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# Natural Resources and Contagious Diseases: A Case of Mosquito-borne Virus

# 自然資源與傳染病：以蚊媒病毒為例

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# 摘要

近年來大量學術研究已經證實，自然資源對於國家發展眾多層面具有負面影響。過去的大部分研究關注的重點集中於自然資源對於經濟發展、政治體制、制度質量、以及內戰方面，鮮少研究涉及到其對疾病傳播的影響。進入二十一世紀之後人類社會更頻繁地被大規模的傳染疾病困擾。那些自然資源相對豐裕的地區，也正是被傳染疾病頻繁影響並造成大規模傷害的地區。瘧疾就是其中一種分布最廣且對公共健康造成巨大威脅的傳染病。這篇文章旨在研究自然資源對於瘧疾傳播的影響。通過所有國家從 2000 至 2014 年時間序列橫截面數據分析，結果證實自然資源豐裕程度以及依賴程度都會導致更多的瘧疾發病數以及更高的死亡數。

關鍵字：自然資源，傳染病，資源詛咒，瘧疾

# Abstract

A lot of researchers have proved that natural resources have adverse effects on the development outcomes. Most of the past researches focus on the effects of natural resources on economic growth, political regime, institutional quality, and civil war. An interesting phenomenon is that countries with rich in natural resources are also those affected frequently by contagious diseases. Malaria is one of the widest spread diseases that poses a major threat to public health. This paper aims to analyze the effects of natural resource abundance and natural resource dependence on the spread of malaria. By using the time-series, cross-sectional data of all countries from 2000 to 2014, the result shows that there is a resource curse on the contagious diseases. Both natural resource abundance and natural resource dependence lead to more confirmed cases and deaths from malaria. The effects on the incidence rate and death rate need further analysis.

*Keywords:* Natural resources, Contagious diseases, Resource curse, Malaria

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# Natural Resource and Contagious Disease:

# A Case of Mosquito-borne Virus

## Chapter I. Introduction

What does an abundance of natural resources, especially mineral resources mean to a state? Is it a blessing or a curse? For a long time, most scholars focus on the positive effects of resource wealth on the economic growth of a state (Rosenstein-Rodan, 1943; Murphy, Shleifer & Vishny, 1989). However, the rapid economic progress made by the states which lack natural resources, such as the Four Asian Tigers in the 1970s and the economic recession of resource-rich states such as Nigeria and Venezuela arouse suspicions on the role of natural resources in a state's development.

One interesting phenomenon is that natural resource-rich states are also those affected frequently by contagious diseases. The Ebola Virus raging in 2014 was breaking out in West Africa where most states depend highly on mining resources. The Middle East Respiratory Syndrome (MERS) infection cases are mainly distributed in the Middle East where these states' economies highly rely on oil resources, such as Saudi Arabia, Qatar, United Arab Emirates (UAE), and Jordan. Most of the damages caused by the Zika Virus are found in the Latin America, where most of the states are rich in mining resources. The epidemic areas and the resource-rich regions highly overlap. Is this a coincidence?

This paper seeks to analyze the impact of natural resources on the spread of contagious diseases. The mosquito-borne diseases, such as Zika, Malaria, Dengue Fever, and Japanese Encephalitis Virus (JEV) have become a major challenge to public health in some developing countries. Except for the climate factors, or the environmental factors, such as the natural environment, living conditions and infrastructure, is there a resource curse on the spread of the mosquito-borne diseases? The author argues that a country's natural resource abundance and dependence will lead to a government failure in controlling epidemics and made the epidemic situation more severe than in other countries.

### 1.1 Background

There is an increasing literature examining the effect of resource abundance or resource dependence on the development outcomes. The resource curse thesis has, to some degree, been confirmed by most scholars (Auty, 1993, 2017; Ross, 2001, 2008, 2012; Sachs & Warner, 1995,1999; Tornelll & Lane, 1999; Tsui, 2011; Torvik, 2001; Alexeev & Conrad, 2011; van der Ploeg, 2011; Gilberthorpe & Rajak, 2017; Papyrakis et al., 2016). Richard Auty (1993) first used the term Resource Curse in his book, *Sustaining Development in Mineral Economies: The Resource Curse Thesis*, to describe the adverse effects of a country's natural resource wealth on the well being of its economies, society, and politics. He finds that states rich in mineral resources are usually incapable of using those resources to boost their economies and have lower economic growth than those without abundant resources. Sachs and Warner's publication (1995) is one of the most influential, in which they provide the first cross-country study and find a negative relationship between economies with a high ratio of natural resource exports to GDP and the long-term economic growth.

Recently, there has been a heated discussion about the detrimental impacts of resource wealth. The resource curse literature has covered many aspects, most of which are its political and economic impacts. Several studies have found a strong negative relationship between oil wealth and political performance (Barro, 1999; Ross, 2001; Andersen & Ross, 2014; Tsui, 2011; Aslaksen, 2010). Oil wealth could lower the democracy level of a country (Tsui, 2011), strengthen the authoritarian regimes and the power of the authoritarian rulers (Andersen & Aslaksen, 2013; Wright, Frantz & Geddes, 2015; Gandhi & Prezeworski, 2007; Cuaresma et al. 2011), thus preventing those states from transferring into democratic states.

Resource booms can enhance rent-seeking activities and lower the economic growth (Tornell & Lane, 1996, 1999; Torvik, 2001; Baland & Francois, 2000). Governments in resource rich countries are more prone to seek rents from natural resource endowment. This could trigger a "Rentier Effect" and lower the institutional quality (Crystal, 1990; Ross, 2001; Auty, 1990; Gelb, 1988). Corden and Neary (1982) have also found a Dutch Disease model to explain how the income shock triggered by mineral wealth could shift labor and capital to the primary sector and cause inflation, thus lowering economic growth.

These studies have shown strong evidences and explanations of the resource curse on economic and political development. In addition, evidences have also been found in other scope of the resource effects. Natural resource seems to cause continual civil conflicts rather than economic benefits (Lujala, 2009,2010; Angrist & Kugler, 2008; Collier & Hoeffler, 1998). Natural resource wealth has also been proved to enlarge the gender inequality. The oil-rich states drive women away from the non-agricultural sectors. Oil production reduces the number of females in the labor force. Less women in labor force leads to less education for girls, and less female influence within family and in public (Ross, 2008, 2012). Assaad (2004) and Do, Levchenko, and Raddatz (2011) also find the detrimental effect of natural resources on the females' status.

Bulte et al. (2005) focus on the natural resources' impact on Human Development

Index and found that people in resource-abundant countries have less access to safe water and suffered more from undernourishment. De Soysa and Gizelis (2013) examined the relationship between natural resources and infectious diseases and found that there is a resource curse on the spread of HIV/AIDS. However, till now there is not enough literature showing whether there is causation between resource wealth or dependence and other diseases, such as the outbreak of a widely spread flu, and a deadly virus.

## 1.2 Motivation

In recent years, there is a more frequent and intense outbreak of contagious diseases. The outbreak of Zika Virus scared some athletes away from the Rio Summer Olympics. Brazil has reported almost 74,000 confirmed human cases of infection since 2015. The spread of Zika Virus brought Brazil with a rising number of children born with congenital microcephaly. From the year 2015 on, the transmission of mosquito-borne Zika Virus has been reported in 84 countries, territories, or subnational areas, mainly on the continents of Africa, the Americas, Asia and the Pacific (World Health Organization, 2017). The outbreak of Zika virus that has slumbered for several decades caused an emergency in the Americas.

Some other mosquito-borne diseases even have greater impacts on public health. They are more widely distributed; have more infected cases, and cause more deaths. Malaria and Dengue Fever are widely spread in more than a hundred countries. The incidence of Dengue Fever has grown rapidly in recent years and more than half of the world population is at the risk of getting infected. Dengue Fever is mostly found in urban and semi-urban areas in tropical and sub-tropical areas around the world. The

America, Southeast Asia and Western Pacific regions are the most seriously affected. There were more than 3.2 million infections in 2015 in these regions and Brazil alone reported over 1.5 million cases in 2015[1]. Similar to Dengue Fever, JEV is mosquitos-borne virus that causes viral encephalitis in Asia. About 3 billion people are at the risk of infection in 24 countries in Southeast Asia and Western Pacific, with about 68,000 yearly cases reported. And till now there is no cure for this disease[2].

One of the United Nations (UN) Millennium Development Goals (MDGs) is to combat malaria. The history of human beings fighting against malaria has been over 100 years. The elimination of malaria is still a challenge to human society. One the of targets of the Sustainable Development Goals (SDGs) is to end the epidemics of malaria by 2030. The incidence rate of malaria has decreased by 37 per cent, and the mortality rate has decreased by 58 per cent from 2000 to 2015 (WHO, 2015). However, malaria still poses a major threat to public health. According to the World Health Organization, 3.3 billion people around the world are at the risk of infection and the disease is still endemic in 97 countries. In 2010, there were 219 million infection cases of malaria and caused 660,000 deaths. And, in 2015, there are 214 million cases and 438,000 deaths. Sub-Saharan Africa has the highest share of global malaria burden with eighty-eight percent of malaria cases and ninety percent of global deaths in 2015[3]. The map below (Figure 1) shows the global malaria incidence rate in 2015, sourced from the University of California, San Francisco (UCSF) global health group’s Malaria Elimination Initiative (MEI). Malaria was a global public health problem in 1945 but more than 100 countries are malaria-free since 2015 and the incidence rates in 28 countries are less than 100.

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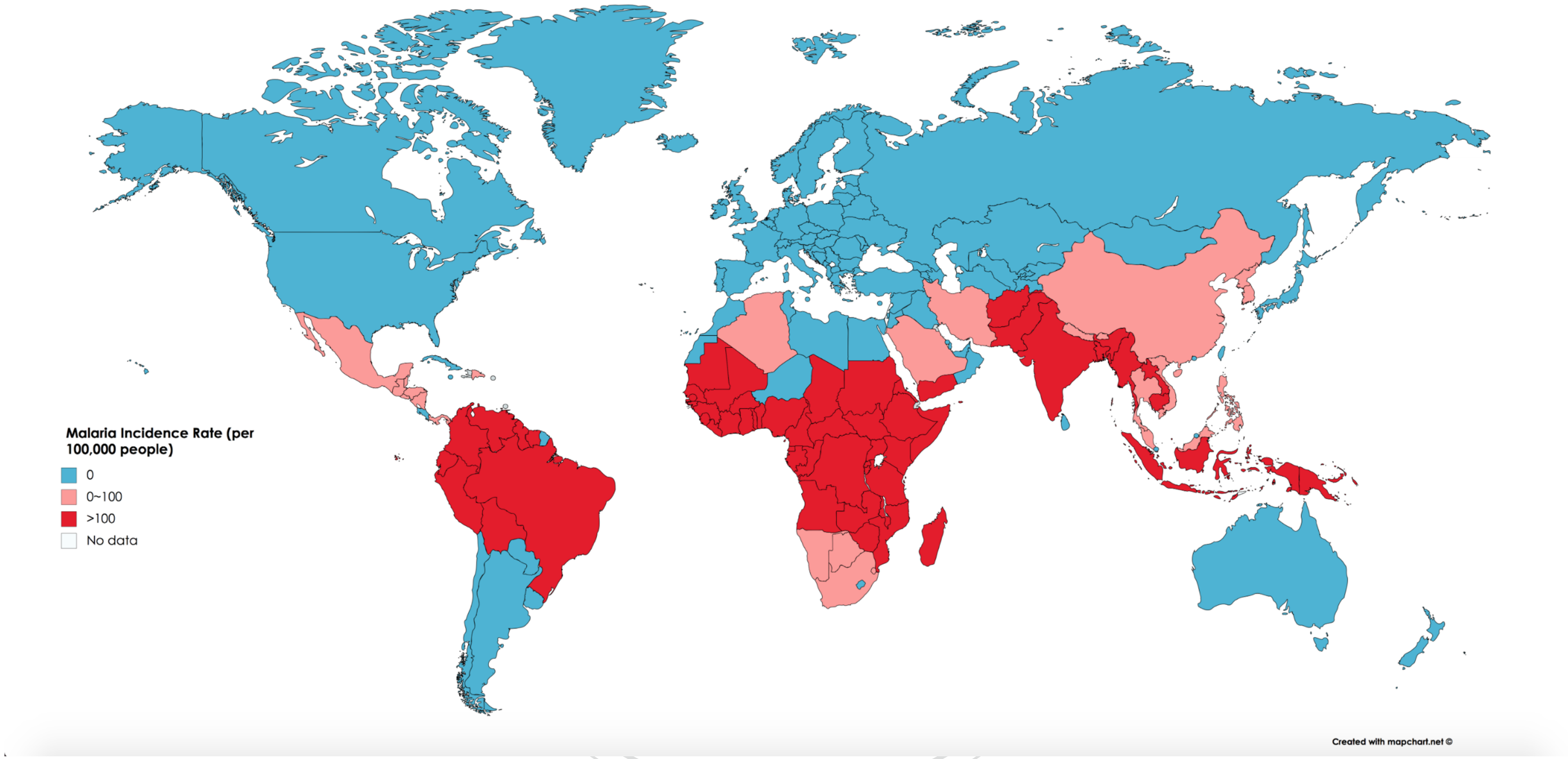
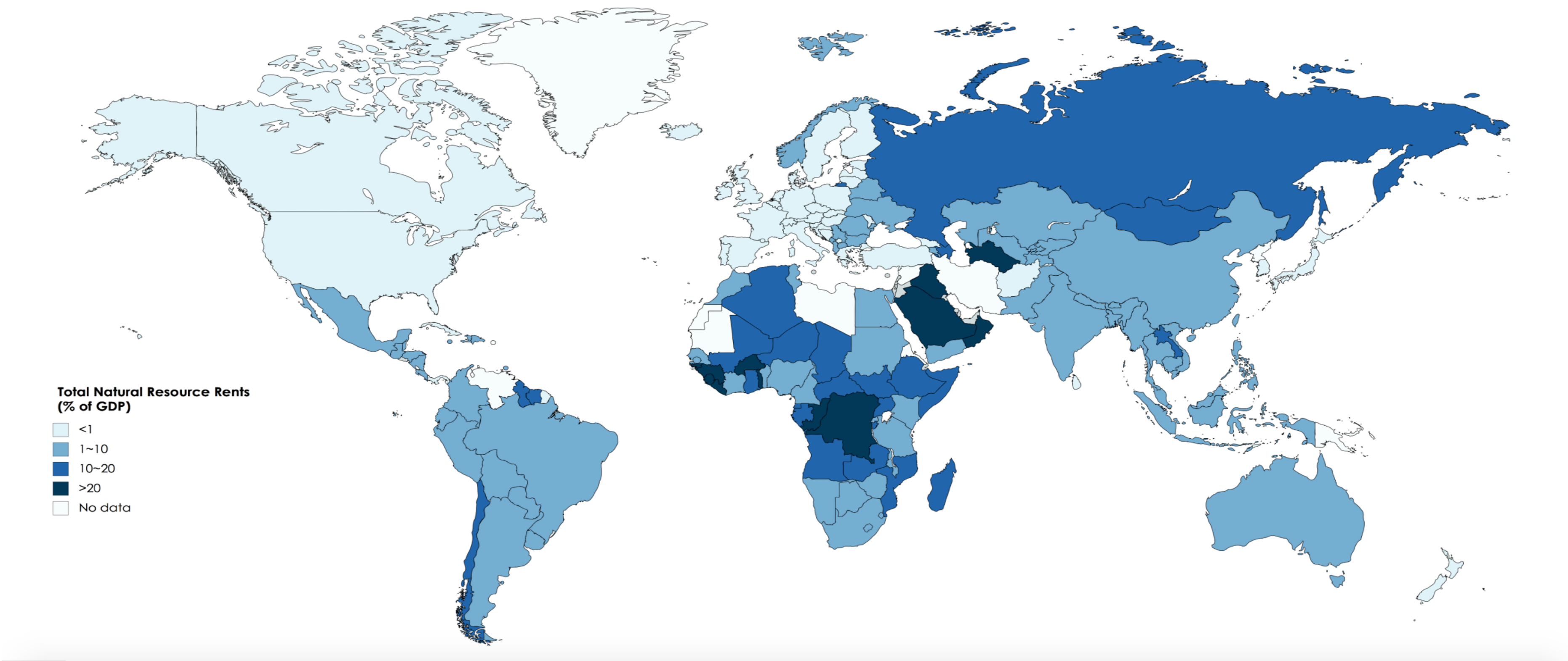
1 World Health Organization, http://www.who.int/mediacentre/factsheets/fs117/en/
2 World Health Organization http://www.who.int/mediacentre/factsheets/fs386/en/
3 World Health Organization, http://www.who.int/mediacentre/factsheets/fs094/en/



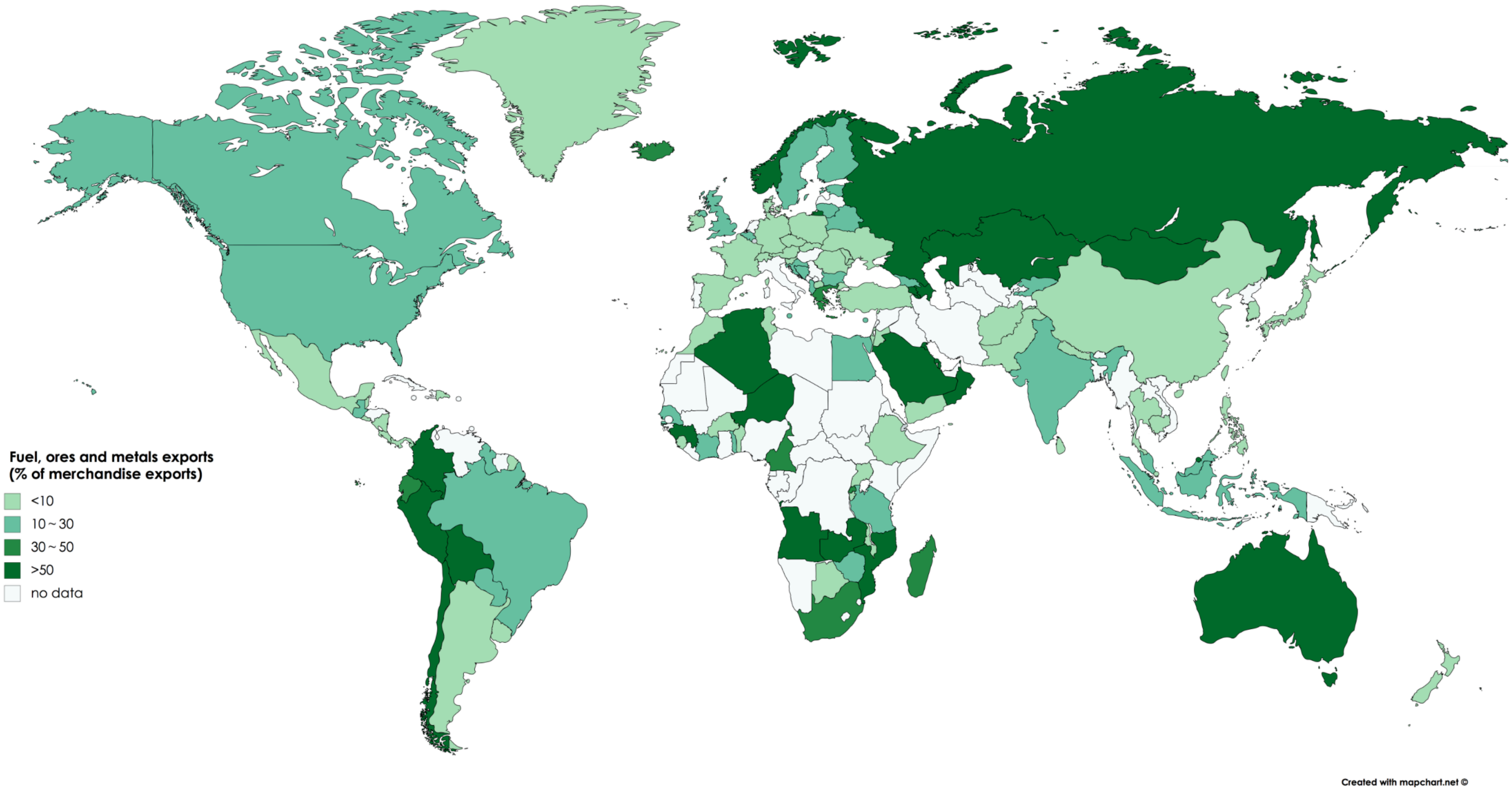

**Graph 1.1 Malaria Incidence Rate, 2015 (per 100,000 people)**

*Source: Malaria Elimination Initiative, UCSF; Gates Foundation, 2016*




**Graph 1.2 Total Natural Resource Rents (% of GDP), 2015**

*Source: World Bank, World Development Indicator, 2016*




**Graph 1.3 Natural Resource Exports (% of Merchandise Exports), 2015**

*Source: World Bank, World Development Indicator, 2016*

These diseases pose a severe threat to the public health and there is an urgent demand to figure out the factors that lead to the wide spread of these diseases and the failure of the government control. The control of the diseases depends a lot on the governments' action to fight them. To find out whether the reliance on resource wealth will affect governmental efficiency on fighting diseases or not is of vital importance to public health.

Figure 2 indicates the total natural resource rents by country. As we can see from the map, the natural resource abundance countries are mainly distributed in Africa, South America, and Asia. The resource abundant areas highly overlap the malaria endemic areas. This raises a question that is the epidemic affected by natural resources?

**1.3 Research Questions**

Taking malaria for an example, this article conducts an analysis on the relation between the spread of contagious diseases and natural resource wealth. The research questions are:

1. Is there a natural resource curse on the spread of contagious diseases, especially the mosquito-borne diseases, such as malaria?

2. Will a country's dependence on natural resource affect the incidence and mortality of malaria?

3. What mechanisms can explain the failure of governmental control of epidemics?

4. How can a country escape a curse on epidemics?

## 1.4 Methods

This article adopts a quantitative research method to analyze the impact of natural resource abundance and natural resource dependence on the spread of mosquito-borne diseases. Among all mosquito-borne virus, malaria has a relatively wider and longer influence. This paper takes malaria for an example. The dependent variables are the number of confirmed malaria cases and the incidence rate. This paper also analyses number of reported deaths and the death rate caused by malaria. Death rate and incidence rate are respectively number of deaths from malaria per 100,000 people and number of confirmed cases per 100,000 people in the country. These data are taken from World Health Organization. The independent variables in this article are natural resource abundance and natural resource dependence. This article uses total natural resource rents (% of GDP) to measure the natural resource abundance. The sum of fuel exports and metal and ores exports (% of merchandise exports) is used to measure the natural resource dependence. This article is also going to analyze the mixed effects of natural resource abundance and natural resource dependence on the spread of malaria. The data are taken from World Bank, World Development Indicator (2016).

The author uses time-series, cross-sectional (TSCS) data (or panel data) for countries all over the world that has the available data over the time period 2000-2014. Panel data provides multiple observations on each individual over time and have become widely available in both developing and developed countries. Panel data has a lot of advantages as Hsiao Cheng (2003) found:

Panel data usually give the researcher a large number of data points, increasing the degrees of freedom and reducing the collinearity among explanatory variables-hence improving the efficiency of econometric estimates. More importantly, longitudinal data allow a researcher to analyze a number of important economic questions that cannot be addressed using cross-sectional or time-series data sets (p.3).

It is important to get original data to analyze some significant questions. Panel data is of special importance to the epidemic topic since most of the diseases affected countries are developing countries, which may not have a long tradition of statistical collection. In order to make sure the real causal relation and avoid reverse causality, the dependent variables are lagged for one year.

This paper also takes into account several control variables such as the economic, political, demographical and geographical factors that may affect the malaria epidemic situation. Economic performance may affect a country's capacity to deal with the diseases. The author controls per capita income, using GDP per capita measured in current US dollars and trade openness, using indicator of trade as share of GDP. All these data are from the World Bank. Political performance such as states capacity and political regime type (Gizelis, 2009) may also affect the epidemic. The author controls the political regime and governance capacity, using Polity IV figures taken from polity datasets (Marshall, Gurr & Jaggers, 2016) and the Relative Political Capacity (RPC) (Arbetman-Rabinowitz et al., 2013). The author uses population density and urban population rate taken from the World Bank to control the demographical factors. For geographical factors, the latitude of the geographic center of the country is controlled. The date are taken from Country Ruggedness and Geographical Data (Nunn & Puga, 2012).



### 1.5 Research Limitations

There has been an increasing number of epidemics around the world in recent years. However, some areas, especially the less developed areas lack of diseases surveillance system and are not able to report the reliant epidemic data. The author is only available to analyze one of the most widespread diseases, namely the mosquito-borne virus. This paper only analyzes The WHO Global Health Observatory (GHO) data reports the annual situation on malaria. The transmission of most of the mosquito-borne diseases are similar, by analyzing the situation of malaria can to some extend represent other mosquito-borne diseases.

### 1.6 Structure of the Article

Chapter two exams the existing literature on the resource curse thesis by looking at the causal mechanisms, and its influence on public health, especially the spread of infectious diseases. Chapter three conducts a statistical test on the effects of natural resources on the number of confirmed cases and the incidence rate of malaria, using time-series, cross-sectional data over the time period 2000-2014. Chapter four analyzes the effects on the number of deaths and death rate. Chapter five concludes the major findings and the policy implications.

# Chapter II: Literature review

## 2.1 Causal Mechanisms

**2.1.1 Dutch Disease.** The Dutch Disease (coined by the *Economist, 1977*) model provides an explanation to the resource curse thesis by explaining how a resource boom could lead to deindustrialization and change the composition of production, then lower the growth rate. Because the level of productivity is determined by the composition of the production (Torvik, 2002), which will more favor primary resources, and cause a drop in total exports (Gylfason, 2001).

This term was originally used to describe the phenomenon of the development of the natural resource sectors and the decline of the tradable sectors in Dutch triggered by the discovery of the natural gas resource in 1960s. When the resource boom is over, it will cost high to move back to the former sector structure since the diversification of the economy has been impeded and it is now highly relying on the volatile mineral markets (Davis & Tilton, 2005).

Corden and Neary (1982) developed the Dutch Disease model which divides a country's economy into three sectors, which respectively are tradable natural resource sector, tradable manufacturing sector, and non-tradable sector. The disease refers to the impact that a resource boom will lead to the contraction of the manufacturing sector and the expansion of the non-traded sector. The side effects are named: the Resource Movement Effect and the Spending Effect. Both effects will result in a shift to the non-primary tradable sectors.

The Resource Movement Effect is the shift of labor and capital from the manufacturing sector to the primary sector. A resource boom will cause a rise in wages in the mineral sector to meet the need of labors in order to expand. The Spending Effect is that a resource boom will lead to a rise in the resource export, thus causing an appreciation to the domestic currency (Corden & Neary, 1982; Corden, 1984). By testing the two-sector economy model, Van der Ploeg (2011) also get similar findings that a resource boom will lead to a rise in the exports of natural resources. This will cause an appreciation of the real exchange rate and ensuing contraction of the traded sector. Krugman (1987), Matsuyama (1992), and van Wijnbergen (1984) also find that a mineral discovery or a terms-of-trade improvement will consequently drive the production factors, such as labor and capital out of the manufacturing sectors. Meanwhile, cause inflation pressure, which decreases the competitiveness of the manufacturing industries.

Early evidence on the Dutch Disease is ambiguous (Leite & Weidmann, 2002, Sala-i-Martin & Subramanian, 2003). However, Caselli and Micheals (2009) find evidences to support the Dutch Disease by conducting a within-country study. By testing the oil dependence of the municipalities in Brazil, they find that onshore oil has a modest effect on non-oil GDP composition. Empirical evidences are also fund in Auty and Evia (2001) for Bolivia, Pegg (2010) for Botswana, Papyrakis and Raveh (2014) for Canada.

The Dutch Disease model cannot always explain the curse because Corden and Neary's model assumes that the flow of labor is based on full employment, when most developing countries are faced with the problem of labor redundancy and capital deficiency. Dutch disease is more likely to happen in countries with corruption, bad institution, and lacks rule of law (van der Ploeg, 2011).

**2.1.2 Crowding-out effect.** Similar to the Dutch Disease model, the natural resource abundance could crowd out other growth-promoting tradable sectors such as manufacturing industries, thus cause a curse on the economy (Sachs & Warner, 1995; Matsuyama, 1992).

Sachs and Warner (1995) conduct a cross-country study to exam the impact of natural resource dependence on economic growth during time period 1970 and 1989. Find that countries with higher share of primary products exports at 1970 is associated with lower economic growth in the following twenty years. They develop an endogenous growth model to explain this phenomenon. The general idea is that industrial structure affects growth. A positive income shock in the natural resource sector could cause an increasing demand for non-traded products, including wages. This will lead to a decrease in the profits of the traded sectors, such as manufacturing and other sectors that use non-traded products as their inputs (Sachs & Warner, 1995, 1999, 2001).

The crowding out of the manufacturing sectors will cause deindustrialization, and then hinder the economic growth and cause a curse to the economy (Frankel, 2010), because the expansion the of natural resource sector cannot compensate the adverse effect of deindustrialization on the economy.

If the reward in the natural resource sector is high enough, it will stimulate more people, in particular the potential innovators and entrepreneurs to work in the resource sector. Thus, natural resource crowd out innovation and entrepreneurs (Gylfason et al., 1999; Sachs & Warner, 2001).

**2.1.3 Learning by doing.** How could a decline in traded sector lead to a resource curse? Both Dutch Disease and Crowding-out Effect cannot fully explain the resource curse thesis. Another popular explanation is the Learning by Doing model, that the traded sector is the driving force for economic growth and can benefit more from the Learning by Doing (Krugman, 1987; Balassa, 1964). Most economic growth is driven by technological progress and accumulating experience, which is faster in the traded sector than in the non-traded sector triggered by Learning by Doing.

Since most economic growth is caused by technological progress, which is mostly triggered by Learning by Doing in the traded sector, the forces that push factors away from traded sectors such as the manufacturing industries will reduce the learning-induced growth and lower the economy growth (Sachs & Warner, 1995). Van Wijnbergen (1984) finds evidence to support the Learning by Doing model by analyzing the relation between the subsidies to the traded sector and the temporary oil revenue. And find that an expansion in the non-traded sector and a temporary decline in traded goods sector caused by a resource boom will lead to long-term lower growth.

Cross-sectional study in Gylfason et al. (1999), base on data from 125 countries during time period 1960 and 1992 find a strong negative relation between the size of primary sector and economic growth. A relative rise in the price of traded goods in terms of non-traded goods (a real appreciation) will lower long-term economic growth because the natural-resource sector does not experience Learning by Doing as the manufacturing sector does.

The precondition of this model is that Learning by Doing only happens in traded sector. Sachs and Warner (1995) assume that there are spillovers to the rest of the economy. An expansion in natural resource sector will lower productivity growth in all sectors. However, Torvik (2001) found that all sectors can contribute to Learning by Doing and there are learning spillovers between sectors. Weather the natural resource abundance will hinder growth depends on the structural characteristics of the economy. More natural resources will lower production if the traded sector has increasing return to the scale (Torvik, 2001, 2002).

**2.1.4 Volatility effect.** Another explanation of the resource curse is the volatility effect. The primary products markets are competitive and the buyers enjoy the market power. Countries that are dependent on primary products export may face the problem of the declining terms of trade of the primary commodities. The primary products markets are instable. The highly volatile price may also create uncertainty for the domestic and overseas investors thus hindering further investment (van der Ploeg & Poelhekke, 2010). The instability of the primary market will also cause volatility in government revenue (Auty, 1998), and make the government hard to carry out prudent fiscal policy (Pieschacón, 2012).

Countries highly rely on a single mineral resource export are most likely to be badly affected by the volatile resource market (Davis & Tilton, 2005). Oil dependent countries such as Venezuela, Russia, and Brazil suffered from an economic downturn because of the long-term relative low oil price. However, evidences have been found in the US copper industry that better governance can prevent the diverse effect of the volatile resource market (Tilton & Landsberg, 1999). Countries like Canada, Chile, Ghana, and Norway have established stabilization funds from the commodity revenue to respond to the possible depressed markets.

**2.1.5 Rentier effect.** A rentier effect is that considerable revenues from the mineral extraction can lower the tax and increase patronage, which can reduce the demand for government accountability and mitigate dissent (Ross, 2001; Mahdavy, 1970). The rentier state is a state that the substantial revenues are from the external rents, such as the oil dependent countries, which depend heavily on the oil exports.

Ross (2001) demonstrates three ways that a rentier effect may occur. The first is based on the assumption that tax revenues and nontax revenues have different influence on the populations' anticipation on the governments' accountability (Ross, 2004; Brautigam et al., 2008). When a government receives considerable revenues from the natural resources, it correspondingly cut the taxes. The low-taxed population will demand less accountability from the government; and therefore the government will accordingly have lower pressure to improve its governance (Crystal, 1990). The mineral revenues can also increase the governmental spending on patronage, which helps the government to mitigate the dissent among the people. Government can also use the revenues to prevent the society from forming into groups which may inclined to ask for more political rights, thus government will have less pressure to satisfy their appeals as well as improving accountability.

**2.1.6 Rent seeking.** Another explanation is that resource boom can increase rent-seeking activities and lower economic growth (Tornell & Lane, 1996,1999; Baland & Francois, 2000; Torvik, 2002). Mineral boom is always associated with rent-seeking behavior to enhance a company's or an individual's share on the wealth by getting access to the resources. Rent seeking can affect regional long-term growth if governments set aside productive activity and pursue profit from the resources (van der Ploeg, 2011). Evidences have also been found that rent-seeking activities lead to social inequality and corruption (Ross, 1999; Sala-i-Martin and Subramanian, 2003; Gupta, M. S., & Abed, M.G.T., 2002).

Torvik (2002) hold the viewpoint that a resource boom can drive the number of entrepreneurs from productive activities to engage in rent-seeking activities. Baland and Francois (2000) denotes that an increase in the resource value will lead to more rent-seeking behavior and decrease aggregate income if a large amount of individuals already engages in rent seeking. By testing effects of the oil boom in late 1970s, they find that countries with small initial industrial base and low entrepreneurship seem to have increased rent seeking upon receiving an oil windfall. Countries with higher industrial base and active entrepreneurship can escape the curse by using the gains to constitute a sound industrial base.

**2.1.7 Poor institutional quality.** Research has found that natural resource abundance can negatively affect the institutional quality (Bulte et al., 2005; Sala-i-Martin & Subramanian, 2003) and keep the persistence of the low institutional quality (Wiens, 2013). Poor institutional quality may also affect development outcomes. Alexeev and Conrad (2009) examine the impact of resource abundance by using cross-country regressions. They find a significant negative relation between institutional quality and the natural point-source resource (such as oil). Subnational and cross-national studies have found evidences that natural resource can increase corruption (Leite & Weidmann, 2002; Vicente, 2010; Ades & Di Tella, 1999; Treisman, 2000), reduce governmental accountability (Jensen & Wantchekon, 2004), prolong the autocratic leaders' stay in power (Ross, 2001), and make the government incapable of carrying out effective economic policies (Karl, 1997).

Sala-i-Martin and Subramanian (2003) found a negative relationship between the mineral exports and several governance measures like government effectiveness, political stability, and the rule of law. However, Brunnschweiler and Bulte (2008) do not support the idea that natural resources have a detrimental impact on institutional quality and thus hamper economic growth. The impact of this is conditional. It is more likely to happen in autocratic countries (Bhattacharya & Hodler, 2010; Arezki & Gylfason, 2013), especially when the government has a dominant role in the resource industry (Loung & Weinthal, 2010).

**2.1.8 Voracity effect.** Tornell and Lane (1999) develop a model in which countries with weak institutions in powerful interest groups may suffer from a voracity effect upon receiving a windfall from a resource boom. Powerful groups are those extract transfers from the rest of the society such as "the provincial governments that extract transfers from the center, strong unions and industrial conglomerates that seek protection, and patronage networks that obtain kickbacks from public works" (Tornell & Lane, 1996). When there is a resource boom, powerful groups may compete for the rents. The competition will lead to a situation where the fiscal transfers they extract grow more quickly than the windfall, and it has to be financed by taxation. A higher taxation from the economy will reduce the raw rate of return, thus hindering investment and lowering growth (Tornell & Lane, 1999).



## 2.2 Natural Resource and Public Health

Some scholars have offered institutional explanations to the control of infectious diseases. A higher state capacity such as the disease surveillance efforts can reduce the spread and the detrimental effects of epidemics (Gizelis, 2009; Boussalis et al., 2012). Gizelis (2009) finds empirical evidence from 117 countries during 1982 and 2000 that countries with higher state capacity (such as better governance and institutional ability) are better able to control the spread of HIV/AIDS. He also finds that democratic countries tend to be more successful in controlling the spread of HIV/AIDS. Klomp and de Haan (2012) also find a positive relation between democracy and the public health.

De Soysa and Gizelis (2013) conduct a research on natural resource dependence and the spread of HIV/AIDS. Using time-series, cross-sectional data for 137 countries from 1990 to 2008. They find that countries with higher share of oil and gas rents per capita is associated with higher HIV/AIDS prevalence rates and death rates. Countries depend more on natural resource wealth tend to behave worse in fighting against HIV/AIDS because the rulers are more likely to neglect public goods provision and effective public action. The oil windfalls will reduce the rulers' incentives to perform effective policies since the expensive cost of fighting disease will redistribute income away from the rulers.

Using large panel data of world countries during 1995 and 2009, Cockx and Franken (2014) find that both resource abundant countries and resource dependent countries tend to spend less portion of their GDP on health. One possible explanation is that, rentier states are more likely to put their priority to invest in strengthen and prolong their stay in power rather than public goods (Acemoglu & Robinson, 2005). However, public spending itself doesn't mean the effectiveness of managing public health. Keefer and Knack (2007) find that political will and the effectiveness of public action matters more than the budget spent on public goods. That's because the outcomes are usually negatively affected due to rent seeking, corruption, and poor institutional quality.

Resource wealth is also associated with occupational diseases. McCulloch (2009) finds that in Africa, workers in mining industries have higher risks of gaining occupational diseases, such as silicosis and tuberculosis. Resource wealth is also found harmful to health systems in sub-Saharan Africa. The sub-national level study on the impact of resource wealth on the structure of health system in the Niger Delta region (Nigeria, Angola, southern Chad, and Southern Sudan) shows that community health is marginalized in the resource curse environment (Calain, 2008).

Sub-national level study has found a negative relation between political accountability and life expectancy. Boussalis et al. examine the life expectancy in thirty-one Mexican states over time period 1994 to 2009 and suggest that the increase of political capacity, especially tax extraction capacity is associated with higher life expectancy in this region.

The effect of natural resources on the spread of disease is still debatable. Sterck (2013) finds no relationship between resource rents and the spread of HIV and Tuberculosis. It still lacks empirical test on the relationship between resource wealth and the spread of disease. However, what is clear is that researches have proved that natural resource abundance or dependence is associated with several economic, political and social outcomes, such as lower economic growth (van der Ploeg, 2011; Frankel, 2010; Tornell & Lane, 1999), higher corruption (Torvik, 2002; Mehlum et al., 2006), less democracy (Tsui, 2011; Ross, 2001; Andersen & Ross, 2014; Aslaksen, 2010), lower institutional quality (Robinson et al., 2006; Mehlum et al., 2006; Bulte et al., 2005; Sala-i-Martin & Subramanian, 2003; Wiens, 2013), more civil war (Lujala, 2010), lower gender equality (Ross, 2008, 2012; Do et al., 2011), and less investment in human capital (Kurtz & Brooks, 2011; Ross, 1999; Auty, 2001). All these factors are associated with governmental control of infectious disease and public health.

Since the public health situation is getting more severe in recent years, the scope of the researches on resource curse needs to be broadened. It still lacks empirical tests on accurate indicator of public health, such as the spread of mosquito-borne disease such as Zika virus, Malaria, Dengue Fever, and the JEV. Resource dependence cause a lower economic growth, poor institutional quality, less democracy, corruption, lower education level, and severe civil war. These may decrease governmental incentives or fiscal capacity to invest in preventing the spread of diseases. Institutional failure caused by resource curse can negatively affect the governmental ability to control the disease.

Most of the epidemic areas are in the developing countries which dependent heavily on primary resource export. To find out the impact of resource dependence on the spread of disease and to give institutional explanation is of vital importance since the social and economic explanation cannot fully explain the causation. To increase the institutional quality, increase the investment in human capital and escape a resource curse may help the countries in Latin America increase the ability to solve Zika epidemics.



### 2.3 How Can Natural Resources Affect Contagious Diseases

**2.3.1 Economic development.** Most developed countries have already eliminated the transmission of malaria. However, malaria is still the leading cause of deaths in some less developed countries. As shown in graph 1, some regions are at the stages of eliminating malaria as their economic develops. Which means in these regions the confirmed incidence rate of malaria is less than 100 cases per 100,000 people and they are likely to eliminate malaria in a near future.

A large literature has proved that natural resources will negatively affect a country's economic performance (Tornell & Lane, 1999; van der Ploeg, 2011;

Frankel, 2012). Lower-income countries have less resources to fight against the diseases and invest in public goods. This made natural resource abundant or natural resource dependent countries more vulnerable to diseases.

**2.3.2 Political will.** Economic development level is not the only determining factor of a contagious disease. The amount of money spends in public goods itself cannot fully explain the efficiency of fighting diseases. Political will matters more than the budget spent (Keefer & Knack, 2007).

Natural resource abundance and natural resource dependence are associated with less democracy (Tsui, 2011; Ross, 2001) while democratic countries are more likely to succeed in controlling diseases such as HIV (Gizelis, 2009). Rulers in countries that rich in natural resources or rely more on natural resources are more prone to spend money in prolonging their stay in power rather than other public goods that may help fighting infectious diseases. Resource windfalls reduces the rulers' incentives to fight diseases since their political wills are strengthening their power.

**2.3.3 State capacity.** It has been proved that states capacity is negatively associated with the damages caused by diseases. Countries with better institutional quality and better governance ability are better able to control the spread of HIV/AIDS (Gizelis, 2009).

Resource wealth will encourage people with lower ability compete for a seat in the office (Brollo et al., 2013). Resource revenue is also proved to hinder states capacities to extract tax (Beblawi, 1987). Natural resource abundant countries and natural resource dependent countries are likely to have lower state capacity that may affect their ability to fight infectious diseases.

# Chapter III. Natural Resource and Incidence of Malaria

## 3.1 Data and Method

### 3.1.1 Data

***Variables and Data Source.***

*Dependent Variables.* This Chapter analyzes the effects of natural resource abundance and natural resource dependence on the incidence of malaria. Some countries have already eliminated malaria in the recent few decades. It is still endemic in most of the tropical sub-tropical areas. Mostly in South America, Asia, and Africa. The United Nations has tried to control the epidemic in its MDGs, but in 2015 there were still 214 million confirmed malaria cases globally (WHO, 2015).

The dependent variables are number of confirmed malaria cases and the incidence rate of malaria. Data are taken from WHO (2015) Global Health Observatory (GHO) dataset. This dataset consists yearly number of confirmed cases and covers the time period 2000~2014, submitted by the national malaria control programs. Incidence rate is the number of confirmed cases per 100,000 people in the country. In order to avoid reverse causality, the dependent variables are lagged for one year.

*Independent Variables.* This paper analyzes the impact of natural resource abundance and natural resource dependence on the spread of contagious diseases. World Bank (2016) database's World Development Indicator (WDI) presents latest accurate global development data. It covers more than 150 economies over the latest

57 years. The main independent variables are total natural resource rents, as the share of GDP and the total natural resource exports, as the share of total merchandise exports. Both data are taken from the World Bank database.

Total natural resource rents, as the share of GDP measures the resource wealth of a country. Total natural resource rents are the sum of oil rents, natural gas rents, coal rents, mineral rents, and forest rents. A larger figure indicates a higher resource abundance. Total natural resource exports, as the share of total merchandised exports measures a country's dependence on natural resources. Again, a higher share of the total merchandised exports represents a higher dependence on natural resources. The author takes the sum of fuel exports, ores and metal exports, as the share of total merchandise exports. The World Bank database provides each country's fuel exports, which comprises mineral fuels based on the Standard International Trade Classification (SITC) section 3[4]. Ores and metal exports comprise commodities in SITC sections 27, which includes crude fertilizer, minerals; section 28, which includes metalliferous ores, scrap; and section 68, which includes non-ferrous metals. The author takes the data of all the countries which cover the time period during 1999 and 2013.

This chapter is going to test the impact of both independent variables separately. It will also analyze the mixed impact of these two variables on the incidence of malaria.

*Control Variables.* The author takes into account several related factors that may also cause a resource curse on the spread of malaria, including economic,



[4] United Nations, "The United Nations Statistics Division", Standard International Trade Classification https://unstats.un.org/unsd/cr/registry/regcst.asp?Cl=14

demographical, political and geographical factors. Resource wealth is always associated with worse economic performance. First, the author controls income per capita by using GDP per capita figures. GDP per capita is the real income per capita measured in US Dollars. Poorer countries may have less resources to fight malaria and may not be able to provide better sanitary environment. The GDP per capita figures are taken from the World Bank and are logged to reduce the effect of extreme values. The author also controls for trade openness, by using trade as the share of GDP from the World Bank, measured as the sum of exports and imports of goods and services as the share of GDP.

Secondly, malaria may be spatially clustered and is more likely to happen in rural areas, where the population are more likely to live under poor conditions of health and sanitary infrastructure. The author controls for population density and urban population rate. Population density is the number of midyear population divided by land area in square kilometer. Again, log the population density to avoid extreme values. Urban population rate measures the degree of urbanization of a country. The figure represents the urban population as a percentage of the total population. Both data are taken from the World Bank database, WDI (2016).

Thirdly, political will and the effectiveness of governmental capacity matters more in fighting a disease (Keefer & Knack, 2007). Autocratic states are less willingly to invest in public goods, because the rulers are more likely to invest in strengthening and prolonging their stay in power (Acemoglu & Robinson, 2005). The author controls political regime type by using the Polity2 score from Polity IV dataset (Marshall, Gurr & Jaggers, 2016). The Polity IV dataset contains information of all independent states on regime and authority characteristics and it covers the year from 1800 to 2015. Polity2 index measures all states' polity scores range from -10 to +10, with -10 being the most autocratic and +10 being the most democratic. All the polity scores are added by 10, and then divided by 2. The polity IV scores in this research range from 0 to 10, with 0 being the most autocratic and 10 being the most democratic.

State capacity is also associated with contagious diseases. It has been proved that a higher state capacity such as disease surveillance efforts can reduce the damages caused by the epidemics (Gizelis, 2009; Boussalis et al., 2012). The ability of revenue extraction is an important aspect of state capacity (Arbetman & Kugler 1997). States can better implement their policies when they have better extractive ability. The author uses Relative Political Capacity Dataset (Arbetman-Rabinowitz et al., 2013) to measure governmental capacity. The Relative Political Capacity Dataset is a dataset that evaluate the governmental ability to mobilize the resource of its population and it covers the time period from 1960 to 2011. It consists of three indicators, respectively are Relative Political Extraction (RPE), Relative Political Allocation (RPA), and Relative Political Reach (RPR). The author focus on the RPE, which estimates the governmental ability to appropriate portions of the national output to advance public goods.

Fourth, geographic factors also contribute a lot to the spread of malaria. Malaria is a tropical disease that mainly happens in tropical and subtropical zones. The author uses the latitude index in Country Ruggedness and Geographical Data (Nunn & Puga, 2012). The figure represents the geographical centroid of the country. The latitude figures range from -90 to 90, with 0 represents geographic equator, -90 represents the South Pole and 90 represents the North Pole.

***Descriptive Data.*** In this chapter, the author uses time-series, cross-sectional data for all the countries over the time period 2000 and 2014. Descriptive statistics are summarized in Table 3.1 (see below).

*Cases and incidence rate of malaria.* Some developed countries have already eliminated malaria. It is still endemic in most of the developing areas. From 2000 to 2014, there were about 336 million confirmed cases of malaria (WHO, 2015). Most of the cases occurred in rural areas in tropical and subtropical regions. There were averagely 103 thousand cases per year in every country. The maximum value happened in Democratic Republic of the Congo in 2014. There were about 9.97 million confirmed case in this country in 2014. Democratic Republic of the Congo is situated in Central Africa where about 145 million people in this region are at high risk for malaria (WHO, 2015). The highest incidence rate happened in Comoros in 2002. The total population of Comoros in 2002 is 575,428 people. In that single year, there were about 1.1 million malaria cases happened in this country. The incidence rate was 191911.1 in Comoros in 2002. Which means on average almost every single person got infected by malaria twice in 2002. Comoros is an island nation located East Africa in the Indian Ocean. The malaria incidence rate of Comoros has declined by 75% between 2000 and 2014 (WHO, 2015). Other regions like the West Africa, South America, and Southeast Asia are also living at high risk of malaria.

*Total natural resource rents and total exports.* The total natural resource rents share about 10.80 per cent of GDP, with a standard deviation of 15.69 per cent every year. The extreme figure happened in Uzbekistan in 2007, with the total natural resource rents share about 92 per cent of Uzbekistan's GDP. But the situation is not quite stable in Uzbekistan, total rents has decreased to about 20 to 30 per cent in recent years. In other resource rich countries such as Republic of Congo, Iraq, Brunei Darussalam, Angola, Azerbaijan, Saudi Arabia, Trinidad and Tobago, Kuwait, Qatar, natural resource rents share more than half of its GDP. These countries are mainly located in the Middle East, North Africa, South America, and Central Asia. Resource poor states such as Iceland and Malta, resource rents are 0 during the time period 1999 and 2013. The natural resource rents of countries such as Japan, Singapore, Cyprus, and Israel are very close to 0.

Total Exports measures a state's dependence on natural resources. The figure is the sum of fuel exports and ores and metal exports, as the share of merchandise exports. Among the 2,370 observations, the figure ranges from 0 to 99.86 per cent. The most resource dependent countries are Iraq and Nigeria, with more than 99 per cent of their exports are natural resources; Angola, Algeria, Libya, Kuwait, Brunei



Table 3.1 Summary Statistics

| Variables | Mean | Std. Dev. | Min | Max | Obs. |
|---|---|---|---|---|---|
| Cases | 103455 | 480747.3 | 0 | 9968983 | 3,244 |
| Incidence Rate | 935.987 | 6437.532 | 0 | 191911.1 | 3,252 |
| Total Rents | 10.798 | 15.688 | 0 | 92.019 | 2,659 |
| Total Exports | 23.800 | 28.646 | 0 | 99.858 | 2,370 |
| ln GDP per capita | 8.258 | 1.651 | 4.612 | 12.174 | 2,981 |
| Trade (% of GDP) | 90.822 | 53.236 | 0.167 | 455.415 | 2,762 |
| ln Pop. Density | 4.346 | 1.592 | -1.990 | 9.980 | 3,236 |
| Urban Pop. rate | 56.868 | 24.693 | 8.036 | 1000 | 3,223 |
| Polity IV | 6.831 | 3.200 | 0 | 10 | 2,365 |
| RPC | 0.975 | 0.345 | 0.09 | 3.113 | 2,207 |
| Latitude | 19.104 | 24.099 | -41.806 | 74.728 | 3,135 |

*Sources: World Bank (2016); World Health Organization (2015); Polity IV Project (2015); Arbetman et al. (2013); Nunn & Puga (2012).*

Darussalam, Yemen, United Arab Emirates, and Venezuela's resource exports share more than 90 per cent of their merchandised exports, while Gambia, Cabo Verde, Tonga, and Belize are the least resource reliant countries.

**3.1.2 Model choice.** This paper uses time-series, cross sectional data to analyze the impact of natural resources on the incidence of malaria. The data are composed of 217 countries cross the time span from 2000 to 2014. The dependent variable is the number of confirmed cases. Generalized Estimating Equations (GEE), negative binominal regression best fits these data. GEE approach is an extension of Generalized Linear Model (GLM) first introduced by Liang and Zeger (1986). GEE models provides researchers with several advantages and are now widely used in researches.

The covariance structure across time is treated as a nuisance in the GEE framework. The covariance structure does not need to be specified correctly for researchers to get reasonable estimates of regression coefficients and standard errors. GEE models allow for substantial flexibility in specifying the correlation structure within cases and offer the potential for valuable substantive insights into the nature of that correlation (Zorn 2001). The software used to estimate the model is Stata14 (Stata Corp. 2015).

$$\text{Number of Deaths}_{it} \sim \text{negative binominal } (\ln \lambda_{it}),$$

$$\ln \lambda_{it} = \alpha + \beta_1 \text{Natural Resources}_{it-1} + \sum_{i=2}^{n} \beta_i C_{it} + \varepsilon$$

## 3.2 Statistical Results

**3.2.1 Natural resources and number of confirmed cases of malaria.** This chapter analyze the effects of natural resource abundance and natural resource dependence on the number of confirmed malaria cases. The independent variables in model 1 and model 2 respectively are total natural resource rents and total natural resource exports. Model 3 indicates the mixed effects of resource rents and resource exports on the number of confirmed malaria cases. The results are shown in Tables 3.2. A positive coefficient indicates a positive relation between the variables and a negative one indicates a negative relation.

As shown in the table, the coefficient of all the variables are consistent in the three models and all the results are significant at 99% per cent confidence level. For the main independent variables, both natural resource rents and natural resource exports have positive effects on the number of confirmed cases of malaria. The results remain the same when tests the mixed effects of natural resource wealth and natural resource dependence in model three.

Holding all the other variables constant, ln GDP per capita, trade openness, urban population rate, and latitude have negative relation with the incidence of malaria. For economic factors, a higher per capita income and a higher trade openness is associated with less malaria cases. Higher levels of urbanization and a higher latitude will also reduce the risks of malaria. On the other hand, ln population density, democracy, and state capacity is positively associated with the incidence of malaria. A larger population size indicates a larger number of infected malaria cases. Higher levels of democracy and better state capacity is associated with more cases. All these results reach 99% significance.

Table 3.2 Natural Resource and Number of Confirmed Malaria Cases, 2000~2014

| | (1) Cases | (2) Cases | (3) Cases |
|---|---|---|---|
| Rents | 0.000000841** | | 0.00000125** |
| | (0.0000000211) | | (0.000000031) |
| Exports | | 0.000000813** | 0.000000587** |
| | | (0.0000000201) | (0.0000000147) |
| ln GDP PC | -0.0000067 ** | -0.0000224** | -0.0000224** |
| | (0.000000202) | (0.000000555) | (0.000000554) |
| Trade (% of GDP) | -0.000000427** | -0.000000641** | -0.000000741** |
| | (0.0000000128) | (0.0000000168) | (0.0000000184) |
| ln Pop. Density | 0.00000183** | 0.00000996** | 0.00000932** |
| | (0.000000111) | (0.000000271) | (0.000000231) |
| Urban Rate | -0.0000085** | -0.000000733** | -0.00000104** |
| | (0.0000000208) | (0.0000000193) | (0.0000000257) |
| Polity IV | 0.00000518** | 0.00000257** | 0.00000309** |
| | (0.0000000128) | (0.0000000696) | (0.0000000765) |
| RPE | 0.00000115** | 0.0000369** | 0.0000258** |
| | (0.000000125) | (0.000000940) | (0.000000655) |
| Latitude | -0.00000109** | -0.00000111** | -0.000000992** |
| | (0.00000267) | (0.0000000274) | (0.0000000244) |
| Constant | 0.0000314** | 0.0000763** | 0.0000904** |
| | (0.00000106) | (0.00000189) | (0.00000224) |
| Observations | 1,865 | 1,668 | 1,655 |
| Countries | 149 | 144 | 142 |
| Wald $\chi^2$ | 1863.77** | N/A | N/A |

*Standard errors in parentheses.* $^{**}p < 0.01$, $^{*}p < 0.05$,

Table 3.3 shows the incidence rate ratio (IRR) of natural resources and the number of confirmed malaria cases. The figures imply the change of the incidence rate of the dependent variables when the independent variables or the control variables increases 1 unit. If it is smaller than one, the incidence rate will decrease when the independent variables or the control variables increase per unit. If it is larger than one, the incidence rate will increase when the independent variables or the control variables increase per unit.

The results are consistent with the results shown in Table 3.2. Our main independent variables are positively related with the number of confirmed malaria cases. When natural resource rents or natural resource exports increases, the incidence rate ratio of malaria is going up. ln population density, democracy, and relative political extraction are also positively related to the number of confirmed malaria cases. As for the other factors, ln GDP per capita, urban population rate, and latitude have a negative impact on the number of malaria cases.



Table 3.3 Natural Resource and Cases of Malaria (IRR), 2000~2014

| | (1)<br>Cases | (2)<br>Cases | (3)<br>Cases |
|---|---|---|---|
| Rents | 1.000001 | | 1.000001 |
| Exports | | 1.000001 | 1.000001 |
| ln GDP PC | .9999933 | .9999776 | .9999776 |
| Trade (%of GDP) | .9999996 | .9999994 | .9999993 |
| ln Pop. Density | 1.000002 | 1.00001 | 1.000009 |
| Urban Rate | .9999991 | .9999993 | .999999 |
| Polity IV | 1.000005 | 1.000003 | 1.000003 |
| RPE | 1.000001 | 1.000037 | 1.000026 |
| Latitude | .9999989 | .9999989 | .999999 |

Table 3.4 Natural Resource and Incidence Rate of Malaria, 2000~2014

| | (4) Incidence Rate | (5) Incidence Rate | (6) Incidence Rate |
|---|---|---|---|
| Rents | 5.767096 | | 24.13872 |
| | (13.84044) | | (23.54578) |
| Exports | | -12.7354 | -21.08248 |
| | | (8 .421481) | (11.55911) |
| ln GDP PC | -176.3001 | -119.4172 | -142.5743 |
| | (198.5657) | (226.9131) | (229.1905) |
| Trade (% of GDP) | -6.371336 | -8.130491 | -8.405186 |
| | (4.040807) | (4.399001) | (4.438779) |
| ln Pop. Density | 509.2466** | 437.9877** | 458.0073** |
| | (142.7768) | (161.1933) | (163.4066) |
| Urban Rate | -17.67786 | -21.028 | -18.3605 |
| | (12.92346) | (14.64176) | (14.95934) |
| Polity IV | -49.22314 | -166.2063* | -140.0745 |
| | (72.51196) | (81.64023) | (86.69805) |
| RPE | 894.4015 | 562.9441 | 589.9705 |
| | (563.6722) | (646.6041) | (659.0847) |
| Latitude | -27.03867** | -26.14276** | -26.33888** |
| | (7.746482) | (8.450602) | (8.492145) |
| Constant | 1697.107 | 3479.156* | 3207.357 |
| | (1325.011) | (1566.987) | (1614.927) |
| Observations | 1,868 | 1,672 | 1,659 |

*Standard errors in parentheses.* **$p < 0.01$, *$p < 0.05$,

**3.2.2 Natural resources and incidence rate of malaria.** Table 3.4 presents the statistical results of effects of the independent variables and control variables on the incidence rate of malaria. Column 4 indicates the effects of natural resource abundance on the incidence rate of malaria. Column 5 indicates the effects of natural resource dependence on the incidence rate. Column 6 indicates the mixed effects of natural resource abundance and natural resource dependence on the incidence rate.

The results of the effects on the incidence rate of malaria is mixed. Only ln population density and latitude reach 99% significance. Population size is positively associated with the incidence rate and latitude is negatively associated with the incidence rate. Trade is negatively related to the incidence rate but only model 5 and model 6 at significant at 90% confidence level. The results need further discussion.

### 3.3 Discussion

**3.3.1 Effects on the number of cases.** First, the results in Table 3.2 indicate the effects of natural resources on the number of confirmed cases of malaria. The main independent variables all have positive effects on number of confirmed malaria cases. The results are all significant at 99% confidence level and are consistent with their effects on the number of deaths result from malaria. This result again, support our expectation that there is a resource curse in the spread of infectious disease. Table 3.3 denotes the incidence rate ratio of malaria cases, which represents the chance of having one more cases when natural resource rents or exports increase one unit. In the first model, a unit increase in total natural resource rents will lead to 0.000001% increase in number of confirmed malaria cases. The figure is not large but still indicates a positive impact on the malaria epidemic. Model 2 tests the effects of natural resource dependence on the number of malaria cases. The result suggests that per unit increase in natural resource exports will lead to 0.000001% increase in the malaria mortality. Model 3 tests the mixed effects of natural resource abundance and natural resource dependence on the number of deaths. All the results indicate a positive effect on the number of deaths. In other words, countries which are richer in natural resources or depend more on natural resources are likely to suffer more deaths from the epidemics.

Per capita income and trade openness are negatively associated with the number of malaria cases. When income per capita rise 1 per cent, the number of confirmed cases drops 0.0000067%, 0.0000224%, and 0.0000224% accordingly. Higher states income is associated with less malaria cases. Although the figure is smaller than the result of GDP per capita, trade openness also has a negative impact on the number of cases. When trade share of GDP increase 1 unit, the number of cases of malaria drops 0.0000004%, 0. 0000006%, and 0. 0000007% in model 1~3.

As for the demographic factors, population size is positively related to the number of cases and urban population rate is negatively related to it. The ln population density has a positive effect on the number of confirmed cases. Countries with larger population size have more risks of getting affected by malaria. When the ln population density increases 1 per cent, the number of cases rises 0.000002%, 0.00001%, and 0.000009% in model 1~3. A higher level of urbanization is related to less malaria cases. When the urban population rate rise per unit, the number of cases drop 0.000009%, 0.0000007%, and 0.000001%. Urbanization helps decrease the impact of the malaria epidemic.

The effects of democracy are mixed. How does a country's regime type affect the number of malaria cases needs further discussion. State capacity is positively associated with malaria. A higher state relative political extraction indicates a higher number of malaria cases, which is quite against our expectations.

The latitude of a country is negatively related to the number of confirmed malaria cases. Per unit increase in the latitude leads to 0.0000011%, 0.0000011%, and

0.000001% decrease in the number of malaria cases. All the results are significant at 99% confidence level.

**3.3.2 Effects on the incidence rate.** In this section the author analyzes the relation between natural resources and the incidence rate of malaria. Incidence rate is the number of confirmed malaria cases per 100,000 people. As we can see from the table, total natural resource rents have a positive coefficient on the incidence rate, but neither of the model reaches statistical significance. The results of other main independent variable, natural resource exports, in model 5 and model 6 is negative. The effects of natural resource dependence on the incidence rate of malaria needs to be further tested.

Income per capita in the three models tend to have a negative impact on the incidence rate of malaria, but none of results reaches statistical significance. Trade openness is negatively related to the incidence rate of malaria. Both the result in model 5 and 6 are significant at 90% confidence level. A higher trade openness indicates a smaller incidence rate. When trade share of GDP increases by 1 unit, the incidence rate will drop by 8.130491% and 8.405186% respectively.

In terms of ln population density, the results are all positive and all reach 99% confidence level. A larger population size implies a larger incidence rate of malaria. The result of the level of urbanization is negative but do not reach the significance.

The relation between polity 2 score and the incidence rate of malaria is negative. The result in model 5 is significant at 95% confidence level. The per unit increase in polity 2 score will lead to a decrease of about 83.10315% decrease in the incidence rate. The effects of state capacity are not clear. None of the results of the relative political extraction reach significance level.

The incidence rate of malaria is negatively affected by latitude. When the latitude of the geographic center increases by 1 percent, the incidence rate will drop by 27.03867%, 26.14276%, and 26.33888% in model 4~6. All these results are significant at 99% confidence level.

### 3.4 Summary

As the statistic results show, holding all the other variables constant, there is a positive relation between natural resource and number of malaria cases. Both natural resource abundance and natural resource dependence are associated with a larger number of confirmed malaria cases. States which are richer in natural resources or which are more economically dependent on the primary natural resources tend to be more vulnerable to the epidemics. The effects of natural resource abundance and natural resource dependence on the incidence rate is not clear. This needs to be further discussed in future study.

A higher per capita income, higher level of trade openness is negatively associated with the number of malaria cases. The result implies that higher-income economies can better perform in the elimination of malaria. Richer countries can have more resources to fight the disease, such as to establish a malaria surveillance system, to provide the people with health facilities, and the equipment to prevent malaria. The results of trade openness indicate that globalization is also a helpful tool for the elimination of malaria.

Countries with larger population size is associated with more risks of getting affected by malaria. But with the progress of urbanization, the risks are decreasing. A higher urbanization level is associated with less confirmed malaria cases. Urban residents are also provided with better sanitary and medical conditions.

As for the political factors, democracy has a mixed effect on the malaria incidence. Out of the 6 models, 4 of the results are negative and 2 of the results are positive. The effect of democracy on the number of malaria cases and the incidence rate needs to be further analyzed. A higher state capacity is again, positively associated with the number of malaria cases. A better extract ability does not indicate a better ability to control a contagious disease. One possible explanation is that resource abundant countries and resource dependent countries are more likely to experience a resource boom and extract revenue from natural resources. But this does not mean that they will spend more money to prevent diseases. Resource abundant countries and resource dependent countries are less likely to spend money on public health (Cockx and Franken, 2014).

For policy makers, the political will of control a disease plays an important role in the elimination of malaria. Policy makers should better put some of priorities to public goods because they are willing to fight the disease. Globalization is also a helpful tool for the elimination of malaria. To increase the economic exchanges with other countries will also help decrease the number of malaria cases. Countries that are rich in natural resource wealth and are dependent on resource export should better reduce their resource dependence. A long-term health economic growth pattern is helpful in reducing the malaria cases.

These results only show the effects of natural resource wealth on the number of confirmed cases and incidence rate of malaria. The deaths and death rate of malaria are also important indicators of the contagious diseases. The effects on the number of deaths and the death rate of malaria will be further discussed in the next chapter.

# Chapter IV. Natural Resource and Deaths of Malaria

## 4.1 Data and Methods

### 4.1.1 Data.

***Variables and data sources.***

*Dependent variables.* Malaria is one the most widespread contagious diseases. It is still one of the top 10 leading causes of deaths in low-income economies[5] and causes more than 400,000 deaths per year (WHO, 2015). Malaria is the leading killer of children and pregnant women, especially in Sub-Saharan Africa. Mortality resulting from malaria is an important indicator to measure the severity of malaria.

In this chapter, the author tests the impact of natural resources on the number of reported deaths caused by malaria, and the death rate result from malaria. The death rate is the number of deaths caused by malaria in a given population (100,000 persons). Data are retrieved from WHO (2015) Global Health Observatory (GHO) dataset.

WHO compiles data on reported deaths from malaria, submitted by the national malaria control programs. The data of the countries or that did not report malaria deaths to WHO are marked as 0. The data are extracted from WHO database, which covers a total of 106 countries from 2000 to 2014. In order to ensure the real causal relation and avoid the situation of reverse causality, the dependent variables are lagged for one year.

5 Media Center, World Health Organization, The Top 10 Causes of Death, 2015.

*Independent variables.* The main independent variables are also natural resource abundance and natural resource dependence. The indicator of total natural resource rents as share of GDP, taken from World Development Indicator (WDI) (World Bank, 2016), is used to measure the abundance of natural resource wealth by country. Total natural resource rents are the sum of oil rents, natural gas rents, coal rents, mineral rents, and forest rents. With a larger figure indicates more resource wealth.

Another independent variable is the natural resource exports as share of total merchandised exports. The figures are the sum of fuel exports, ores and metal exports as share of total merchandised exports. It includes the exports of mineral fuels, crude fertilizer, minerals, metalliferous ores, scrap, and non-ferrous metals. All data are taken from World Bank's WDI (2016).

This chapter tests the impact of natural resource abundance and natural resource dependence on the deaths and death rates resulting from malaria separately. Natural resource abundance and natural resource reliance may also have a mixed effect on contagious diseases. This chapter will also analyze the mixed impact of these two variables on malaria.

*Control Variables.* The control variables are the same as those in chapter three, including some economic, demographic, political, and geographic variables. For the economic variables, the author first controls the per capita income measured by GDP per capita figures in current US dollars. Data are taken from the World Bank and are logged to reduce the effect of extreme values. Another economic control variable is trade openness measured by trade as the share of GDP. The figure represents the sum of exports and imports of goods and services and the data are also taken from the World Bank.

As for the demographic factors. The author controls for population size and level of urbanization. Population size is measured by population density which represents the number of midyear population divided by land area in square. Logged again to avoid extreme values. Urban population rate measures the degree of urbanization of a country. The figure represents the urban population as a percentage of the total population. Both data are taken from the World Bank database, WDI (2016).

In terms of political factors, the author controls political regime type by using the Polity2 score from Polity IV dataset (Marshall, Gurr & Jaggers, 2016). The scores range from -10 to +10, with -10 being the most autocratic and +10 being the most democratic. Again, the scores are added by 10, and then divided by 2. To make it range between 0 and 10 with a larger value represents more democracy. Another political variable is the state capacity measured by relative political extraction (RPE), taken from Relative Political Capacity (RPC) Dataset (Arbetman-Rabinowitz et al., 2013). RPC evaluate the governmental ability to mobilize the resource of its population and it covers the time period from 1960 to 2011 and RPE estimates the governmental ability to appropriate portions of the national output to advance public goods.

Finally, the author controls for the geographic factors by using the latitude index in Country Ruggedness and Geographical Data (Nunn & Puga, 2012). The figure is the geographical centroid of the country ranging from -90 to 90.

***Descriptive Data.*** Descriptive statistics are summarized in Table 4.1 (see below).

*Deaths and death rate of malaria.* There are more than 1.83 million reported deaths cause by malaria during 2000 and 2014 (WHO, 2015). Malaria has been a major threat for a lot of countries for long, and there are averagely more than 0.122

million reported deaths every year. Number of reported deaths has been increasing since 2000 and reached the first peak at 2003, with about 0.16 million reported deaths. Another peak happened in 2010, with about 0.15 million reported deaths globally. Of all the deaths caused by malaria, most of them happens in Sub-Saharan Africa. From 2000 on, 0.33 million people died from malaria in Kenya, 0.23 million people died in Democratic Republic of Congo.

Table 4.1 Summary Statistics

| Variables | Mean | Std. Dev. | Min | Max | Obs. |
|---|---|---|---|---|---|
| Deaths | 562.571 | 2926.191 | 0 | 51842 | 3,253 |
| Death Rate | 3.6365 | 14.444 | 0 | 231.245 | 3,252 |
| Total Rents | 10.798 | 15.688 | 0 | 92.019 | 2,659 |
| Total Exports | 23.800 | 28.646 | 0 | 99.858 | 2,370 |
| ln GDP per capita | 8.258 | 1.651 | 4.612 | 12.174 | 2,981 |
| Trade (% of GDP) | 90.822 | 53.236 | 0.167 | 455.415 | 2,762 |
| ln Pop. Density | 4.346 | 1.592 | -1.990 | 9.980 | 3,236 |
| Urban Pop. rate | 56.868 | 24.693 | 8.036 | 1000 | 3,223 |
| Polity IV | 6.831 | 3.200 | 0 | 10 | 2,365 |
| RPC | 0.975 | 0.345 | 0.09 | 3.113 | 2,207 |
| Latitude | 19.104 | 24.099 | -41.806 | 74.728 | 3,135 |

*Sources: World Bank (2016); World Health Organization (2015); Polity IV Project (2015); Arbetman et al. (2013); Nunn & Puga (2012).*

There are averagely 526.57 deaths caused by malaria in each country every year. The highest figure happened in Kenya in 2003. There were 58,142 reported deaths caused by malaria in Kenya in 2003. Higher death rate (number of deaths every 100,000 people) is also likely to happen in Sub-Saharan Africa, such as Angola, Gabon, Kenya, and Cote d'Ivoire. The highest death rate happened in Angola in 2003.

More than 243.245 people in every 100,000 died from malaria that year. The average death rate is 3.64 globally since 2000. This average value is not high because there is a big difference among countries. Malaria is still a major threat to public health to some less developed countries.

*Total natural resource rents and total exports.* Among all the 2,659 observations, total natural resource rents share about 10.80 per cent of GDP, with a standard deviation of 15.69 per cent. The extreme figure happened in Uzbekistan in 2007, with the total natural resource rents share about 92 per cent of Uzbekistan's GDP. But the situation is not quite stable in Uzbekistan, total rents has decreased to about 20 to 30 per cent in recent years. In other resource rich countries such as Republic of Congo, Iraq, Brunei Darussalam, Angola, Azerbaijan, Saudi Arabia, Trinidad and Tobago, Kuwait, Qatar, natural resource rents share more than half of its GDP. These countries are mainly located in the Middle East, North Africa, South America, and Central Asia. Resource poor states such as Iceland and Malta, resource rents are 0 during the time period 1999 and 2013. The natural resource rents of countries such as Japan, Singapore, Cyprus, and Israel are very close to 0.

Total Exports measures a state's dependence on natural resources. The figure is the sum of fuel exports and ores and metal exports, as the share of merchandise exports. Among the 2,370 observations, the figure ranges from 0 to 99.86 per cent. The most resource dependent countries are Iraq and Nigeria, with more than 99 per cent of their exports are natural resources; Angola, Algeria, Libya, Kuwait, Brunei Darussalam, Yemen, United Arab Emirates, and Venezuela's resource exports share more than 90 per cent of their merchandised exports, while Gambia, Cabo Verde, Tonga, and Belize are the least resource reliant countries.

**4.1.2 Model Choice.** The author uses time-series, cross sectional data and the data is composed of 217 countries cross the time span from 2000 to 2014. The dependent variable is number of deaths, which can only be discrete positive integer. The author estimates the models using Generalized Estimating Equations (GEE), negative binominal regression. GEE approach is an extension of Generalized Linear Model (GLM) first introduced by Liang and Zeger (1986). GEE models provides researchers with several advantages and are now widely used in researches.

The covariance structure across time is treated as a nuisance in the GEE framework. The covariance structure does not need to be specified correctly for researchers to get reasonable estimates of regression coefficients and standard errors. GEE models allow for substantial flexibility in specifying the correlation structure within cases and offer the potential for valuable substantive insights into the nature of that correlation (Zorn 2001). The software used to estimate the model is Stata14 (Stata Corp. 2015)

$$\text{Number of Deaths}_{it} \sim \text{negative binominal } (\ln \lambda_{it}),$$

$$\ln \lambda_{it} = \alpha + \beta_1 \text{Natural Resources}_{it-1} + \sum_{i=2}^{n} \beta_i C_{it} + \varepsilon$$

## 4.2 Statistical Results

**4.2.1 Natural resources and deaths from malaria.** In Table 3.2, the author estimates the effect of resource abundance and resource dependence on the number of deaths from malaria. The independent variables in column 1 and 2 respectively are total natural resource rents and total natural resource exports. Column 3 indicates the mixed effects of resource rents and resource exports on the number of deaths from malaria. A positive coefficient indicates a positive relation between the variables and a negative one indicates a negative relation.

First, the author tests the effects of natural resource abundance and dependence on the number of deaths from malaria. Holding all the other variables at their mean values, there is a positive relation between number of deaths and the independent variables. The results are all statistically significant at 99% significance level. Which means an increase in natural resource rents or exports will lead to a higher number of deaths from malaria. A mixed effect or resource rents and exports shows the same result. In this sense, resource abundant countries and resource dependent countries are more vulnerable to malaria.

The other control variables are all significant at 99% level. There is a negative relation between per capita income and number of deaths from malaria. Holding other variables at their mean values, a higher GDP per capita indicates less malaria deaths. Trade openness, population density, urban population rate, also negatively affect number of deaths from malaria, and the results are all significant at 99% in all three models. For geographic factors, a higher latitude indicates less deaths from malaria. These all meet our expectations.

For the political factors, there is a positive relation between relative political capacity (extraction), and the results are all significant are 99% in all models. The relation between political regime type and deaths from malaria is not clear. There is a positive relation between number of deaths and total natural resource rents, which means, holding other variables at their mean values, democratic countries tend to be more vulnerable to malaria while autocratic countries are less affected by malaria. Which do not meet the author's expectations in chapter two. This needs further discussion. The correlation coefficient in model 2 and model 3 are negative and are significant at 99% significance level.

Table 4.2 Natural Resource and Number of Deaths of Malaria, 2000~2014

| | (1)<br>Deaths | (2)<br>Deaths | (3)<br>Deaths |
|---|---|---|---|
| Rents | 0.0001469** | | 0.0000922** |
| | (0.00000342) | | (0.00000422) |
| Exports | | 0.0000671** | 0.000048** |
| | | (0.00000167) | (0.00000163) |
| ln GDP PC | -0.0017108** | -0.0013159** | -0.001367** |
| | (0.0000401) | (0.0000396) | (0 .0000468) |
| Trade (% of GDP) | -0.0000545** | -0.0000479** | -0.0000737** |
| | (0.00000132) | (0.00000221) | (0.00000291) |
| ln Pop. Density | -0.0002136** | -0.0004403** | -0.0000838** |
| | (0.000006) | (0.0000187) | (0.0000265) |
| Urban Rate | -0.0002008** | -0.0002607** | -0.0002844** |
| | (0.00000467) | (0.00000652) | (0.00000716) |
| Polity IV | 0.00014** | -0.000116** | -0.00004** |
| | (0.00000339) | (0.00000356) | (0.00000727) |
| RPE | 0.003036** | 0.0022343** | 0.0033201** |
| | (0.0000711) | (0.0000705) | (0.0001025) |
| Latitude | -0.0001527** | -0.0001308** | -0.0001366** |
| | (0.00000356) | (0.00000331) | (0.00000347) |
| Constant | 0.0128917** | 0.0113487** | 0.0130345** |
| | (0.0002995) | (0.0003139) | (0.0003733) |
| Observations | 1,867 | 1,670 | 1,657 |
| Countries | 149 | 144 | 142 |
| Wald $\chi^2$ | 1860.95** | 1665.06** | 1651.00** |

*Standard errors in parentheses.* $^{**}p < 0.01$, $^{*}p < 0.05$,

Table 4.3 indicates the incidence rate ratio (IRR). If it is larger than one, it means the incidence rate of death rate from malaria will increase as the independent variables or the control variables increase per unit. If it is smaller than one, the incidence rate will decrease when the independent variables or the control variables increase per unit. Column 1 shows the relation between resource abundance and the incidence rate of deaths result from malaria. Column 2 shows the relation between resource dependence and the incidence rate of deaths result from malaria. Column 3 shows the mixed effect of natural resource abundance and resource exports.

Table 4.3 Natural Resource and Number of Deaths of Malaria (IRR), 2000~2014

| | (1) Deaths | (2) Deaths | (3) Deaths |
|---|---|---|---|
| Rents | 1.000147 | | 1.000092 |
| Exports | | 1.000067 | 1.000048 |
| ln GDP PC | .9982906 | .998685 | .9986339 |
| Trade (%of GDP) | .9999455 | .9999521 | .9999263 |
| ln Pop. Density | .9997865 | 1.00044 | 1.000084 |
| Urban Rate | .9997992 | .9997393 | .9997156 |
| Polity IV | 1.00014 | .999884 | .99996 |
| RPE | 1.003041 | 1.002237 | 1.003326 |
| Latitude | .9998473 | .9998692 | .9998634 |

**4.2.2 Natural resources and death rate from malaria.** Table 3.4 presents the statistical results of effects of the independent variables and control variables on the death rate from malaria. Column 4 indicates the effects of natural resource abundance on the death rate of malaria. Column 5 indicates the effects of natural resource dependence on the death rate. Column 6 indicates the mixed effects of natural resource abundance and natural resource dependence on the death rate.

Table 4.4 Natural Resource and Death Rate of Malaria, 2000~2014

| | (4) | (5) | (6) |
|---|---|---|---|
| | Death Rate | Death Rate | Death Rate |
| Rents | 0.0715757$^{**}$ | | -0.0609282 |
| | (0.0269019) | | (0.0391572) |
| Exports | | 0.000294 | 0.0217221 |
| | | (.0140164) | (0.0192231) |
| ln GDP PC | -1.043248$^{**}$ | -0.518311 | -0.4389688 |
| | (0.3859554) | (0.3776668) | (0.3811496) |
| Trade (% of GDP) | -0.0009473 | -0.0094929 | -0.0095796 |
| | (0 .0078352) | (0.00773216) | (0.0073818) |
| ln Pop. Density | -0.4441189 | -0.6255394$^{*}$ | -0.6935256$^{**}$ |
| | (0.2775175) | (.2682849) | (0.2717493) |
| Urban Rate | -0.1128249$^{**}$ | -0.131905$^{**}$ | -0.140905$^{**}$ |
| | (0.0251195) | (0 .0243693 | (0.0248778) |
| Polity IV | 0 .0567349 | -0.2977672$^{*}$ | -0.3797199$^{**}$ |
| | (0.1409427) | (0.1358793) | (0.144181) |
| RPE | 8.006955$^{**}$ | 5.344631$^{**}$ | 5.091983$^{**}$ |
| | (1.095619) | (1.079516) | (1.096075) |
| Latitude | -0.1005734$^{**}$ | -0.0791597$^{**}$ | -0.0781066$^{**}$ |
| | (0.015057) | (0.0140649) | (0.0141227) |
| Constant | 14.41204$^{**}$ | 17.94599$^{**}$ | 19.03635$^{**}$ |
| | (2.575446) | (2.608043) | (2.6856650) |
| Observations | 1,868 | 1,672 | 1,659 |

*Standard errors in parentheses.* $^{**}p < 0.01$, $^{*}p < 0.05$,

### 4.3 Discussion

**4.3.1 Effects on number of deaths.** First, the author tests the effects of natural resources on the number of deaths caused by malaria. The main independent variables all have positive effects on number of malaria deaths. The results are all significant at 99% confidence level. The incidence rate ration (IRR) is shown in Table 4.3. IRR represents the change of the incidence rate of the dependent variables when the independent variables or the control variables increases by per unit. If IRR is larger than 1, it means per unit increase in this variable will lead to an increase in the number of deaths caused by malaria. As shown in table 4.3, the increase in total natural resource rents, natural resource exports and relative political capacity will lead to an increase in the incidence rate of deaths from malaria. Per unit increase in the ln GDP per capita, trade openness, urban population rate, and latitude will decrease the incidence rate of deaths from malaria. The effects of ln population density and polity 2 score are mixed. The results are in accordance with the results shown at table 3.2.

In the first model, a unit increase in total natural resource rents will lead to a 0.000147% increase in number of deaths caused by malaria. The figure is not large but still indicates a positive impact on the malaria epidemic. Countries which are richer in natural resources tend to have more deaths caused by malaria. Model 2 tests the effects of natural resource dependence on the number of deaths caused by malaria. The result suggests that per unit increase in natural resource exports will lead to 0.000067% increase in the malaria mortality. Model 3 tests the mixed effects of natural resource abundance and natural resource dependence on the number of deaths. All the results indicate a positive effect on the number of deaths. In other words, countries which are richer in natural resources or depend more on natural resources are likely to suffer more deaths from the epidemics. When natural resource rents and exports increase per unit, the chance of getting one more deaths from malaria will increase by 0.00092% and 0.000048%.

In terms of the control variables, these two economic variables all meet our expectations. The results of ln GDP per capita in the three models all indicates a negative relation between the national income and the number of deaths caused by malaria. The results demonstrate that a unit rise in logged personal income will respectively lead to 0.00171094%, 0.001315%, and 0.0013661% drop in number of deaths caused by malaria in the three models. These results are all significant at 99% confidence level. A higher personal income is associated with less deaths from malaria. Most high-income countries have already eliminated malaria, but it is still the one of the leading cause of deaths in low-income economies.

Trade openness is also negatively associated with number of deaths result from malaria. Countries which are more open to international trade are less likely to suffer from malaria. Per unit rise in trade openness will lead to 0.00000545%, 0.00000479%, and 0.00000737% drop in the three models. Globalization is positively associated with the elimination of malaria.

As for the two demographic variables, ln population density and urban population rate both have negative effects on the mortality of malaria in the three models. A larger population size in a society indicates less deaths from malaria.

Holding all the other variables at their mean value, a higher urbanization level is also associated with deaths caused by malaria. When the urban population rises by 1 per cent, the number of deaths resulting from malaria will drop by 0.0002008%, 0.0002607% and 0.0002844% in the three models. All the results are statistically significant.

Polity 2 score has mixed effects on the number of malaria deaths. In the first model, the result indicates a positive effect on the number of deaths. Which means a higher level of democracy is associated with more deaths from malaria. The result reaches the 99% significance level. In model 2 and model 3, the results suggest a negative impact on the number of deaths. Per unit increase in democracy level will respectively lead to 0.0000116% and 0.000004% drop in the number of deaths. All results are significant at 99% level. The effect of democracy on the number of deaths from malaria needs further discussion.

The results of RPE indicates a positive relation between political capacity and the number of deaths caused by malaria. All results reach 99% confidences level. This result does not meet our expectation that states with higher state capacity are more able to control the epidemics and lower the damages cause by malaria. This needs to be further discussed.

Latitude has a negative effect on the number of malaria deaths. A higher latitude indicates less deaths caused by malaria. The results in the three models are all significant at 99% confidence level. Malaria is a mosquito-borne disease which is easier transmitted in tropical and sub-tropical areas. People living at higher latitude areas have less risks of killed by malaria.

**4.3.2 Effects on death rate.** In this section the author tests the effects of natural resource abundance and natural resource dependence on the death rate caused by malaria. The result of natural resource rents in model 4 implies that 1 per cent increase in total natural resource rents will lead to 0.0715757% increase in the death rate of malaria. The result is significant at 99% confidence level. When testing the mixed effects of resource abundance and resource dependence, the relation is negative but the result is not statistically significant.

The results of natural resource exports on the death rate of malaria indicates a positive relation, but neither of result reaches significance level. The effects of the natural resource dependence on the death rate caused by malaria needs to be further tested.

In terms of the economic variables. Both ln GDP per capita and Trade openness has a negative impact on the death rate of malaria. Considering the coefficient of the results in the three models, the results are in accordance with the impact on the number of deaths from malaria. However, only the result of ln GDP per capita in the first model reaches 99% confidence level.

Similar to the result of model 1 to model 3, the results of ln population density indicates a negative relation between death rate of malaria. A higher population size implies smaller death rate from malaria. The result in model 5 is significant at 95% confidence level and the result in model 6 reaches 99% confidence level.

The effect of urban population rate on the death rate consistent with the effects on the number of deaths. There is a negative relation between urban population rate and death rate of malaria. Per unit increase in urban population rate will cause 0.1128249% decrease in death rate in model 4, 0.131905% decrease in model 5 and 0.1409054% decrease in model 6. All results are significant at 99% confidence level.

Democracy has mixed effects on the death rate of malaria. The result in model 4 indicates a positive relation, but this result does not reach the significance level. The results in model 5 and model 6 indicates a negative relation between democracy and death rate of malaria and reaches at least 95% confidence level. ln model 5 and model

6, states with higher level of democracy has less death rate from malaria. The impact of democracy on malaria death rate need further discussion.

The results of relative political extraction (RPE) suggest a positive relation between state capacity and death rate from malaria. When RPE increases by one per cent, the death rate of malaria will increase by 8.006955%, 5.344631% and 5.091983% in each model. All results are significant at 99% confidence level.

The impact of latitude on malaria mortality rate is also obvious. Higher latitude indicates smaller death rate. There is a negative relation between latitude and malaria death rate. All results reaches 99% confidence level. Per unit increase in latitude will cause 0.1005734%, 0.0791597%, and 0.0781066% decrease in model 4, 5, and 6.

**4.4 Summary**

The results strongly suggest that natural resource abundance and natural resource dependence plays an important role in the malaria epidemic. Controlling for other economic, social, political, and geographical factors, the result shows that resource abundance and resource dependency are correlated with a larger number of deaths caused by malaria. The results support the argument that there is a resource curse on the spread of mosquito-borne virus. A higher wealth or dependence on natural resources will lead to worse situation in the mosquito-borne diseases, such as malaria.

However, the impact of natural resource on the death rate of malaria is mixed. Natural resource abundance is positively associated with death rate of malaria, but the result of natural resource dependence does not reach significance level. The impact of natural resource dependence on death rate of malaria needs future research.

A higher per capita income is associated with less deaths from malaria. Wealthier countries have more resources to provide the residents with better sanitary and medical conditions. Natural resource wealth has been proved to lower the economic growth (Tornell & Lane, 1996, 1999; Torvik, 2001). Countries with lower economic level will have less resources, especially economic and medical resources to fight a disease. When a contagious disease breaks out in the country, more residents are likely to die.

A higher urbanization level is associated with less deaths from malaria. Urban residents are also provided with better sanitary and medical conditions. Countries wither higher urbanization levels are mostly better developed countries in better economic condition. A higher population density is also associated with less malaria deaths. Which means a higher population density does not necessarily been associated with worse environmental conditions, less medical resources. Most densely populated areas are urban places like Hong and Singapore, where the places are equipped with better disease surveillance system and better medical technology. While in rural areas with low population density, especially in the less developed areas, it will be harder for the government to provide them with ever safe water, not to mention medical care and disease surveillance system.

In terms of political regime, in most models, more democracy is associated with less deaths and smaller death rate from malaria. This result is in accordance with most of the previous researches that democratic countries are more successful in controlling diseases (Gizelis, 2009) and safeguard public health. One possible explanation is the "rentier effect". People will have different anticipation on tax revenues and nontax revenues. When government receive more revenues from natural resources, people will have less anticipation on government (Ross, 2004; Brautigam et al., 2008). Autocratic countries tend to spend more money to prolong their stay in power, rather than public goods. However, the result in the model 1 and model 4 does not support this argument. When the independent variable is natural resource rents, controlling for other variables, the relation between political regime and number of deaths from malaria is positive. This requires more thorough test in future study.

One unexpected result is that a higher relative political capacity is associated with a higher number of deaths and a higher death rate from malaria. The author uses relative political extraction (RPE) to measure political capacity. A better extract ability does not indicate a better ability to control a contagious disease. One possible explanation is that resource abundant countries and resource dependent countries are more likely to experience a resource boom and extract revenue from natural resources. But this does not mean that they will spend more money to prevent diseases. Resource abundant countries and resource dependent countries are less likely to spend money on public health (Cockx & Franken, 2014).

The development level of a country is important for the elimination of infectious diseases, but some other factors also matter. First, autocracies are suggested to invest more in public goods. If low-income economies are not able to develop the economy in a short time, policy makers, especially the policy makers in autocratic countries should be aware that their incentives are also important to minimize the damages caused by malaria. The adverse effects of natural resource abundance and natural resource dependence on development is obvious. To reduce the deaths and death rate caused by malaria, countries that rich in natural resources should reduce its dependence on the primary goods exports. Long-term healthier economic growth pattern is important for the elimination of malaria in the middle- and low-income countries.

# Chapter V. Conclusion

## 5.1 Theoretical Contributions

Previous studies focus on the effects of natural resources on the economic development (Sachs & Warner, 1995; van der Ploeg, 2011), Political performance (Ross, 2001; Tsui, 2011; Aslaksen, 2010) and civil war (Collier & Hoeffler, 1998; Lujala, 2010). This paper extends the scope of the resource effects to the spread of contagious diseases.

Taking mosquito-borne diseases for an example, this paper analyzes the effects of resource abundance and resource dependence on the spread of malaria. Using time-series, cross sectional data during the time period 2000 to 2014, this research finds that there is a resource curse on the spread of this disease. There are at least three major findings.

First, a higher total natural resource rents is associated with a larger number of deaths and a larger number of confirmed cases of malaria. Although the coefficient is not very large, countries with higher resource abundance are more likely to suffer from malaria. Second, a higher share of total natural resource exports is also associated with a larger number of deaths and confirmed cases of malaria. Countries that are more economically dependent on the natural resources are more likely the be affected by infectious diseases, such as malaria. Third, a higher total natural resource rent is significantly associated with higher death rate of malaria.

The effects of natural resource exports on the death rate of malaria and the effects of total natural resource rents and resource exports on the incidence rate of malaria is not clear. This needs further research.

However, most of the dependent variables are positively associated with the independent variables and most of them are significant at 99% confidence level. In this sense, both natural resource abundance and natural resource dependence are positively related to the epidemic situation of malaria. There is a resource curse on the spread of contagious diseases.

The control of infectious diseases depends a lot on governmental accountability and the construction of infrastructure. However, as the government in resource abundant and resource dependent countries receives considerable revenues from natural resources, this could trigger a "rentier effects". When government enjoys considerable revenue from natural resources, it will reduce the tax from people. People have different anticipations to tax revenue and non-tax revenue. People in low-tax countries will have less anticipations to their government, for example, governmental accountability, infrastructure construction, public goods, and public service. Correspondingly, government will have less pressure to improve its governmental ability. The ruling party will spend less portion of the governmental revenue on the infrastructure. When a severe infectious disease breaks out, the natural resource abundant and resource dependent countries are less capable of control it.

In a long-term, natural resource abundance crowd out other sectors, including the medical industry. Countries that are richer and more dependent on natural resource will depend more on the resource extraction and the primary resource exports. This impedes the development of the medical industry. If those governments do not release policies to help the preserve the development of domestic medical industry, other sectors including the medical industry could be crowded-out. Every time a contagious disease breaks out, those countries can only wait for the assistance from the international organizations and lack the ability to fight against contagious diseases.

### 5.2 Policy Implications and Future study

These findings have implications for all the resource-rich and resource-dependent countries, especially across the developing world. Given the great efforts by the international organizations to the elimination of malaria in the developing countries, the worst-hit countries are still those rich or dependent on natural resources. Policymakers in these countries should understand the fact that natural resource is more a curse than a blessing.

First, in order to reduce the damages caused by malaria, policymakers in lower-income countries are suggested to decrease their reliant on the primary resources and to carry out long-term healthy economic policies to boost the economy. Income level and governmental ability will affect the control of the infectious diseases. What is more important is the political will of the ruling elites. Policymakers, especially those in the autocratic countries are suggested to spend more resources in public goods, such as the facilities that help prevent the diseases and the establishment of disease surveillance system. Policymakers in resource abundant and dependent countries are also suggested to protect the medical industry.

The donors should be aware of the fact that governmental will and intention matters more than the donation in the control of the disease. They are suggested to establish mechanisms to ensure the governments receive those donations spend the resources on the control of the epidemics.

For international governmental organizations (IGOs) and international non-governmental organizations (NGOs), in order to control the epidemics, such as the elimination of malaria, and some other infectious diseases. They are suggested to put the priority of their limited resources more to the resource abundant areas. Resource rich and dependent countries are always those affected heavily by the epidemics, the control of the epidemics in these countries are of vital importance to the control and even the elimination of the disease.

This research only focus on the spread of mosquito-borne virus. The effects of natural resources on other kind of diseases needs to be further tested. Future research can also focus on the regional or subnational level analyses of the resource effects on the spread of disease.

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