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THE BRITISH NORTH SEA: THE IMPORTANCE OF AND  
FACTORS AFFECTING TAX REVENUE  
FROM OIL PRODUCTION

By

Mark Thomas Hill

A thesis submitted to the faculty of  
Brigham Young University  
in partial fulfillment  
Of the requirements for the degree of  
Master of Arts

The David M. Kennedy Center  
Brigham Young University  
December 2003

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BRIGHAM YOUNG UNIVERSITY

GRADUATE COMMITTEE APPROVAL

of a thesis submitted by

Mark Thomas Hill

This thesis has been read by each member of the following graduate committee and by majority vote has been found to be satisfactory.

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BRIGHAM YOUNG UNIVERSITY

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## ABSTRACT

# THE BRITISH NORTH SEA: THE IMPORTANCE OF AND FACTORS AFFECTING TAX REVENUE FROM OIL PRODUCTION

Mark Thomas Hill

The David M. Kennedy Center for International Studies

Master of Arts

The oil industry is the richest and most influential industry in the world. The industry has moved the fates of nations. Oil is required to fight wars and exert power, and the restriction of this energy source is paramount to the restriction of movement, control, and in the end, power. Management of this resource and the tax revenue it generates are of serious strategic importance, both domestically and internationally. Understanding the results of taxation for this important commodity is important to international relations as well. The tax system affects tax revenue, government actions, oil company actions, and the oil supply itself. Each of these is important to international relations.

The North Sea came to prominence as a major producer of oil during the shortages in the early 1970's, when the price of oil tripled, and the world scrambled to find new, stable sources of oil outside the grasp of the OPEC cartel. In 1971, the Brent

oil field was discovered, and the British sector of the North Sea was suddenly politically important. Coinciding with first production in 1975, the government of the United Kingdom introduced a complex fiscal system to tax and regulate crude oil production in the North Sea. The British government has changed the fiscal system several times. The goals have always been for the government to receive a fair rent for production of the oil resources, without causing undue stress to the industry.

In this project I have developed and tested a model to show the effects of different variables on the amount of tax revenue received annually by the Exchequer of the United Kingdom directly attributable to the production of North Sea oil and gas. The model helps show the dramatic effects of the 1993 changes in the British tax code. This model should be able to serve as a predictor of future tax revenues and the comparative influence of different variables on tax revenues. The results of the model indicate that the United Kingdom could increase the tax rates on oil production and thereby increase tax revenue from that production.

## ACKNOWLEDGEMENTS

I would like to thank my family for their continual support. Thank you very much to my twin brother Mike and his lovely wife Julie for their support and editing work. Without my family's continued belief in and support of me, I surely would not have been able to finish. I would like to thank my cousin Daniel for his ideas, data, research, inspiration, and for letting me sit in on his course in Oslo.

I would like to thank all of my committee members for their willingness to serve on my committee and for the time they have put in. Thank you very much to Dr. Showalter for his help, expertise, patience and willingness to serve as the committee chair, and his help with the econometrics. I greatly appreciate the time he spent working with me, as well as the help and inspiration he provided.



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***Note on Terminology:***

The United Kingdom of Great Britain and Northern Ireland is the official name for probably the most important nation involved in and possessing part of the North Sea. It goes by many different names, many of which are used more or less interchangeably in this paper. Great Britain is the name of the island on which England, Wales and Scotland sit. They, united with many and diverse possessions acquired during and before the British Empire make up the nation of the United Kingdom. References in this paper to Great Britain, British Isles, Scotland, England, or the United Kingdom all make reference to the same nation or peoples. The technical distinctions between the terms are sufficiently small as to not merit discussion in this paper. The UK Continental Shelf (UKCS) refers to that part of the North Sea surrounding the island of Great Britain that is controlled and taxed according to treaty by the government of the United Kingdom.

The terms fiscal system, tax system, and fiscal regime are also used interchangeably throughout the paper to indicate the same thing. These terms include the tax, legislative, contractual and fiscal aspects that govern the exploration, development, and production of petroleum resources within a nation's sovereign boundaries, or whatever area they control.

## Introduction

The oil industry is an industry that changes the fates of nations. It drives wars and can cause consternation in peace. The oil industry is a rich industry, and many people have died fighting over it. The technology employed in the search for oil has been compared to that required to land a man on the moon. The average citizen in every nation in the world takes part in some aspect of the oil industry. Although the oil industry is both hated and loved, one cannot deny its importance to the world economy.

The North Sea is an important area to the oil industry. The North Sea's political and economic importance extends far beyond just the oil produced there. It represents a substantial deposit of oil outside the grasp and political instability of OPEC. The North Sea's deep waters and harsh conditions provided a proving ground for much of the technology utilized in the search for oil in offshore environments around the world.

The oil industry can also thank the North Sea for another important aspect – unit of measurement. Around the world, the most standard or accepted unit of measure is the 42-gallon barrel. This number comes from 1482 England under Edward IV. He established the 42-gallon barrel as the standard size for herring trading, in order to cut down on dishonesty in the fish trade. Herring fishing was the largest industry in those days in the North Sea. Today, that same barrel is used in the biggest business in the North Sea; only today that business is oil production.

This thesis is about North Sea oil, in particular, British North Sea oil. The focus of the paper is the historical and political significance and taxation of that oil by the government of the United Kingdom.

The paper is divided into three sections. The first section discusses the history of the oil industry, from its ancient usage to its modern beginnings in Pennsylvania, through to oil's place in today's society. The section covers in more detail the history and political importance of North Sea oil production. The first section includes a discussion of the international politics of oil and oil's importance to international relations.

The second section focuses on one important aspect of oil industry history, taxation. The discussion begins with natural resource taxation and different aspects of oil taxation in particular. The section includes a discussion of different tools and taxes used by governments to tax oil production. It also covers the history of North Sea taxation, briefly touching on the Norwegian tax system, and covering the British fiscal system in detail. The particular tools and taxes used by the British to tax North Sea oil are explained and briefly analyzed.

Focusing further, the next section concerns the tax revenue received by the Exchequer of the United Kingdom from the different taxes levied on North Sea oil production. An econometric model that describes the influence of different variables on revenues received by the British government from North Sea oil production has been formulated and is discussed in this final section. The model is described, and the results are discussed.

This is how the paper fits together, and the sequence of logic that ties each section into one thesis. The result is a discussion of British North Sea oil and the tax revenue that is directly attributable to it. The model raises some interesting questions about the methods and goals of the taxation of oil from the United Kingdom Continental Shelf.

## I. The History of Oil and the International Politics Surrounding It

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On the afternoon of Saturday, August 27, 1859, near Titusville, Pennsylvania, Colonel Edwin L. Drake and William A. “Uncle Billy” Smith made one final turn on their makeshift drill. At sixty-nine feet the drill hit a crevice and dropped six inches in the hole. They thought it was another in a string of many cave-ins, and took the rest of the day off. The next day, Sunday, Uncle Billy returned to find bubbling crude in the well bore. The news set off a boom that eventually affected the entire world. This was arguably the first commercially successful oil well in the modern world.

What do we mean when we say oil, or more specifically petroleum? The word “petroleum” comes from the Latin *petra*, meaning rock, and *oleum*, meaning oil. It refers to liquid hydrocarbons (hydrogen/carbon compounds) extracted from the upper strata of the earth, either pumped to the surface as a result of human engineering, or oozed to the surface, naturally escaping through geological formations. Petroleum is a synonym for crude oil. The phrase ‘petroleum industry’ generally refers to the extraction of natural gas as well as crude oil. Thus, the term “petroleum” refers to a large and complex group of liquid, gaseous, and semi-solid hydrocarbons.<sup>1</sup>

Oil (as well as natural gas) is lighter than water, so it naturally tries to flow upward through ground water. Where possible, it rises to the earth’s surface, and escapes in oil seeps. Much of the tar found on beaches is in fact crude oil that has seeped to the earth’s surface and collected on the beach. Some oil, however, is trapped in its upward journey through the earth in the pores of rock beneath an impermeable rock layer,

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<sup>1</sup>Forest Gray, *Petroleum Production for the Non-technical Person* (Tulsa: PennWell Publishing Company, 1986), 1.

forming an oil reservoir. Oil companies search for oil by drilling into formations that are likely candidates for oil reservoirs.<sup>2</sup>

The oil, or petroleum, industry is actually thousands of years old. Around 3000 BC or so, Mesopotamians used oil from seeps to seal boats and build roads.<sup>3</sup> The Chinese were the first known to drill for oil. Confucius wrote in 600 B.C. of wells producing water and natural gas near the Tibetan border. The Romans used containers of oil as weapons of war.<sup>4</sup> Alexander the Great supposedly burned oil to scare the battle elephants of opposing armies.<sup>5</sup> When Marco Polo visited the Persian city of Baku in 1246, now part of modern day Azerbaijan, he wrote of gushing oil, flaming hillsides (from natural gas seepage), and oil being harvested from holes dug in the ground.<sup>6</sup> People used oil as a waterproofer, and as a fuel, particularly for illumination. Oil seepages have been noted throughout history in various places throughout the world. Oil was a traded commodity in the Middle East for centuries before the Western world found widespread use and established control over it.

The need for illumination drove people to search for oil in the nineteenth century. Whale oil was the main source of fuel for lamps, but by the 1840's whales were scarce, and the world needed a cheaper source of light. A reliable kerosene lamp was invented in 1854. The process and technology for refining petroleum to make kerosene had recently

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<sup>2</sup> Royal Dutch/Shell website, "The Story of Oil"; available from [www.shellus.com/welcome/history/oil\\_story.html](http://www.shellus.com/welcome/history/oil_story.html)

<sup>3</sup> Energy Information Administration website, "Petroleum Milestones"; available from the Department of Energy [www.eia.doe.gov/kids/milestones/petroleum.html](http://www.eia.doe.gov/kids/milestones/petroleum.html)

<sup>4</sup> American Petroleum Institute website, "All About Petroleum"; available from [www.classroom-energy.org/teachers/petroleum/aboutpetroleum01.html](http://www.classroom-energy.org/teachers/petroleum/aboutpetroleum01.html)

<sup>5</sup> Department of Energy, Fossil Energy website, "The History of Oil"; available from [www.fe.doe.gov/education/oil\\_history.html](http://www.fe.doe.gov/education/oil_history.html)

<sup>6</sup> San Joaquin Geological Society website, "The History of the Oil Industry" available from [www.sjgs.com/history.html#ancient\\_to\\_present](http://www.sjgs.com/history.html#ancient_to_present)



been developed, and kerosene quickly surpassed whale oil to become the most important fuel for illumination.

The biggest challenge for the new industry was an assured supply. Extracting oil from seeps and skimming off the top of water were common but unreliable, unproductive, and expensive. These methods could not provide enough production to supply the quickly expanding demand for light. A group of investors put their trust in Colonel Edwin L. Drake and his foreman Uncle Billy Smith to find a way to extract oil, and in 1859 he earned their trust with the world's first commercially successful oil well. He drilled the well at the site of an oil seep long known to native Indians and white settlers in the area. That he struck oil with his first well was an unbelievable stroke of luck. Even with the advanced technology present in today's oil industry, the success rate is not much better than one successful well in every ten attempts. Drake and Smith found success on their first attempt.

With the Drake and Smith well, the United States gained an early advantage in the new oil industry, and in 1861 started exporting kerosene to Europe and the rest of the world. In the 1870's and 1880's, kerosene was the fourth-largest U.S. export by value, and almost all of it came from Pennsylvania.<sup>7</sup> Pennsylvania was responsible for one half the world's production of oil until the East Texas oil boom of 1901.<sup>8</sup> Technology for finding, producing, and transporting oil moved forward at a very fast pace. Standard Oil dominated the American oil market, and soon became a monopoly. Though Standard Oil was later broken into several pieces, the remnants still make up most of America's large and successful oil companies.

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<sup>7</sup> Daniel Yergin, *The Prize* (New York: Simon & Schuster, 1991), 56.

<sup>8</sup> The Paleontological Research Institution website, "The Drake Well in Pennsylvania" available from [www.priweb.org/ed/pgws/history/Pennsylvania/Pennsylvania2.html](http://www.priweb.org/ed/pgws/history/Pennsylvania/Pennsylvania2.html)

### *From Light to Fuel*

The 1877 invention of the incandescent light bulb by Thomas Edison seemed at first to ring the death knell for the oil industry. As the light bulb penetrated the market for illumination, it took away the biggest market for oil – refined kerosene as an illuminator. As one market diminished, however, another opened. The internal combustion engine was invented in the late 1800's, and quickly captured the imaginations of industrialists and inventors who sought to put the world on wheels. Automobiles opened a new market for oil, as a means of propulsion.

The use for oil changed almost entirely from kerosene to gasoline, and from 1905 onward, due to the work of Henry Ford and others like him, the market exploded. As Ford and others equipped the nation with automobiles, oil companies supplied fuel to run those automobiles. The search for ample supplies of raw crude oil became increasingly important. This search took place throughout the United States, as oil was discovered in California, and then in Texas. Overseas exploration became more important as well, although the United States was still the leading oil producing nation by far.

Foreign competition became a factor as oil companies started springing up in different parts of the world. In the 1870's the Nobel brothers, along with the Rothschild family developed oilfields in Baku, then a part of Russia. They later formed Shell Oil. In the following decade, the Royal Dutch Petroleum Company successfully drilled for oil in the Dutch East Indies. These two companies later merged to form one of the most powerful oil companies today, Royal Dutch/Shell. Royal Dutch/Shell has been accused of wielding more power and international influence than some national governments.

The Middle East became important in the world of oil exploration in the early 1900's. In 1901 the Shah of Persia and a consortium of British businessmen, with the full support of the British government, signed the Anglo-Persian agreement to search for and produce oil in Persia (modern day Iran). This was the first oil development in the Middle East, which was later to become the most dominant region for the oil industry - a title it still holds. It gave a prominence to Persia that it had not enjoyed since the ancient Persian Empire. This hinted at oil's future importance to international relations in the region. It also marked the beginning of another of today's huge oil companies, British Petroleum, or BP as it is now named.

### ***Oil and National Security***

A major concern for the British Empire during this time was changing technology in naval warfare. The United Kingdom and Germany had begun a naval arms race in the late 1800's. This forced the United Kingdom to modernize its fleet, and convert its main fuel source from its reliable, domestic supply of Welsh coal to fuel oil. Recognized as a superior fuel for propulsion, fuel oil was another refined product of crude oil, which was not found in significant quantities anywhere within the British Empire. The Anglo-Persian agreement helped secure a reliable supply of oil for the Royal Navy. This was one of the earliest oil contracts entered into for national security reasons. The British government even purchased a share in the Anglo-Persian Oil Company in order to ensure the Navy's needs were met, one of the first direct investments by a government into an oil company. This later became the norm rather than the exception.

World War I ushered in a new era of warfare dependant upon the internal combustion engine, and the oil that fueled it. Ships, airplanes, tanks, and automobiles were all central to military power. Now all were powered by some derivative of oil. Thus, military power relied on control of oil supplies. Although German U-boats failed to fully enforce their blockade of Allied Europe, the Allies were fairly effective at limiting supplies getting to Germany during World War I. The Germans faced a critical oil shortage, and this aided greatly in their defeat. They conquered Romania for its oil fields, and attempted to take Baku for the same reasons. Oil had established itself as a critical resource in the making of war and the security of nations.

In the aftermath of World War I, the conquering nations of Europe (the United Kingdom and France) divided up the old Ottoman Empire – primarily Mesopotamia (modern day Iraq) - based in part on oil resources. To this point, oil companies had by and large controlled the destiny and ownership of the oil industry, apart from some intervention by governments. Now, for the first time, nations decided the fate of oil fields and resources, not just businesses. This would not change – governments had permanently usurped the power of making oil decisions. Oil had become a critical resource in the area of national security; oil equaled power to the modern world, and still does today.

In 1919, a retiring government official wrote President Wilson that the lack of foreign oil supplies constituted the most serious international problem facing the United States. That was the first recorded recognition of that fact in the United States. It has had

serious influence on American foreign policy ever since.<sup>9</sup> American oil companies turned to the Middle East for oil, and would slowly make inroads into the region.

One noteworthy event for oil history took place in the 1930's. It was the formation of Saudi Arabia. When Ibn Saud first began consolidating the area now known as Saudi Arabia under his control, he could carry all of his possessions in his saddlebags.<sup>10</sup> A skilled leader and astute businessman, Saud developed a vast international power base from a nation of desert and nomads based almost solely on oil resources. His nation and dynasty have since been courted by the great nations of the world because of the power contained in those oil resources. The first concession of drilling rights in Saudi Arabia was granted in 1933 to an American company. Kuwait soon followed suit and allowed for oil exploration. The Middle East was growing in importance in the oil industry.

Oil played an important part in the road to the Second World War. Japan was expanding its empire into Southeast Asia in order to secure natural resources, most notably oil. An island nation with few natural resources of its own, Japan sought to reduce its dependence on imported oil from the United States. Japan's overly aggressive advances caused concern worldwide, and resulted in the United States instituting an oil embargo on Japan. In an effort to take America temporarily out of the way and thereby allow acquisition of Southeast Asian oilfields, Japan attacked at Pearl Harbor. Japan precipitated America's entry into World War II because of threats to its petroleum supplies. Later in the war, the Japanese imperial navy was heavily restrained in its movements for lack of fuel, and was in some cases even unable to take evasive action.

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<sup>9</sup> Yergin, *The Prize*, 194

<sup>10</sup> *Ibid.*, 284.

The Japanese were not the only party in World War II to have trouble with oil. The Germans also had no native supplies of their own. Having failed to develop a workable alternative to oil using synthetic fuels, the Germans also failed to put enough resources into capturing Baku and the other Caucus oilfields, and it cost them dearly. Lack of fuel bogged down Germany's armies on the steppes of Russia. Fuel shortages stopped Rommel in the North African desert. The grand German army was reduced to a horse-drawn one by the time the allies invaded Germany. The Allies had reliable supplies of oil in the United States, which produced 90 percent of all oil used by the Allies in World War II<sup>11</sup>. Oil was clearly a strategic resource in World War II, and helped the Allies win the war.

### ***Increasing Nationalism and the OPEC World***

The 1930's saw the rise of nationalism sentiment around the world, and a re-examination of the ownership of natural resources among oil-producing nations. Former colonies sought to exert control over their own natural resources for their own national good. They arrested greater control from the foreign oil companies operating within their borders. This was to have a profound effect on oil policy around the world. The Shah of Persia expropriated the Anglo-Persian oil company and demanded better terms for his treasury before he would give it back. Mexico nationalized all foreign oil companies operating in Mexico. The oil producing countries were starting to realize they could demand a bigger percentage of the oil profits. They were starting to realize they were the landlord, and wanted to increase the tenants' rent. The poor nations of the world wanted their fair share. This was to have big implications for oil taxation.

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<sup>11</sup> Ibid., 393.

In 1940, the Middle East produced 5% of the world's oil; the United States produced 63%.<sup>12</sup> It was clear that these percentages could not be sustained longer-term. The most eminent geologist of that time period, Everette DeGolyer reported that the Middle East was the place to be for oil – the center of gravity for world oil production was changing, and it was moving east. His analysis was taken seriously. As a result, the President of the United States sought to develop strategic relationships with influential Middle Eastern rulers, and every American president since has followed suit.

After the famous meeting with Stalin and Churchill in Yalta, Roosevelt flew to the Suez Canal Zone in Egypt for a much lesser known meeting with Ibn Saud, the King of Saudi Arabia. This was the start of a long relationship between the leaders of these two countries, and it signaled the future political importance of Saudi Arabia and the Middle East to the world. It also signaled a new concern about power in the post World War II era. Oil is required to fight wars and exercise power in modern times, and restriction of that source of energy is paramount to the restriction of movement, control, and in the end, power.

The establishment of the state of Israel after World War II polarized the Arabian populace from the Western world. This division is still a huge feature of international politics. Ibn Saud was staunchly opposed to a Jewish state in Palestine, a policy position his progeny has continued, and which has since had significant implications for the security of United States and the world.

The polarization between former colonies turned newly rich nations and the oil-consuming world was also increased, as nationalistic oil-producing governments demanded a greater share of oil profits. Iran, Saudi Arabia and Venezuela all

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<sup>12</sup> Ibid.

nationalized their oil industries, capturing all foreign-owned oil assets. The Israel issue continued to be a wedge, at least among the Arab oil producers.

The Suez crisis led to the first post World War II energy crisis. In 1955, petroleum was 2/3rds of the canal's traffic.<sup>13</sup> Egypt's dictator, Colonel Gamal Nasser, rode the tide of rising Arab nationalism. Antagonistic toward Western powers, he took control of the Suez Canal, which was jointly owned by the British and French at the time, and considered a strategic waterway by both. The British and French, along with Israel, attacked Egypt in order to regain control of the canal. Their primary concern was to ensure the security of Europe's main oil supply route from the Middle East.

With Nasser in charge, he could control and restrict the supply. Thus, worry about oil supply was the catalyst behind the international incident. The United States, anxious to court Arab and Middle Eastern goodwill for its own oil needs, opposed the action. The United States government imposed oil sanctions on the European countries to force withdrawal from the Canal Zone. This, and the temporary disabling of the canal by the Egyptians led to an energy crisis in Europe.

Having been ignored by American politicians in their pursuit of a favorable oil trade arrangement, Venezuela capitalized on this rising flood of Arab nationalism for its own economic ambitions. The result was the formation of the Organization of Petroleum Exporting Countries (OPEC) in 1960. The cartel's goal was to control the world oil price. The formation of OPEC was a response not only to rising nationalism (particularly Arab nationalism) in developing countries, but also a response to falling oil prices caused primarily by rising Soviet overproduction. OPEC's five founding members accounted for

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<sup>13</sup> Ibid., 480.



over 80 percent of the world's crude oil exports at that time.<sup>14</sup> The organization was not taken seriously at first – the CIA devoted only four lines to the organization in a 43-page report on “Middle East Oil” in 1960.<sup>15</sup> OPEC would prove soon enough that it could be successful in exerting its power.

The Arab wars against Israel – particularly the Yom Kippur War of 1973, and the ensuing embargo brought by the Arab countries against the United States and the industrialized nations supporting Israel signaled the power of a new weapon of war - oil. Such a weapon had never been effectively wielded before by small, otherwise insignificant and weak oil-producing nations against major oil-consuming world powers. This followed almost two decades of discussion and threats in the Arab nations about use of the “oil weapon.”<sup>16</sup>

The status of oil changed after the embargo. Kissinger claimed to know nothing about oil before 1973, but he could not ignore it now.<sup>17</sup> The resulting oil shock terrified the developed world. Pictures of long lines at the fuel pump and other problems caused by a lack of oil were burned into the collective memory of much of the world. The world feared OPEC and the Arab countries, and the power they could exert by restricting oil supplies. Countries around the world attempted to conserve energy, and thus lower demand for oil and their reliance on foreign oil supplies.

In a way, the Arab boycott backfired, because not only did countries cut back on their oil demand, they also sought out new, non-OPEC sources of supply. The three most notable new oil provinces were Alaska, Mexico, and the North Sea. All three had been

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<sup>14</sup> Ibid., 523

<sup>15</sup> Ibid.

<sup>16</sup> Ibid., 609.

<sup>17</sup> Ibid., 613

previously discovered, but became important only in the presence of high oil prices. These new areas of production were very important to the security strategies of the Western World, and allowed them some level of relief from the Arab oil weapon.

Luckily for the non-OPEC world, the instability of the OPEC nations and their tendency to cheat on self-imposed quotas made them unable to control the oil price over the long term. Although the pain from the oil embargo was very real and politically important, it did not last as long or was as effective and stable as OPEC would have liked. The Shah was overthrown in Iran in 1978, and the Iran-Iraq war started in 1980. Both events added more instability to world markets and further mobilized the industrial world in its search for new supplies and increased conservation efforts. OPEC members also cheated on a regular basis, pumping more oil than agreed under the supply-limiting pact. OPEC's influence was waning in the late 1970's and 1980's, and they no longer controlled price to the degree they believed. The last several years has seen a resurgence in the power OPEC wields in controlling oil price, but time will tell if they can truly control price over a long period of time.

### *After OPEC?*

Oil prices fell during the 1980's, and the whole oil issue was put on a back burner. The 1985 economic summit in Bonn showed how world politics had changed with respect to oil. Oil was not a major issue – the supply of oil had become sufficiently large and reliable that the world's major powers no longer needed to discuss it at every turn. The only other security issue involving oil was when Iran began mining the waters and attacking shipping in the Persian Gulf. Although tense at the time, it was not a world-

shaping confrontation. Oil supply was still a very important issue, but the OPEC nations had clearly hurt themselves with the problems of the late 1970's. Great Britain's Margaret Thatcher even dissolved the British National Oil Company, originally formed to ensure a reliable oil supply to the United Kingdom. Oil supplies appeared to be secure.

Having seemingly secured oil supplies in the foreseeable future, the overriding issues surrounding oil in the 1980's and going into the early 90's were environmental in nature. Pollution was the main problem facing the oil industry. Then, Saddam Hussein invaded Kuwait. Had he held Kuwait, Hussein would have controlled 20% of OPEC production, and 25% of the world's reserves, not to mention being in a prime position to take over Saudi Arabia. This did not sit well with the world, and an international coalition removed the Iraqis from Kuwait. Despite politically correct claims to the contrary, the coalition that gathered against Saddam Hussein did so to protect against the disruption of the world oil supply. They proved that oil is still worth going to war over.

Terrorism and weapons of mass destruction have since dominated the security concerns of the United States and most of the Western world, but oil remains a primary economic, if not security concern in the world today. It is difficult, if not impossible to downplay the effects oil has played on foreign policy issues.

## **Oil and World Politics**

The oil industry is the world's biggest business, and probably the most international. It is an industry that moves nations, and is deeply intertwined in today's national strategies and global politics and power. It has been part of global politics for quite some time, and affected the destinies of many nations. Although politics were mentioned some in the previous section, the influence that oil has had on international politics is worth of a separate discussion of its own.

### ***The Early Days of Oil***

The Anglo-Persian agreement of 1901 played a part in the international politics of the day, concerning the rivalry that was developing between the British and Russia for control of Central Asia. This was a victory for Great Britain, which sought to keep a buffer between the expanding Russian empire and her own holdings in India. Russia was expanding into the region, seeking to acquire a warm water port and a naval presence in the Persian Gulf. The agreement proved to be a stumbling block for them in this pursuit. The British wanted to defend their possessions in India. The Persian economy was at the time very integrated with the Russian economy, and the British feared the increase of influence to the point of military occupation by the Russians. The British therefore pushed the oil concession agreement, and with it, were able to hold off Russia from expanding its sphere of influence in the Persian Gulf.<sup>18</sup>

The oil economy affected the formation of other parts of the Middle East as well. On the Arabian Peninsula, even though most countries had been formed, much of the

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<sup>18</sup> Ibid., 135.

territory under their control was expansive desert. The states only began to define all of their borders when oil companies sought to determine the exact boundaries of their concessions.<sup>19</sup>

### ***World Wars***

Oil also played a crucial role in the pre-World War I arms race between Germany and Great Britain. The arms race forced the United Kingdom to modernize its fleet, which meant changing its fuel for propulsion from coal to fuel oil. This was not an easy transition for the British, considering that Great Britain produced very little in the way of oil, but the Welsh hills provided an abundant and ready (if not strategic) supply of coal. This was a significant risk to the British because they depended heavily on an oil supply from Iran. The hard-pushing Winston Churchill was in charge as Secretary of the Navy, and once the availability of supply was established, the Royal Navy made the conversion. For the first time in history, oil as a fuel became a strategic tool/weapon of war, driving the fate of nations that were able to utilize its capabilities and attain reliable supplies. It has not yet relinquished this position of importance in world affairs.

The First World War was the first war where the internal combustion engine became an important way of powering the war machine. This involved ships, airplanes, and land transport. The internal combustion engine changed the mobility of mankind, and the mobility of destructive force. One of the first demonstrations of the value of the internal combustion engine may have saved Paris. When Germany threatened to close in on Paris, thousands of troops were rushed to the front using Paris taxicabs. The railways

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<sup>19</sup> Simon Bromley, *American Hegemony and World Oil: The Industry, the State System and the World Economy* (Cambridge, UK: Polity Press, 1991), 108-9.

had been shut down and marching would have taken too long. The internal combustion engine and the oil industry had saved the day.<sup>20</sup> This was one incident in one battle, but clearly the internal combustion engine, and along with it, the fuel that powered it had a large influence in the outcome of the war.

Oil was also pivotal in deciding the fate of World War II. Japan attacked the United States in part because we shut off its oil supply – forcing Japan to acquire new resources in South East Asia. Hitler attempted to grab oil fields in the Caucasus. Indeed, the near-empty fuel tanks of the enemy were critical in winning World War II for the Allies. At that time, America was the largest and most dominant oil producer in the world, and it was in part this assured supply that gave the Allies the upper hand.

### ***Oil in the Middle East***

Discovery of large oil reserves in the Middle East brought peripheral nations to international prominence in terms of wealth and influence. Suddenly nations like Saudi Arabia, whose economies were formerly dominated by nomadic herders and trading, were nations of wealth and seemingly endless resources. Initially, private companies from the great empires of the world (mainly Great Britain and the United States) dominated these resources, rather than the locals.

These developing nations soon learned the principle of nationalization, however, and took control of the resources. Persia/Iran's nationalization of British Petroleum and Saudi Arabia's nationalization of Aramco were two of the most prominent and important nationalizations in the region. Governments of the great powers of the world could no longer dominate the industry, and were forced to rely on supplies from these peripheral

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<sup>20</sup> Yergin, *The Prize*, 171.

nations. This made the nations of Western Europe and North America nervous, and their paranoia would be justified by events in the Middle East.

The Arab wars against Israel, although losing affairs for the Arab nations, showed the influence that oil had on the region. People and nations who before had very little wealth, now suddenly had tremendous resources with which to purchase arms and make war on well-supplied and militarily well-supported Israel. Without their oil resources, the Arabs would never have been able to pay for or mount such a series of wars. In addition, the Arab oil embargo, as previously mentioned, showed how effective the “oil weapon” could be. Saddam Hussein further proved in the early 1990’s that the world, led by the heavily industrialized nations, still considered oil a valuable resource worth fighting for.

As Daniel Yergin makes reference to in The Prize, oil is the only commodity whose doings and controversies can be found regularly not only in the business news, but also on the front page.<sup>21</sup> It can be argued that the oil industry has played a more prominent role in world politics over the past century than any other industry. It continues to be important to the world, and will be for many years to come. From fuels to fertilizers, to plastics to roads, the oil and gas industry has become a part of our daily lives. We cannot be separated from it, just as it cannot be reasonably or easily separated from international politics.

That is why oil is important to international relations.

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<sup>21</sup> Ibid., 13.

## The North Sea Oil Province and its Importance

In this section, I seek to explain the significance of the North Sea and why it is worth studying in an international relations context.

The North Sea lies between Norway, the British Isles and the continent of Europe. The area is 575,000 km<sup>2</sup> and the average depth is 94 m. The deepest part of the North Sea is approximately 400 meters deep (in the Norwegian Trench).<sup>22</sup> The North Sea is a cold, inhospitable place. It is notorious for its fierce tidal currents and sudden changes in weather. The North Sea has high winds, massive swells, strong currents, low temperatures, intense pressure, long periods of darkness in the winter, and a rough seabed landscape. The water is deep, and the waves are high and treacherous.

The oil industry operates in harsh weather conditions around the world, from tundra to desert to tropical storms, but the North Sea contains some of the worst operating conditions in the entire industry. North Sea oil development is incredibly expensive. It also required an entire new generation in technology to exploit the resources below the angry waves. Given this information, one may be surprised to learn the level of importance of the North Sea as an oil-producing province. Following the Arab oil embargo in the seventies, the North Sea became arguably the most important offshore oil province in the world.

The North Sea has a great influence on world markets. Crude oil from the Brent Field on the United Kingdom continental shelf, referred to as Brent Crude, is generally accepted to be the main world benchmark crude oil, even though sales volumes of Brent Crude oil are far below other crude oil blends. According to the International Petroleum

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<sup>22</sup> The Norwegian Petroleum Directorate, "History of the North Sea," available from [www.npd.no/English/Emner/Geografiske+omraader/Nordsjoen/NordsjoenHistorikk.htm](http://www.npd.no/English/Emner/Geografiske+omraader/Nordsjoen/NordsjoenHistorikk.htm)



Exchange, Brent is used to price about 65% of the world's internationally traded crude oils.<sup>23</sup> The Norwegian North Sea is important in the oil industry as well. Norway is the world's third largest exporter of oil, and is a technological pioneer of offshore activity.<sup>24</sup> The North Sea was not always so influential.

Geologists realized the North Sea must contain petroleum reserves after a 1959 gas discovery onshore in Holland because the geology was very similar. Great Britain and Norway divided up the larger part of the North Sea in a 1965 treaty. The technology was partially there – offshore drilling had been successful as far back as 1947. Development was slow, however, owing to the large costs, high risk, new technology, and low priority of the North Sea compared to “lower risk” and lower-cost oil provinces in the Middle East.

Although many tried, no one found much success anywhere in the North Sea until Phillips Petroleum struck oil in November 1969. The well turned out to be a major discovery – the Ekofisk field. Even though the conditions were terrible – the rig nearly sank in a storm at one point - Phillips proved that there was oil beneath the cold, pounding waves of the North Sea. The British sector proved fertile as well, with major discoveries coming in 1970 and 1971 of the giant Forties and Brent fields.

Production in the British sector of the North Sea began in 1975, and by 1978, the United Kingdom was producing one million barrels of oil per day. The oil industry has had and still has a very significant impact on the British economy, particularly that of Scotland. On nearly any oilrig and in nearly every dusty oilfield in the world one can

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<sup>23</sup> International Petroleum Exchange website, “*Brent Futures Contract*”; available at [www.ipe.uk.com/contracts/bcf\\_index.asp](http://www.ipe.uk.com/contracts/bcf_index.asp)

<sup>24</sup> Norway Online website “North Sea Saga”; available at [www.norwayonline.no/book.asp?bookid=223](http://www.norwayonline.no/book.asp?bookid=223)

hear a British accent. The British have been important to the development of the oil industry, just as the oil industry has been important to the British.

Undoubtedly, oil production would have become a very important resource to the North Sea countries anyway, but the Arab oil embargo of 1973 precipitated an explosion of North Sea oil development. An untapped and politically stable oil province in Northern Europe suddenly became very attractive, both for oil companies and Western governments. The idea of political stability with relatively friendly governments was very attractive, and allayed concerns about high cost and tough drilling conditions. Nearly every international oil company wanted into the North Sea. The high prices that resulted from the political turmoil also made North Sea production profitable, despite the high costs and risky conditions.

The Arabs, in their quest to punish the Western nations and at the same time take higher profits from lower oil production, unwittingly gave the biggest boost possible to a rival producer. The British were quite keen to develop their North Sea oil and gas resources both to alleviate the supply issues in their home market, and to take advantage of the high prices and secure for themselves more tax revenue. At once, their interests were divided – as a friend and an enemy of OPEC. The price of oil went from the \$2 per barrel range in the early 1970's to \$40 per barrel in 1981. Suddenly, the difficult and expensive operating environment was economically feasible and the North Sea became politically necessary to develop. Development came quickly, and in 1975, the British began first production.

By 1983, the North Sea was producing more oil than Algeria, Libya and Nigeria combined, and production was still increasing.<sup>25</sup> Production grew rapidly - from negligible levels of production in the mid 1970's, in ten years the United Kingdom sector was producing 2.5 million barrels per day in 1985.<sup>26</sup> The development of the North Sea as an oil province was one of the greatest investment projects in history. The technology and experience gained there has been transferred to other offshore areas, and greatly aided in pushing the oil industry into deeper and deeper waters.

The North Sea oil industry also played an important, though lesser-known role in ending the Cold War. In the 1980's, the USSR had 35% of the world's proven natural gas reserves, and sought to market its gas in Western Europe. The Reagan administration lobbied Western Europe to develop the Troll gas field on the Norwegian continental shelf rather than relying on a Russian supply as a better and more secure gas supplier for Europe. Although hesitant to blindly follow the United States in a move that was more political than economic, the nations of Western Europe signed up to have the North Sea satisfy its natural gas needs for years to come. This helped alleviate a perceived potential Soviet stranglehold on Western Europe, and further hurt the USSR economically.<sup>27</sup>

It is difficult to properly enumerate the effect the North Sea oil production has had in terms of international relations. It came on stream at a very important time in world history for the oil industry. The Arab nations were taking advantage of their hegemony of the world oil industry, effectively yielding the "oil weapon." It seemed the western world, particularly the United States, was susceptible to the whims of the Arab world.

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<sup>25</sup> Yergin, *The Prize*, 720.

<sup>26</sup> Kemp, Alex, "North Sea Oil," *Leopard Magazine*, May 2003; available from [www.leopardmag.co.uk/feats/northsea.html](http://www.leopardmag.co.uk/feats/northsea.html)

<sup>27</sup> Norway Online, *North Sea Saga*

There was a great need to secure a politically stable supply of energy. Alaska and the North Sea came immediately to the forefront in this discussion. The North Sea has provided a reliable and ready supply of oil and natural gas to Europe since the 1970's. It does not provide for all of Europe's needs, but has been a strong factor in stabilizing Europe's supply. It also has helped a great deal in lessening the damage caused by oil shocks due to Middle East and other oil-producing nations' political instability.

The United Kingdom is an island nation, with relatively few natural resources, and yet they remain to this day a significant military and economic power in the world. The discovery and production of oil resources on the British continental shelf changed the way the British thought about energy. From the days of Winston Churchill as Secretary of the Navy attempting to secure a reliable supply of fuel oil for the British Royal Navy, significant national effort has been concentrated on securing an adequate supply of energy. Then British suddenly had their own secure domestic supply of energy.

The 1901 Anglo-Persian agreement between the Shah of Persia and the British to search for and produce oil in Persia was a major step at the time in securing a reliable supply of oil for the United Kingdom. The issue was British state security, in the name of fuel oil supply for British war ships. The Suez crisis of 1956 was as much about oil as anything else. The British and the French sought to maintain control of the Suez Canal to keep up the flow of Middle Eastern oil. When Nasser seized the canal, he blocked the normal supply route for three quarters of European oil imports. This was their main security concern, and the reason they risked the ire of their United States ally. Oil was also the reason the United States reacted the way it did, in an effort to curry favor in the Middle East, and thereby maintain its own influence over the world's oil supply.

Although two of the world's largest oil companies had their roots in the British Empire (British Petroleum and Shell), the British, like most Western nations, struggled to secure reliable energy sources. Later, as oil prices were consistently low, concerns over oil cost, supply, and security eased a bit. Although dismissed as slanted and foolish at the time, the words of Fritz Shumacher regarding the unreliability of the oil supply would come back to haunt the Western world. Fritz Shumacher argued that oil was a poor commodity on which to depend because the richest and cheapest reserves were located in some of the world's most politically unstable countries.<sup>28</sup> The supply shocks of the 1970's would prove his concerns well founded, but the discovery of oil in the North Sea would hurt his overall argument, and help those nations that depended upon its supply.

With the emergence of the North Sea as an oil-producing province, the British and Norwegian national goals suddenly reversed course. They were now torn between the conflicting goals of helping their Western Allies maintain an adequate supply of energy, and increasing national income and maintaining favorable balances of trade. In the form of regulations and tax systems, the British and Norwegian governments approached the issues differently, with different goals. The British sought more development, greater free enterprise, and improved balance of payments, while the Norwegians leaned more toward conservation, government participation and fear of adverse impact of and dependence on oil production for the national economy as a whole. Both nations have had a profound effect on the oil industry economically, politically, and technologically, as well as on the entire world economy.

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<sup>28</sup> Yergin, *The Prize*, 599

## II. The Taxation of Natural Resources

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The Shetland and Orkney Islands were part of the Kingdom of Denmark, Norway and Sweden until 1469, and ruled by King Christian. The Scandinavian king's daughter Margaret was to marry King James III of Scotland. As part of the agreed dowry, Christian was to give 60,000 florins – 10,000 immediately, and the rest later. As a pledge to pay the rest, he conceded the Orkney Islands. However, when the time came to pay, Christian could only raise 2,000 of the initial 10,000. He therefore gave up the Shetland Islands as an additional pledge. Christian never made the rest of the payment, and the islands have remained Scottish possessions ever since. The land area of these islands is relatively small, and the possessions most likely resulted in small income from taxes for Christian when he had them anyway. Five hundred years later, these islands took on an entirely new value. It is somewhat ironic that most of the early oil and gas discoveries in the North Sea were made in waters lying just to the East of Orkney and Shetland.<sup>29</sup> That territory is regulated and taxed by the United Kingdom. It may have taken five hundred years, but those islands are finally valuable lands from which rich taxes are collected.

Coinciding with first North Sea oil production, in 1975 the British government introduced a complex fiscal system to tax and regulate crude oil production in their sector of the North Sea. The idea was to gain a fair rent payment from oil production without the taxes being so overbearing as to limit investment and development. The fiscal system was designed to collect economic rents for production of the nation's natural resources.

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<sup>29</sup> D. I. MacKay and G. A. MacKay, *The Political Economy of North Sea Oil* (London: Martin Robertson & Co. Ltd., 1975), 50.

The United Kingdom government designed the tax system “to secure a fairer share of profits for the nation and to maximize the gain to the balance of payments.”<sup>30</sup>

Over the years, the British have made a number of changes to the fiscal system. These changes had different aims, depending upon the time frame and the conditions that were present in the oil industry, national and international politics, or the geological understanding of the North Sea at the times of the changes. Each of the changes resulted in a change in United Kingdom government tax revenue and balance of payments, as well as a change in the economics of North Sea field development. This paper is mainly concerned with the revenue generated by the tax system, and how other factors affected that revenue generation. In general, the British system encouraged development of the North Sea and the British oil economy.

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<sup>30</sup> Alexander G. Kemp and D. Crichton, “Effects of Changes in UK North Sea Oil Taxation,” *Energy Economics*, (October 1979): 224.

## Economic Rent

The theory of economic rent is important in petroleum taxation. There are a number of subtleties to the ways in which it is defined. David Ricardo wrote on the subject of economic rents in *The Principles of Political Economy and Taxation*. He defined rent, “that portion of the produce of the earth, which is paid to the landlord for the use of the original and indestructible powers of the soil.”<sup>31</sup> The “original and indestructible powers of the soil” referred, in his example of wheat production, to the soil’s natural fertility. In terms of natural resource production, the original powers of the soil refer to the coal, oil, gold, or other resource that can be extracted from the ground. Like soil fertility, coal, oil, gold and other minerals are there to begin with, and not due to any work or effort by human hands. Under Ricardo’s notion of rents profits result from the differences in nature’s gifts. Some pieces of ground demand higher rents than others because they have been endowed with more bounteous natural gifts.

Ricardo defined economic rent as the difference between the value of production and the cost to bring it to market. The highest-cost producer will receive no economic rent, but will receive only enough return on his investment to keep him in business. Lower-cost producers receive the same market price, but have lower costs, so they will receive as economic rent that amount above their costs. For the purposes of natural resource extraction industries, the cost to bring the resource to market consist of exploration, development, and operating costs, as well as a sufficient share of profits based upon industry standards. Any profit above this is considered rent. Landlords are

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<sup>31</sup> David Ricardo, *Principles of Political Economy and Taxation* (London: John Murray, 1821), 2.1.



generally the recipients of the rent, while tenants pay the rent. In the case of the oil industry, and definitely in the North Sea, governments have established themselves as the landlords, and the operating oil companies are the tenants.

Daniel Johnston defines economic rent in *International Petroleum Fiscal Systems and Production Sharing Contracts* as “equivalent to ‘excess profits.’ Therefore it is the governments’ objective to extract all rent which is consistent with allowing a share of profits for the industry sufficient to encourage as much exploration and development as the government desires.”<sup>32</sup> He goes on to explain that through various levies, taxes, royalties, and bonuses, governments attempt to capture the rent without adversely affecting their own development goals for the resources under their control.

The importance of the concept of economic rents for taxation of natural resource extraction industries is the idea that rents can be captured without affecting the production of the mineral being produced. Because economic rent is that over and above the amount of profit required for producers to explore for and produce the natural resource, landlords or governments are able to keep some of the rent for themselves while still maintaining the same level of development of the resource. Thus, taking only economic rent will not interfere with the efficient allocation of resources. In theory, a well-designed tax would only take the economic rent.

Governments try to extract economic rent as efficiently as possible, meaning they aim to take only the surplus over and above what is necessary to maintain the land in its present use or form of production. If they take more than this, it has a negative impact on production. If they take less, they forego additional revenue. Finding this middle ground

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<sup>32</sup> Daniel Johnston, *International Petroleum Fiscal Systems and Production Sharing Contracts* (Tulsa, Oklahoma: PennWell Publishing Company, 1994), 6.

is difficult. Governments want the jobs and economic development, but they also want to maximize state income from the extraction of that resource.

Efficient oil taxation is challenging because it is difficult, if not impossible to measure economic rent. A normal industry yield on the investment is also difficult to obtain. Economists consider a normal return on capital a cost, and therefore not part of economic rent. If companies did not get a normal return on their capital, they would invest elsewhere. This would negatively affect the production of the resource. Transfer prices between different divisions of the same integrated oil companies confuse the calculation because they may or may not accurately reflect market prices or costs.

Aside from in the United States, natural resources like petroleum are generally owned by the state (although the United States government owns a great deal as well, owing to reserves on public lands and in offshore areas). Governments issue licenses to companies funded with private funds to develop the reserves. This is true of the resources under the British North Sea. The issues surrounding natural resource production and development are potentially inflammatory ones because they are often seen like the crown jewels. They often make up a large and important part of the local economy, and there are vast sums of money involved. The people feel entitled to and want to see benefit from the exploitation of the natural resources. Nations generally tax the industries associated with the extraction of mineral resources with separate tax systems. This is due to relatively high returns associated with such industries.

## Petroleum Taxation

“Some oil companies are comparable in strength and wealth to national governments. In 1977 Shell earned \$55 billion from 4.2 million barrels per day, while Exxon earned \$58 billion producing 4.9 million. By contrast the revenues of Saudi Arabia were only \$38 billion and 9.2 million barrels per day, and the revenues of Iran were \$23 billion and 5.7 million barrels. As Secretary of State, I learned that relations between governments and oil companies were rather like treaty negotiations.”  
-Tony Benn, Diaries, 11 January 1977.<sup>33</sup>

### *Development of Petroleum Taxation*

Petroleum taxation has matured a great deal since its beginnings. Peter the Great of Russia may have been the first ruler to establish a separate tax for the production of oil. Having conquered the Khanate of Baku in Persia in 1723, Peter allowed commercial exploitation of the petroleum reserves in the region in exchange for a certain percentage of the profits. Taxation and regulation of oil exploration and production has steadily become much more sophisticated.

At the beginning of the petroleum industry, ownership was regulated by the rule of capture. This is a principle based on English Common Law. If a game animal or bird from one estate migrated to another, the owner of the latter estate was free to kill the game as his own on his land. Similarly, owners of land had the right to draw out whatever wealth lay beneath it, namely, oil.<sup>34</sup> This policy led to over production in an effort to suck the oil out of the reservoirs before your neighbor got to it, and subsequently damaged a large number of oil reserves. A system of unitization was introduced in the United States in the 1920's, and the rest of the world soon followed suit. Governments

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<sup>33</sup> Christopher Harvie, *Fool's Gold – The Story of North Sea Oil*. (London: Hamish Hamilton, 1994), 175.

<sup>34</sup> Yergin, *The Prize*, 32.

more closely regulated the production of oil and gas, and were better able to set goals for the extraction and exploitation of those natural resources.

From the beginnings of the oil industry, private companies made the majority of the decisions surrounding the exploration for and production of oil and gas.

Governments at first had little bargaining power to demand higher economic rents or increased control over the natural resources that were contained in their sovereign territory. Much to the chagrin of the major oil companies, this soon changed. The Mexican government was the first to nationalize the subsoil in the early 1900's, effectively establishing ownership over the oil under its surface. Along with Mexico, oil-producing nations and monarchs around the world rebelled bit by bit against powerful international oil companies and the traditional colonial powers from whence they came. As the value of the commodity came to be more fully realized, the extent to which the oil companies profited from its production was resented more and more by the previously poor and disorganized countries. The governments wanted their piece of the profits too.

Governments not only demanded a greater share of and more control over the oil reserves beneath their surfaces, they also introduced new and increasingly innovative methods of taxing the producers of those resources. Both sides, governments and oil companies, increased their levels of sophistication as new deals and tax systems were negotiated and the rent was distributed in different and more innovative ways.

Production sharing contracts, risk service contracts, special petroleum duties, and other specialized fiscal devices were introduced into specific fiscal regimes devoted to the oil industry in attempts to further capture the economic rent for the state. Participation and nationalization battles took place in oil producing countries all over with world. The

formation of the OPEC cartel, and the effective wielding of its power for price-control and political purposes were high points in the rise of the power of the oil-producing states. Taxation and fiscal systems for oil and gas production have continued to evolve, however, as economies change and the effects of various kinds of taxes are better understood. It is against this historical backdrop that Norway and the United Kingdom formulated their fiscal regimes and state policies toward the oil exploration, development, and production on the North Sea Continental Shelf. Countries are more able today than ever before to understand and plan on the effects of different taxation schemes for oil and gas production.

### ***Types of Mineral Taxes***

There are several categories of tax levied by oil producing nations on oil producing companies operating within their respective jurisdictions. Although some more unique individualized forms of taxation are used in different places, the main categories are: income taxes, severance excise taxes, and property taxes. Each must be evaluated in terms of efficiency, equity, and impact of the tax.<sup>35</sup>

The fiscal systems and taxation devices used to tax oil production by different countries around the world vary a great deal from country to country. Although many countries use many different methods of collecting economic rent including production sharing contracts and risk services contracts, the contracts in place in this paper are straight concessionary systems. In this type of system, title to the minerals transfers to the company producing them, and the company is then subject to payment of royalties

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<sup>35</sup> G. H. K. Schenck, *Handbook of State and Local Taxation of Solid Minerals* (University Park, PA: Department of Mineral Economics, The Pennsylvania State University, 1984), 39

and taxes. This concept of ownership transferring to the producer comes from Anglo-Saxon legal tradition, so not surprisingly it is used in the United Kingdom North Sea.<sup>36</sup>

Corporate income taxes are taxes that every profitable (for-profit) company is subject to, unless some special tax holiday is in effect. Income taxes use the net income as the tax base. Because of this, the effect of the tax is heavily dependent on the allowed deductions as well as rates of and provisions on depreciation and depletion, loss offsetting, and rate of the tax. They are either a flat rate for all sizes of income, or progressive, increasing as net income increases. Income taxes should not increase the relative tax burden on firms during low oil prices, and in theory should be neutral with regard to production decisions.

Property taxation is another form of taxation for the mineral industry. The value of the mine, including the mineral deposits, is the base for the tax. The distinction between land value and capital improvements on the land is an important consideration for this tax. A property tax can produce distortion in the form of encouraging accelerated rates of extraction and therefore inefficient use of economic resources. The reason is, the producer will pay property tax whether production takes place or not, so the incentive is to produce early and as quickly as possible. This can cause inefficient extraction of the resource.

Royalties or production taxes are the most traditional reward for the landlord.<sup>37</sup> A royalty generally consists of a payment made on gross production. It is taken straight off the top out of gross production, and is a required payment amount independent of cost structures or market conditions. Because of this, as Kemp describes, such traditional

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<sup>36</sup> Johnston, *International Petroleum Fiscal Systems and Production Sharing Contracts*, 21.

<sup>37</sup> Alexander Kemp, *Petroleum Rent Collection Around the World* (Halifax, Nova Scotia: The Institute for Research on Public Policy, 1987), 91.

royalties or production levies can cause undue hardship to marginal fields. As oil price decreases, the payment becomes an increasingly high percentage of gross profits. As oil price increases, the royalty becomes an increasingly smaller percentage, and thus the portion of economic rent extracted becomes increasingly smaller. Royalties also can hasten the abandonment of oilfields because they can be so hard on marginal fields. This is usually not something that governments want, as abandonment of oilfields decreases economic development and lowers government tax revenue. Most royalty arrangements used by governments have been modified in an attempt to nullify the crude nature of the royalty or production tax.<sup>38</sup> The United Kingdom is an example of this; they originally charged a royalty of 12.5 percent on gross production, but eliminated the royalty in 1983 in an attempt to modernize and improve their fiscal arrangement.

Another layer of taxation that is used most notably by North Sea oil producing countries are special profits-related taxes. The United Kingdom version of the tax is called Petroleum Revenue Tax (PRT). It is not an income tax per se, although it is related to income. These taxes are levied on individual fields, and have a number of different provisions. The purpose of this tax is to collect a higher percentage of economic rent. The famous “ring fence” provision was introduced to the world by the British and limits deductions for this tax to individual oil fields.

Bids and bonuses are frequently used in the oil and gas industry as well. This is when companies bid for the right to develop the oil and gas assets with bonuses. The company that bids the highest bonus wins the contract. This is not necessarily a tax like the other taxes described here, but must be considered part of the fiscal system. The difference is that this sort of tax comes before any revenue is seen. This type of tax

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<sup>38</sup> Ibid., 92.

transfers risk from the government to the oil company participating because the oil company must pay the bonus before it receives any revenue or income.

Some economists like a strict version of a bid or bonus system as an efficient collector of economic rents. Because a system made up of only a lump sum payment made before any production takes place does not introduce any distortions into the system, this type of fiscal arrangement would seem to be efficient. The risk would be transferred completely to the oil company. Given that the bonus would be sunk cost, investment and production decisions would (theoretically) be made on a rational economic basis, and none of the distortions that are introduced as a result of a complex system would be introduced. Also, because investors themselves are the best judges of economic rent (a fundamental argument for the free market in which we live), theoretically they will transfer a more accurate estimate of economic rent to the host government if given a chance to competitively bid on the bonus.<sup>39</sup>

Unfortunately, although this would be an efficient collector of rents, it is not practical. The largest problem is the risk that is inherent in the oil industry. The risk/reward trade-off is huge – nearly nine out of ten wells drilled are unprofitable. Oil companies would demand a lower bid because of the high risk, and citizens would feel that rent was not effectively captured if huge discoveries were made on smaller bids. If more information were known about exploration acreage, a system based on a simple bonus bid might be practical. Given current technology, however, the information about

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<sup>39</sup> United Nations. Centre on Transnational Corporations. UNCTC Advisory Studies. *Financial and Fiscal Aspects of Petroleum Exploitation* Series B, No. 3, (New York: United Nations, 1987), 5.



exploration acreage is sufficiently small as to make this system impractical, and hence it is not used.<sup>40</sup>

### ***Evaluation of Tax Systems***

Taxation or fiscal systems can be judged in their effectiveness by a number of different factors. Petroleum fiscal systems may be evaluated based on the ability of the tax to collect economic rents, the economic or operating distortions caused by the tax, and the ability of the tax or fiscal system to meet the various goals of the government. Two goals of a tax are to be neutral, and to secure an equitable share of profits.<sup>41</sup> A tax is neutral if it does not cause economic or operating distortions because it is levied. This helps to ensure a lack of operating and economic distortions caused by the tax. If a tax is neutral, there is still economic efficiency, which is good.

Securing an equitable share is somewhat akin to efficiently collecting economic rents, although clearly not always the same thing. As natural resource extraction is such a potentially inflammatory subject, and there is so much money involved, it is necessary to ensure that government coffers or other recipients are receiving a “fair” share. The word “fair” is obviously subject to a great deal of debate. The general public, as well as many legislators and some economists, see oil and other mineral-producing companies receiving a very high return on their invested dollars. This is to say they do not pay high enough mineral taxes. An example of this can be found from Alt, Baumann and Zimmerman, in their paper, *The Economics of Western Coal Severance Taxes*. They

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<sup>40</sup> Johnston, *International Petroleum Fiscal Systems and Production Sharing Contracts*, 8.

<sup>41</sup> Dr. Ian Rutledge, and Dr. Philip Wright, “North Sea Oil Taxation, Methods and Evidence,” *CEPMLP Paper No CP 10/98*, (Dundee, Scotland: Center for Energy, Petroleum and Mineral Law and Policy, University of Dundee, 1998) 1-2.

argue that Wyoming does not charge high enough taxes on coal extraction, and should raise taxes in order to secure revenue for the state.<sup>42</sup> The state thus does not secure an “equitable share” of the proceeds. This could lead to political turmoil and to problems both for the state government, as well as for the producing companies themselves.

Designers of a taxation or fiscal system generally do not want to introduce changes in operating conditions because of the tax. If a tax impairs exploration, development of new fields, production, or causes fields to be prematurely abandoned, distortions have clearly been introduced by the tax. The goal for taxation is usually something along the lines of collecting economic rent while still ensuring economically efficient use of resources, so this is a problem. One possible distortion that tax designers might like to introduce is one of increased conservation. Governments might want to slow exploitation of the resource or to spread tax revenue over a longer time range. An example of this can be seen in the North Sea. The Norwegians have designed their tax system around a slower exploitation goal than the British.

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<sup>42</sup> Christopher B. Alt, Michael G. Baumann, and Martin B. Zimmerman, “The Economics of Western Coal Severance Taxes” *Journal of Business*, Volume 56, Issue 4 (October, 1983), 519-536.

## North Sea oil production - United Kingdom and Norwegian oil policy

It is often said that on nearly every oilrig in the world, one can hear a British accent. On very few can one hear a Norwegian accent. One reason for this is the United Kingdom has a much higher population than Norway. However, one must also consider the effects of the taxation and development policies surrounding the two countries' exploitation of their respective parts of the North Sea Continental Shelf, and the effects that has had on the development of the countries' respective oil economies. Norway provides an interesting comparison to the United Kingdom because of the similarities between the geology, operating conditions, and costs to that of the United Kingdom Continental Shelf. Aside from government taxation and regulations, for most of the fields, the main difference between the British and Norwegian sectors is an imaginary line in the ocean drawn by treaty. Thus, it is a reasonable comparison.

From the beginning, the British have followed a policy of lower level of taxation and a more rapid development of the oil and gas reserves. The Norwegians, on the other hand, have followed a much more cautious policy based on conservation, conservatism, and capturing a larger portion of the economic rent. As a result, the British oil economy is much more developed, as are British oil and oil services companies. For example, Aberdeen, Scotland is the world's largest heliport, based on it's servicing of the North Sea oil industry.<sup>43</sup> The United Kingdom quickly developed a significant and influential oil economy. The Norwegians have a strong oil economy as well, but it is much smaller.

When oil was discovered in large quantities under the North Sea, the British and Norwegian governments faced a steep learning curve in establishing oil policies. Neither

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<sup>43</sup> BAA corporate website "About Aberdeen" available from [http://www.baa.com/main/airports/aberdeen/about\\_aberdeen\\_frame.html](http://www.baa.com/main/airports/aberdeen/about_aberdeen_frame.html)

government had any direct experience with oil production. Technical aspects were for the most part a mystery to the government workers. The respective political situations for both governments were also complex, particularly after the 1973 oil price shock.

With large oil reserves in the North Sea, the British and Norwegian governments both suddenly saw themselves as future oil-exporting countries with goals corresponding to those of the OPEC nations. They saw the history of the early development of the OPEC nations, and did not want to fall into the same traps that brought such disorder and instability to many of those countries, despite the newfound wealth. In many cases, less-developed countries with little experience with the oil industry were in part taken over by the oil companies, who grabbed control over a significant amount of that nation's natural resources, to the detriment of the people and government of the nation. An overreaction by the government to take control and wealth from the oil companies also did not often result in an improvement in the situation. The governments of the United Kingdom and Norway wanted to do it right, or as close to "right" as possible, the first time around.

Not surprisingly, the United Kingdom and Norway wanted a more balanced and controlled approach. In addition, both countries had different economic goals at the time. The Norwegian economy was strong, with low unemployment. The British economy was somewhat sluggish, and the country suffered from a stiff balance of payments problem. Thus, the United Kingdom could greatly use the economic boost and new source of employment and investment capital, while the Norwegians didn't necessarily need the economic boost, and were wary of causing a major disruption in their domestic economy. Thus, the two nations approached the creation of an oil policy from different points of view, and with different goals.

### *Norwegian policy*

From the beginning, the Norwegians followed a conservative development policy that consisted of high tax rates and low depletion rates, and kept control in the hands of the Norwegian government. They, like the members of OPEC, believed that oil in the ground is a preferable investment to money in the bank. The Norwegian government did not want to adversely affect its relatively small economy with fast-paced growth, but it did want to maintain secure control of its natural resources, as well as secure a greater share of the proceeds from the exploitation of oil reserves in the North Sea. Rapid exploitation of its natural resources was generally considered by the Norwegian government to be somewhat disadvantageous for the economic health of the country. The Norwegian Government has exercised much tighter control over offshore development than Great Britain. Statoil was formed in the early 1970's to represent operational state participation as the Norwegian national oil company. Even today, two Norwegian companies, Statoil (recently partially privatized) and Norsk Hydro control 80% of operations on the Norwegian Continental Shelf.<sup>44</sup>

Kemp evaluated the effects of the Norwegian fiscal regime in his publication, "North Sea Oil Taxation in Norway." His focus was the effects of the significant 1975 tax package, introduced just years after first Norwegian production began. The fiscal regime was found to be a relatively inefficient collector of economic rents, detrimental to investment in higher-cost marginal fields. It inordinately favors capital-intensive projects. The Norwegian system also requires a large percentage of government

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<sup>44</sup> Offshore Engineer by OilOnline, "Norway Overview... Reform and Function" April 1, 2002, available from [http://www.oilonline.com/news/features/oe/20020401.Norway\\_O.8569.asp](http://www.oilonline.com/news/features/oe/20020401.Norway_O.8569.asp)

participation in the form of Statoil, the Norwegian state oil company. Kemp found Statoil's participation to not be prohibitive to companies searching for oil in Norway.

### ***British Policy***

Initially, Great Britain's objective for its North Sea oil fields was one of rapid exploitation. Great Britain was a large consumer and importer of energy, much of it foreign, imported oil. The government was keen to develop any potential domestic supply of energy. Between 1964, when the United Kingdom petroleum rights were first extended to the United Kingdom continental shelf, to 1972 the British government offered four offshore licensing rounds.<sup>45</sup> This compares to the conservative Norwegians only offering two much smaller licensing rounds within the same time period. The potential problem of premature depletion of the North Sea oil fields was not given much consideration, and oil producers were allowed to determine field depletion rates and oilfield policies rather than the government legislating depletion policies.

This policy was followed in part because of a general world-wide belief at the time that oil prices would decrease over time; thus the goal in that situation becomes producing as much as soon as possible in order to obtain the highest price. When the 1973 oil shock took place, the generally accepted predictions of oil price saw big increases over time. Also about that time, the estimation of United Kingdom reserves was sharply increased. With this, the government realized that the resource base must be much bigger, and a more valuable asset needs greater protection and planning to be a

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<sup>45</sup> British Department of Energy, Department of Trade and Industry, "Brown Book 2001" available from <http://www.dbd-data.co.uk/bb2001/book.htm>, Appendix 8.

benefit further into the future. Also, the government may no longer have felt the need to keep the oil companies happy. Every oil company wanted a foothold in the North Sea; attracting private investment to the North Sea was no longer a major concern.<sup>46</sup>

Thus, United Kingdom government policy was reevaluated. The tax regime first placed on the first North Sea licenses granted between 1964 and 1973 was greatly criticized for its low rate of taxation. When significant production began in 1975, a new higher tax structure was in place. A comprehensive national oil policy is an evolving system that is changed frequently over time to reflect changing political moods and/or hopefully more effective economic or regulatory policies.

The shift was toward greater government intervention in North Sea oil production. The British National Oil Company, or BNOC, was created to give the government a greater presence and more control in oil production. It represented the British government and took interests in the North Sea oil fields. Prime Minister Margaret Thatcher disbanded BNOC in the 1980's in a privatization effort both because of government bureaucratic inefficiency, and also a lack of national security justification for a national oil company. Even considering these policies controlling and regulating the North Sea, the British North Sea had a much lower tax regime and a quicker and more private-sector development than that of Norway.

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<sup>46</sup> Colin Robinson and Jon Morgan, *North Sea Oil in the Future*, (London: The Macmillan Press Ltd, 1978), 25.

## Specifics of British Petroleum Taxation

The fiscal regime governing oil production in the British sector of the North Sea has developed over time, and is still developing. The goals have changed as the province has matured. The North Sea, the British sector in particular, has gone from an unknown, high-cost province with rough conditions and untried technology but huge world-class oilfield discoveries, to a mature oil province focusing on the development and maintenance of much smaller fields using tried technology and methods. The tax system has evolved to reflect these changes. Still, the principle goal of the tax system, to maximize the benefit for the nation, has not changed.

The 1934 Petroleum Production Act vested oil and gas ownership with the Crown. The 1964 Continental Shelf Act extended the government's rights to the oil contained under the United Kingdom Continental Shelf. The Oil Taxation Act of 1975 established the modern fiscal regime for the taxation of oil in Great Britain. It introduced Petroleum Revenue Tax (PRT) and introduced "ring fencing" to the world. Both are fundamental parts of the United Kingdom tax system. A series of smaller acts have added or taken away provisions in the system or increased or decreased the different rates of taxation.

The fiscal regime from 1975 to present has generally consisted of three parts, Royalty, PRT, and Corporate Tax (CT). There are many specific points of law within and governing calculation of these provisions. The Royalty was originally 12 ½ percent of gross production. For the fields where exploration rights were granted in the earliest four licensing rounds, transportation costs are deductible before calculation of the Royalty, but after that, no costs can be deducted. The Royalty was abolished for fields



receiving development approval after April 1, 1982. As of January 1, 2003, the Royalty was officially abolished for all oil fields. As the data for this paper only cover up to the year 2001, this is not a factor. For the purposes of the data in this paper, a Royalty is still payable for oil fields older than 1982.

Petroleum Revenue Tax, or PRT, is a special tax on oil and gas production. It is a field-based tax, and is levied on the profits of individual fields rather than all the oil profits made by an oil producing company. Thus, the development and operating costs can only be set against the profits from the field for which they occurred. The rate of PRT has been as high as 75 percent and as low as 45 percent (0 percent on gas discoveries before PRT was introduced in 1975), but the current rate of PRT is 50 percent. This is only applied to fields receiving development approval before March 16, 1993. PRT was abolished for fields receiving development after that date. There are also a series of allowances, provisions, losses, and costs that can be set against PRT for various situations and circumstances. One of the purposes of PRT was to collect economic rent, and to ensure that projects where no economic rent was likely (the high-cost producers) were protected from tax.

Corporation Tax is the standard income tax charged to corporations operating in Great Britain. One difference, however, is the “ring fence” that applies to oil companies. Ring fencing prevents oil companies from offsetting profits with other losses within the company from excessive interest payments or losses otherwise unrelated to oil exploration, development or production. This provision is designed to ensure that taxes on profits from oil production are paid and not offset by other losses made when engaged in other, non-oil related activities. In other words, the government wants to make sure to

capture the economic rent from the oil production. Profits from other operations can, however be offset for the purposes of corporation tax with losses from petroleum operations in the North Sea. Both Royalty and PRT payments are deductible for the purposes of computing Corporation Tax. Since oil production began and ring fencing was introduced in 1975, the rate of Corporation Tax has been as high as 52 percent, and as low as its current 30 percent.

This is obviously a simplified look at the United Kingdom fiscal regime, and many complexities exist within the many-layered system. Over the years, the British government has tried different ways of changing the fiscal system structure to tweak the government take, induce different behavior, or tax different things. A Supplementary Petroleum Duty (SPD) of 20 percent was added in 1981 in an attempt to increase government tax revenue, but the tax was withdrawn after only two years. That was the high point of the British government's percentage take of oil revenue in the form of taxes.<sup>47</sup>

The British have sought to correct perceived flaws in the fiscal system several times, either to reflect changes in the political or economic environment, or correct perceived injustices. The 1978 changes made marginal fields newly liable to PRT. The system gave a marked advantage to operators involved in a multi-field operation over those engaged in smaller operations. Revenue from PRT was extremely elastic to changes in oil price, capital costs, recoverable reserves and the sterling/dollar exchange

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<sup>47</sup> Johnston, Daniel, *International Petroleum Fiscal Systems Analysis* (PennWell), 121e.

rate.<sup>48</sup> The United Kingdom fiscal system has often been accused of not accurately targeting economic rents.<sup>49</sup>

Petroleum Revenue Tax has been widely complemented as an efficient collector of economic rents. When the tax was in place, however, the British system levied a high rate of taxation compared to the systems of other nations. When the British government suspended the Petroleum Revenue Tax, the system became quite competitive internationally in terms of taxation levels and encouraging investment, but became much less efficient as a system of collecting economic rents.<sup>50</sup> A system that only includes corporation tax is inefficient. Petroleum Revenue Tax was both neutral and relatively efficient as a rent collector.<sup>51</sup>

The British North Sea petroleum fiscal system has been studied and evaluated many times. The main components are Royalty, Corporation Tax, Petroleum Revenue Tax, and Supplementary Petroleum Duty. One other major component of tax structure is the ring fence provision, limiting cost recovery to specific oil fields. The British tax code went from being one of the highest in the world of its kind in the early 1980's to one of the lowest in the world after changes made in 1993. These changes met British political goals and also affected tax revenue received from those taxes. The next section looks at the variables affecting tax revenue from oil production.

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<sup>48</sup> Alexander G.Kemp and David Cohen, *The Impact of the System of Petroleum Taxation in the UK on Oil Operations and Government Revenue*, (Glasgow: Fraser of Allander Institute, University of Strathclyde, 1980), 38.

<sup>49</sup> Alexander G.Kemp, "International Petroleum Taxation in the 1990's" *The Energy Journal* Vol. 15, Special Issue (1994): 294-5.

<sup>50</sup> Alexander G.Kemp and Linda Stephens, "The UK Petroleum Fiscal System in Retrospect" in *The UK Energy Experience: A Model or a Warning?: Proceedings of the British Institute of Energy Economics Conference, University of Warwick, 11-12 December 1995*. (Warwick: University of Warwick, 1995), 76-7.

<sup>51</sup> Lei Zhang, "Neutrality and Efficiency of Petroleum Revenue Tax: A Theoretical Assessment" *The Economic Journal*, Vol. 107, No. 443 (July 1997), 1116.

### III. Description of the Model

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Oil is an important commodity. The oil industry is a large, powerful, and important force in the world. The United Kingdom is an important and influential producer of oil; the North Sea must be considered in any comprehensive study of the worldwide oil industry. Because the commodity is so important, the tax structure that regulates and taxes the supply of this oil is important as well. The tax system affects tax revenue, government actions, oil company actions, and the oil supply itself. Understanding the effects of oil taxation is important to the topic of international relations.

The purpose of this section is to determine the effects of different variables on the amount of tax revenue directly attributable to North Sea oil and gas production received annually by the Exchequer of the United Kingdom. The model tested and employed several variables in an attempt to determine the most important variables and the degree to which they influence the level of United Kingdom government revenue from North Sea oil production. The final model estimates the effects of these variables on United Kingdom government revenue over time since the start of North Sea oil production in 1975 up to the year 2001. At least in theory, this model should be able to predict future tax revenues by establishing the comparative influence of these variables on those tax revenues. Other models were tested, and the interaction of different variables was added and tested, as will be described below.

Many factors affect oil and gas production. Similarly, many factors affect the level of tax revenue collected on that production. These sets of factors significantly

overlap; many factors that affect oil and gas production also affect the tax revenue related to oil and gas production. Consequently, a model predicting quantities of oil and gas production or quantities of tax revenue cannot use measurements of quantities of oil and gas production and quantities of tax revenue. Production and tax revenue exhibit too much correlation and thus multicollinearity issues arise.

The level of taxation is an important set of variables when estimating a model to predict the level of United Kingdom government revenue from North Sea oil production. As described earlier, the United Kingdom has a complex system for taxing North Sea oil and gas production. The tax system greatly influences the revenue from oil and gas taxes. In the short term, when taxes are increased, tax revenue increases. Over the long term, however, the level of taxation affects profitability and therefore investment decisions. Estimates of the economics of an oilfield will be the overriding factor in the decision of whether or not to develop that oilfield, or to what extent to develop it. The level of industry investment in the long term naturally affects the quantity of oil produced, which also affects the level of tax revenues the government receives. The United Kingdom taxes or has taxed oil production with several different kinds of taxes or layers of taxation. This model considers the different layers of the United Kingdom tax regime both as individual exogenous variables as well as in a summary calculation of combined tax level, or a calculation of “take.” The tax code variables are Royalty Rate, Petroleum Royalty Tax Rate, Corporate Tax Rate, Supplementary Petroleum Duty, and Government Take. In addition to the variables the United Kingdom government controls, namely the tax code variables, other variables affect tax revenue. This model uses Oil

Production, Oil Price, European Rotary Rig Count, World GDP, and a measurement of United Kingdom Capital Expense spending.

In an attempt to explain the level of tax revenue from oil production, several specifications of the model were tested. The model follows the form of:  $\ln Y = \beta \ln x + \epsilon$ . The function for tax revenue from oil operations follows the basic form of (Total tax from British North Sea oil production) = (quantity of oil produced)\*(oil price)\*(tax rates). After taking the log of both sides, the model estimates values for each variable. The quantity of oil produced is eliminated as an explanatory variable because of multicollinearity issues as previously mentioned. In addition to the variables already identified, other explanatory variables potentially add to the explanation of (or at least have an effect on) the level of United Kingdom tax revenue. They include European rig count, world GDP numbers, date variables, lags, and interactions of these variables. The model in its various iterations and combinations reveals a number of interesting results.

The data for this model is time-series data. This is appropriate given the time nature of the problem of oil production and tax collection. The data frequency is annually. This makes sense because the government collects tax yearly, and tax data is therefore available on a yearly basis. For consistency, the rest of the data must also be annual data. Although annual data is the logical choice for the model, it is not perfect. Some variables do not lend themselves to a simple annual measurement. Oil price, for example fluctuates on a daily basis, and other data, such as rig counts, might be better represented on a monthly or other basis. The other potential disadvantage is that because it is annual data, it is a smaller data set. Still, an annual average does reflect the

numerical level of the variables over time, even if it does lack a little accuracy in some cases.

### **The Variables:**

- *Tax revenue* – United Kingdom government tax revenue attributable to oil and gas production in the British sector of the North Sea

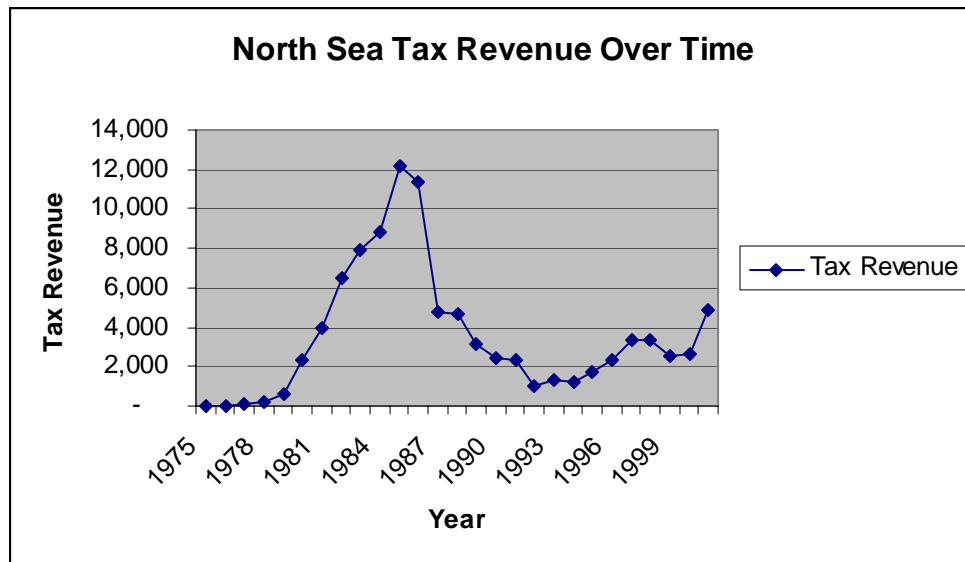
Tax revenue figures are in British Pounds, and relate to the revenue collected from Royalties, Supplementary Petroleum Duty, Corporation Taxes, and Petroleum Revenue Taxes on oil produced from offshore oil fields. Although there is some onshore production in the United Kingdom, it is insignificant. The tax system is designed around offshore oil production, geared to the operating conditions, capital requirements, profitability, and risk factors present in the North Sea.

Small onshore oil production actually began in 1968, but remains insignificant to this day. Because of the small numbers involved, and the emphasis in all aspects of the British oil industry on the offshore provinces, the onshore oil is ignored for the purposes of this paper. British North Sea oil production began in 1975, and therefore taxation revenues from that production began in 1975. The first offshore licensing round occurred in 1964, with the British government awarding the first exploration and production licenses that year. Development was slow and risky, and did not receive any urgent attention until the Arab Oil embargo described earlier. That is the main reason for the lag of nine years between the first license award and first oil production. Although some revenues

from licensing and fees can be attributable to North Sea production before 1975, these amounts are ignored in the model because of the small, insignificant numbers involved.

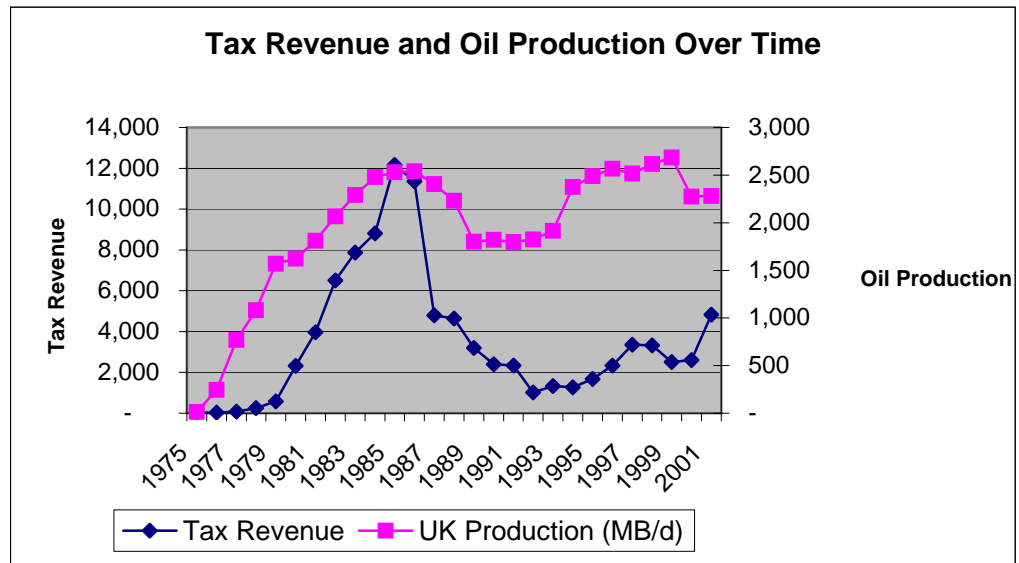
The numbers for tax revenue are in real terms, adjusted for inflation based on a price index in which 1974 is the base year. Thus the numbers are in 1974 Pounds. Figure 1 shows a graph of British North Sea tax revenue up to the year 2001. Two points worth noting on the graph are the peak revenue that occurred in 1985 and the increase in revenue after 1993. The British decreased the tax rates after 1985, and subsequently increased tax rates in 1993. Figure 2 shows the same data with oil production as a new line on the same graph.

**Figure 1**





**Figure 2**



- *Oil price* – Yearly average oil price from 1975 to 2001

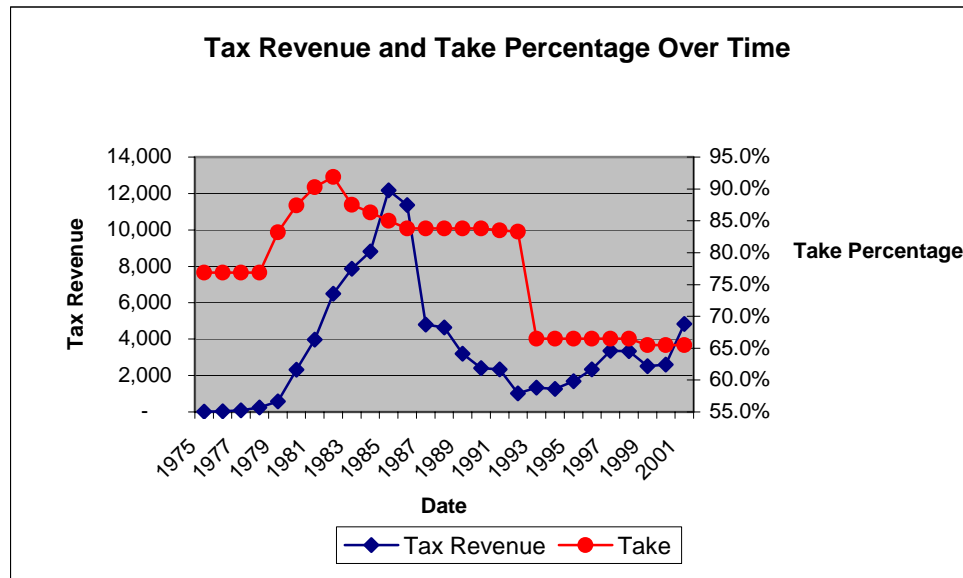
These prices are based on the average price of a basket of American crude oils. Although crude oils from different oil fields are all priced differently based on purity, sulfur content, weight, and other factors, the price differences are not great. Indeed, the trends will be the same for all crude oils, as oil is an important commodity traded worldwide. The trend of the prices is more important to the model than the actual value in dollars or pounds. These numbers are in real terms, adjusted for inflation based on a 1974 base year price index.

- *Government Take* – The percentage of the government’s total share of the profit oil, that is the government’s share of revenue above allowances for cost recovery

This is a common form of measurement of tax systems in the international oil and gas business. Although there are of course many other aspects and measurements to consider when evaluating an oil and gas producing nation’s tax

structure, and there are some weaknesses to the calculation; the take figure is an influential and important number. It is a measure of the government's percentage of the profits from the exploration of oil and gas within its sphere of control. The take calculation is an aggregate figure of all the different taxes that the government levies on the oil production. In this case, the take percentage includes the percentages for Royalties, Petroleum Revenue Tax, Corporate Tax, and Supplementary Petroleum Duty. These historical tax and take figures for the United Kingdom come from material for a World Bank seminar Workshop on Petroleum Revenue Management with Daniel Johnston. As this tax rate increases, so should tax revenue, so the  $\beta$  should be positive. Although not included in the model individually, the taxes included in the take calculation are described briefly below. Figure 3 shows the trend of the government over time as compared to the tax revenue over time.

**Figure 3**



- *Petroleum Revenue Tax Rate* – PRT is a special tax weighed on oil production. It allows for various deductions and cost recovery.
- *Royalty* – A royalty is a tax on gross oil production. Originally introduced at 12.5 percent, the royalty was abolished in 1983.
- *Corporation Tax* – The corporate tax rate is the normal corporate taxation rate for any corporation operating within the United Kingdom without tax holidays or other special taxation provisions.
- *Supplementary Petroleum Duty* – SPD is a special tax designed to further tax oil and gas production, and designed to increase government take in the oil industry. The United Kingdom introduced the tax in 1981, but withdrew it after only two years.

**Table 1: United Kingdom Layers of Taxation**

<b>Tax</b>	<b>How it works</b>	<b>Effects of Tax</b>
<i>Royalty</i>	Flat rate of 12.5% tax on gross revenues from oil production	-Easy calculation and estimation for government -Costs (and risk) borne mostly by producer -Makes some marginal fields uneconomic -Incentive to abandon field prematurely
<i>Petroleum Revenue Tax (PRT)</i>	-Additional tax weighed on oil profits -Tax base is Revenue less Royalty paid -Cost recovery depends on specific field licensing round -Costs are ring-fenced per field for cost recovery purposes	-Greater sharing of risk between government and producer -Efficient collector of economic rents -Does not punish marginal fields or encourage premature abandonment -Government receives revenue later in life of field – after some costs are recovered
<i>Corporation Tax</i>	-Income tax on corporations operating in the UK -Tax base is Revenue less Royalty and PRT paid -Allowable costs are ring-fenced per field	-Neutral (in theory) with regard to production and costs -Like PRT, it does not punish marginal fields -The effect of the tax depends on specific allowable expenses
<i>Supplementary Petroleum Duty (SPD)</i>	-Flat rate of 20% tax on gross revenues from oil production -Allowance per field of 1 million tons	-Much the same as a royalty -Punishes marginal fields and encourages premature abandonment -Inefficient collector of economic rents -Greatly increased government take

- *Europe Rig Count* – The rig count is the number of rotary rigs operating in and around the continent of Europe. Every month, Baker Hughes Corporation counts

the number of rigs operating in different areas around the world. These numbers allow the oil industry predict drilling activity and serve as an indicator of the health of the oil economy as well as future oil production. A large portion of the oil rigs in use in Europe over the past three decades have been used for drilling in the North Sea. Therefore, we can assume this number is a reliable indicator of the level of North Sea drilling activity.

- *World GDP* – World GDP is the International Monetary Fund calculations of world gross domestic product, calculated on a yearly basis. This variable was considered as a function of demand for oil.
- *Date Variable* – This is a variable introduced to show a time trend in the regression. Rather than using years, the date variable uses integers 1 to 27 counting up with first oil production coming in 1975 being number one, and the last year of the data, 2001, being the number 27.
- *Take Dummy* – This is a dummy variable for post 1993 data. The dummy contains zeros for the years up to 1993, and a one thereafter. This cancels out the pre-1993 variables, and allows isolation of variables post-1993.

As mentioned earlier, the British government relaxed the tax rates in 1993 in an attempt to encourage more development and further stimulate the economy. The data shows that the relaxed rates had a significant effect on the percentage of government take and therefore the collection of tax revenue. The purpose of this dummy and the interaction of it with other variables is to highlight and test the difference from the 1993 changes.

**Table 2: Descriptive Statistics**

Variable Name	Mean	Std. Deviation	Minimum	Maximum
<i>TaxRev</i>	4243	4069.4	37	14699
<i>Price</i>	23.136	9.8292	12.59	47.41
<i>Take</i>	0.78038	9.08E-02	0.66	0.92
<i>Royalty</i>	3.50E-02	5.88E-02	0	0.13
<i>PRT</i>	0.61923	0.1289	0.45	0.75
<i>Corporate Tax</i>	0.39654	8.71E-02	0.3	0.52
<i>SPD</i>	1.54E-02	5.43E-02	0	0.2
<i>Rig Count</i>	147.92	43.312	81	235
<i>GDP</i>	21384	7136	9291	32277
<i>Date</i>	14.5	7.6485	2	27
<i>TakeDummy</i>	0.34615	0.48516	0	1
<i>LnTax</i>	7.7573	1.3974	3.6109	9.5955
<i>LnTake</i>	-0.25467	0.11894	-0.41552	-0.083382
<i>LagLnTax1</i>	7.5681	1.6164	3.5264	9.5955
<i>LnPrice</i>	3.0653	0.38658	2.5329	3.8588
<i>LnRigs</i>	4.9548	0.29795	4.3944	5.4596
<i>LnGDP</i>	9.909	0.37088	9.1368	10.382
<i>NewTax</i>	0.66962	0.16435	0.5	1.08
<i>NewTax 93</i>	0.17308	0.24258	0	0.5

These variables, according to theory are factors that explain the level of tax revenue from North Sea oil production received by the government of the United Kingdom. Table 4 (following) shows the expected signs of the variables in the regression. The oil price and tax variables should have a positive relationship with tax revenue. Because the taxes are based on prices received for the oil by the oil producers, the higher the oil price, the more revenue that should come from the production of oil. Higher taxes should also lead to higher tax revenues unless they are beyond the rate producing maximum government revenue as described by downward sloping portion of the Laffer Curve. If the tax rate is too high, the taxes collect more than just economic rent, and they discourage capital investment. The result is decreased industry spending on maintaining and increasing oil production output, which results in lower production

numbers, which may in turn lead to lower tax revenues received from that output. It may be important to note that maximum production does not necessarily equal maximum tax revenue. This is due to the effects of all the different variables on tax revenue. Although the production and tax revenue do have a positive relationship, one can see from Figure 2 that they are not perfectly correlated.

**Table 3: Expected Sign of Variables in Regression**

<b>Variable Name</b>	<b>Description</b>	<b>Expected Sign in Regression</b>
<i>TaxRev</i>	UK Tax Revenue	+ (Positive)
<i>Price</i>	Oil Price	+ (Positive)
<i>Take</i>	Government Take Percentage	+ (Positive)
<i>Royalty</i>	Royalty – 12.5%	+ (Positive)
<i>PRT</i>	Petroleum Revenue Tax	+ (Positive)
<i>Corporate Tax</i>	UK Corporation Tax	+ (Positive)
<i>SPD</i>	Supplementary Petroleum Duty – 20%	+ (Positive)
<i>Rig Count</i>	Count of Rigs Operating in Europe	+ (Positive)
<i>GDP</i>	World GDP	??
<i>Date</i>	Date Variable – 1-27	??
<i>TakeDummy</i>	Dummy variable – post 1993	??
<i>LnTax</i>	Log (tax revenue)	+ (Positive)
<i>LnTake</i>	Log (Government Take)	+ (Positive)
<i>LagLnTax1</i>	Log (1 year Lag Government Take)	+ (Positive)
<i>LnPrice</i>	Log (Oil Price)	+ (Positive)
<i>LnRigs</i>	Log (Rig Count)	+ (Positive)
<i>LnGDP</i>	Log (World GDP)	??
<i>NewTax</i>	Log (Royalty+PRT+Corp Tax+SPD)	+ (Positive)
<i>NewTax 93</i>	Log (NewTax * Take Dummy)	+ (Positive)

Other outside factors that have some effect upon tax revenue are immeasurable.

These can be grouped into an error term. Such outside factors may include but are not limited to severe storms in the North Sea that hamper exploration or production activities,

unforeseen political conditions, large oil spills, or disasters – natural or otherwise. For example, perhaps the most famous incident that would surely be included in an error term in these regressions is the Piper Alpha tragedy, the world’s worst offshore disaster. In 1988, an oil and gas production platform operated by Occidental Petroleum in the Piper oil field exploded into a massive fireball. The natural gas pipeline fed flames that could be seen up to 60 miles away to form the largest cutting torch the world has ever seen. The mishap tore apart and melted nearly the entire platform, killing 167 people in the process. The tragedy disrupted oil production across the North Sea by destroying a significant pipeline structure, and forced the rest of the offshore world to take pause. A significant part Britain’s production was either slowed or stopped with the destruction of the pipeline structure that serviced other fields along with the Piper field. Because of the significant loss of life, rigs in the North Sea shut down to double check their safety precautions and procedures. Many offshore rigs around the world followed suit. Although an isolated and unpredictable incident, it nevertheless affected oil production in the North Sea, and along with it, government tax revenue from that oil production. Other such events no doubt exist, and are unpredictable, and so end up included in the random error term.

### **Results of the regression:**

The primary goal in the initial stages of formulating the model was to find one where the results logically made sense and where the variables appeared to be significant. After trying out and evaluating several specifications using different combinations of variables, three models were selected and are described here. The models were



calculated using ordinary least squares (OLS). The OLS regressions were calculated using Shazam 9.0 Professional Edition.

### ***Specification 1***

The first specification follows the form:

$$\begin{aligned} \text{Ln(Tax)} = & \beta_0 + \beta_1\text{Ln(Take)} + \beta_2\text{Ln(Price)} + \beta_3\text{Ln(Rigs)} + \beta_4\text{Lag(Lntax1)} \\ & + \beta_5\text{Date} \end{aligned}$$

Tax is the tax revenue collected by the government of the United Kingdom from oil and gas exploration and production in the North Sea. Take is government take. Price is the oil price. Rigs refers to the Baker Hughes European rig count. Lagtax1 is the Tax variable lagged for one time period. Date refers to the date variable. This is probably the most straightforward model of the ones to be described. It combines the tax rates into one variable, Take, along with the date trend.

The results are as follows:

**Table 4: Regression Result of Model 1**

Variable Name	Estimated Coefficient	T-Stat (20 DF)	Std. Error
<i>Constant</i>	-6.7983	-1.744	3.898
<i>LNTake</i>	-4.1243	-2.249	1.834
<i>LNPrice</i>	0.76423	2.909	0.2627
<i>LN Rigs</i>	1.1136	1.405	0.7926
<i>LagLNTax1</i>	0.78692	7.368	0.1068
<i>Date</i>	-0.021424	-.06493	0.033

R-square: 0.9425  
Adjusted R-square: 0.9281

As with all the models to be analyzed here, this one has a strong R-squared, indicating the model explains a high percentage of the residuals. In this model, the t-statistics, except for the Date Variable, are all significant with 20 degrees of freedom at a ten percent significance level. In fact, all of the t-statistics are significant at the five percent level except Date and Rigs. The F-statistic from the Anova table is 65.57 with degrees of freedom of 5 and 20. Thus we can reject the null hypothesis that none of the variables have an effect on government revenue.

The effect of most of the variables is plausible. As is important with all of these models, the Price variable is consistent, and makes sense. The idea that as oil price rises, government revenue rises is pretty straightforward. Higher oil prices even encourage higher production and investment by oil companies, so not only is there a boost in tax revenue from higher industry profits, but also from increased production. The model also shows a positive relationship between price and rig counts.

The only questionable result is the coefficient for the Take variable. Interestingly, it shows a negative relationship with tax revenue. This is not intuitive, unless the tax rates are on the downward sloping portion of the Laffer curve. If this is true, the government could decrease taxes, which decreases their Take, and thereby increase tax revenue.

### ***Specification 2***

The next model follows the form:

$$\begin{aligned} \text{Ln(Tax)} = & \beta_0 + \beta_1\text{Ln(newtax)} + \beta_2\text{Ln(newtax93)} + \beta_3\text{Ln(Price)} + \\ & \beta_4\text{Ln(Rigs)} + \beta_5\text{Lag(Lntax1)} \end{aligned}$$

Tax is the tax revenue collected by the United Kingdom from oil and gas production in the North Sea. Newtax is Royalty, Petroleum Revenue Tax, and Supplemental Petroleum Duty tax rates added together to form one variable. Newtax93 is interaction with Newtax and the Take Dummy variable (Newtax\*takedum). Price refers to the oil price. Rigs refers to the Baker Hughes European rig count. LagLntax1 is the Tax variable lagged for one time period.

The results are as follows:

**Table 5: Regression Result of Model 2**

Variable Name	Estimated Coefficient	T-Stat (20 DF)	Std. Error
<i>Constant</i>	-6.0778	-2.283	2.662
<i>NewTax</i>	-0.50551	-0.4329	1.151
<i>NewTax93</i>	1.3336	1.865	0.715
<i>LnPrice</i>	0.61492	1.94	0.317
<i>LN Rigs</i>	1.3695	2.234	0.613
<i>LagLNTax1</i>	-.60778	12.43	0.05603

R-square: 0.9434

Adjusted R-square: 0.9293

Again this specification has a strong R-squared, indicating the model explains a high percentage of the residuals. In this model, the t-statistics, aside from the Newtax variable, are all significant with 20 degrees of freedom at a five percent significance level. The F-statistic from the Anova table is 66.68 with degrees of freedom of 5 and 20. Thus we can reject the null hypothesis that none of the variables have an effect on government revenue. We can therefore reject that the entire model has no significance.

The effect of the variables is plausible. The model shows a positive relationship between both price and rig counts with tax revenue. The coefficients for the Newtax and Newtax93 variables are interesting. The coefficient for Newtax is negative, showing a negative relationship with tax revenue. Conversely, the coefficient for Newtax93 is positive, showing a positive relationship with tax revenue. These results indicate the importance of the tax change made in 1993.

The relationship between the tax structure and tax revenue seems to have changed post-1993. This seems to suggest that before the 1993 changes, as tax rates increased, government revenue decreased. This means the rates would be on the downward sloping side of the Laffer Curve. Post-1993, the position is reversed, so as tax rates increase, tax revenue increases. This indicates that the United Kingdom could increase its take percentage on North Sea oil production, and tax revenues would increase.

### *Specification 3*

The third model is as shown:

$$\begin{aligned} \text{Ln(Tax)} = & \beta_0 + \beta_1 \text{Ln(newtax)} + \beta_2 \text{Ln(newtax93)} + \beta_3 \text{Ln(Price)} + \\ & \beta_4 \text{Ln(Rigs)} + \beta_5 \text{Lag(Lntax1)} + \beta_6 \text{Date} \end{aligned}$$

Tax is the tax revenue collected by the United Kingdom from oil and gas production in the North Sea. Newtax is Royalty, Petroleum Revenue Tax, and Supplementary Petroleum Duty tax rates added together to form one variable. Newtax93 is interaction with Newtax and the Take Dummy variable (Newtax\*takedum). Price refers to oil price.

Rigs refers to the Baker Hughes European rig count. Lagtax1 is the Tax variable lagged for one time period. Date is the date variable.

The results are as follows:

**Table 6: Regression Result of Model 3**

Variable Name	Estimated Coefficient	T-Stat (20 DF)	Std. Error
<i>Constant</i>	-4.5092	-1.286	3.506
<i>NewTax</i>	-0.45892	-0.393	1.168
<i>NewTax93</i>	1.5983	1.956	0.8171
<i>LnPrice</i>	0.60684	1.889	0.3213
<i>LN Rigs</i>	1.0204	1.281	0.7965
<i>LagLNTax1</i>	0.75566	7.435	0.116
<i>Date</i>	-0.023303	-0.6999	0.03329

R-square: 0.9448

Adjusted R-square: 0.9274

Once again this specification has a strong R-squared, indicating the model explains a high percentage of the residuals. In this model, the t-statistics are not quite as high as for the last model, but they are for the most part significant with 19 degrees of freedom. Newtax and Date are a little weak in significance in this model. The F-statistic from the Anova table is 54.231 with degrees of freedom of 6 and 19. Thus we can reject the null hypothesis that none of the variables have an effect on government revenue. We can therefore reject that the entire model has no significance.

The effect of the variables is plausible. The model shows a positive relationship between both price and rig counts with tax revenue. The coefficients for the Newtax and

Newtax93 variables show the same interesting nature. The coefficient for Newtax is again negative, showing a negative relationship with tax revenue while Newtax93 is again positive, showing a positive relationship with tax revenue. This re-emphasizes the importance of the tax change in 1993. The advantage this specification has over the last one is the time trend. The second specification does not contain a time trend.

## Implications of the Model

Every government is concerned with taxation. Governments establish tax codes with specific goals in terms of revenue generation and industry development. Each oil-producing nation has its own unique fiscal system. The level of overall taxation and the level of specific aspects of that taxation is the subject of constant debate. Politicians, government employees, as well as many outside watchers, including oil companies, economists, and the press participate in the debate. Because of the United Kingdom's history of free governments and skilled policy, its tax policies, in particular foster a lively debate. Further, the British offer a politically stable environment in which to examine the factors affecting tax revenues.

As it has matured as an oil-producing nation, the United Kingdom has changed its tax regime for oil production a number of times. These changes reflect both changing conditions within the oil industry or the North Sea itself, and differing goals within the British government. Although the United Kingdom sometimes wants to encourage more development and investment, and is therefore willing to take a short-term cut in tax revenues, its goals for a tax regime do not include a smaller share of the oil profits. In addition to carrying out its role as a wise steward of the nation's natural resources, the government also wants higher tax revenues in order to carry out more public projects. When the United Kingdom wants to increase tax revenue, the natural reaction may be to increase the tax rates. This model shows that many other factors affect the United Kingdom's revenue from oil and gas production. Interestingly, it suggests that the natural reaction to increase the tax rate may not always result in more money in the government's coffers.

One of the more fascinating things about this model is the effect of the 1993 changes. The first specification made no distinction or highlight of the 1993 changes in the tax code. In that model, the variable that represented the tax rates (Take) showed a negative relationship with tax revenue. This seems quite counter-intuitive, as one would expect that as taxes increase, tax revenue should increase as well. This suggests that the British tax regime, or at least some component of the regime may be too high.

The second and third models shed more light on this subject. When the interaction with the dummy variable breaks out the tax effects of the 1993 changes, the difference between the tax rates becomes apparent. Pre-1993 taxation figures (newtax) still showed a negative relationship with tax revenue, but post-1993 tax variable (newtax93) showed a positive relationship with tax revenue.

This indicates that the British government could have increased tax revenue before 1993 by decreasing taxes. The model indicates that since the restructuring of the tax regime, the government has missed out on some potential tax revenues. To increase tax revenue from North Sea oil production, the British government should increase the rates of taxation on that production.

The model indicates that the British government could collect more economic rent than it has been doing since 1993. It is possible the British government is keeping the tax rate low in order to encourage more investment and development. Keeping taxes low transfers more of the economic rent to the risk-takers in the industry. In the past, the British government has followed a policy of rapid development of their sector of the North Sea, and has shown great interest in encouraging investment in that sector of its economy. The positive relationship since 1993 between government take and tax



revenues indicates the British government may want to re-evaluate the tax code for North Sea oil and gas production in order to increase tax revenue.

The British government would ideally like to be at the top of the Laffer Curve, where either decreasing or increasing the rate of taxation would lower revenues. It would be difficult to determine just where that place is, and questions remain whether or not that point changes over time, as other factors change. The model suggests that the government could increase tax rates before reaching that point.

The other variables showed fairly predictable effects. The influence of price is important, as expected. The number of rigs operating in Europe had a bigger effect as a predictor than anticipated. It does however make intuitive sense that if more rigs are drilling, more oil will soon be pumping out of the ground. The lagged dependent variable, the lag of taxes, had a large positive relationship with tax revenues as well. This indicates that tax revenue this year is a good indicator of tax revenue next year. Given the nature of the industry and its relatively stable cash flows once the risk factors have been mitigated, this makes intuitive sense as well.

Analysis of taxation systems is a full-time job, and in many cases a full-time career. This is a relatively simple model with a relatively small number of observations. Part of that, as mentioned previously, has to do with the nature of the data. Taxation data is annual data, and is rarely available on a monthly or shorter basis. Conversely, most of the data for the other variables used in this project are available at shorter intervals, and in much greater detail. Data from individual fields and from individual companies operating in the oil province would provide a more realistic picture of effects on tax

revenue from oil and gas production. Further work beyond that shown here could follow in that direction.

Notwithstanding the flaws of this model, it provides evidence of how a number of factors affect the United Kingdom's revenue from the taxation of oil and gas production. It also provides a warning that increasing the tax rate too much may reduce tax revenue rather than increase it.

## Conclusion

In this paper, we have covered the history and importance of oil, and in particular, the importance of North Sea oil as it relates to the subject of international relations. The North Sea has been and continues to be an important province in the international oil and gas industry. This is significant because the oil and gas industry is one of the most important in the world, in terms of size and political significance.

One important aspect of any such an industry is the regulation and taxation of that industry. This affects the industry in many ways, and controls its development. Taxation of a natural resource such as oil also affects the host government's level of tax revenue generated by the tax system, the development of local resources as well as its supporting industries, and the international economy surrounding that resource. Understanding the results of taxation is important for understanding the resource and its influence on international politics.

The model developed and described in this thesis estimates the effect of different variables on the tax revenue generated by British North Sea oil production. Although the data set is small and some elements of it would be better served as not annual data, the model is a good one. It raises some interesting questions about how the United Kingdom taxes its petroleum resources. It would be difficult to justify making policy decisions simply from this data, but it does highlight some things to think about.

The model indicates the significance of the 1993 changes to the tax code. The tax rates were lowered quite a lot, and the model suggests that the government could raise taxes and collect more revenue. In terms of proper government policy, however, one

must also consider the divergent goals of the United Kingdom government. Obviously the government wants more tax revenue, but it also wants to increase the development of the oil economy within the United Kingdom. The British oil and oil services economies are very strong, and the government would like to keep them that way. The two goals of increased tax revenue and economic development are conflicting aims, so the government is forced to compromise between them. This could be the reason the British government has kept the taxes so low.

## Appendix A: Shazam Results

### Specification 1:

```
Welcome to SHAZAM - Version 9.0 - AUG 2001 SYSTEM=WIN-98 PAR= 2000
CURRENT WORKING DIRECTORY IS: C:\SHAZAM\
|_read (C:\My Documents\Int Rel\Thesis\Spreadsheets\UKTax.txt)TaxR Price
Roy PRT Corp SPD Take Rigs GDP Capex Date TakeDum Date93
UNIT 88 IS NOW ASSIGNED TO: C:\My Documents\Int
Rel\Thesis\Spreadsheets\UKTax.txt
```

```
...SAMPLE RANGE IS NOW SET TO:          1          27
|_*sample 1 27
|_genr lnT=log(TaxR)
|_genr lnP=log(Price)
|_genr lnR=log(Rigs)
|_genr lnG=log(GDP)
|_genr lnCap=log(Capex)
|_genr lnTak=log(Take)
|_genr lnT1=lag(lnT,1)
..NOTE.LAG VALUE IN UNDEFINED OBSERVATIONS SET TO ZERO
|_genr lnT2=lag(lnT,2)
..NOTE.LAG VALUE IN UNDEFINED OBSERVATIONS SET TO ZERO
|_genr llnC=lag(lnCap,1)
..NOTE.LAG VALUE IN UNDEFINED OBSERVATIONS SET TO ZERO
|_genr llnC2=lag(lnCap,2)
..NOTE.LAG VALUE IN UNDEFINED OBSERVATIONS SET TO ZERO
|_genr llnG=lag(lnG)
..NOTE.LAG VALUE IN UNDEFINED OBSERVATIONS SET TO ZERO
|_genr llnG2=lag(lnG,2)
..NOTE.LAG VALUE IN UNDEFINED OBSERVATIONS SET TO ZERO
|_genr llnr=lag(lnR)
..NOTE.LAG VALUE IN UNDEFINED OBSERVATIONS SET TO ZERO
|_genr date93=takedum*date-18
|_genr Date2=Date*Date
|_genr lntak93=lnTak*takedum
|_genr rigeff=date*lnr
|_genr take2=Take*Take
|_genr take93=Take*takedum
|_genr newtax=Roy+PRT+spd
|_genr newtax93=newtax*takedum
|_genr tax93=Date93*lnTak
|_sample 2-27
```

```
|_ols lnT lnTak lnP lnR lnT1 Date /rstat gf anova
```

```
REQUIRED MEMORY IS PAR=          11 CURRENT PAR=          2000
OLS ESTIMATION
      26 OBSERVATIONS      DEPENDENT VARIABLE= LNT
...NOTE..SAMPLE RANGE SET TO:          2,          27
```

```
R-SQUARE =      0.9425      R-SQUARE ADJUSTED =      0.9281
VARIANCE OF THE ESTIMATE-SIGMA**2 =      0.14034
STANDARD ERROR OF THE ESTIMATE-SIGMA =      0.37462
SUM OF SQUARED ERRORS-SSE=      2.8068
MEAN OF DEPENDENT VARIABLE =      7.7573
LOG OF THE LIKELIHOOD FUNCTION = -7.95365
```

MODEL SELECTION TESTS - SEE JUDGE ET AL. (1985,P.242)  
 AKAIKE (1969) FINAL PREDICTION ERROR - FPE = 0.17273  
 (FPE IS ALSO KNOWN AS AMEMIYA PREDICTION CRITERION - PC)  
 AKAIKE (1973) INFORMATION CRITERION - LOG AIC = -1.7645  
 SCHWARZ (1978) CRITERION - LOG SC = -1.4742  
 MODEL SELECTION TESTS - SEE RAMANATHAN (1998,P.165)  
 CRAVEN-WAHBA (1979)  
 GENERALIZED CROSS VALIDATION - GCV = 0.18244  
 HANNAN AND QUINN (1979) CRITERION = 0.18620  
 RICE (1984) CRITERION = 0.20048  
 SHIBATA (1981) CRITERION = 0.15778  
 SCHWARZ (1978) CRITERION - SC = 0.22896  
 AKAIKE (1974) INFORMATION CRITERION - AIC = 0.17127

ANALYSIS OF VARIANCE - FROM MEAN				
	SS	DF	MS	F
REGRESSION	46.013	5.	9.2027	65.575
ERROR	2.8068	20.	0.14034	P-VALUE
TOTAL	48.820	25.	1.9528	0.000

ANALYSIS OF VARIANCE - FROM ZERO				
	SS	DF	MS	F
REGRESSION	1610.6	6.	268.43	1912.727
ERROR	2.8068	20.	0.14034	P-VALUE
TOTAL	1613.4	26.	62.053	0.000

VARIABLE NAME	ESTIMATED COEFFICIENT	STANDARD ERROR	T-RATIO	P-VALUE	PARTIAL CORR.	STANDARDIZED COEFFICIENT	ELASTICITY AT MEANS
LNTAK	-4.1243	1.834	-2.249	0.036	-0.449	-0.3510	0.1354
LNP	0.76423	0.2627	2.909	0.009	0.545	0.2114	0.3020
LNR	1.1136	0.7926	1.405	0.175	0.300	0.2374	0.7113
LNT1	0.78692	0.1068	7.368	0.000	0.855	0.9102	0.7677
DATE	-0.21424E-01	0.3300E-01	-0.6493	0.524	-0.144	-0.1173	-0.0400
CONSTANT	-6.7983	3.898	-1.744	0.096	-0.363	0.0000	-0.8764

DURBIN-WATSON = 1.7014 VON NEUMANN RATIO = 1.7695 RHO = -0.02057  
 RESIDUAL SUM = -0.18652E-13 RESIDUAL VARIANCE = 0.14034  
 SUM OF ABSOLUTE ERRORS= 6.5409  
 R-SQUARE BETWEEN OBSERVED AND PREDICTED = 0.9425  
 RUNS TEST: 12 RUNS, 10 POS, 0 ZERO, 16 NEG NORMAL STATISTIC = -0.5542  
 COEFFICIENT OF SKEWNESS = -0.2207 WITH STANDARD DEVIATION OF 0.4556  
 COEFFICIENT OF EXCESS KURTOSIS = 0.7389 WITH STANDARD DEVIATION OF 0.8865

JARQUE-BERA NORMALITY TEST- CHI-SQUARE(2 DF)= 0.3451 P-VALUE= 0.842

GODNESS OF FIT TEST FOR NORMALITY OF RESIDUALS - 10 GROUPS  
 OBSERVED 0.0 1.0 1.0 2.0 12.0 3.0 5.0 1.0 1.0 0.0  
 EXPECTED 0.2 0.7 2.1 4.1 5.9 5.9 4.1 2.1 0.7 0.2  
 CHI-SQUARE = 10.8272 WITH 2 DEGREES OF FREEDOM, P-VALUE= 0.004  
 |\_diagnos /het acf

REQUIRED MEMORY IS PAR= 23 CURRENT PAR= 2000  
 DEPENDENT VARIABLE = LNT 26 OBSERVATIONS  
 REGRESSION COEFFICIENTS  
 -4.12430643959 0.764232320793 1.11362719565  
 0.786924945894

-0.214237272176E-01 -6.79830268085  
 HETEROSKEDASTICITY TESTS

	CHI-SQUARE TEST STATISTIC	D.F.	P-VALUE
E**2 ON YHAT:	5.860	1	0.01549
E**2 ON YHAT**2:	5.375	1	0.02043
E**2 ON LOG(YHAT**2):	6.227	1	0.01258
E**2 ON LAG(E**2) ARCH TEST:	0.044	1	0.83466
LOG(E**2) ON X (HARVEY) TEST:	4.359	5	0.49896
ABS(E) ON X (GLEJUSER) TEST:	8.083	5	0.15170
E**2 ON X			
KOEKNER(R2):	7.812	5	0.16688
B-P-G (SSR) :	9.305	5	0.09750
E**2 ON X X**2 (WHITE) TEST:			
KOEKNER(R2):	10.295	10	0.41502
B-P-G (SSR) :	12.262	10	0.26793
E**2 ON X X**2 XX (WHITE) TEST:			
KOEKNER(R2):	17.878	20	0.59544
B-P-G (SSR) :	21.293	20	0.38005

RESIDUAL CORRELOGRAM

LM-TEST FOR HJ:RHO(J)=0, STATISTIC IS STANDARD NORMAL

LAG	RHO	STD ERR	T-STAT	LM-STAT	DW-TEST	BOX-PIERCE-
LJUNG						
1	-0.0189	0.1961	-0.0965	0.1252	1.7014	0.0104
2	0.0661	0.1961	0.3370	0.4278	1.5076	0.1429
3	0.0225	0.1961	0.1147	0.1349	1.5582	0.1590
4	-0.3761	0.1961	-1.9177	2.2155	2.2679	4.8394
5	-0.0175	0.1961	-0.0891	0.1056	1.3602	4.8500
6	-0.0217	0.1961	-0.1104	0.1288	1.3548	4.8671
7	-0.0962	0.1961	-0.4907	0.6033	1.5035	5.2219

LM CHI-SQUARE STATISTIC WITH 7 D.F. IS 4.074

```

|_*ols lnT newtax newtax93 lnP lnR lnT1 /rstat gf anova
|_*diagnos /het acf
|_*ols lnT newtax newtax93 lnP lnR lnT1 Date /rstat gf anova
|_*diagnos /het acf
|_*stop

```

## Specification 2:

```
Welcome to SHAZAM - Version 9.0 - AUG 2001 SYSTEM=WIN-98 PAR= 2000
CURRENT WORKING DIRECTORY IS: C:\SHAZAM\
|_read (C:\My Documents\Int Rel\Thesis\Spreadsheets\UKTax.txt)TaxR Price
Roy PRT Corp SPD Take Rigs GDP Capex Date TakeDum Date93
UNIT 88 IS NOW ASSIGNED TO: C:\My Documents\Int
Rel\Thesis\Spreadsheets\UKTax.txt
```

```
...SAMPLE RANGE IS NOW SET TO:          1          27
|_*sample 1 27
|_genr lnT=log(TaxR)
|_genr lnP=log(Price)
|_genr lnR=log(Rigs)
|_genr lnG=log(GDP)
|_genr lnCap=log(Capex)
|_genr lnTak=log(Take)
|_genr lnT1=lag(lnT,1)
..NOTE.LAG VALUE IN UNDEFINED OBSERVATIONS SET TO ZERO
|_genr lnT2=lag(lnT,2)
..NOTE.LAG VALUE IN UNDEFINED OBSERVATIONS SET TO ZERO
|_genr llnC=lag(lnCap,1)
..NOTE.LAG VALUE IN UNDEFINED OBSERVATIONS SET TO ZERO
|_genr llnC2=lag(lnCap,2)
..NOTE.LAG VALUE IN UNDEFINED OBSERVATIONS SET TO ZERO
|_genr llnG=lag(lnG)
..NOTE.LAG VALUE IN UNDEFINED OBSERVATIONS SET TO ZERO
|_genr llnG2=lag(lnG,2)
..NOTE.LAG VALUE IN UNDEFINED OBSERVATIONS SET TO ZERO
|_genr llnr=lag(lnR)
..NOTE.LAG VALUE IN UNDEFINED OBSERVATIONS SET TO ZERO
|_genr date93=takedum*date-18
|_genr Date2=Date*Date
|_genr lntak93=lnTak*takedum
|_genr rigeff=date*lnr
|_genr take2=Take*Take
|_genr take93=Take*takedum
|_genr newtax=Roy+PRT+spd
|_genr newtax93=newtax*takedum
|_genr tax93=Date93*lnTak
|_sample 2-27
|_*ols lnT lnTak lnP lnR lnT1 Date /rstat gf anova
|_*diagnos /het acf
```

```
|_ols lnT newtax newtax93 lnP lnR lnT1 /rstat gf anova
```

```
REQUIRED MEMORY IS PAR=          11 CURRENT PAR=          2000
OLS ESTIMATION
      26 OBSERVATIONS      DEPENDENT VARIABLE= LNT
...NOTE..SAMPLE RANGE SET TO:          2,          27
```

```
R-SQUARE =      0.9434      R-SQUARE ADJUSTED =      0.9293
VARIANCE OF THE ESTIMATE-SIGMA**2 =      0.13815
STANDARD ERROR OF THE ESTIMATE-SIGMA =      0.37168
SUM OF SQUARED ERRORS-SSE=      2.7629
MEAN OF DEPENDENT VARIABLE =      7.7573
LOG OF THE LIKELIHOOD FUNCTION = -7.74880
```



MODEL SELECTION TESTS - SEE JUDGE ET AL. (1985,P.242)  
 AKAIKE (1969) FINAL PREDICTION ERROR - FPE = 0.17002  
 (FPE IS ALSO KNOWN AS AMEMIYA PREDICTION CRITERION - PC)  
 AKAIKE (1973) INFORMATION CRITERION - LOG AIC = -1.7803  
 SCHWARZ (1978) CRITERION - LOG SC = -1.4899  
 MODEL SELECTION TESTS - SEE RAMANATHAN (1998,P.165)  
 CRAVEN-WAHBA (1979)  
 GENERALIZED CROSS VALIDATION - GCV = 0.17959  
 HANNAN AND QUINN (1979) CRITERION = 0.18329  
 RICE (1984) CRITERION = 0.19735  
 SHIBATA (1981) CRITERION = 0.15531  
 SCHWARZ (1978) CRITERION - SC = 0.22538  
 AKAIKE (1974) INFORMATION CRITERION - AIC = 0.16859

ANALYSIS OF VARIANCE - FROM MEAN				
	SS	DF	MS	F
REGRESSION	46.057	5.	9.2114	66.680
ERROR	2.7629	20.	0.13815	P-VALUE
TOTAL	48.820	25.	1.9528	0.000

ANALYSIS OF VARIANCE - FROM ZERO				
	SS	DF	MS	F
REGRESSION	1610.6	6.	268.44	1943.158
ERROR	2.7629	20.	0.13815	P-VALUE
TOTAL	1613.4	26.	62.053	0.000

VARIABLE NAME	ESTIMATED COEFFICIENT	STANDARD ERROR	T-RATIO	20 DF	P-VALUE	PARTIAL CORR.	STANDARDIZED COEFFICIENT	ELASTICITY AT MEANS
NEWTAX	-0.50551	1.151	-0.4392		0.665	-0.098	-0.0595	-0.0436
NEWTAX93	1.3336	0.7150	1.865		0.077	0.385	0.2315	0.0298
LNP	0.61492	0.3170	1.940		0.067	0.398	0.1701	0.2430
LNR	1.3695	0.6131	2.234		0.037	0.447	0.2920	0.8747
LNT1	0.69666	0.5603E-01	12.43		0.000	0.941	0.8058	0.6797
CONSTANT	-6.0778	2.662	-2.283		0.033	-0.455	0.0000	-0.7835

DURBIN-WATSON = 1.4698 VON NEUMANN RATIO = 1.5285 RHO = 0.11316  
 RESIDUAL SUM = -0.25036E-13 RESIDUAL VARIANCE = 0.13815  
 SUM OF ABSOLUTE ERRORS= 6.5353  
 R-SQUARE BETWEEN OBSERVED AND PREDICTED = 0.9434  
 RUNS TEST: 10 RUNS, 10 POS, 0 ZERO, 16 NEG NORMAL STATISTIC = -1.4019  
 COEFFICIENT OF SKEWNESS = -0.1783 WITH STANDARD DEVIATION OF 0.4556  
 COEFFICIENT OF EXCESS KURTOSIS = 0.4259 WITH STANDARD DEVIATION OF 0.8865

JARQUE-BERA NORMALITY TEST- CHI-SQUARE(2 DF)= 0.1393 P-VALUE= 0.933

GOODNESS OF FIT TEST FOR NORMALITY OF RESIDUALS - 10 GROUPS  
 OBSERVED 0.0 1.0 1.0 3.0 11.0 2.0 6.0 1.0 1.0 0.0  
 EXPECTED 0.2 0.7 2.1 4.1 5.9 5.9 4.1 2.1 0.7 0.2  
 CHI-SQUARE = 9.9212 WITH 2 DEGREES OF FREEDOM, P-VALUE= 0.007  
 |\_diagnos /het acf

REQUIRED MEMORY IS PAR= 23 CURRENT PAR= 2000  
 DEPENDENT VARIABLE = LNT 26 OBSERVATIONS  
 REGRESSION COEFFICIENTS  
 -0.505511427776 1.33363059433 0.614924599397  
 1.36948747358  
 0.696656703372 -6.07782640707

HETEROSKEDASTICITY TESTS

	CHI-SQUARE TEST STATISTIC	D.F.	P-VALUE
E**2 ON YHAT:	7.388	1	0.00657
E**2 ON YHAT**2:	6.966	1	0.00831
E**2 ON LOG(YHAT**2):	7.630	1	0.00574
E**2 ON LAG(E**2) ARCH TEST:	0.096	1	0.75624
LOG(E**2) ON X (HARVEY) TEST:	6.821	5	0.23426
ABS(E) ON X (GLEJUSER) TEST:	9.836	5	0.08003
E**2 ON X TEST:			
KOENKER(R2):	9.093	5	0.10540
B-P-G (SSR) :	9.666	5	0.08526

...MATRIX INVERSION FAILED IN ROW 8

...RESULTS MAY BE UNRELIABLE

E**2 ON X X**2 (WHITE) TEST:			
KOENKER(R2):	*****	10	*****
B-P-G (SSR) :	*****	10	*****

...MATRIX INVERSION FAILED IN ROW 8

...RESULTS MAY BE UNRELIABLE

E**2 ON X X**2 XX (WHITE) TEST:			
KOENKER(R2):	*****	20	*****
B-P-G (SSR) :	*****	20	*****

RESIDUAL CORRELOGRAM

LM-TEST FOR HJ:RHO(J)=0, STATISTIC IS STANDARD NORMAL

LAG	RHO	STD ERR	T-STAT	LM-STAT	DW-TEST	BOX-PIERCE-
LJUNG						
1	0.1034	0.1961	0.5272	0.6718	1.4698	0.3113
2	0.1195	0.1961	0.6094	0.8666	1.4151	0.7445
3	0.0286	0.1961	0.1460	0.1815	1.5257	0.7704
4	-0.3204	0.1961	-1.6337	1.9597	2.1521	4.1672
5	-0.0256	0.1961	-0.1304	0.1825	1.3984	4.1899
6	-0.0309	0.1961	-0.1575	0.2239	1.3894	4.2246
7	-0.1111	0.1961	-0.5666	0.6982	1.5438	4.6978

LM CHI-SQUARE STATISTIC WITH 7 D.F. IS 3.702

```

|_*ols lnT newtax newtax93 lnP lnR lnT1 Date /rstat gf anova
|_*diagnos /het acf
|_stop

```

### Specification 3:

```
Welcome to SHAZAM - Version 9.0 - AUG 2001 SYSTEM=WIN-98 PAR= 2000
CURRENT WORKING DIRECTORY IS: C:\SHAZAM\
|_read (C:\My Documents\Int Rel\Thesis\Spreadsheets\UKTax.txt)TaxR Price
Roy PRT Corp SPD Take Rigs GDP Capex Date TakeDum Date93
UNIT 88 IS NOW ASSIGNED TO: C:\My Documents\Int
Rel\Thesis\Spreadsheets\UKTax.txt
```

```
...SAMPLE RANGE IS NOW SET TO:          1          27
|_*sample 1 27
|_genr lnT=log(TaxR)
|_genr lnP=log(Price)
|_genr lnR=log(Rigs)
|_genr lnG=log(GDP)
|_genr lnCap=log(Capex)
|_genr lnTak=log(Take)
|_genr lnT1=lag(lnT,1)
..NOTE.LAG VALUE IN UNDEFINED OBSERVATIONS SET TO ZERO
|_genr lnT2=lag(lnT,2)
..NOTE.LAG VALUE IN UNDEFINED OBSERVATIONS SET TO ZERO
|_genr llnC=lag(lnCap,1)
..NOTE.LAG VALUE IN UNDEFINED OBSERVATIONS SET TO ZERO
|_genr llnC2=lag(lnCap,2)
..NOTE.LAG VALUE IN UNDEFINED OBSERVATIONS SET TO ZERO
|_genr llnG=lag(lnG)
..NOTE.LAG VALUE IN UNDEFINED OBSERVATIONS SET TO ZERO
|_genr llnG2=lag(lnG,2)
..NOTE.LAG VALUE IN UNDEFINED OBSERVATIONS SET TO ZERO
|_genr llnr=lag(lnR)
..NOTE.LAG VALUE IN UNDEFINED OBSERVATIONS SET TO ZERO
|_genr date93=takedum*date-18
|_genr Date2=Date*Date
|_genr lntak93=lnTak*takedum
|_genr rigeff=date*lnr
|_genr take2=Take*Take
|_genr take93=Take*takedum
|_genr newtax=Roy+PRT+spd
|_genr newtax93=newtax*takedum
|_genr tax93=Date93*lnTak
|_sample 2-27
|_*ols lnT lnTak lnP lnR lnT1 Date /rstat gf anova
|_*diagnos /het acf
|_*ols lnT newtax newtax93 lnP lnR lnT1 /rstat gf anova
|_*diagnos /het acf

|_ols lnT newtax newtax93 lnP lnR lnT1 Date /rstat gf anova
```

```
REQUIRED MEMORY IS PAR=          11 CURRENT PAR=          2000
OLS ESTIMATION
      26 OBSERVATIONS      DEPENDENT VARIABLE= LNT
...NOTE..SAMPLE RANGE SET TO:          2,          27
```

```
R-SQUARE =      0.9448      R-SQUARE ADJUSTED =      0.9274
VARIANCE OF THE ESTIMATE-SIGMA**2 =      0.14176
STANDARD ERROR OF THE ESTIMATE-SIGMA =      0.37651
SUM OF SQUARED ERRORS-SSE=      2.6935
MEAN OF DEPENDENT VARIABLE =      7.7573
```

LOG OF THE LIKELIHOOD FUNCTION = -7.41786

MODEL SELECTION TESTS - SEE JUDGE ET AL. (1985,P.242)

AKAIKE (1969) FINAL PREDICTION ERROR - FPE = 0.17993  
(FPE IS ALSO KNOWN AS AMEMIYA PREDICTION CRITERION - PC)

AKAIKE (1973) INFORMATION CRITERION - LOG AIC = -1.7288  
SCHWARZ (1978) CRITERION - LOG SC = -1.3901

MODEL SELECTION TESTS - SEE RAMANATHAN (1998,P.165)

CRAVEN-WAHBA (1979)  
GENERALIZED CROSS VALIDATION - GCV = 0.19399  
HANNAN AND QUINN (1979) CRITERION = 0.19568  
RICE (1984) CRITERION = 0.22445  
SHIBATA (1981) CRITERION = 0.15938  
SCHWARZ (1978) CRITERION - SC = 0.24905  
AKAIKE (1974) INFORMATION CRITERION - AIC = 0.17750

ANALYSIS OF VARIANCE - FROM MEAN				
	SS	DF	MS	F
REGRESSION	46.127	6.	7.6878	54.231
ERROR	2.6935	19.	0.14176	P-VALUE
TOTAL	48.820	25.	1.9528	0.000

ANALYSIS OF VARIANCE - FROM ZERO				
	SS	DF	MS	F
REGRESSION	1610.7	7.	230.10	1623.153
ERROR	2.6935	19.	0.14176	P-VALUE
TOTAL	1613.4	26.	62.053	0.000

VARIABLE	ESTIMATED	STANDARD	T-RATIO	PARTIAL	STANDARDIZED	ELASTICITY
NAME	COEFFICIENT	ERROR	19 DF	P-VALUE	CORR. COEFFICIENT	AT MEANS
NEWTAX	-0.45892	1.168	-0.3930	0.699	-0.090	-0.0396
NEWTAX93	1.5983	0.8171	1.956	0.065	0.409	0.0357
LNP	0.60684	0.3213	1.889	0.074	0.398	0.2398
LNR	1.0204	0.7965	1.281	0.216	0.282	0.6518
LNT1	0.75566	0.1016	7.435	0.000	0.863	0.7372
DATE	-0.23303E-01	0.3329E-01	-0.6999	0.492	-0.159	-0.0436
CONSTANT	-4.5092	3.506	-1.286	0.214	-0.283	-0.5813

DURBIN-WATSON = 1.5990 VON NEUMANN RATIO = 1.6629 RHO = 0.02291

RESIDUAL SUM = -0.17319E-13 RESIDUAL VARIANCE = 0.14176

SUM OF ABSOLUTE ERRORS= 6.4874

R-SQUARE BETWEEN OBSERVED AND PREDICTED = 0.9448

RUNS TEST: 12 RUNS, 12 POS, 0 ZERO, 14 NEG NORMAL STATISTIC = -0.7746

COEFFICIENT OF SKEWNESS = -0.1940 WITH STANDARD DEVIATION OF 0.4556

COEFFICIENT OF EXCESS KURTOSIS = 0.4772 WITH STANDARD DEVIATION OF 0.8865

JARQUE-BERA NORMALITY TEST- CHI-SQUARE(2 DF)= 0.1750 P-VALUE= 0.916

GOODNESS OF FIT TEST FOR NORMALITY OF RESIDUALS - 10 GROUPS

OBSERVED 0.0 1.0 1.0 2.0 10.0 4.0 6.0 2.0 0.0 0.0

EXPECTED 0.2 0.7 2.1 4.1 5.9 5.9 4.1 2.1 0.7 0.2

CHI-SQUARE = 7.2479 WITH 1 DEGREES OF FREEDOM, P-VALUE= 0.007

|\_diagnos /het acf

REQUIRED MEMORY IS PAR= 29 CURRENT PAR= 2000

DEPENDENT VARIABLE = LNT 26 OBSERVATIONS

REGRESSION COEFFICIENTS

-0.458922955472            1.59825998937            0.606843856560  
 1.02042446797  
 0.755662741073            -0.233033273745E-01       -4.50918553362

HETEROSKEDASTICITY TESTS

	CHI-SQUARE TEST STATISTIC	D.F.	P-VALUE
E**2 ON YHAT:	6.819	1	0.00902
E**2 ON YHAT**2:	6.272	1	0.01226
E**2 ON LOG(YHAT**2):	7.221	1	0.00721
E**2 ON LAG(E**2) ARCH TEST:	0.079	1	0.77890
LOG(E**2) ON X (HARVEY) TEST:	7.799	6	0.25324
ABS(E) ON X (GLEJSER) TEST:	8.518	6	0.20253
E**2 ON X                    TEST:			
KOEKNER(R2):	8.047	6	0.23467
B-P-G (SSR) :	8.723	6	0.18976

...MATRIX INVERSION FAILED IN ROW    9

...RESULTS MAY BE UNRELIABLE

E\*\*2 ON X X\*\*2        (WHITE) TEST:  
     KOEKNER(R2):            \*\*\*\*\*        12    \*\*\*\*\*  
     B-P-G (SSR) :            \*\*\*\*\*        12    \*\*\*\*\*

...MATRIX INVERSION FAILED IN ROW    9

...RESULTS MAY BE UNRELIABLE

E\*\*2 ON X X\*\*2 XX (WHITE) TEST:  
     KOEKNER(R2):            \*\*\*\*\*        27    \*\*\*\*\*  
     B-P-G (SSR) :            \*\*\*\*\*        27    \*\*\*\*\*

RESIDUAL CORRELOGRAM

LM-TEST FOR HJ:RHO(J)=0, STATISTIC IS STANDARD NORMAL

LAG	RHO	STD ERR	T-STAT	LM-STAT	DW-TEST	BOX-PIERCE-
LJUNG						
1	0.0204	0.1961	0.1038	0.1438	1.5990	0.0121
2	0.0696	0.1961	0.3551	0.5049	1.4762	0.1592
3	0.0132	0.1961	0.0671	0.0812	1.5285	0.1647
4	-0.3554	0.1961	-1.8123	2.1239	2.2098	4.3450
5	-0.0199	0.1961	-0.1016	0.1460	1.3787	4.3587
6	-0.0116	0.1961	-0.0594	0.0835	1.3456	4.3637
7	-0.1063	0.1961	-0.5419	0.6711	1.5293	4.7964

LM CHI-SQUARE STATISTIC WITH    7 D.F. IS        3.733  
 |\_stop

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