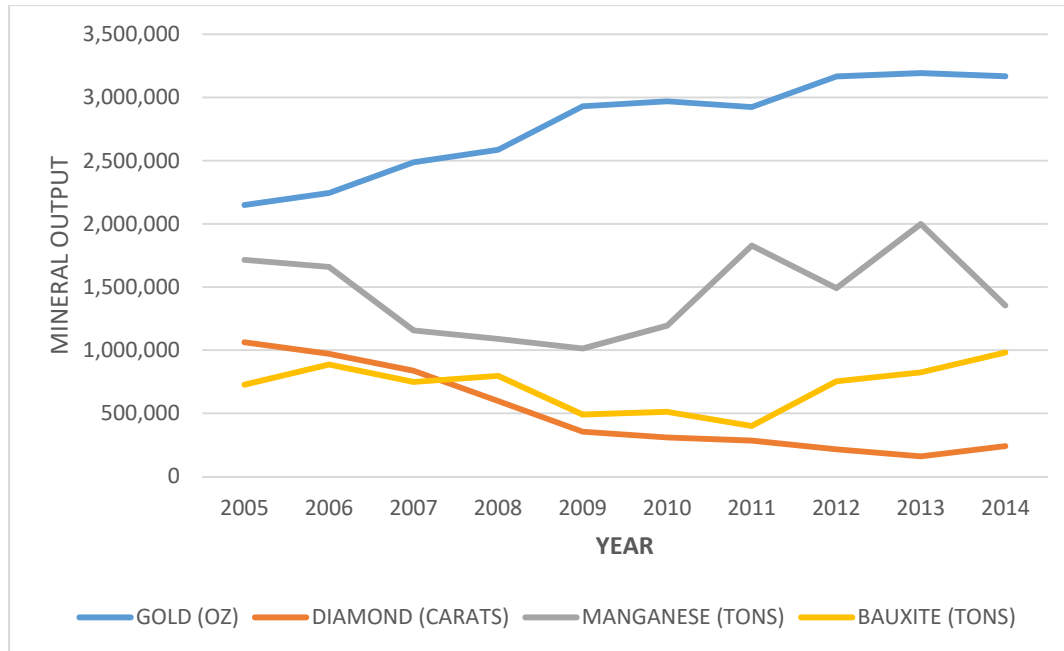


Figure 2.1 Trend of output for some important minerals in Ghana

Source: The Ghana Chamber of Mines

Figure 2.1 shows the trend in output of gold, diamond and manganese. Clearly, gold output shows a positive growth throughout the period of consideration. This reiterates the significance of the gold sector in Ghana. The diamond sector as shown by Figure 2.1, has exhibited a continuous decline from the year 2005 to the year 2014 with manganese showing the greatest fluctuations in its output trend. Bauxite output also showed some fluctuations in the initial period but from 2012, it begun to rise steadily.

2.7 Exports in the mining sector

The input of the mineral sector to Ghana's GDP was higher in the late 90s and 2000s (in the region of 4-5% of GDP) as compared to the early 90s which stood at less than 2% (Appiah, 2013). Gold, clearly the major mineral was responsible for about 95% of the total export turnover in the mineral sector (Ghana Chamber of Mines, 2006).

The gold sector continues to lead the charge in the mineral sector consistently contributing over 90% of the entire mineral export earnings. In the year 1983, total mineral exports was 27.7% of total exports while the gold sub-sector retained a whopping 93.8% of total mineral export. In 1990, the share of mineral to total export declined to about 23% with gold contributing a relatively very low 83.2% of total mineral export. In 1998, the mineral share was 33.5% and gold's contribution was about 96% of total mineral export. In 2009, gold's share increased to 97.4% of total mineral export. Gold exports was worth US\$5.6 billion in 2012 (KPMG, 2014).

Table 2.7.1 Total Mineral Export and its percentage to GDP

YEAR	Total Mineral Export (in Millions of US\$)	% Share of Mining and Quarrying Sector in GDP	% Share of Total Mineral Export to Total Merchandise Export
2005	995.7	5.1	34.53
2006	1,420	5.4	38.1
2007	1,793.3	5.9	42.75
2008	2,303.9	5.6	43.72
2009	2,925.8	5.6	50.10
2010	3,724.8	5.7	46.80
2011	4,778.5	8.0	37.37
2012	5,447.3	8.8	40.19
2013	4,753.8	7.9	34.57
2014	3,943.4	6.0	29.84

Source: Ghana Chamber of Mines

From Table 2.7.1, a ten year period (2005 to 2014) of total mineral export in millions of US\$ and its share to GDP and to total merchandise exports is highlighted. The period shows a high of 8.8% share to GDP in 2012 and a low of 5.1% share in 2005. The average for the ten-year period is 6.4%. In relation to mineral export as a share of total merchandise exports, the period under consideration shows a high of 50.1% which occurred in 2009 and a low of 29.84% which occurred in 2014. It is suspected that, the dwindling nature of the share to total export from 2011 was due to falling prices of gold and its lowest in 2014 will suggest directly to the extreme low oil prices in 2014. Impressively, the average for the period was 39.797% which is more than one-third of the total merchandise exports. This again reiterates the immense contribution of mineral resources to the nation.

2.8 Revenue in the mining sector

The mineral sector is commendably a key contributor to Ghana's revenues through earnings from mineral royalties, employee income taxes and corporate taxes. The share of mining to total collections from the Ghana Revenue Authority (GRA) increased from 8.9% in 1990 to 21.3% in 2010. Averagely, the mineral sector has accounted for not less than 13.3% of the total GRA collections (Appiah, 2013). Government generates its revenue from minerals through the various mineral taxes that are available in the mining sector

Table 2.8.1 Mineral tax contribution to the Ghana Revenue Authority

Year	Corporate Tax In millions of GHC	Mineral Royalties In millions of GHC	PAYE In millions of GHC	Reconstructi on Levy In millions of GHC	Total Mining Contributi on to GRA In millions of GHC	Total GRA collection In millions of GHC	% Mining To Total
2005	27	23.6	19.4	2.3	72.3	644.6	8.94%
2006	40.4	31.6	21.7	1.1	74.8	733.4	6.25%
2007	47.4	40.9	34.6	-	123	901.2	6.67%
2008	73.6	59	47.1	-	180	1,222.3	12.83%
2009	124.6	90.4	103	-	319	1,731.6	14.89%
2010	241.6	144.7	132.5	-	519.7	2,441.3	17.88%
2011	649.9	222	161.8	-	1,034.2	3,746	14.49%
2012	893.8	359.4	207.5	-	1,461.2	7,461.2	11.47%
2013	518.5	364.7	220.1	-	1,104	5,900	12.13%

Source: Ghana Revenue Authority

Table 2.8.1 shows the revenue the GRA gets from the mineral taxes in Ghana. Clearly, the mineral royalty tax as well as the corporate tax are the most important taxes throughout the period. Corporate tax revenue contribution averaged GHC290.75 million with 2012 receiving the highest contribution of GHC893.8 million and 2005 receiving a low of GHC27 million. For the royalty tax revenue, it averaged GHC148.48 million and achieved a high of GHC364.7 million in 2013 and a low of GhC23.6 million. PAYE also contributed substantially to GRA mineral tax collections with an average of GHC105.3 million for the period having a high of GHC220.1 million in 2013 and a low of GHC19.4 million in 2005. The total average mineral tax contribution to GRA was GHC543.13 million. The total mineral contribution to GRA per the total GRA collections for the period was a high of 17.88% in 2010 and a low of 6.25% in 2006. Since 2008

to 2013, the mineral sector has contributed over 10% of the total GRA revenues. This suggests that the sector is key to the tax receipts of the GRA.

2.9 Conclusion

The various trends showed by the revenue, output and investment in the mining sector speak volumes with regards to the sector's contribution to the national economy. As a nation however, there is always more room for improvement. Ghana cannot rest on its laurels but ensure that she continues doing the good things that would enhance the sector, improve upon them, eliminate unnecessary bottlenecks that serve as barriers to important investments in the sector, and more importantly, ensure that the nation gains significantly especially by using the appropriate taxation tools.

On the average, the total receipts from mineral exports as a share of total merchandise export is about 40% for the period between 2005 and 2014. This alone gives a clear indication of the importance of the sector. Again, the sector's contribution as a share of total tax revenue averaged 11.73% for the nine-year period from 2005 to 2013.

CHAPTER THREE

REVIEW OF LITERATURE

3.0 Introduction

This chapter looks at the overview of both empirical and theoretical frameworks of optimal taxation and tax reforms in the mining industry with its related issues such as taxation and tax administration among others. The empirical study looks at related research on methods used to estimate the optimal royalty tax. Lessons on both the empirical and theoretical literature are highlighted.

3.1 Taxation and Revenue Mobilization

The various types of taxes affect investment behavior and government fiscal administration. “For instance, taxes based on units of production irrespective of profitability may create economic inefficiencies by discouraging the exploitation of lower grade ore and shortening the lifespan of some mines. Conversely, taxes on corporate profits (and to a lesser degree income) are more efficient and recognize the inherent risks in mining operations, particularly wide fluctuations in international mineral prices and the difficulties of anticipating all geological technical, financial and political factors over the mine’s lifetime” (Mitchell, 2009).

In designing resource tax regime, rent extraction is the primary element. It is clear that tax revenue issues in the mining sector brings about keen interest among the various stakeholders. During the

1980s and 1990s the main challenge of mining was to attract investments hence policies were directed at this while concurrently balancing the interests of governments and mining companies.

3.1.1 Key tax administration issues

Revenue administration which is often the weak link in resource rent collection to ensure economic wealth is critical. Some strategies to assist the administration of resource revenue are highlighted below;

1. Develop sound tax policies. That is, a tax regime that is simple, clear, well designed and robust.
2. Adopt modern tax organization that is easy to integrate and would reflect principles of specialization and would properly segment the taxpayer.
3. Ensure that the procedures used are efficient that is simple, effectively harmonized with existing trends and reflecting the principles of self-assessment and risk-based compliance strategy.
4. Extensively equip the capacity of the revenue authority with well trained and motivated staff.
5. Clarify roles, responsibilities and relationships among key actors

(Slemrod and Yitzhaki, 2002)

The following are key tax administration issues that must be considered in carrying out a tax policy;

1. Access to tax information: This is an example of information asymmetry. Resource extractors are likely to understate the available resource stock as well as overstate the difficulty of resource extraction which presents a challenge for the tax administrator. The taxpayer bears his or her tax information and the tax administrator must uncover it to administer the tax. In discovering tax information, tax administrators can use administrative powers. However, these powers have limits and it will call for tact and diligence to discover tax information.

2. Capacity building of tax administrators: Taxation and tax administration come with them complex tax issues especially when it comes with the extractive sectors not least cross-border issues. This may present complex situations that may require information exchange to counter international tax avoidance and evasion. Many investors are foreign and it will require a ‘strong’ administrative body with respect to tax administration. Differing complexities with administering various taxes is also crucial in considering the appropriate tax policy to use.

It is true however that once more resources are put into the collection and administering of the tax system, there would be a likelihood that more revenue would be collected and the issue of tax evasion would also thus be reduced.

3.1.2 The role of Taxation

In discussing tax reforms, it is proper that the nation knows the role that tax plays as a macroeconomic tool. “One of the biggest contribution that most mines will make to sustainable development – through building social, human and manufactured capital while extracting a non-renewable resource – will be through paying of taxes. If taxes and royalties are not properly accounted for or invested wisely, then the relevant country or region may miss out on a unique

opportunity to spark wider development through inward investment” (Stoianoff and Kaidonis, 2005). Funds accumulated from taxation and the foreign exchange earned from exports of minerals is a major source of government revenue.

Taxation plays a key role in driving capital formation. Foreign aid usually comes with it complex strings and it is relatively unreliable while the rate of savings in the country is low especially given the high inflation rate. Taxation therefore remains key for government capital formation. It is the important instrument of underdeveloped countries to break the vicious cycle of poverty and to emerge from poverty (Yeh, 1972). For any country to develop, it must have a very good infrastructure base. Many developing countries have infrastructure deficits especially in the area of road networks and energy. In 2015, the Minister of Finance of Ghana, Seth Terkper, explained on Ghana Today.com that Ghana needed about US\$1.5 billion annually to close its infrastructure deficit. With a formidable tax structure, the formation of capital would be enhanced.

When government spending or its expenditure exceeds its revenue, then the deficit of the country increases and for many developing countries, budget deficit is a major economic challenge. In Ghana, government expenditure continues to increase which is not matched by increases in revenue collection hence the large fiscal imbalance plaguing the country (Ahmed, 2010). The endogenous growth model of Romer (1986) indicates that, a country can achieve growth and fiscal balances either by reducing expenditure or by increasing tax revenue. Wagner’s law clearly suggests that, rising government expenditure is as a result of the growth in the industrial sector (Demirbas, 1999).

Previously and even now, taxation was seen as a major policy tool that ensures that resources are transferred to the public sector for government developmental agenda as well as cajoling the free market operators to conform to fiscal objectives of the government (Fölster and Henrekson, 2001).

The IMF also attests that taxation is a distortionary tool and as tax policy aims at raising revenue for government it can be used as a means to minimize the level of its associated distortions in the economy (Auerbach and Hines, 2002). As a result of lack of certain know-how especially in dealing with foreign companies in the mineral sector, some African countries especially quite clearly are unable to maximize its revenue receipts from their chief exports in the sector that is gold and oil (Gajigo *et al.*, 2012)

3.2 Theory on Tax Reforms

Tax reform aims at changing the way taxes are administered, collected and managed. Tax reforms will most likely improve revenue generation. Studies on tax reforms have been expanding suggestive of the fact that its importance is gaining grounds in both theory and practice. Usually, analysis of tax reforms has focused mainly on the objectives of the tax not least, revenue generation. Revenue adequacy of a tax system is the basic standard that the tax system must achieve (Appiah, 2013). After all, what most developing countries consider in any tax reform is firstly to increase their revenues.

In Ghana today, the government loses so much prospective revenue from the informal sector because a vast majority of them do not pay taxes. The income tax catchment is not wide enough thus only a minority of Ghanaians contribute to the income tax basket. A case for a major tax reform to help government in its revenue generation attempt can be built from here. The issue of tax reforms has become key to public policy discussions. It has also gained ground in discussions in international organizations (World Bank, 1988). For instance as stated by Muriithi & Moyi

(2003) of Kenya, one key objective in the tax reform debate is to ensure that the system could be administered to alleviate the ever present fiscal challenges.

A good tax system must be administratively feasible and must as much avoid the problem of resource misallocation and misappropriation. The system should not distort the trend in trade, production, consumption, savings as well as investment (Appiah, 2013). A tax reform should aim firstly at improving revenue and productivity. Public expenditure would continue to increase thus, reforms in the sector should also aim at increasing revenue if possible by at least as much as increases in the public expenditures. Appiah (2013) argues that tax revenue is very important and in the long run, revenues should not lag behind expenditure.

Mansfield (1972) suggests that, the buoyancy and elasticity of a tax system can be used to determine if tax reform would be successful in raising revenue. Tax buoyancy is the total response of tax revenue in percentage terms to a percentage change in GDP (Ahmed, 2010). Tax elasticity is a hypothetical construct that measures what tax revenue would have been if the previous year's laws continued to apply in the current year (Ahmed, 2010). Thus, they both in their own unique way give information about the efficiency of the tax system. How responsive the tax is to income changes is a key indicator in extrapolating revenue and a basic means for assessing whether or not the tax system is good enough (Twerefou, *et al.*, 2010).

Tax reform as opposed to tax design considers the looking out for and analyzing of systems which may be enhancements upon the existing system (Ahmad and Stern, 1991). Thus, for any reform, there is the need to look critically at the existing policy to help design an improvement. Income taxes or value added taxes can be reformed into one considered comparably economically liberal. Other reforms may deal with the problem of externalities and yet others may aim at more neutrality. According to McMahon and Berrios (1991), tax reforms are necessary especially when

the existing systems are deficient in achieving the objectives of adequacy in revenue, economic efficiency, equity as well as simplicity.

3.3 Optimal Taxation

The standard theory of optimal taxation proposes that a tax system should be selected such that it would maximize a social welfare function given a set of constraints (Mankiw *et al.*, 2009). The study of optimal royalty tax is extensive in theory. Optimal taxation presents several complexities on its own not to talk of ‘Optimal Taxation’ in the mining industry of Ghana. For some, the mere title of the field is off-putting: how can any aspect of public policy, with all its political constraints and administrative problems, ever hope to be optimal? Particularly, how can anything as unpopular as taxation be described in such terms? (Heady, 1993).

The ‘Father of Modern Economics’, Adam Smith listed four basic characteristics or truths in Smith (1776) with regards to what an optimal tax ought to be. They include;

1. **Equity:** that is people should be charged taxes in proportion to their income
2. **Certainty:** the tax liability should not be arbitrary but must be clear and certain in both the eyes of the payer and the collector
3. **Convenience in payment:** collection of taxes should be done in such a way, manner and time that would be as convenient as possible to the taxpayer.
4. **Economy in collection:** thus in collection of taxes, the cost (transaction costs) involved should be reasonable and also importantly, should not discourage business activities.

In looking at an optimal tax policy, it is critical that the goals of efficiency and accountability do not supersede that of social welfare. The two should not be isolated. The country cannot look at the theory of optimal taxation without looking at the eight most prominent lessons suggested by the optimal tax theory. These lessons are:

1. Optimal Marginal Tax schedules depend on the dissemination of ability. According to Mirrlees (1971), the marginal tax rate schedule is the critical issue in the tradeoff between efficiency and equity
2. The Optimal Marginal tax schedule could fall at high income levels. In early numerical simulations of Mirrlees' model, Tuomala (1990) concludes that it will be seen that in all the observed situations, the marginal tax rate declines as income rises except at income levels within the bottom decile.
3. A flat tax, with a generally lump-sum transfer, could be close to optimal.
4. The optimal extent of redistribution rises as the wage inequality rises and vice versa.
5. Optimal taxes should necessarily depend on personal attributes as well as on income
6. Only final goods ought to be taxed and they must be uniformly taxed
7. Capital income should be untaxed at least in expectation
8. In Stochastic, Dynamic economies, optimal royalty tax policy necessitates increased complexities.

Slemrod (1989) argues that optimal tax theory is incomplete because it has not yet reconciled with the fact that taxation entails coercively mobilizing revenues from people and institutions who may tend to resist. He comes up with a theory of optimal tax systems, which extensively accepts the ideals of optimal taxation but looks at the dimension of the technology of raising revenues through taxation and the constraints that plagues the tax policy as a result of deficiencies in technology.

3.3.1 Optimal tax and Tax reform

In academic research, optimal tax theory still exerts a major influence over the study of tax reforms. The optimal taxation approach stresses the importance of analyzing the impact of tax reforms and assess both its administrative costs and effects on social welfare (Appiah, 2013). The first major short-coming of this is the lack of substantial data especially in most developing countries.

Again, for optimal taxation to thrive, there is an assumption that there must exist a perfect administration. However, evaluation of the tax reforms in developing countries show that these countries seriously lack the required administrative set up, that is their administrative abilities cannot accommodate such a tax structure. The influence of optimal taxation on tax reform in many less developed nations has been meagre and mostly indirect because of this administrative deficit in developing countries (Gordon and Li, 2009).

Optimal taxation theories are parallel theories to the investigation of the principles of taxation, where lump-sum taxes are not applicable (Appiah, 2013). The optimal commodity taxation analysis started with the work of Ramsey (1927) and expanded in the 1970s following the publication of the Diamond-Mirrlees papers of 1971. It is the intense concern in tax policy by many economic researchers that has propelled studies in optimal taxation. This notwithstanding, the breakaway from the theory to practicality may not be vivid. Many still believe that this theory is solely academic with little practical relevance (Heady, 1993).

The general principles underlying optimal taxation are summarized as follows:

1. Tax revenue is most efficiently raised by taxing goods and factors possessing inelastic demands or supply, and

2. Taxation should as much as possible tackle the problems of externalities, market failures and inequality with distribution.

In situations of externalities, a nation should look to tax or subsidize directly the good or service that produces such externalities (Ballard and Medema, 1993). With inequality in distribution, one should identify where inequalities exist and implement taxation accordingly.

With regards to shadow prices, a tax should be increased if its direct impact on the households making the change is more than the cost at shadow prices of the extra demand generated. A shadow price of a good embodies the welfare consequences of the general equilibrium adjustments that flow from an extra demand for that good. Thus, the shadow price depends on the way in which the economy adjusts (Drèze and Stern, 1990).

A tax structure where there is no other possible reform that would enhance the social welfare is known as the optimal tax. The aim of tax reforms is usually to find a better tax system and not to find the best system. The more modest aims of tax reform analysis leads to smaller informational requirements: it is only necessary to know how economic agents will respond to fairly small changes in taxes rather than the large changes that might be involved in a move to the optimal tax structure (Heady, 1993).

Thus, a country that goes along a path where each tax reform progressively is an improvement of the previous would gradually approach optimality. It is however not the best for a country to continually change its tax system. A more practical approach in dealing with a favorable tax policy is to combine the intuitions of both the optimal tax theory and the analysis of tax reforms. Musgrave (1969) argues that tax reforms in developing nations requires extensive issues of

economic policy and an insight into the specific problems that plagues the structure and its administration.

3.4 Empirical Literature Review

This section reviews some empirical studies on optimal taxation, revenue mobilization, tax reforms and deforestation as a result of mining. The main thrust of the empirical review however would be on the methods used by researchers to estimate the optimal tax structure. The question of the optimal tax structure in mining has for some time now led researchers to bring out varied opinions on the structure that ought or ought not to be. Slemrod (1989) is of the view that one reason the theory of optimal taxation is incomplete as a standard for the structure is that, its ideals like many other models have no real practicability. These theories are drawn based on the assumption that the market is perfect which has never been the case.

Mirrlees (1971) explores what standards should oversee an optimal income tax, what such an optimal path should look like and what extent of inequality will still exist. He is of the view that optimal marginal tax rates is between 0 and 1. Again, optimal marginal tax rates equal 0 at the top end of the skill distribution and unless there exist a positive measure of agents at the bottom end, optimal marginal tax rates also equal 0 at the very top of the skill distribution (Sadka, 1976; Seade, 1977). Mirrlees (1971) therefore concludes that the optimal tax schedule should be approximately linear and the income tax is not so effective in ensuring reduced inequalities and also, he observes that complementary taxes to the income tax to handle the difficulties that the income tax has to face should be put in place. Tuomala (1990) however uses a range of realistic values of the

elasticity of substitution between consumption and work effort and finds that the optimal tax schedule is strictly non-linear.

Golosov *et al.*, (2014) used a dynamic stochastic general equilibrium (DSGE) model where the implementation of an optimal tax would solve the problem of externalities that come with the global warming. As was suggested by Espinosa and Fornero (2014), externalities which are a known market failure can be tackled by the implementation of proper policy instruments. The Kyoto protocol which is a multinational treaty sets binding obligations to coordinate activities in the reduction of greenhouse gases. This protocol allows for the trading of pollutant units thus the price for the marginal unit of gas emitted is determined by taxation known as 'green' taxes. Golosov *et al.*, (2014) show that the structure of this tax depends on time discounting rate that is how much the future generation is considered, the scope of externality damage and the carbon cycle structure.

Bovenberg and Goulder (1996) analyze the optimal environmental taxation in the presence of other taxes using a general equilibrium analysis. The study shows how the Pigouvian tax principle in a second-best condition is different from other environmental taxes present. In their analytical model used, it was shown that optimal environmental tax rates are usually below that of Pigouvian principle. The numerical analysis also show that the optimal carbon tax rate should be between 6 and 12% which is below the additional environmental damages. It also shows that, with reality policy constraints, the optimal carbon tax rate are far below the marginal environmental damages.

Saji (2010) studies mining taxation with respect to Mali. He uses an optimal control theory to estimate the optimal royalty tax in the Malian gold sector and finds that by reducing the royalty tax, Mali would ensure that risks in the sector are shared effectively between the government and

the mining companies and this would also be good enough to provide incentives to attract new explorations into the sector.

West and William (2007) used household data in the US to estimate parameters that are important to calculate the optimal second-best gasoline tax. It was found that gasoline is a relative complementary good to leisure and that the optimal gasoline tax is substantially greater than the marginal damage. Even with no clear negative externalities with the use of gas, the optimal gas tax will be about 33% of the before tax price of gasoline. However, with externalities, the optimal tax exceeds marginal damages. Typically, optimal environmental taxes are less than the marginal damage. Thus, the results show that estimating a cross-price elasticity with leisure rather than imposing a restrictive assumption in order to determine elasticities is important.

Corlett and Hague (1953), establish that an optimal tax rate on a commodity largely depends importantly on its cross-price elasticity with leisure. Leisure however cannot be taxed and thus, individuals consume to an extent which is largely an inefficient level. Thus, given three goods say, X, Y and Leisure, L, if good X or Y is taxed, the consumer will reduce his leisure and work more depending on how complementary the taxed good is to leisure. The study shows that for instance, if X is more complemented to leisure and good X is taxed, the consumer will reduce his or her leisure and work more.

Vocke and Oomes (2003) use a dynamic optimization procedure to estimate an optimal diamond tax rate. In studying diamond taxation and smuggling in Sub-Saharan Africa, the study models diamond smuggling with the optimal tax where government chooses a tax rate that will increase its revenues while taking into consideration its effect on smuggling. In answering the question of the reason alluvial diamond production is less beneficial to government revenue than kimberlite production activities, the study concluded that with artisanal mining, the incentives for smuggling

exists more than in corporate mining. Artisanal mining is done in uncontrolled and insecure areas with little competition between buyers. Thus, ones smuggling is high, profits are substantially reduced.

Tilton (2004) also studies optimal taxation on mining by firstly looking at three key reasons for the need to adopt higher taxes in the resource sector. Firstly, Tilton argues that extractive resources belong to the citizens of the state and they must benefit from these resources. Secondly, he argues that governments must also get their fair share of revenues from the resources and lastly, since mining companies make too much from resource extraction, it would only be fair that mining companies pay part of these wealth they accrue to host governments to undertake developmental projects. He suggests that host governments should aim at maximizing the net present value of revenues flowing from the mineral sector to its coffers.

Vandar (2014) investigates the optimal path of taxation of non-renewable resources in the existence of an imperfect renewable resource as a substitute. An optimal growth model is used to show that the economy gradually moves from the use of the non-renewable resource and gradually converges at a steady state where it uses only the renewable resource. An optimal rule for taxation is obtained and it is showed that, the path can be increasing, decreasing or U-shaped depending on the previous state of the economy and the nature of the clean steady state that the economy would achieve.

Otto *et al.*, (2000) present that, in some nations, manipulation of the tax base in the tax policy design is what is targeted instead of targeting the tax rate. It is important that in designing a suitable tax policy, the optimal tax level must be considered. When taxes are too high, it would discourage not only current mining companies but also prospective companies. If it is too low, government would not be able to maximize her revenue from the sector. The tax that would maximize the Net

Present Value (NPV) of revenues moving to the government sector would lie between the high and low and this is represented in the Laffer curve of Figure 3.1.

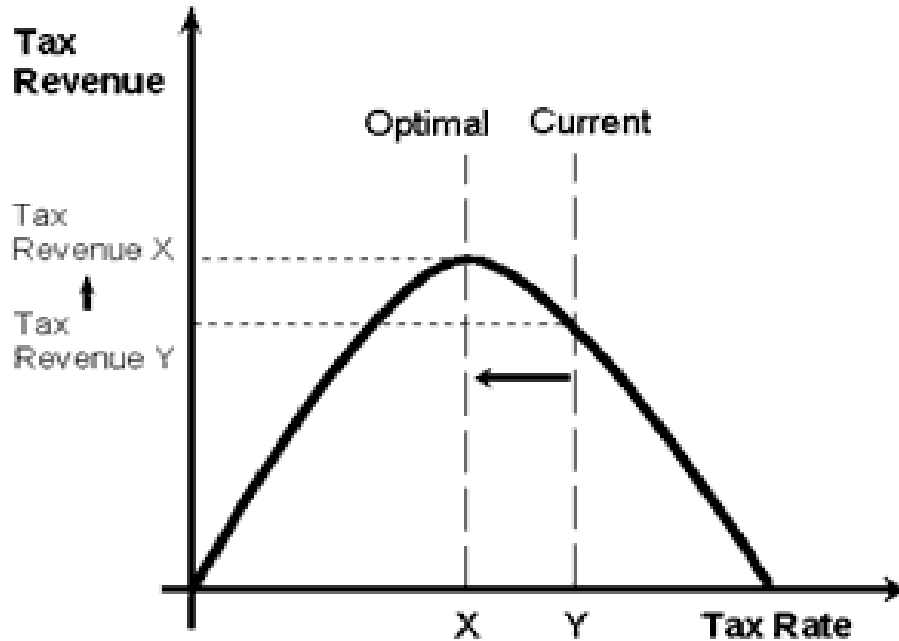


Figure 3.1 Laffer Curve

At 0 tax, the government makes 0 revenue. As the tax rate is increased towards the optimal level, X, government revenue from the extractive sector continues to increase. The optimal tax corresponds to the highest possible revenue that can accrue to the government. Beyond the optimal tax that is, moving from the tax rate X towards Y and beyond, government revenue from the mining sector falls.

Monterroza Humanez (2014), in the wake of coal price hikes in Columbia studies the current royalty rate in the coal industry using a mixed integer linear programming model. This method allows for approximations that maximize the NPV from the mining firm to the government. The results of this study show that the current royalty rate charged is close to optimal however, it poses great risk to exploration and new investment activities in the coal industry.

Artist (2009) in his problem statement bemoans the fact that the current taxation regime in Suriname is not optimal and thus in his study of the bauxite industry, various taxation systems as applied to other mineral rich nations is compared with the Suriname tax situation. A hypothetical bauxite mine is modeled and basic financial evaluation is used against tax regimes used in five other resourced countries in addition to Suriname. The result showed that, there was no single tax regime that could be classified as optimal for Suriname. Again, although he agrees that the tax regime is not in favor of investors the tax structure does not ensure improved financial benefits when prices are high.

Akpalu and Parks (2007), use a dynamic model to estimate an optimal tax in the mining sector. In their view, mining leads to the destruction of the forest which provides diverse means of livelihood to resource rich countries not least, Ghana. Thus, a royalty tax on gross revenue is shown to be used to compensate for the cost associated with the loss in forests benefits as a result of mining. A social planner's model and a miner's problem are optimized and juxtaposed to get an expression for the optimal royalty tax. Their results show that, the 3% royalty tax charged initially was too low and does not compensate Ghana for the loss in forest benefits. Their model however concentrates on the royalty tax component and does not include other key tax revenue sources in their modelling.

3.5 The effective tax rate

Otto (2013) explains what the effective tax rate should be. The effective tax rate (ETR) is a measure of government take expressed as a percentage of the effective net cash flow of all amounts payable by the company to the government.

$$\text{ETR} = \frac{\text{Value of all amounts paid to government}}{\text{Value of project before tax cash flow}}$$

To estimate the ETR, a model that estimates the mine's revenues and costs and all the imposts that the mine pays to the government over the lifetime of the project is needed. James Otto in estimating the ETR usually models a typical mine and applies the nation's fiscal or proposed fiscal regime to it. Again, a policy maker must know the objectives of the government whether it is for more short term benefits or for more long term benefits. If the goal is for short-term maximization then the policy designer must use a high ETR which would ensure increased payments from individual mines but in the long run, overall payments would fall because there would be fewer mining operations and less investment in the sector. However, if the goal is for long term maximization then the policy designer must charge a lesser ETR thus, there would be less initial payments from individual mines but in the long run as a result of increased investments in the sector and more mining operations, revenues from the sector would increase.

3.6 Conclusion

The theoretical literature regarding optimal taxation and its related issues remain impressive. The empirical studies however have been limited. In designing an optimal tax, key tax administration issues must be considered to improve access to information by both the tax payer and the tax collector as well as ensuring the capacity building of tax collectors. The literature on tax reform suggests revenue adequacy as the main goal of any tax reform effort. Again, the literature also suggests that, the buoyancy and elasticity of a tax system can be used to determine the potency of a tax to enhance revenue. Critical principles and properties of an optimal tax structure are also highlighted in the theoretical review. For the empirical review, Saji, (2010) uses a dynamic optimization model to determine an optimal tax for the Mali gold industry. Akpalu & Parks (2007) also use a dynamic optimization model to determine the optimal royalty tax as a corrective measure for the destruction of the environment due to mining in the Ghanaian gold setting.

This study applies many of the ideas used in Akpalu & Parks (2007) firstly because it applies to the Ghanaian situation and secondly, the mathematical modeling of the objective functions is clear though quite complicated.

CHAPTER FOUR

METHODOLOGY OF THE STUDY

4.0 Introduction

This chapter looks at the methods used to carry out the analysis of the study. A dynamic optimization technique using the current value Hamiltonian in continuous time space as explained by Perman, (2003) is used. The model used is an extension of that used by Akpalu and Parks (2007). The theoretical and analytical framework explains the basic model and shows how the Hamiltonian is used to optimize the objective function given the constraints. This stage also explains the parameters used and their sources in order to get the expression for the optimal tax. The reason for the use of the royalty tax as the central rate to be optimized is made plain.

4.1 Theoretical and Analytical Framework

Mining leads to the destruction of the forest as well as water bodies and also the ecosystem of plants and animals. FAO (2010) estimates Ghana's deforestation at about 135,395 hectares per annum and mining of minerals are the main contributors to deforestation in the country (Contreras-Hermosilla, 2000 and Ismi, 2003) although Zaitunah (2004) thinks otherwise. Contreras-Hermosilla (2000) also writes that, deforestation is the second major cause of global warming and results in the destruction of some 12 million hectares of fertile land annually. Thus, the destruction of the forest and its ecosystem cannot be ignored in determining a relevant tax policy as far as gold

mining is concerned. In determining a tax structure for the sector, these negative externalities must be internalized.

It is the aim of any investor to maximize profits whereas the government aims at maximizing tax revenue so that it uses the funds at its disposal to promote social welfare. The means to this end is for the mining company to maximize the Net Present Value (NPV) of its income flows overtime with the government also maximizing the NPV of its streams of revenue flows over time given a set of constraints.

The mine operator's problem is to determine the length of time, T for the stock to be completely extracted while maximizing his or her profits. He would also choose the extraction plan $q(t)$ that maximizes the Present Value (PV) of the mine's operations. If it is assumed that the mineral is extracted evenly in each year, then the tax structure has no effect on the extraction. This may not be optimal if future cash flows are discounted (Heaps and Helliwell, 1985). This will however not hold since the price of the mineral as well as other important factors will always affect the amount of mineral extracted.

This study uses Optimal Control to optimize the objective function of the social planner given the constraints which include the loss of forests and destruction of waterbodies and the numerous species the forest supports. It is important to state that, the benefit that the forest provides the rural population and the poor who are mostly engaged in hunting and gathering is taken away once mining activities take place in these areas (Dottey, 2005). For instance, Asibey (1974) and Benhin and Barbier (2004) assessed that about 75% of protein in West Africa comes from the meat from game hunting. Palmer *et al.*, (2010) also write that, mining is the main culprit for the destruction of water resources and its biodiversity. The indirect ecological function use values of the forests in the country are vast and substantial thus.

The Food and Agriculture Organization (FAO, 2004) estimates that the forests provides direct employment for over 75,000 people nationwide and livelihood for over two million other people. More alarming is the plant species used for traditional medicines that the rural people rely on for their health needs being lost as a result of mining activities. All these are detrimental to the livelihoods of the indigenes as well as the pollution (noise and dust) that come with mining. Akpalu and Parks (2007) write that surface mining which is one of the cheapest ways of mining which stripes the ground in the rainforest of its gold leads to massive deforestations to the tune of about 2 million acres per year.

Again, given the social planner's objective function, the private firm must definitely make profits from mining since massive investment is involved in both exploration and extraction of minerals. Thus investors who are private businessmen with the main aim of making profits should have an incentive to continue to engage in mining by making non-zero profits.

The basic model is dynamic and since the forests benefits are the opportunity cost for mining, they are included in the constraints of the model (Akabzaa and Darimani, 2001). After mining, all the benefits and uses of the forests are completely lost because mining leads to destruction of the forest. Thus, the forest is unable to provide subsistence livelihood for the numerous people it would have supported. Schueler *et al.*, (2011) write that the environmental and social costs of Ghana's gold may be higher than it is perceived.

Ghana's gold output as a share of the world's constitute a small percentage which is less than 2.5% of total world output thus, the context used here is that of a perfectly competitive market and coupled with the fact that the price of gold is exogenous (Ghana's gold sector takes the gold price as given). It is also assumed that, both the resource owner and mineral firm will use the same rate

of time preference and also, all firms are treated identically. The theory and test results thus shown among other things, are assumed with great certainty (Chermak and Patrick, 2001).

4.1.1 The Basic Model

The model used is derived by fine-tuning the one used by (Akpalu and Parks, 2007). The government's non-contributing share of any mineral venture in the country is 10%. Thus, government earns 10% in dividend from the profits of mining firms. However, over the few years, government earns more in corporate profit tax than any other mineral tax. Corporate taxes have become the highest tax contributor to mineral revenue over the last few years. Corporate tax charged on profit of mineral firms in Ghana is currently 35% and is an important component in structuring a fiscal policy for the mining sector. Thus corporate tax is included in the model. The tax to be optimized however is the royalty tax which is unique to the mining firm. Also, besides the corporate tax, the royalty tax which is charged on the total revenue of any mining firm has also been a major contributor to Ghana's tax revenue. Thus,

Total royalty revenue is $\theta * P * y$

Total revenue from corporate tax is $\beta[(1 - \theta)P * y - C(y)]$

Where P is the exogenous price of gold

θ is the royalty tax rate and it is charged on the firms total revenue, $P * y$

y is the quantity of gold extracted in a year

β is the corporate income tax rate which is charged on the firm's profit, $[(1 - \theta)P * y - C(y)]$

C is the cost involved in mining which is dependent on the quantity extracted, y

4.1.1.1 The Social Planner's Problem

The social planner aims at choosing a time path that will maximize the stream of surpluses subject to the constraints of reduction in the gold stock ($-y$) and the destruction of the forest $\left(-\frac{1}{\alpha}y\right)$ which are assumed linear for simplicity. Again, this will continue as long as the stream of revenue moving to the firm is positive.

Where α is the gold yield per acre of the forest stock

Thus, the social planner will;

$$\max_{(\theta, y)} \int_0^T \{\theta Py + a(f) + \beta[(1 - \theta)Py - C(y)]\} e^{-rt} dt \quad (1)$$

Subject to the equations of motion,

$$\dot{x} = -y \quad (2a)$$

\dot{x} is the gold stock depletion

$$\dot{f} = -\frac{1}{\alpha}y \quad (2b)$$

\dot{f} is the forest stock depletion

$$\text{and } \int_0^T [(1 - \beta)[(1 - \theta)Py - C(y)]] e^{-rt} dt \geq 0 \quad (3)$$

which is the constraint that the mining firm should be making profit

where r is the interest rate. T is the time period at which the gold stock is exhausted.

f is the non-timber benefit and $a(f)$ is its functional form

With $x \geq 0, y \geq 0, f \geq 0, \beta > 0, f(0) = f_0$ and $x(0) = x_0$

The current value Hamiltonian becomes,

$$H = \{\theta Py + a(f) + \beta[(1 - \theta)Py - C(y)]\} - \frac{\mu}{\alpha}y - \lambda y + \varphi\{(1 - \beta)[(1 - \theta)Py - C(y)]\}$$

With λ and μ being the shadow prices and φ being a multiplier associated with the firm's profit constraint

$$H = \theta Py + a(f) + \beta(Py - \theta Py) - \beta C(y) - \frac{\mu}{\alpha}y - \lambda y + \varphi\{(1 - \beta)[Py - \theta Py - C(y)]\}$$

$$H = \theta Py + a(f) + \beta(Py - \theta Py) - \beta C(y) - \frac{\mu}{\alpha}y - \lambda y + \varphi\{Py - \beta Py - \theta Py + \theta \beta Py - C(y) + \beta C(y)\}$$

$$H = \theta Py + a(f) + \beta Py - \beta \theta Py - \beta C(y) - \frac{\mu}{\alpha}y - \lambda y + \varphi Py - \varphi \beta Py - \varphi \theta Py + \varphi \beta \theta Py - \varphi C(y) + \varphi \beta C(y)$$

Differentiating H with respect to θ and y ,

$$H_{\theta} = Py - \beta Py - \varphi Py + \varphi \beta Py = 0$$

$$\Rightarrow Py(1 - \beta)(1 - \varphi) = 0$$

$$\therefore \varphi = 1 \text{ or } \beta = 1$$

But the corporate tax, β charged in Ghana is 35% of the firm's profit so β cannot be equal to one.

$$H_y = \theta P + \beta P - \beta \theta P - \beta C_y - \frac{\mu}{\alpha} - \lambda + \varphi P - \varphi \beta P - \varphi \theta P + \varphi \beta \theta P - \varphi C_y + \varphi \beta C_y$$

With C_y the partial derivative and it is assumed to be positive

But $\varphi = 1$

$$H_y = \theta P + \beta P - \beta \theta P - \beta C_y - \frac{\mu}{\alpha} - \lambda + P - \beta P - \theta P + \beta \theta P - C_y + \beta C_y$$

$$\therefore H_y = P - C_y - \frac{\mu}{\alpha} - \lambda = 0 \quad (4)$$

The co-state equations are:

$$\dot{\lambda} - r\lambda = 0 \quad (5)$$

$$\dot{\mu} - r\mu = -a_f \quad (6)$$

It is assumed that there is a constant stock of gold and forest resources that is, there exists no new exploration as well as there exists no new rebuilding of forest stock. Also, the direct cost of mining has no opportunity cost to the country thus, it is not included in the objective function.

The decision to harvest the resource depends on the marginal benefit from harvesting the resource ($r\lambda$) and the marginal opportunity cost ($\dot{\lambda}$). Again, the return on all other assets is $r = \frac{\dot{\lambda}}{\lambda}$, which is the growth in the shadow price per ounce of gold. Equation (6) states that at the optimal path, the return on all other assets of the economy (r) equals the growth in the shadow price per hectare of the forest stock ($\frac{\dot{\mu}}{\mu}$) plus the value of the loss in marginal benefits of the forest stock adjusted by the shadow price of the forest stock ($\frac{a_f}{\mu}$).

With $a_f > 0$, that is as the forest stock increases, the non-timber forest benefits also increase and it is assumed that it increases at a constant rate.

4.1.1.2 The Miner's Problem

The miner aims at choosing an extraction path that maximizes the net present value of profits subject to the gold stock constraint. Thus, after paying his taxes to the government and for the other extractive costs, he should be able to maximize the remaining benefit from the extraction process. He will thus

$$\max_y \int_0^T [(1 - \beta)\{(1 - \theta)Py - C(y)\}]e^{-rt} dt \geq 0$$

Subject to; $\dot{x} = -y$

$x \geq 0$ and $x(0) = x_0$

The current value Hamiltonian is;

$$H = (1 - \beta)(1 - \theta)Py - C(y) - \lambda y = 0$$

Differentiating the above with respect to y ,

$$H_y = (1 - \theta)(1 - \beta)P - C_y - \lambda = 0 \quad (7)$$

4.2 The Optimal Tax for both the Social Planner and the Miner

A tax charged will definitely increase the cost incurred by the firm and produces the same effect as an increase in the average cost from the extraction (Dasgupta and Heal, 1979). Thus, the

marginal profit to the firm for harvesting the gold is $(1 - \theta)(1 - \beta)P - C_y$ which is equal to the firm's user cost of the remaining gold stock (that is, λ). The optimal path of the firm as given in Equation (7) is different from that of the social planner as in Equation (4) thus, the firm will not follow the optimal path set out by the social planner.

To get an expression of the corrective tax, following Parks and Bonifaz, (1994), the optimal path of the social planner is equated to that of the firm. Thus;

$$\text{Equation (4); } P - C_y - \frac{\mu}{\alpha} - \lambda = 0$$

$$P - C_y = \frac{\mu}{\alpha} + \lambda$$

$$\text{Equation (7); } (1 - \beta)[(1 - \theta)P - C_y] - \lambda = 0$$

$$(1 - \theta)P - C_y = \frac{\lambda}{(1 - \beta)}$$

$$P - \theta P - C_y = \frac{\lambda}{(1 - \beta)}$$

$$P - C_y = \theta P + \frac{\lambda}{1 - \beta}$$

Equation (4), the social planner's solution;

$$P - C_y = \frac{\mu}{\alpha} + \lambda, \text{ and}$$

Equation (7) which is the miner's solution;

$$P - C_y = \theta P + \frac{\lambda}{1 - \beta}$$

$$\Rightarrow \frac{\mu}{\alpha} + \lambda = \theta P + \frac{\lambda}{1 - \beta}$$

$$\theta P = \frac{\mu}{\alpha} + \lambda - \frac{\lambda}{1-\beta}$$

$$\theta P = \frac{\mu}{\alpha} - \frac{\lambda\beta}{1-\beta}$$

$$\therefore \theta = \frac{\mu}{P\alpha} - \frac{\lambda\beta}{P(1-\beta)}$$

$$\Rightarrow \theta = \frac{1}{P} \left(\frac{\mu}{\alpha} - \frac{\lambda\beta}{(1-\beta)} \right)$$

Which is an expression for the optimal royalty tax.

Again, a_f the marginal benefits of the forest from Equation (6) is linear thus, an expression for the optimal path of the forest, $\mu(t)$ is,

$$\mu(t) = \mu_0 e^{rt} + (1 - e^{rt}) \frac{a_f}{r} \quad (10)$$

Where $\mu_0 e^{rt}$ is the initial marginal value of the forest stock, valued at current prices and $(1 - e^{rt}) \frac{a_f}{r}$ is an adjustment for the deviation in the marginal non-timber benefit which is valued at current prices with a_f and μ_0 being positive constants. It is assumed that, the scarcity value of the forest stock (and the value of the water bodies) will be increasing overtime thus μ increases with time.

Since the royalty rate is positively related to the marginal damage of the forest, the tax can be used as a corrective measure to be able to ensure damage reduction of the forest and the water bodies from mining activities. That is, the higher the additional damage to the forest and the water bodies as a result of mining, the higher the royalty tax rate.

From Equation (5), $\dot{\lambda} - r\lambda = 0$. Therefore, to get an expression for the shadow price of gold, by integrating Equation (5), the result is,

$$\lambda(t) = \lambda_0 e^{rt} \quad (11)$$

Thus, substituting Equations (10) and (11) into the expression for the optimal tax, the result is,

$$\theta = \frac{1}{P} \left(\frac{\mu_0 e^{rt} + (1 - e^{rt}) \frac{a_f}{r}}{\alpha} - \frac{\lambda_0 e^{rt} \beta}{1 - \beta} \right) \quad (12)$$

Equation (12) is an extended form of the expression for the optimal tax. Parameter estimates for the shadow price of the forest (μ_0), the marginal benefit from the forest, (a_f) are chosen as per other empirical studies. The initial analysis is carried out for a 10% and 5% interest rate. Again, in exploring the various time paths of the tax, the average price of gold over the 15 year period is used. Later on in the analysis, the price of gold is treated as a variable that is, each year will correspond to the annual average price of gold. However for the second session where each year will correspond to its price, a 10% interest rate will be used since this will not be the main thrust of the discussions. A 15 year period from 2000 to 2014 was used to carry out the analysis because the parameter value for marginal non-timber forest benefits adjusted for by the interest rate, ($\frac{a_f}{r}$) corresponds to the late 1990s.

The expression for $\mu(t) = \mu_0 e^{rt} + (1 - e^{rt}) \frac{a_f}{r}$ is used to calibrate the values of the shadow price of the forest at various time periods. a_f which is the marginal benefit of forests is pegged at \$170.15 (Akpalu and Parks, 2007). That is \$8.15 per acre estimated potential annual genetic resource value (Sampson *et al*, 1996) and the annual sustainable non-timber forest product harvest value per acre, \$162 (Bann, C. 1997).

For the initial value of the shadow price of the forest, μ_0 , the assumption that the shadow price of the forest is increasing over time is considered.

Thus, $\frac{\delta\mu(t)}{\delta t} > 0$

$$\frac{\delta\mu(t)}{\delta t} = re^{rt}(\mu_0 - \frac{a_f}{r}) > 0$$

$$\therefore \mu_0 > \frac{a_f}{r}$$

With $a_f = 170.15$, three values for μ_0 are chosen thus, {1800, 2300 and 2800} based on the restriction. At the point where the interest rate, r is chosen to be 5%, the three chosen values for μ_0 are {3500, 4000 and 4500}.

The gold yield per acre, α is also chosen to be 19.07ounce. That is from Akpalu and Parks (2007), a total of 37 million ounces of gold exists within a 1.94 million acres of deforested land. Thus, the gold yield per acre of deforested land is obtained by dividing 37million by 1.94million to get $\alpha=19.07$ ounces.

Shadow prices exist when there exists no competitive markets for a particular resource. Thus, in the case of the forest resources whose value may not be determined in the market, the use of other means to determine the value of these benefits is reasonable (Perman, 2003; Chermak and Patrick, 2001). Thus, attaching a shadow price to the resources of the forest is understandable. However, there exists a competitive market for gold or at least we assume that the market for gold is competitive. Thus, gold prices are determined exogenously and there are so many individual buyers and sellers of gold around the globe. Hence, the shadow price of gold will be equal to the competitive price of gold. That is, $P=\lambda(t)$.

$$\theta = \frac{\mu_0 e^{rt} + (1 - e^{rt}) \frac{af}{r}}{P\alpha} - \frac{P\beta}{P(1-\beta)}$$

$$\theta = \frac{\mu_0 e^{rt} + (1 - e^{rt}) \frac{af}{r}}{P\alpha} - \frac{\beta}{1-\beta} \quad (13)$$

Equation (13) is the new expression for the optimal tax

Therefore, substituting the various parameters into Equation (13), the optimal royalty tax expression with 10% interest rate (r) and $\mu_0 = 1800$, will be simplified to Equation (14).

$$\theta = \frac{1800e^{0.1t} + 1701.5 - 1701.5e^{0.1t}}{19.06P} - \frac{0.35}{0.65}$$

$$\theta = \frac{1}{P} (94.4386e^{0.1t} + 89.2707 - 89.2707e^{0.1t}) - 0.5385$$

$$\theta = \frac{1}{P} (5.1679e^{rt} + 89.2707) - 0.5385 \quad (14)$$

It is worth noting that, comparative statistics analysis will be used to determine the relationship between the optimal royalty tax and the price, the time period and the interest rate by differentiating the optimal tax expression with respect to each of the required variables to determine the relationship.

4.3 Why the royalty tax?

This study concentrates on determining the optimal level of the royalty tax in the mining sector. Although the royalty tax is a reliable source of government revenue, it has the disadvantage of increasing the marginal cost of mining projects and as well as reducing the functional life of some projects and can make new projects inviable (Rota-Graziosi *et al.*, 2014).

The royalty tax is one distinguishing factor of the mineral sector. It is payment firstly for the right given the mining company to mine the mineral resource and secondly, payment that gives the mining company the power to develop the resource in a way that would benefit it (Cawood, 2004). Thus, this tax is specific to the mining sector of Ghana. Other taxes that is, the corporate income tax, PAYE and others apply to other sectors of the Ghanaian economy too. Again, royalty payment symbolizes a commitment for an investor to pay for the reduction of risk (Otto *et al.*, 2000).

No other tax with respect to the resource sector creates so much controversy around the world as the royalty tax. It manifests itself based on the profitability of a project or in more regular terms based on quantity of output or the value of the mineral mined. The nation's sovereignty with its resources must be guarded and this can be done by reexamining the royalty tax.

4.4 Nature of data used

In light of the nature of the optimal tax expression, the average annual historical price of gold is the most important data required to determine the optimal tax in this study which was gotten from kitmo.com. Suffice to say that, for every typical mine, the life spans from 25 to 30 years (Akpalu and Parks, 2007). Thus, various simulations of the model within the timeframe can be carried out. All the other parameters used as stated earlier were as a result of studies carried out elsewhere. These parameters can be changed to suit a particular policy making objective.

CHAPTER FIVE

ANALYSIS AND DISCUSSION

5.0 Introduction

This section discusses the results from the simulation analysis. Emphasis is placed on the nature of the graph and not the numerical values that were acquired. Comparative static analysis is carried out to determine the relationship between the optimal royalty tax and the other variables (the price, the interest rate and the time). These simulation analysis and the graphs were carried out with the help of STATA and Microsoft Excel.

5.1 Comparative Static Analysis

Comparative static analysis compares different economic parameters before and after a change in an exogenous variable. Thus, when all other independent variables are held constant, the relationship between the said variable and the dependent variable can be determined and this process is the comparative static analysis. This is done by differentiating the dependent variable with respect to the variable of interest.

5.1.1 The price of gold and the optimal tax

Holding all other variables constant, what is the relationship between the optimal royalty tax rate and the price of gold based on the model specified? Thus, differentiating equation (14) with respect to the price of gold,

$$\theta = \frac{1}{P} (5.1679e^{rt} + 89.2707) - 0.5385$$

$$\frac{\delta\theta}{\delta P} = -\frac{1}{P^2} (5.1679e^{rt} + 89.2707) < 0$$

Holding time and interest rate constant, a higher price should lead to a lower growth in the optimal royalty tax rate and a lower price should lead to a higher growth in the optimal royalty tax rate. The mining firm should enjoy improved share per unit price of the gold when prices of gold go up. Because the royalty tax is used as a check against deforestation, price changes have nothing to do with deforestation. Prices are determined exogenously and no single miner's activity can influence the world price. An increase in the world price is not as a result of increase in the single firm's output or increased destruction of the forest hence, the increased price should not translate into high tax charges. Consequently, increases in the world price of gold is not a necessary justification for increases in the royalty tax rate. With increases in prices the mining firm should have a higher share per unit price of the gold.

5.1.2 The interest rate and the optimal tax

Again, holding all other variables constant and differentiating the optimal royalty tax expression with respect to interest rate, r as in Equation (14),

$$\frac{\delta\theta}{\delta r} = 5.1679e^{rt} \frac{t}{p} > 0$$

Holding all other variables constant, there is a positive relationship between the interest rate and the optimal royalty tax rate. Thus, a higher interest rate will lead to an increase in the optimal tax rate all other things equal. The possible reason is that, a higher interest rate signifies scarcity of resources which implies that, the optimal path of the resource will increase (production levels will increase) and thus, the path of the royalty tax. With higher interest rates, investors will be better off converting their stock of minerals for other higher interest yielding assets like bonds. This will thus boost the production of gold and will ensure a higher optimal path of the royalty tax of the resource.

5.1.3 Time and the optimal tax

Again, holding interest rate and the price of gold constant, what will happen to the optimal royalty tax rate with time?

$$\frac{\delta\theta}{\delta t} = 5.1679e^{rt} \frac{r}{p} > 0$$

Differentiating the expression of the optimal royalty tax rate (θ), with respect to time, it is observed that the optimal royalty tax rate is positively related to the time period. Specifically, the optimal tax increases with time. This is rightly so in that, the shadow price of the forest is positively related to time or it increases with time. As gold becomes more and more scarce with time and the non-timber forest benefits continue to reduce, their values (shadow prices) increase and thus, the optimal royalty tax rate should increase with time to compensate for the reduced non-timber forest

benefit of forest resources. Thus, the path of the shadow price of forest using $(\mu(t) = \mu_0 e^{rt} + (1 - e^{rt}) \frac{a_f}{r})$ is indicated in Figure 5.1.

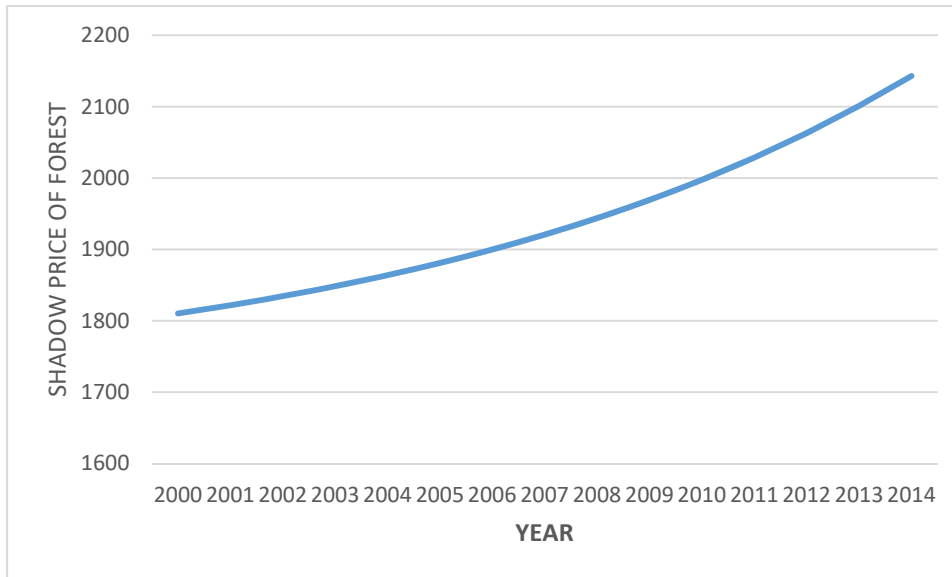


Figure 5.1 The Optimal path of the shadow price of forest

Source: Author's simulation

From Figure 5.1, the shadow price of forests is ever increasing with its initial value, $\mu_0=1800$ and at an interest rate of 10%. Supporting the fact that higher taxes should be charged to compensate for the loss of forest.

5.2 The optimal path of the optimal royalty tax

The optimal path of the optimal royalty tax rate helps to show the nature of the optimal royalty tax rate based on the parameter values. To determine the nature of the optimal path of the optimal royalty tax rate, simulations for various parameters were undertaken and observed. Firstly, interest rate is taken to be 10% with values for the shadow price of the forest, $\mu_0 = 1800, 2300$ and 2800. This section typically answers the question, what will increasing the shadow price of the forest do to the optimal path of the optimal royalty tax rate?

5.2.1 The Optimal path with $\mu_0 = 1800$ and $r = 10\%$

Thus, with the other parameters remaining the same and substituting the parameters respectively into Equation (13), the result is;

$$\theta = \frac{1800e^{0.1t} + 1701.5 - 1701.5e^{0.1t}}{826.1027 \times 19.06} - 0.5385$$

$$\theta = \frac{98.5e^{0.1t} + 1701.5}{15745.5175} - 0.5385$$

$$\theta = 0.0062756e^{0.1t} + 0.1081 - 0.5385$$

$$\theta = 0.0062756e^{0.1t} - 0.4304$$

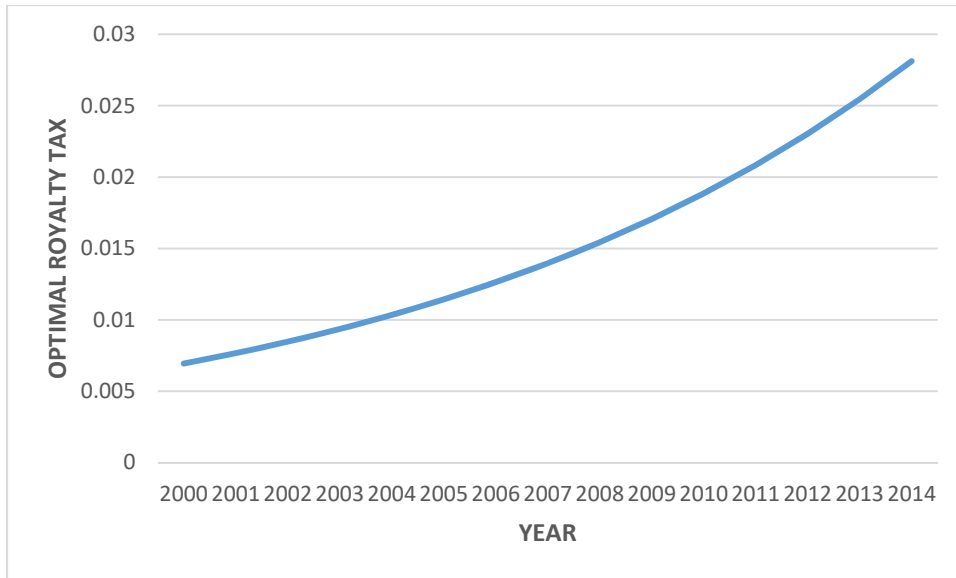


Figure 5.2 The Optimal path with $\mu_0 = 1800$ and $r = 10\%$

Source: Author's simulation

The slope of the curve in Figure 5.2 is 0.0062756. This path shown in Figure 5.2 is increasing with time. Thus as expected, the optimal royalty tax rate is increasing with time.

5.2.2 The Optimal path with $\mu_0 = 2300$ and $r = 10\%$

Now substituting these parameters into Equation (13), the result is;

$$\theta = \frac{2300e^{0.1*t} + (1 - e^{0.1*t})1701.5}{826.1027*19.06} - 0.5385$$

$$\theta = \frac{2300e^{0.1*t} + 1701.5 - 1701.5e^{0.1*t}}{15745.517462} - 0.5385$$

$$\theta = \frac{598.5e^{0.1*t} + 1701.5}{15745.517462} - 0.5385$$

$$\theta = 0.03801e^{0.1*t} + 0.1081 - 0.5385$$

$$\theta = 0.03801e^{0.1*t} + 0.4304$$

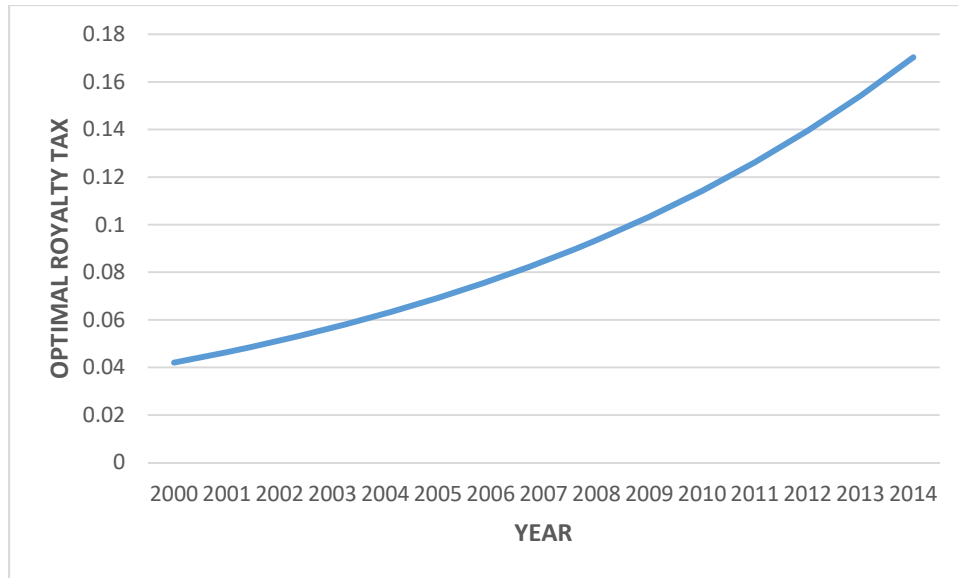


Figure 5.3 The Optimal path with $\mu_0 = 2300$ and $r = 10\%$

Source: Author's simulation

Comparing Figures 5.2 and 5.3, it is realized that the slope of Figure 5.3 (that is 0.03801), which shows the optimal path for a higher shadow price of the forest is steeper hence, it indicates increased scarcity of the forest benefits as a result of increased destruction of forest resources for mining.

5.2.3 The Optimal tax with $\mu_0 = 2800$ and $r = 10\%$

Substituting these parameters into Equation (13) the result is;

$$\theta = \frac{2800e^{0.1*t} + (1 - e^{0.1*t})1701.5}{826.1027*19.06} - 0.5385$$

$$\theta = \frac{2800e^{0.1*t} - 1701.5e^{0.1*t} + 1701.5}{15745.5175} - 0.5385$$

$$\theta = \frac{1098.5e^{0.1*t} + 1701.5}{15745.5175} - 0.5385$$

$$\theta = 0.0698e^{0.1*t} + 0.1081 - 0.5385$$

$$\theta = 0.0698e^{0.1*t} - 0.4304$$

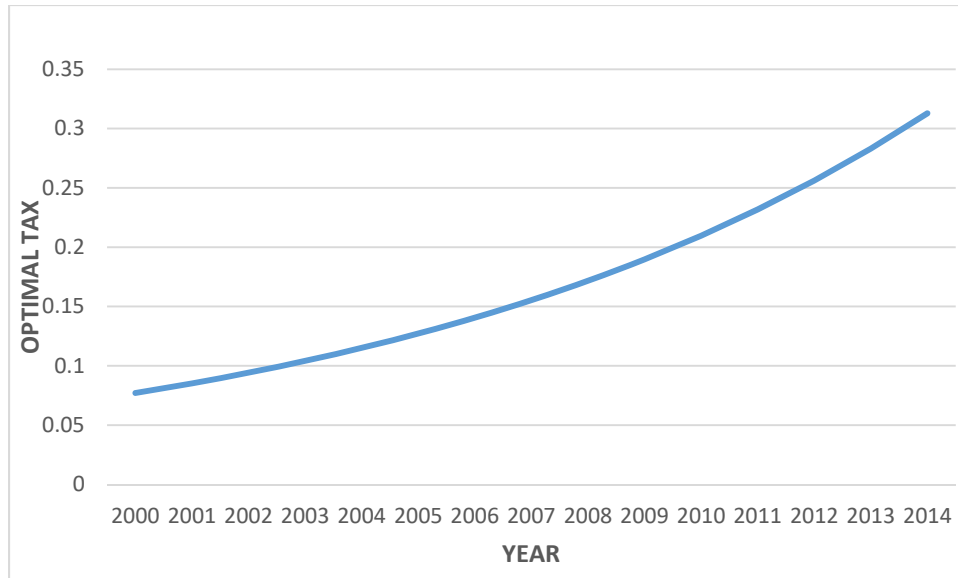


Figure 5.4 **The Optimal tax with $\mu_0 = 2800$ and $r = 10\%$**

Source: Author's simulation

Again, overstating the shadow price of the forest the optimal path of the optimal royalty tax becomes much steeper (0.0698) where as the previous, 0.0062756 and 0.03801 for $\mu_0 = 1800$ and 2300 respectively indicates smaller slopes in comparison. Thus, in cases where the destruction of forest as a result of mining is greater, the optimal tax rate should grow at a higher rate since the time to exhaustion of the mineral resource is reduced. Thus, the optimal path shown in this section shows an increasing path of the optimal royalty tax rate for all the chosen values of the shadow price of the forest whereas the difference comes with their respective slopes.

5.3 The Optimal path of the Optimal royalty tax rate with a fall in interest rate (from 10% to 5%)

In section 5.2, the optimal path of the optimal tax rate was simulated with respect to an interest rate of 10%. In this section, the optimal path for the optimal royalty tax is simulated with respect to a lower interest rate of 5%. It is expected that, the path will be ever increasing however, what effect will the decrease in the interest rate have on the slope? It is important to note that, a lower interest rate will increase the values chosen for the shadow price of forest given the restriction that $\mu_0 > \frac{a_f}{r}$. Thus, with $a_f \approx 170.15$, $\frac{a_f}{r} \approx 1701.5$ when interest rate is 10% and 3403 when interest rate is 5%.

Simulations for the optimal royalty tax rate for μ_0 values, 3500, 4000 and 4500 are carried out with interest rate, $r = 5\%$.

5.3.1 The Optimal Path of the optimal royalty tax with $\mu_0 = 3500$ and $r = 5\%$

Now substituting $\mu_0 = 3500$ and $r = 5\%$ into Equation (13) and simulating, the results are as follows;

$$\theta = \frac{3500e^{0.05t} + 3403 - 3403e^{0.05t}}{826.1027 \times 19.06} - 0.5385$$

$$\theta = \frac{97e^{0.05t} + 3403}{15745.5175} - 0.5385$$

$$\theta = 0.00616e^{0.05t} + 0.2161 - 0.5385$$

$$\theta = 0.00616e^{0.05t} - 0.3224$$

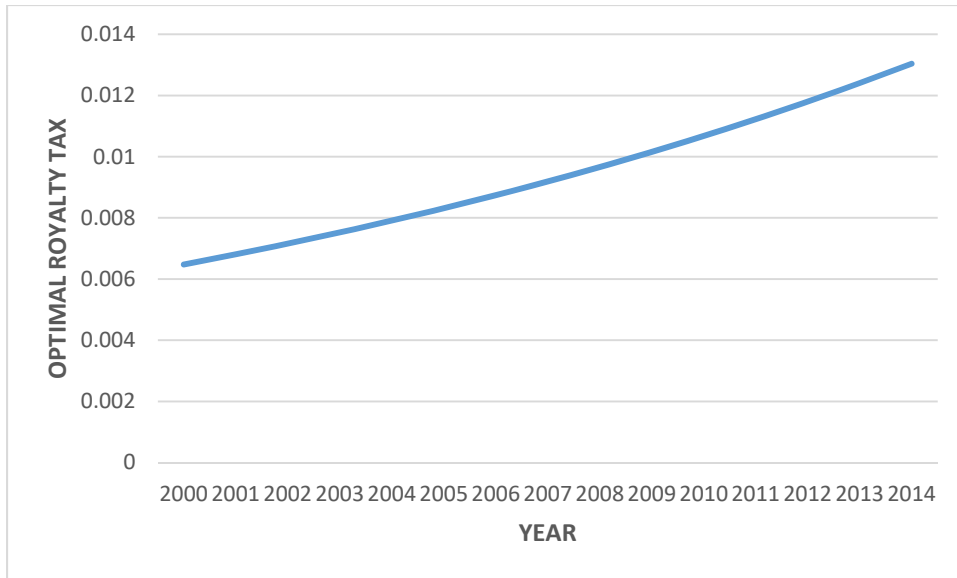


Figure 5.5 The Optimal path with $\mu_0 = 3500$ and $r = 5\%$

Source: Author's simulation

Under an interest rate of 5% and the shadow price of the forest at a low of 3500, the slope of the graph as shown in figure 5.5 is 0.00616. As expected, the path shown is ever increasing.

5.3.2 The Optimal path with $\mu_0 = 4000$ and $r = 5\%$

From previous analysis, it is expected that an increase in the shadow price of the forest will not change the optimal path of the optimal tax. It is expected that the path will be rising throughout. Again, all other variables are as before with the shadow price of forest being 4000 and the interest rate of 5%. Thus, substituting into Equation (13) the result is;

$$\theta = \frac{4000e^{0.05t} + 3403 - 3403e^{0.05t}}{826.1027 \times 19.06} - 0.5385$$

$$\theta = \frac{597e^{0.05t} + 3403}{15745.5175} - 0.5385$$

$$\theta = 0.0379e^{0.05t} + 0.2161 - 0.5385$$

$$\theta = 0.0379e^{0.05t} - 0.3224$$

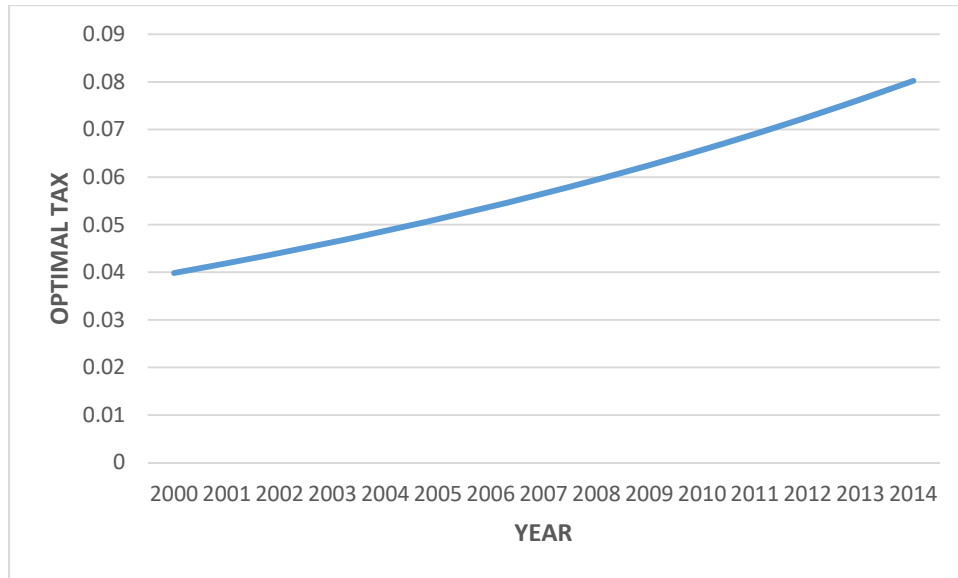


Figure 5.6 The Optimal path with $\mu_0 = 4000$ and $r = 5\%$

Source: Author's simulation

The slope of the graph in Figure 5.5 (0.00616) is lower than that in Figure 5.6 (0.0379). Thus, an increase in the shadow price of the forest will increase the slope and thus increase the production. This reiterates the fact that, an increase in the shadow price of the forest should lead to an increase in the growth of the optimal royalty tax rate.

To make this argument clearer, what will happen when the shadow price of the forest is increased to 4500 at the same interest rate?

5.3.3 The Optimal path with $\mu_0 = 4500$ and $r = 5\%$

In this section, the shadow price of the forest is increased further to determine the effect it has on the optimal path. From 5.3.1 and 5.3.2, it is expected that the slope of the optimal path will increase. Again, with all other parameters held constant and substituting these into Equation (13) the result obtained is;

$$\theta = \frac{4500e^{0.05t} + 3403 - 3403e^{0.05t}}{826.1027 \times 19.06} - 0.5385$$

$$\theta = \frac{1097e^{0.05t} + 3403}{15745.5175} - 0.5385$$

$$\theta = 0.0697e^{0.05t} + 0.2161 - 0.5385$$

$$\theta = 0.0697e^{0.05t} - 0.3224$$

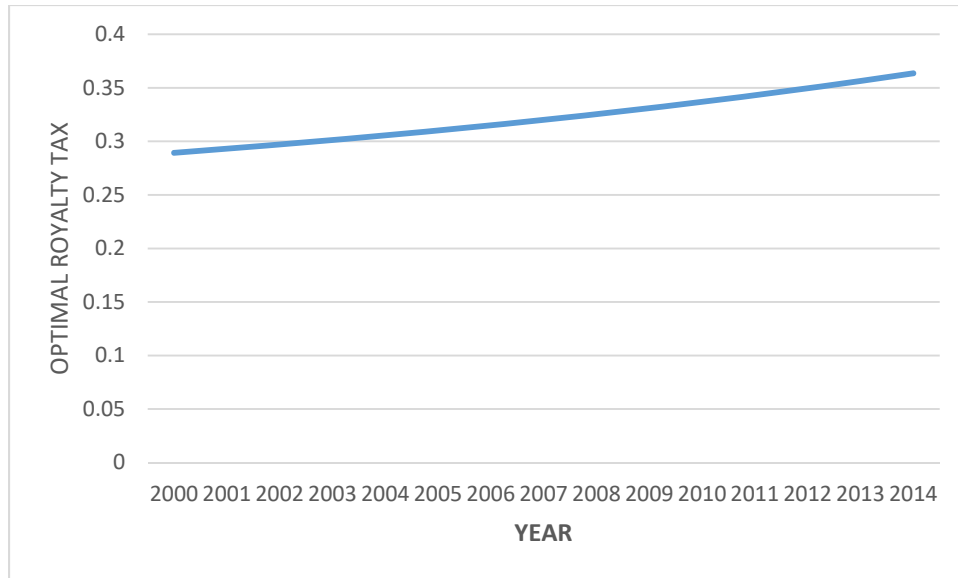


Figure 5.7 The Optimal path with $\mu_0 = 4500$ and $r = 5\%$

Source: Author's simulation

From Figure 5.7 with slope 0.0697 (which is greater than the slopes of the initial paths with lower shadow prices of the forest) the path shown is ever increasing and if the vertical axis for all the different parameters is in equal units, figures with greater slopes will be clearly steeper.

Now, at interest rate 10%, the respective slopes are, 0.0062756, 0.03801 and 0.0698 with the shadow price of forest, $\mu_0=1800, 2300$ and 2800 and with interest rate of 5%, the respective slopes are: 0.00616, 0.0379 and 0.0697 with shadow price of forest, $\mu_0=3500, 4000$ and 4500 respectively. Although a higher interest rate shows an increase in the slope by a somewhat small amount, as in the comparative static analysis, a higher interest rate is expected to increase the optimal path of the optimal royalty tax.

Thus, at higher interest rate, it is likely there will be an increase in the production of gold. When the US interest rates increase, people as much as possible want to free up their stock of precious metals for liquid assets to invest into more productive assets as a result of the increase in interest rate. Another possibility is that, when interest rates rise, mineral producers have to sell more gold in order to defray off their debts since the increase in interest rates will increase the cost of the debt thus, increase in production. As more gold is extracted, the optimal path of the gold will increase hence greater share of the optimal royalty tax.

5.4 The Optimal path with corresponding yearly average gold prices

In the previous section, the study explored the nature of the optimal path of the optimal royalty tax with the 15 year average price of gold. In this section, the study will explore the optimal path with respect to corresponding yearly average gold prices. Thus, this section will concentrate on values for the shadow price of forest $\mu_0 = 1800$ and 2300 at interest rate, r at 10%.

5.4.1 The Optimal path at $\mu_0 = 1800$ and $r = 10\%$.

The beginning point here is from Equation (14) where the basic expression for the optimal royalty tax with $\mu_0 = 1800$ and $r = 10\%$ and inserting these values into the equation and using information on average yearly price from 2000 to 2014 and simulating the optimal path is shown in Figure 5.8;

$$\theta = \frac{1}{P} \left(\frac{1800e^{0.1t} + (1-e^{0.1t})1701.5}{19.06} \right) - 0.5385$$

$$\theta = \frac{1}{P} (94.4386e^{0.1t} + 89.2707 - 89.2707e^{0.1t}) - 0.5385$$

$$\theta = \frac{1}{P} (5.1679e^{0.1t} + 89.2707) - 0.5385$$

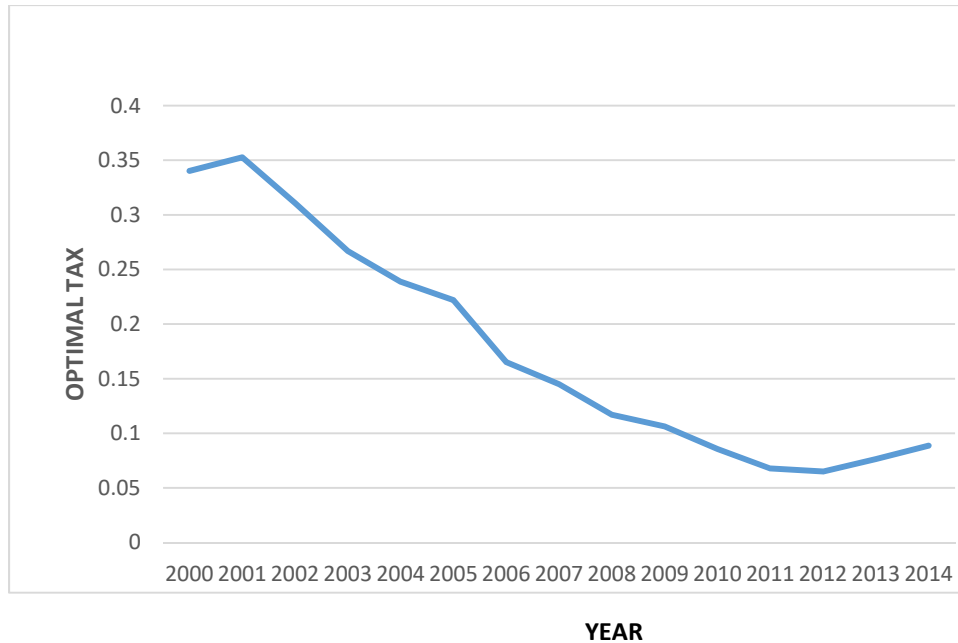


Figure 5.8 The Optimal path at respective years with $\mu_0 = 1800$ and $r = 10\%$.

Source: Author's simulation

The path shown by Figure 5.8 implies a decreasing optimal path which begins to rise after the year 2012. This path is typically negatively related to the yearly price of gold. Whereas the optimal path for Figure 5.6 is downward sloping and rising slightly after the year 2012, the path shown by the price of gold as in Figure 5.9 is upward sloping and then falls after the year 2012. This suggests that gold price increases will lead to a fall in the optimal path and vice versa and thus confirms the results of the comparative static analysis.

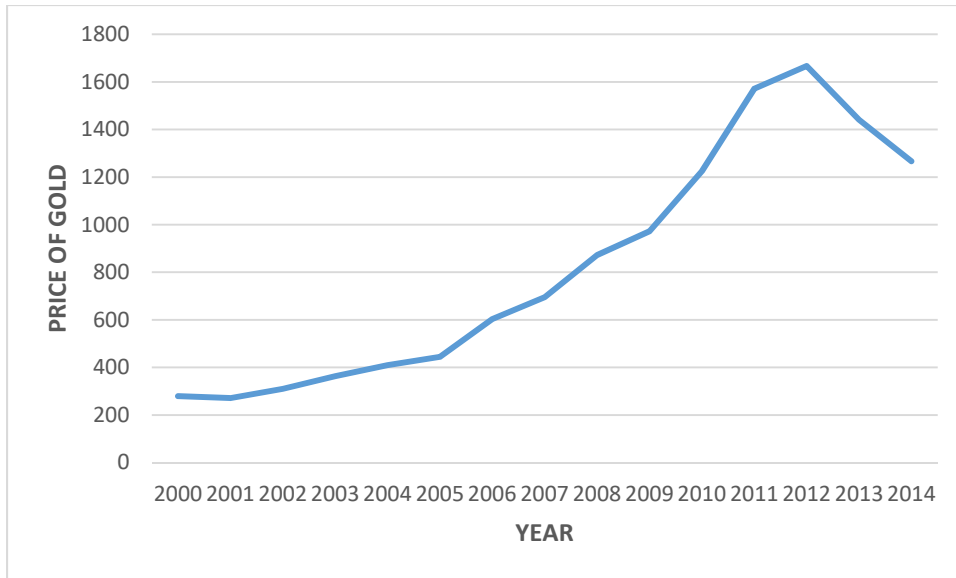


Figure 5.9 Price of gold

Source: Author's simulation

Figure 5.9 which is the path of the price of gold from 2002 to 2014 rises initially and falls thus indicating a reverse to the path of the optimal tax.

5.4.3 The Optimal path at $\mu_0 = 2300, r = 10\%$

With the shadow price of forest increasing from 1800 to 2300, what will be the optimal path of the optimal royalty tax? Will the path change significantly? By substituting the new shadow price of forest into Equation (14) the result is:

$$\theta = \frac{2300e^{0.1t} + 1701.5 - 1701.5e^{0.1t}}{19.06 \times P} - 0.5385$$

$$\theta = \frac{590.5e^{0.1t} + 1701.5}{19.06 \times P} - 0.5385$$

$$\theta = \frac{1}{P} (31.4008e^{0.1t} + 89.2707) - 0.5385$$

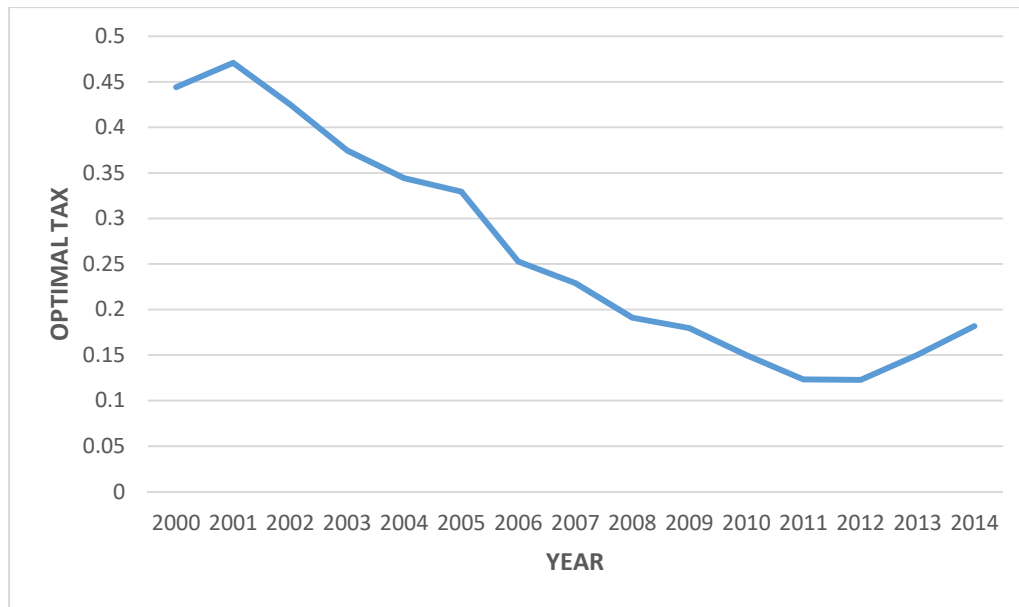


Figure 5.10 Optimal path with $\mu_0 = 2300$ and $r=5\%$

The path shown in Figure 5.10 is similar to that shown in Figure 5.8 when the shadow price is lower. It falls initially and attains a minimum in 2011 and 2012 and rises in 2012 forward. This trend exist irrespective of the interest rate used or the value of the shadow price of forest used.

5.5 Conclusion

Knowledge of the path of the optimal royalty tax rate which explains the nature of the tax structure is critical in designing an optimal tax policy in the mineral sector. The discussions above firstly used a comparative static analysis to determine the relationship between the optimal royalty tax and key variables. The analysis showed that; there exists a negative relationship between the price of gold and the optimal royalty tax rate, a positive relationship between interest rate and the optimal royalty tax rate, and the optimal royalty tax rate increases with time.

Again, the optimal path was determined using the average yearly price of gold for the 15 year period from 2000 to 2014 and analysis carried out for various shadow prices of the forest. The results showed that in line with empirical studies and vindicating the results from the comparative static analysis, the optimal royalty tax rate increases with time. Also, overstating the shadow price of the forest will increase the slope of the optimal path of the optimal royalty tax and a higher interest rate is likely to increase the slope of the optimal path of the optimal royalty tax.

Lastly, analysis were carried out to determine the optimal path of the optimal royalty tax with respective yearly average price of gold with varying shadow prices of the forest. The results showed that irrespective of understating or overstating the shadow price of the forest, the optimal path is essentially the same. It will fall, reach a minimum and then rise. It was also observed that this trend of the optimal path is inversely analogous to the yearly average price of gold.

CHAPTER SIX

SUMMARY, CONCLUSION AND RECOMMENDATIONS

6.0 Introduction

This chapter which is the final of the study brings down the curtain to the study on the optimal taxation in the mining sector of Ghana by again reiterating some of the key issues in the study and based on the analysis, provides recommendations to the fiscal policy makers with respect to taxation in the mining sector. Again, in light of the fact that studies in this area remains handicapped, recommendations for further studies as well as other ways to improve this study are suggested. Last but not least, the limitations of the study are briefly highlighted.

6.1 Summary and Conclusion

Ghana's mineral sector could be sustained in the long run if the pact governing the sector, including expansion and broadening of the sector, consolidation of the association with other sectors and also improving the fiscal regimes that exist are well implemented. Again, limiting the reliance on imports, reducing public expenditure and thus the debt, and enhancing the output through training regimes for workers and appropriate technological and capital allocation are also important considerations needed to improve the sector and the economy as a whole.

The SAP of the 1980s ensured that policies and government control in the mining sector were reviewed. Some of the changes in the mineral Act as a result of the reform and some post reform

tax regulatory changes were discussed. Several incentives to investors as a result of the reform ensured that FDIs in the mining sector increased and the result was that, gold output increased in the 1990s to 2000s. The periods between 2004 and 2014 saw the mineral sector's contribution to GDP not being more than 6%. Gold however continues to lead the mineral sector in terms of its contribution to GDP, exports and others and thus the study concentrates on the gold sector.

Taxation remains an important means for the government of Ghana to generate its due from mining. Over the period (2005 to 2014), the sector has contributed an average of not less than 10% to total revenue collected by the Ghana Revenue Authority. Many taxes exist in the gold sector, key amongst them are the royalty and the corporate profit tax. Mineral royalties and corporate income tax remain the most important taxes in the sector and this study considers these two taxes charged in the sector with the royalty tax the tax rate to be optimized and the corporate tax an independent variable in the model. The 10% dividends that government receives is also an important source of government revenue in the sector. Implementing a new tax regime especially when it imposes additional costs to mining companies can be challenging irrespective of the long-term benefits available to both parties (the mining firm and the government).

The tax administration of a tax system is important in drawing an optimal tax structure. In order to ensure effectiveness and efficiency of the system the tax structure should be sound enough for both the collectors and the payers. Thus, the system should be clear and easy to be integrated into the national system or trends. The system must be devoid of ambiguity for easier administration.

Minerals are non-renewable resources thus, the nation must bear in mind that the opportunities that the mineral wealth gives today will not be available for future generations. This consideration is key to ensuring sustainable development. The resources that Ghana has today do not belong only to this generation thus, policy makers must ensure an efficient tax system that will enable the

present generation to meet their needs without conceding in any substantial way the ability of future generation to meet their own needs (Giddings *et al.*, 2002).

Most of the empirical studies on optimal taxation in the mining sector use the dynamic optimization procedure to optimize the objective functions (Examples, Akpalu and Parks, 2007; Vocke and Oomes, 2003 and Saji, 2010). Again, some theoretical models also explain optimization using a dynamic optimization model. Mining usually leads to the destruction of forests with the ecosystem that it supports. This fact was considered in estimating the optimal royalty tax of the mining sector. A dynamic optimization model was used with the present value Hamiltonian to optimize the social planner and miner's objective functions given the equations of motion and their constraints.

6.2 Recommendations

The recommendations as discussed in this section are compartmented into general and specific recommendations. The general recommendations are discussed as a result of various issues that came up during the overview and the literature review of the study. These general issues may or may not be directly related to the optimal taxation in the mining sector but these will encourage discussions and research in such areas which will help improve taxation in the mining sector of Ghana. The specific recommendations are highlighted based on the analysis and discussions of the study. As part of the recommendations, suggestions for further studies will also be given.

6.2.1 General Recommendations

The literature review and overview of this study have brought to light certain key aspects with respect to the design of tax policy in the mining sector of Ghana. Improvement in long-term revenue should be the main aim of the design of a tax policy. Some studies such as Saji (2010) and Akpalu and Parks (2007) have suggested based on empirical results an appropriate tax level to be charged in the mining sector or have suggested that a particular tax rate may or may not be optimal.

In the real world however, and in this study for that matter, it is not possible to confidently come out with a particular tax rate and declare it as optimal. What the nature of this optimal tax should be is the aim of this research. Importantly however, these suggestions will help improve the tax revenue in the long run.

Firstly, tax administration of the particular tax structure can enhance the revenue for the mining sector. No matter how high a tax rate is, if it is not administered well, it will not enhance the mining tax revenue. Thus, important in mining tax collection, access to information by the tax collectors is important. Mining companies are usually economical about information concerning resource stock, output level, cost and the time frame to exhaustion among others. Tax administrators must be empowered by building their capacity with relevant training and encouraging tax collectors with the needed resources to enhance their tax collection efforts. Measures that will deter miners from evading taxes should be strengthened and tax evaders should be punished severely to discourage others from evading taxes.

Secondly, issues concerning sustainable development are needful in designing mining tax policies. When a mineral is mined, the nation is denied a resource and other direct costs to the nation which includes the destruction of forests, interfering with the culture and other relevant economic

activities that a community is engaged in. In a case where the mineral deposits are exhausted, these communities may lose forever their indigenous economic and social activities that they hitherto were engaged in. When sustainable development is considered, productive capacities to ensure that some of these communities are able to maintain some other viable forms of economic activity must be put in place. This can be ensured if and only if the tax policy considers these massive indirect cost of mining in its formulation.

Again, other measures to improve the revenue collection in the mining sector should be considered. For instance, in an effort to expand the tax base, small scale miners who have not yet been registered should be brought on board. Again, in the wake of the activities of many illegal miners, in the interest of the nation at large, government should give them ultimatums to be properly registered and thus regulate their activities. Many of these illegal miners destroy the water bodies that supports life for several communities by their alluvial gold mining. What these illegal miners do essentially is to trade Ghana's gold for water and if water is life, then they are destroying lives indeed with the use of their dredging machine to crush the rock supposedly containing the gold. Vigorous sanctions should be placed against such illegality without partiality and steps should be taken to ensure that mining is done without such unreasonable long-term costs.

Moreover, surface mining which is the norm in Ghana brings about massive destruction of the land. Although underground mining which is more environmentally friendly is riskier, modern ways to make it less risky are used in major mining countries like Australia and South Africa. In order to reduce the destruction of arable land and forests, policy makers should look critically at underground mining. There should be healthy debate in critically exploring if the nation should consider underground mining amidst the modern safety measures.

Finally, great benefit can accrue to the nation if the linkages available in the sector are well explored and developed. The mining sector has the potential to provide great wealth and employment for the nation if the nation pays attention to the linkages that this sector can provide. A chain of intermediate and manufacturing industries that will convert the nation's minerals into value-added metals can greatly enhance growth and development. Most of the capital in terms of machinery, logistics and chemicals used in mineral extraction are imported thus, in terms of backward linkages, there may not be a lot in it for the nation but when it comes to forward linkages, the nation can develop a distribution chain that will add value to the mineral resources of Ghana before it is finally exported. The starting point is building the human capital and enhancing the infrastructure in the sector. Other non-mining operations will also definitely benefit from such improvements.

6.2.2 Specific Recommendations

In line with the results and discussions of this study, some specific recommendations have been outlined. These recommendations are aimed at furnishing policy makers with some important considerations in the design of the optimal royalty tax.

Firstly, it is important that the optimal tax structure should bring about an increase in the royalty tax with time. This is important because the shadow price of the forest stock continues to increase with time. As the benefits of the forest are destroyed as a result of mining, the other uses that the forest will offer will increase in cost. For instance, scarcity of certain herbal plants will bring about increased costs of them. As minerals are continuously mined, they become scarce and scarce and thus all things being equal they will attract higher prices relative to the prices of other capital

goods. Thus, as time elapses, it is important to ensure a higher royalty tax to take advantage of the scarcity value of these metals.

Secondly when policy makers are designing a tax policy in the mining sector, they must take into consideration the volatility of the interest rates. From the results, higher interest rate is likely to increase the optimal path of the optimal royalty tax thus, when interest rates rise the time period to exhaustion of the resource reduces. This is as a result of the desire to divert minerals and some other assets into higher interest yielding investments. Again, higher interest rates will mean mining firms will have to pay more to defray their debts and thus they will extract more of the metal. Thus the desire (demand) for the minerals will increase and hence, the growth of the optimal tax should increase.

Furthermore, the relationship between the tax structure and the price is important. Based on the analysis in this study, an average price will ensure that the optimal path of the optimal tax is decreasing thus prices should be negatively related to the optimal tax. In mineral tax planning, policy makers should not charge a higher tax when gold prices increase. Miners should benefit from the increase in price by enjoying a greater share of it. In the same vein, for optimality to be ensured, miners should not push for lower taxes when world market prices go down. Investment is a risk and low prices is a risk that miners have to battle with.

Last but not least, this study assumes that the mining sector is a perfectly competitive industry however, not all information can be known with certainty in the real world. For instance, the shadow price of the forest is used because there is no organized market for the non-timber forest benefit. This study uses values from previous studies to represent the shadow price of the forest however, policy makers in Ghana must be able to estimate values for non-timber forest benefits especially since the various non-timber uses of the forest will vary from country to country.

6.2.3 Recommendation for further studies

Although the royalty and the corporate income tax are the most significant taxes in the mining sector, other taxes exist although they seem insignificant compared to the royalty and the corporate income tax. However, these taxes may jointly be of great significance. In light of this, new research can introduce these other taxes as a unit or as a constant before estimating the objective functions. The dividend tax for instance which is the government's non-contributing share to all gold mining ventures is also an important tax in the mining sector so is the PAYE and future research can take these into consideration.

Also importantly is estimating the cost function in the mining sector of Ghana. In this study, the cost function featured but during the optimization, it cancelled out. However, if the objective function is re-specified and modified, the cost function may not escape. Although data on the cost in the mining sector is not readily available, data on the cost of some individual mining firms are available and given the restriction in the availability, the data of a single firm can be hypothetically used to represent the entire gold sector.

Again, in order to appreciate the full costs (social and environmental) of surface mining activities in Ghana, a study to undertake this task will be helpful. There are some methods to value environmental cost like the Hedonic pricing approach, travel cost method, replacement cost method and so on. When an appropriate proxy is used to determine the externalities that come with mining especially surface mining, then including these indirect costs to mining in the formulation of the tax policy will be a step in the right direction.

Finally and not quite directly to taxation, exploring the direct and indirect linkage effects of the gold sector using the Input-Output model to better understand the linkage effects of the sector will

provide great empirical insight. It has been conjectured widely even in empirical studies that the linkage effects of gold mining to the various fabrics of the economy leaves a lot to be desired. Analyzing the mining sector with the model will provide a sound empirical bases of how the mineral sector is linked to other sectors and to also determine the role taxation plays in the model. In conclusion, the study attempted to estimate the optimal royalty tax in the mining sector albeit based on prevailing circumstances and certain parameter values chosen. It was observed that in designing an optimal tax structure, it is more important to know the path of the optimal tax as well as how changes in some important parameter values will affect the tax structure.

6.3 Limitations of the study

This study principally determined the optimal path of the optimal tax in the mining sector. In determining the optimal royalty tax in the mining sector, the following limitations came to play;

- There is no organized market available for the non-timber forest benefits and thus, the shadow price of these forest benefits was used thanks to studies elsewhere although the parameter used may not be entirely accurate;
- Modeling mathematically the objective functions of the miner and the social planner was very challenging and including other important considerations such as the dividend tax and the functional form of the cost function which would have made the research richer was overlooked due to these complexities that will arise in the model;
- Inability to acquire data of the cost incurred by mining sector and estimating it thereby ensured that the cost function was dependent on only the output; and

- The empirical studies of the mining sector as have been highlighted in previous chapters remain highly unpopular. The gold sector for decades remains an invaluable sector of the Ghanaian economy and thus prior to this study, the believe that numerous empirical literature will be available existed. This was not the case however and as a result, the methodology proved challenging to draw.

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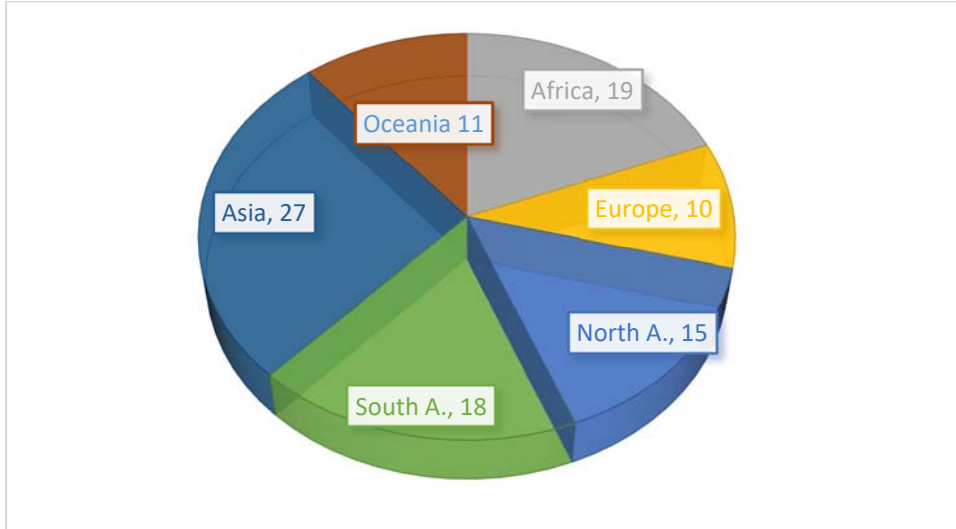
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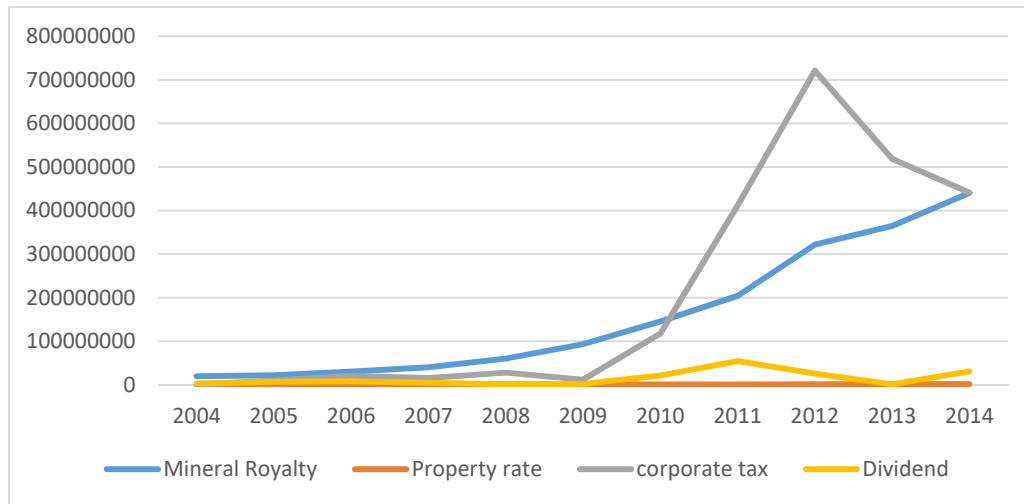
APPENDIX

APPENDIX A: World Gold Output in 2014 in percentage according to continents



Source: GFMS survey, 2015

APPENDIX B: Trend of some major mineral tax revenue



Source: Ghana Chamber of Mines

APPENDIX C: GOLD OUTPUT AND PRICE

Year	gold output in ounce	price in US\$
1980	437669	615
1981	349870	460
1982	335724	376
1983	311707	424
1984	282641	361
1985	283819	317
1986	447796	368
1987	328939	447
1988	374051	437
1989	418070	381
1990	522517	383.51
1991	946269	362.11
1992	1006943	343.82
1993	1251010	359.77
1994	1396887	384
1995	1630309	383.79
1996	1550814	387.81
1997	1644622	331.02
1998	2353000	294.24
1999	2257681	278.98
2000	2315000	279.11
2001	2205473	271.04
2002	2115196	309.73
2003	2208154	363.38
2004	1794496.969	409.72
2005	2029217.666	444.74
2006	2244679.578	603.46
2007	2486821.374	695.39
2008	2585913.152	871.96
2009	2930328.253	972.35
2010	2970078.852	1224.53
2011	2924383.84	1571.52
2012	3166483	1666.98
2013	3192647.838	1441.23
2014	3167754.763	1266.4

Source: Minerals Commission (output) and www.kitmo.com (price)

APPENDIX D: Proof of Equation (10)

From $\dot{\mu} - r\mu = -\alpha_f$

The integrating factor is e^{-rt}

Thus, multiplying the integrating factor by both sides of equation (6),

$$\dot{\mu}e^{-rt} - r\mu e^{-rt} = -\alpha_f e^{-rt}$$

$$\frac{d}{dt}(\mu e^{-rt}) = -\alpha_f e^{-rt}$$

$$\int \frac{d}{dt}(\mu e^{-rt}) dt = -\int \alpha_f e^{-rt} dt$$

$$\mu e^{-rt} = \frac{\alpha_f}{r} e^{-rt} + K$$

Where K is a constant

$$\therefore \mu(t) = \frac{\alpha_f}{r} + K e^{rt}$$

But at $t=0$, $\mu(0) = \frac{\alpha_f}{r} + K e^0$

$$\rightarrow K = \mu_0 - \frac{\alpha_f}{r}$$

$$\mu(t) = \mu_0 e^{rt} + (1 - e^{rt}) \frac{\alpha_f}{r}, \text{ as required}$$

APPENDIX E: Proof of Equation (11)

From $\dot{\lambda} - r\lambda = 0$,

The integrating factor is e^{-rt}

Multiplying both sides of the equation by the integrating factor,

$$\dot{\lambda}e^{-rt} - r\lambda e^{-rt} = 0$$

$$\frac{d}{dt}(\lambda e^{-rt}) = 0$$

$$\int \frac{d}{dt}(\lambda e^{-rt}) dt = \int 0 dt$$

$$\lambda e^{-rt} = K$$

Where K is the constant of integration

$$\lambda(t) = K e^{rt}$$

$$\text{But } \lambda(0) = K e^0$$

$$\therefore K = \lambda_0$$

Hence, $\lambda(t) = \lambda_0 e^{rt}$, as required.

Source of proofs: Writer's workings

Note: Appendixes G to I show simulation results that correspond to a single average price level used for each year whereas J and K relate to the corresponding average price of the corresponding year.

APPENDIX F: Simulation results of the Optimal Path of the Shadow price of forest

YEAR	OPTIMAL PATH
2000	1810.359
2001	1821.808
2002	1834.461
2003	1848.445
2004	1863.899
2005	1880.979
2006	1899.855
2007	1920.716
2008	1943.771
2009	1969.251
2010	1997.41
2011	2028.531
2012	2062.926
2013	2100.938
2014	2142.946

Source: Writer's Computation

APPENDIX G: Simulation results of the Optimal tax with $\mu_0 = 1800$ and $r = 10\%$

YEAR	OPTIMAL TAX
2000	0.0069356
2001	0.007665
2002	0.0084712
2003	0.0093621
2004	0.0103467
2005	0.0114349
2006	0.0126375
2007	0.0139666
2008	0.0154355
2009	0.0170588
2010	0.0188529
2011	0.0208357
2012	0.023027
2013	0.0254488
2014	0.0281253

Source: Writer's computation

APPENDIX H: Simulation results of the Optimal tax with $\mu_0 = 2300$ and $r = 10\%$

YEAR	OPTIMAL TAX
2000	0.0420075
2001	0.0464255
2002	0.0513081
2003	0.0567043
2004	0.0626679
2005	0.0692587
2006	0.0765427
2007	0.0845928
2008	0.0934895
2009	0.1033219
2010	0.1141884
2011	0.1261977
2012	0.13947
2013	0.1541381
2014	0.170349

Source: Writer's computation

APPENDIX I: Simulation results of the Optimal tax with $\mu_0 = 2800$ and $r = 10\%$

YEAR	OPTIMAL TAXATION
2000	0.0771409
2001	0.0852539
2002	0.0942201
2003	0.1041294
2004	0.1150807
2005	0.1271839
2006	0.1405599
2007	0.1553428
2008	0.1716803
2009	0.1897361
2010	0.2096908
2011	0.2317442
2012	0.2561169
2013	0.283053
2014	0.3128219

Source: Writer's computation

APPENDIX J: Simulation results of the Optimal tax with $\mu_0 = 3500$ and $r = 5\%$

YEAR	OPTIMAL TAX
2000	0.0064758
2001	0.0068079
2002	0.0071569
2003	0.0075238
2004	0.0079096
2005	0.0083151
2006	0.0087415
2007	0.0091896
2008	0.0096608
2009	0.0101561
2010	0.0106768
2011	0.0112243
2012	0.0117997
2013	0.0124047
2014	0.0130407

Source: Writer's computation

APPENDIX K: Simulation results of the Optimal tax with $\mu_0 = 4000$ and $r = 5\%$

YEAR	OPTIMAL TAX
2000	0.0398432
2001	0.041886
2002	0.0440335
2003	0.0462912
2004	0.0486646
2005	0.0511596
2006	0.0537827
2007	0.0565402
2008	0.059439
2009	0.0624865
2010	0.0656903
2011	0.0690583
2012	0.072599
2013	0.0763212
2014	0.0802343

Source: Writer's computation

APPENDIX L: Simulation results of the Optimal tax with $\mu_0 = 4500$ and $r = 5\%$

YEAR	OPTIMAL TAX
2000	0.2893736
2001	0.2931304
2002	0.2970799
2003	0.3012318
2004	0.3055966
2005	0.3101852
2006	0.315009
2007	0.3200802
2008	0.3254113
2009	0.3310159
2010	0.3369077
2011	0.3431017
2012	0.3496132
2013	0.3564586
2014	0.3636549

Source: Writer's computation

APPENDIX M: Simulation results of the Optimal tax with $\mu_0=1800$, $r = 10\%$ and corresponding yearly average price of gold

YEAR	OPTIMAL TAX
2000	0.3403035
2001	0.352652
2002	0.3107437
2003	0.266884
2004	0.2386779
2005	0.2218987
2006	0.1651768
2007	0.1449145
2008	0.1169568
2009	0.1062565
2010	0.0855805
2011	0.0677234
2012	0.0649277
2013	0.0764816
2014	0.0887805

Source: Writer's computation

APPENDIX N: Simulation results of the Optimal tax with $\mu_0=2300$, $r = 10\%$ and corresponding yearly average price of gold

YEAR	OPTIMAL TAX
2000	0.444176
2001	0.4708667
2002	0.4250713
2003	0.3745809
2004	0.3442397
2005	0.329376
2006	0.2527162
2007	0.2288708
2008	0.1909539
2009	0.1795927
2010	0.1499383
2011	0.1231451
2012	0.1226707
2013	0.1502933
2014	0.1816166

Source: Writer's computation

APPENDIX O: MINERAL OUTPUT OF SOME METALS IN GHANA

YEAR	GOLD (OZ)	DIAMOND (CARATS)	MANGANESE (TONS)	BAUXITE (TONS)
2005	2,149,372	1,062,930	1,714,797	727,000
2006	2,244,680	970,751	1,658,701	886,000
2007	2,486,821	837,586	1,156,339	748,000
2008	2,585,993	598,042	1,089,021	796,000
2009	2,930,328	354,443	1,012,941	490,000
2010	2,970,080	308,679	1,194,074	512,000
2011	2,924,385	283,369	1,827,692	400,000
2012	3,166,483	215,118	1,490,634	753,000
2013	3,192,648	159,074	1,997,911	824,000
2014	3,167,755	241,120	1,353,486	981,000

Source: The Ghana Chamber of Mines and KPMG (2013)

APPENDIX P: Various mineral tax receipt in the gold sector

Year	Mineral Royalty(GHC)	Property rate(GHC)	corporate tax(GHC)	Dividend(GHC)
2004	19604676.4	185654.7	58077.8	3130502.5
2005	21856777.5	234893	9565558.2	6840923
2006	30241585	682498	20830991	8000884
2007	40205526	776286	15474933	4714248
2008	60344673	798232	28221450	1348439
2009	93284469	876841	12024257	1973364
2010	145654968	798354	117695684	21607670
2011	204332587	620721	411910573	54392757
2012	321834983	1203413	721231540	25808214
2013	364,673,038	1609722	518545259	1129498
2014	440328469	1519340	441209832	31034930

Source: The Ghana Chamber of Mines

APPENDIX Q: Export earnings from some metals in Ghana

YEAR	GOLD(in US\$)	MANGANESE(in US\$)	DIAMOND(in US \$)
1999	693,689,319	18,528,288	9,100,000
2000	654,276,233	20,577,665	10,630,000
2001	598,885,263	25,197,100	18,510,000
2002	658,136,210	24,856,860	15,959,682
2003	793,536,510	28,178,729	21,750,000
2004	731,232,992	30,247,600	26,010,921
2005	903,899,619	39,028,514	34,729,560
2006	1,327,455,774	39,932,287	30,021,594
2007	1,711,511,381	35,778,281	26,366,914
2008	2,202,878,021.22	62,348,266.00	18,892,291.87
2009	2,842,821,528.41	64,860,940.00	6,991,087.68
2010	3,620,766,466.83	77,809,077.00	11,126,088.93
2011	4,630,255,618.82	119,920,951.00	14,850,558.37
2012	5,309,042,206.83	98,605,517.00	11,163,106.66
2013	4,610,284,056.54	135,475,951.00	8,030,807.66
2014	4,108,582,925.87	91,147,458.00	10,700,961.83

Source: The Minerals Commission of Ghana

APPENDIX R: TOTAL MERCHANDISE EXPORT

YEAR	TOTAL MERCHANDISE EXPORT IN US\$
2005	2802207028
2006	3726680000
2007	4194720000
2008	5269726000
2009	5839710000
2010	7960090000
2011	12785420000
2012	13552350000
2013	13751920000
2014	13216770000

Source: World Development Indicator (WDI)