

Pink Gold: Potash and Poverty

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Abstract

This paper explores how the development of potash mines in Canada could potentially reduce poverty in Sub-Saharan Africa (SSA) through simple market mechanisms. Assuming no market distortions, by opening one potash mine in Canada and increasing the supply of fertilizer on the international market, we can expect its price to drop. This could lead to an increase in the use of fertilizer as an input for Sub-Saharan African farmers. With a particular focus on the Ethiopian agricultural market, we can expect this additional use (or adoption in many cases) to increase agricultural production by 1.2 percent. As a simple poverty measure, by using fertilizer one household can increase their consumption by 0.2 percent, ensuring their food security. This paper also explores the market distortions that reduce the effect of the market outcome. Some of these distortions include the controlled supply of international potash fertilizer by Canadian producers, distribution and transportation costs and the risk that low-income farmer's face in their decision to purchase fertilizer. The first section of this paper covers the basics of fertilizer use in agriculture. The next section contains an industry analysis that examines the market demand, market supply, and the price of potash fertilizer. The final section is an analysis of poverty reduction and the potential for this market solution when all distortions are removed.

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1. Introduction

1.1. Purpose of Paper

The objective of this research paper is to determine whether developing another potash mine in Canada would be an effective way of reducing poverty in the world. By reducing the price of fertilizer, through its supply and making it a viable option for farmers in poverty to increase agricultural productivity, this could potentially increase the income as well as sustenance for the farmer. Increasing a farmer's productivity, and the supply of food, has the potential to reduce the scarcity of food, leading to lower prices. Ramping up the supply of food can affect an economy in two ways. First, by reducing the price of food, it becomes more accessible to consumers. This generates an increase in the consumer surplus. The second effect of increasing the food supply is the resulting additional income generated by the higher crop yield for the farmers. This benefits the producer surplus, ensuring future compensation on the investment made into their crops. The goal here is to determine whether increasing the supply of food by way of reducing the price of fertilizer would be an efficient way of reducing poverty and ensuring food security. As a form of indirect development assistance, this could be a successful tool in providing food security in the years to come.

1.2. Why is this Important?

Food, necessary and essential for our survival, has recently become a scarcer commodity in many regions. "The survival and well-being of humans and animals depends on plant production, which in turn depends heavily on the availability of minerals and other nutrients" (Roy, Finck, Blair and Tandon, 2006, page 25). This demonstrates the connection between human well-being and proper nutrition. As a basic food necessity, plants can provide people with the needed nutrients to perform our biological functions, but in order to do that we must supply the plants with these nutrients without placing them in a toxic environment. This process is performed at the agricultural level and beyond just providing a source of

nutrition and sustenance, agriculture provides a source of livelihood to developed and developing regions.

Globally the world has 5.5 billion people living in developing nations, with approximately 2.6 billion living in rural areas who depend on agriculture as a means of living (Dethier and Effenberger, 2011). The number of people who generate their income through agriculture account for over a third of the world's population. In low-income countries, the agricultural sector accounts for 60 percent of the total workforce, yet contributes only 25 percent of GDP (Dethier and Effenberger, 2011). In the Horn of Africa, "80 percent of the people ... rely on agriculture as their main source of food and income" (Food and Agriculture Organization of the United Nations, 2011), although very little of their food production is used to generate a source of income. On the other hand, other developing regions, such as China have achieved self-sufficiency in the agricultural sector leading to surpluses due to the help of farmers, the green revolution, government, industry, farm advisors and scientists (Roy et al., 2006).

Since the 1950's, agricultural surplus has aided in lowering food prices in North America. Families of four have reduced their expenditure on food from 50 percent to 15 percent (Roy et al., 2006). This has provided North American families access to a wider variety of foods and eventually a higher calorie and protein diets. Agricultural surplus increased the standard of living among developed nations and most recently in developing nations, such as China. Unfortunately, however, we are still faced with starvation and malnutrition concentrated mainly in Sub-Saharan Africa (SSA) and most recently centered in the Horn of Africa, which includes countries such as Somalia, Ethiopia, Djibouti and Eritrea.

The Food and Agricultural Organization of the United Nations has estimated that the food crisis in combination with a severe drought that has not been seen since the 1950's, have left 12 million people

requiring emergency assistance (2011). Specifically, parts of southern Somalia are suffering from famine, since there have been “high local cereal prices, excessive livestock mortality, conflict and restricted humanitarian access in some areas” (FAO, 2011). Access for the SSA population is an important factor to their survival. Not only do humanitarians have problems in accessing the people, the people have problems in accessing food. High food prices are placing the people out of reach from available food, and severe droughts limiting access to high (even normal) crop yields. The importance of this food crisis also has implications among the political and financial economy. Although the increase in food prices creates high profit margins for western farmers, many developing countries are experiencing significant social unrest due to the high crop prices. In 2008, food shortages combined with a global recession and high food prices helped spark rioting across the world, especially in regions such as Cameroon, Egypt, Morocco and South Africa (Moody’s, 2011). These riots were not limited to Africa, but were experienced globally in other regions such as Bangladesh, Pakistan, Sri Lanka, Yemen, Bolivia and Mexico, to name a few.

Fertilizer plays a large role in the production technology of some basic food staples, such as wheat, corn and rice. Its ability to reduce the price of these commodities in regions such as the Horn of Africa would be a huge step towards reducing famine and providing food security. Furthermore reducing the price of fertilizers can potentially create a secondary effect of reducing poverty among farmers. According to a recent literature survey on agriculture development and the issues facing growth in Africa performed by Dethier and Effenberger (2011), encouraging agricultural growth can help develop income and jobs for the rural sector, as well as providing food at reasonable prices and jobs with low wages in the modern sector.

In SSA, where fertilizer application rates and standard of living is the lowest in the world, a lower fertilizer price could offer substantial assistance to this region. This could be a possible market alternative to conventional poverty reducing measures such as direct infusions of monetary or food aid. Given that the population of Ethiopia is approximately three times the size of Canada (Central Intelligence Agency, 2011), and 80 percent of the population in the Horn of Africa (which includes Ethiopia) work the agricultural industry, then 72 million people in Ethiopia depend on agriculture as a source of both food and income. This paper finds that if the fertilizer prices were to decrease, a farmer's risk of losses, given any level of precipitation, would be reduced. Farmers are then more willing to use fertilizer when faced with the risk of a bad rain season. Using fertilizer in SSA is estimated to increase this region's consumption by 0.2 percent.

After a description of the methodology, the following section will provide background information on fertilizers and their agricultural uses. The third section will consist of an industry analysis of the fertilizer market and will consist of three parts reflecting potash fertilizer demand within the fertilizer demand, the relative supply of potash to the fertilizer market and will finish with the market price equilibrium. The final section will provide an analysis on poverty, and will use the information presented in the previous sections to amalgamate an estimate for the potential poverty aid.

1.3. Methodology

By understanding the role that the potash fertilizer industry plays in the agricultural chain, we can contextualize the effect that this mineral could have on poverty and consumption. The methodology of this paper is to survey the available literature in agricultural development and analyses of the potash fertilizer industry to gain an understanding of this industry. First, by analysing the demand for potash we can illustrate a framework for understanding how SSA and its demand elasticity fits in as a consumer agent. Secondly, the supply side of the market will be analysed to determine the feasibility and benefits

of opening a new mine in Canada. With these estimates in place, we can understand how the market price for fertilizer is determined based on the bargaining powers presented on each side of the market. Finally, a poverty analysis is provided to determine the impact that a marginal mine could add to poverty reduction by its impact on the price of food and farmer's income.

2. Brief Description of Fertilizer use in Agriculture

2.1. Fertilizer Descriptions and Use

Derived from the Latin term *fertilis*, meaning fruit bearing (Roy et al., 2006), fertilizers provide plants with a source of nutrition for optimal growth. Fertilizers are essential for providing the nutrients that are prerequisites to maximizing quality crop yields. Plants require 16 nutrients: 6 macronutrients and 10 micronutrients. The three most commonly used nutrients in fertilizers are nitrogen, potassium and phosphate (United States Geological Survey, 1999). However, soils used for agriculture can become depleted of nutrients and frequently require fertilizing before the soils can be used successfully again. Using an excessive amount of mineral fertilizers can be very toxic to soils and plants, decreasing the crop's yield (Roy et al., 2006).

Not all regions are identical in soil requirements; fertilizers can come in a variety of forms and can be properly suited to meet the requirements of certain soil deficiencies. Fertilizers can be "... natural [or] manufactured chemicals containing nutrients known to improve the fertility of soils" (USGS, 1999, page 1). Fertilizers are differentiated products based on their types, such as synthetic, mineral, inorganic, artificial or chemical (Roy et al., 2006). Some of these terms are not mutually exclusive as they can sometimes be used interchangeably, such as synthetic, chemical or artificial. Although manufactured fertilizers may carry a negative connotation, there is nothing inferior about them. They originate from natural sources and can offer a better nutrient supply than organic fertilizers, which is a common source

of fertilizer in Sub-Saharan Africa and other low-income developing nations. Something important to note is that “[although] organic fertilizers are also being prepared and used, they are not yet covered by the term fertilizers, largely owing to tradition and their generally much lower nutrient content” (Roy et al., 2006, page 92).

Manufactured fertilizers can be either a pure fertilizer, which contains only one of the three main nutrients, or a complex/compound fertilizer, which contain at least two of the main nutrients. Stated on the package, the blend or grade of fertilizer is expressed as a percentage by weight. For example, a grade of 12-32-16 for an NPK fertilizer represents the presence of 12 percent nitrogen (N), 32 percent phosphorus pentoxide (P_2O_5) and 16 percent potash (K_2O), or 60 percent total nutrients. Fertilizers containing nitrogen and potassium (NK) are perhaps the most important. They typically contain 13 percent nitrogen and 37 percent potassium (potash). It is useful for intensively grown crops, such as tomatoes, potatoes, tobacco, leafy vegetables and fruits, and in greenhouses.

2.1.1. Nitrogen (N)

The most abundant and consumed mineral in plants is nitrogen. It plays an important role in a plant's growth and represents “part of the chlorophyll (the green pigment in the leaves) [which] is an essential constituent of all proteins” (Roy et al., 2006, page 28). Nitrogen fertilizer is responsible for a plant's colour, growth rate, branching, leaf production and size and yield formation. If a plant is missing nitrogen from its production cycle (i.e., it is deficient), the plant will experience a reduction in its growth rate and its stem's girth. In the event of nitrogen toxicity (a case of an oversupply of nitrogen to a crop), a crop could experience prolonged growth and crop maturity.

The supply of nitrogen is plentiful and easily accessible for the production, thanks to "Fritz Haber and Carl Bosch, who [in 1909] devised the first industrial process to turn nitrogen gas (N_2) in the air into ammonia (NH_3)" (Nosenga, 2003, page 894). Ammonia represents about 32 percent of the total fertilizer nitrogen used; urea and urea-ammonium nitrate solutions together represent 37 percent; ammonium nitrate, 5 percent; and ammonium sulphate, 2 percent (USGS, 1999). The remaining 24 percent of nitrogen fertilizers are complex fertilizers containing either phosphate and/or potash. Since nitrogen is captured from the air, production is mainly based on input prices, such as oil or natural gas (Roy et al., 2006). With natural gas being relatively inexpensive at around \$4.50/mmBTU, "North American producers will likely generate substantial profits of more than \$200/metric ton" of nitrogen, says Moody's Investor Services (2011, page. 7).

Nitrogen is a popular fertilizer used by farmers, due to its availability and inexpensiveness. However, more recently scientists and environmentalists have noticed a negative externality with the fertilizer is growing use. It is noted that half of the nitrogen fertilizer consumed by is washed away into the local ground water instead of being ingested by the crops (Nosengo, 2003). This runoff can cause two problems in local water supplies. The primary negative externality is an over growth of algae, which can decrease the fish stock due to a lack of oxygen in the water from the algae. An effect secondary to algae growth is a buildup of nitrogen in local drinking water. This can result in a rare but potentially fatal side effect called 'blue baby syndrome' or methaemoglobinaemia, where red blood cells are unable to carry oxygen in the body (Nosengo, 2003).

2.1.2. Phosphate (P_2O_5)

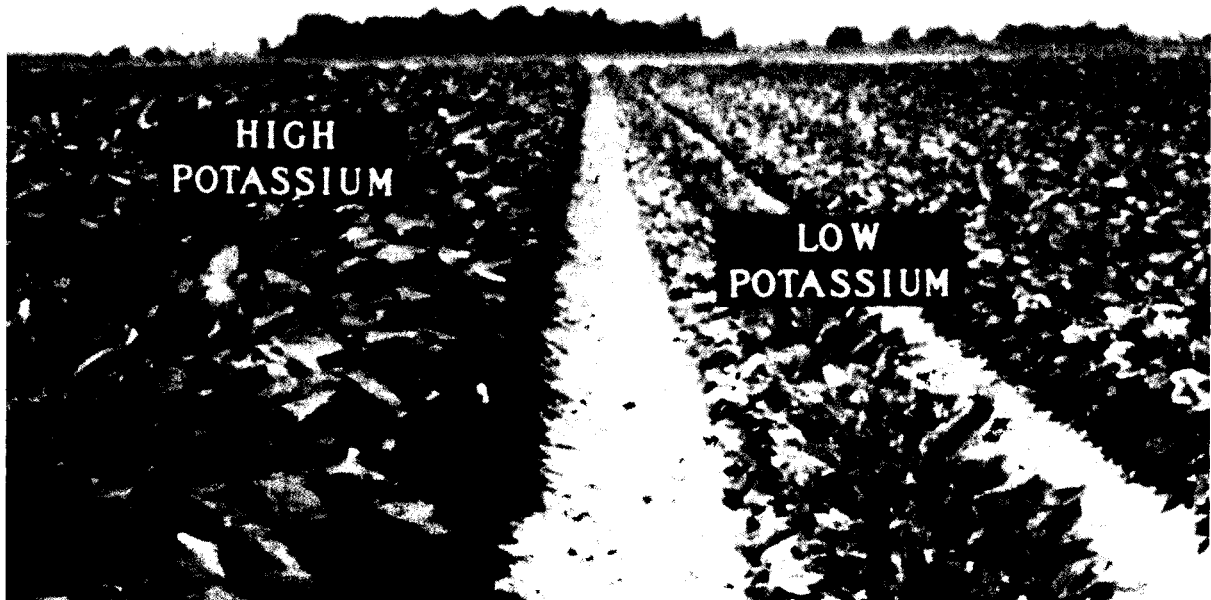
Phosphate is essential for a plant's growth, affecting seed and fruit development as well as early ripening (Roy et al., 2006). That is, when a plant faces a phosphorus deficiency, the plant experiences

stunted growth, delayed ripening and poor root development. Phosphate rock, or apatite mineral, is the only economical source of phosphorus for manufacturing phosphate fertilizers. A common phosphate fertilizer made from that rock is DAP. Although distributed throughout the world, the major deposits of phosphorus can be found in the United States, Russia and Northern Africa (namely in Morocco, Algeria and Tunisia) (Roy et al., 2006).

2.1.3. Potash (K_2O)

Potash is a term used to describe many different types of potassium-based fertilizer. The most common form is potassium chloride (KCl). The formation of this mineral, underneath the earth's crust, created millions of years ago when the seawater that used to cover the area where potash is now found evaporated. Layers of common salt (NaCl) are covered by smaller layers of potassium minerals, which then hardened to rock under pressure.

Figure 1 – Crop yields with and without potassium



Source: USGS Fact Sheet: Fertilizers – Sustaining Global Food Supplies

Potassium is an essential nutrient for plant growth. After nitrogen, it is the second most abundant nutrient found in a plant. Like phosphorus, potassium is a mobile element in plants, it helps the plant's metabolism operate efficiently, and has an added feature that boosts resistance of a plant to stresses such as drought and disease (USGS, 1999). Plants lacking potassium can suffer from chlorosis which can spread to the rest of the plant if the deficiency increases, which is seen below in figure 1. Supplying the proper nutrients to a plant can avoid deficiencies, such as chlorosis, which is a loss of pigment in the plant's leaves as well as a general sign of health, usually followed by a brown colour leading to death of the tissue (Roy et al., 2006). Other symptoms of potassium deficiencies include stunted growth, weak stalks, greater incidences of pests and disease, low yield and generally low crop quality. There does not appear to be any effect if the plant is over-supplied by potassium (Roy et al., 2006).

2.1.4. The Green Revolution

The Green Revolution refers to a package of inputs that a farmer can use alongside proper farming practices to increase crop yields. Cereal crops increased substantially due to an increase in productivity caused by this package over the period 1965-90 (Roy et al., 2006). The required input package needed to increase crop yields includes high yielding seed varieties (HYVs), chemical fertilizer, irrigation systems, pesticides and in some cases, farming machinery. The green revolution was applied to crops such as wheat, rice and maize in order to boost the global supply of food. This led to the subsidization of fertilizer use, which puts a heavy burden on government budgets of developing nations, as well a loss in soil quality due to over use (Dethier and Effenberger, 2011). This combination gave way to the revolution of new farming practices, which in turn led to successful new crop yields in lesser-developed countries such as China, India, Indonesia, Pakistan and Bangladesh. Overall the global agriculture sector grew by 2.6 percent. The majority of this growth can be attributed to some Asian economies, such as China (Dethier and Effenberger, 2011). Africa has continued to struggle with adopting green revolution

technologies, while other countries like China have grown after adopting such inputs. It is acknowledged that Africa faces a different situation than Asia, being less dependent on wheat and rice, which are large fertilizer consuming crops (Dethier and Effenberger, 2011). Along with a poor infrastructure, it is true that Africa might need more than a green revolution, but its adoption might be a good place to start.

3. Industry Analysis

Understanding market prices requires a firm grasp on the key economic agents that interact within a market setting. Interactions among agents determine the proportional allocation of resources in a market and their value added to the production chain. The bargaining power and strategies used between agents over a good can help make more sense of the goods price, since, as Besanko and Braeutigam (2005) illustrate, prices are the mechanisms that ration scarce resources. An analysis into the industry will lead to a clearer picture on how potash fertilizer is allocated and any welfare properties that may be inferred from them.

In a recent report by the Canadian House of Commons, a majority of the Members of Parliament (MPs) seemed to have a difficult time understanding why fertilizer prices were so high, creating tension between fertilizer suppliers and farmers (House of Commons, 2010). They recommended that an investigation by the Competition Bureau should be performed in order to look into the matter. Unfortunately, the Competition Bureau could not comment on the issue or whether an investigation would happen. Agriculture and Agri-Food Canada completed a similar report on the North American fertilizer market in 1998. Their results showed that prices in the fertilizer industry were subject to offshore demand and that there exists evidence to support capacity driven prices. That is, prices rise as the industry reaches full capacity and falls when there is excess capacity. Another form of competitive

behaviour is demonstrated when the industry exhibits price movements on both sides of the border that move together and that the main determinant of regional price differentiation is transportation costs. This report also addressed some non-competitive behaviour such as the large concentration ratios. This will be discussed later once the framework for the current industry has been established.

By conducting an industry analysis, this section attempts to investigate these issues presented by the Canadian House of Commons. Although it may be important to consider that Canada's House of Commons concerns surround Canada's domestic Agricultural market, the scope of this report is to investigate competition levels internationally, which will play an important role in understanding the world price of fertilizer and its effect on African Farmers. Since these prairie corporations do have a large presence on the international market and hence SSA's choice of fertilizer use, the issues put forth by the House of Commons are still relevant to this paper.

3.1. Fertilizer demand

The demand for fertilizer can be seen as an extension of the demand for food. When the demand for food increases, so too does its price. When farmers observe an increase in their output price, and thus their revenue, they will want to increase their output and their productivity in order to maximize their profits. As a result, the demand for fertilizer as an input to production will increase as well. Fertilizer demand is expected to increase because of both an increased world demand for food, as well as the continued rise in the demand for biofuels (Moody's, 2011). There are still hesitations among farmers in the SSA to adopt fertilizers, which will provide insight into factors that shape demand. The next two sections will take a closer look at who is demanding fertilizers and to what extent farmers are using fertilizers.

3.1.1. Trends in World Wide Fertilizer Consumption

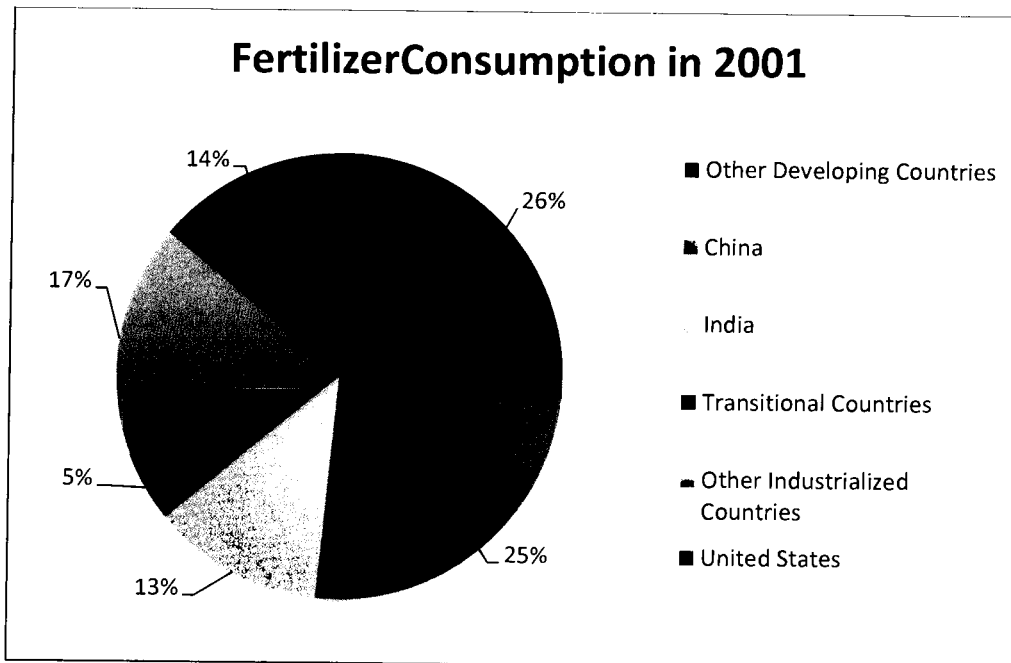
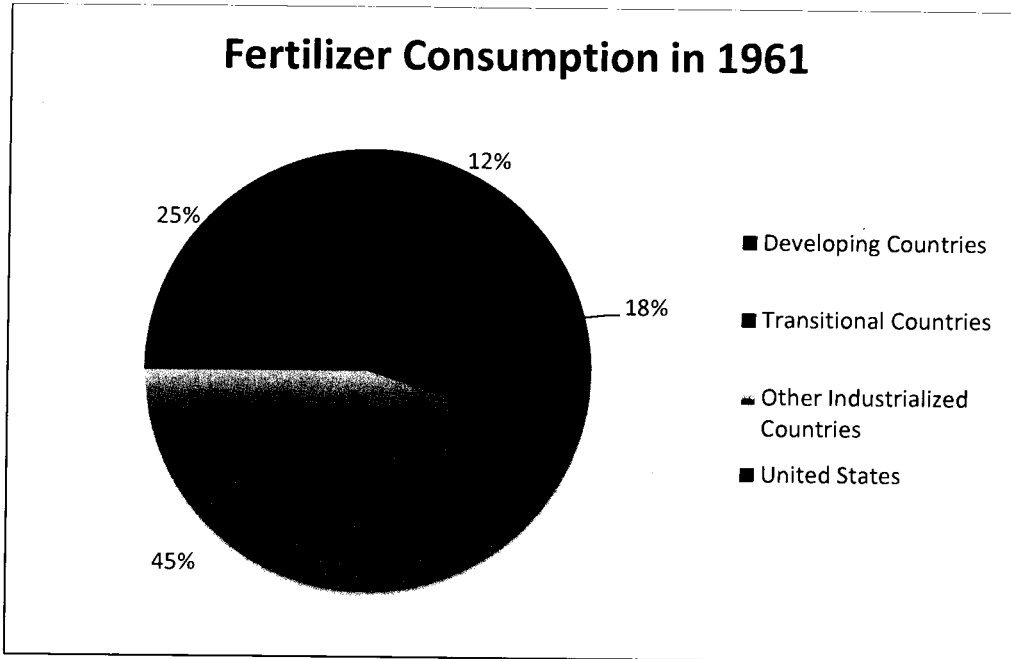
Before the Green Revolution took hold in the 1970s, the United States consumed the largest amount of chemical fertilizer, approximately 25 percent of global consumption (Heisey and Norton, 2007).

Developing economies only contributed 12 percent of global consumption. Including the United States, industrialized countries together consumed a total of over ten times the amount of fertilizer consumed by developing countries. Over time, this trend changed. Twenty-three years later, transitional economies, such as the former Soviet Union and Eastern Europe, began to consume less than industrialized nations. At the same time, China became the world's leading consumer in fertilizer and India followed. Together the two countries represent approximately 40 percent of global fertilizer consumption by 2001. This change in dominance in fertilizer consumption from developed nations to developing nation is depicted below in Figure 2. In 1961 the developed countries represented over 50 percent of fertilizer consumption and the U.S. represents 25% of global fertilizer consumption. By 2001, China and India alone represent a larger share of fertilizer consumption than all other developed nations.

From the data presented by Heisey and Norton (2007), a high buyer concentration of countries is established among the grouping of countries; although once the market approached 2001, the buyer concentration dropped. Usually this is indicative of a decrease in the buying power of consumers due to an increase in demand, but in this case, only a slight variation. If we were to consider the concentration among countries, a further reduction in concentration is seen to change the buyer concentration to moderate.

When considering the fertilizer use in SSA, compared to the rest of the world, SSA is a region with very low application rates. They represent a very small percentage of consumers in the global market. The

Figure 2 – Global Fertilizer Consumption in 1961 and 2001



Source: Heisey and Norton, 2007

main fertilizer consumers in Africa are Egypt, South Africa and Morocco (Heisey and Norton, 2007).

Africa will remain a major exporter of phosphate products, and nitrogen fertilizer export potential is expected to triple in the period under consideration. For potash, Africa relies almost entirely on compound fertilizer imports. At one percent of global consumption, SSA has lagged in its application rates over the years and has especially fallen behind when compared to China and other developing countries that, before the Green Revolution, had similar fertilizer application rates. Today, China applies a minimum average of 200kg/ha, whereas SSA applies 8kg/ha (Heisey and Norton, 2007). The recommended application rate for potash fertilizers according to Roy et al. (2006) is around 60 – 300 kg/ha, with at least 60-150 kg/ha for developing countries. Faced with such low application rates in SSA there is a large potential to increase crop yields, an additional 52kg/ha (60kg/ha – 8 kg/ha) would make a substantial contribution to the success of a crop yield if the proper nutrients are applied given the regional soil requirements.

Over 50 percent of consumption in fertilizer is by farmers producing cereal crops (Heisey and Norton, 2007). This is true across all regions including developing, industrialized and transition economies.

Wheat makes up the majority of this consumption in fertilizer, the bulk of which is produced in Asia, Western Europe and North America. Two other components to cereal production that require fertilizer use include rice and maize (corn). When including these fodder crops to the list, it ranks as number four among cereal crops (Heisey and Norton, 2007).

Between the five major fertilizer consumers (China, India, United States, France and Brazil), nitrogen is the most demanded fertilizer at 50 million tonnes of nitrogen in 2003 (Roy et al., 2006). Accounting for 24 percent of total nutrients consumed, global consumption of phosphate amounted to 33.6 million

tonnes in 2003. China alone consumed 10 million tonnes of phosphorus. Potash consumption volumes in 2003 remained the least demanded fertilizer nutrient at **23.3** million tonnes of nutrients, accounting for 16 percent of global nutrient consumption.

Potash consumption exceeds phosphate consumption in large-consuming developed and developing countries such as the United States of America, Brazil and France while it is well below phosphate consumption in India and China. The three major potash consumers, of the five mentioned, are the United States, China and Brazil representing 50 percent of potash consumption. From this data, we know that the average global nutrient ratio fed to plants is 15:6:4 of nitrogen, phosphate and potassium respectively. Although this seems to indicate the demand for potash, the nutrient soil requirement will vary from region to region. This means that the preferences of farmers are heterogeneous. Given these heterogeneous needs, there are other factors behind the demand of potash fertilizer consumption. The next section will explore these factors for a better understanding of fertilizer demand.

3.1.2. Drivers of Fertilizer Demand

3.1.2.1. Food Crisis

Since 2006, the price of food has experienced shocks that have led to new highs in the price of basic commodities such as corn, soybeans and wheat. In a brief review of the agricultural literature by Dethier and Effenberger (2011), they point to at least five different factors that caused the recent spike in food prices. The first is high fuel prices increasing the costs of inputs, such as fertilizer. They also looked to dietary changes that are significantly influencing the demand for food. China and India are prime examples of countries that, with growing populations, have developed more sophisticated tastes in their food preferences. Third is the production of biofuel, specifically the subsidized US and European corn production which increases the demand of feed stock contributing to higher pressure on corn prices.

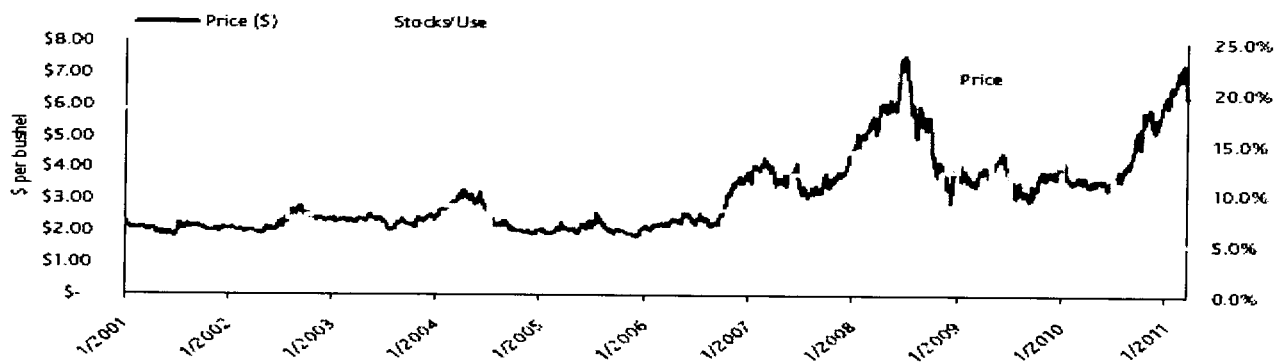
Brazil is contributing to corn production as well but in a competitive environment and not subsidized. The fourth factor contributing to the global food crisis is weather shocks, such as drought and floods, reducing the returns expected on crops as well as the overall supply (this issue will be investigated further, for the risk involved in purchasing fertilizer). Finally, the financial speculation in the agricultural commodity markets may have affected the increase in food prices.

In March earlier this year, the prices of soybeans, wheat and cotton increased to levels 50, 40 and 150 percent respectively to the price levels a year-prior. The global price trends for these three crops are plotted with their corresponding stock-to-use ratio in figures 3.A, 3.B and 3.C. The stock to use ratio is useful to measure the supply and demand balances. This indicator represents the carryover stocks, or excess supply, remaining in the industry as a percentage of the demand or use. If this ratio is declining then demand has increased and/or the supply has decreased, and the price increases as the carryover becomes smaller relative to the demand. This indicates a tight market supply. As the stock to use ratio increases, then the price begins to decrease as firms attempt to sell off left over supply.

Figure 3 – Prices and Corresponding Stock/Use Ratios for three common grains

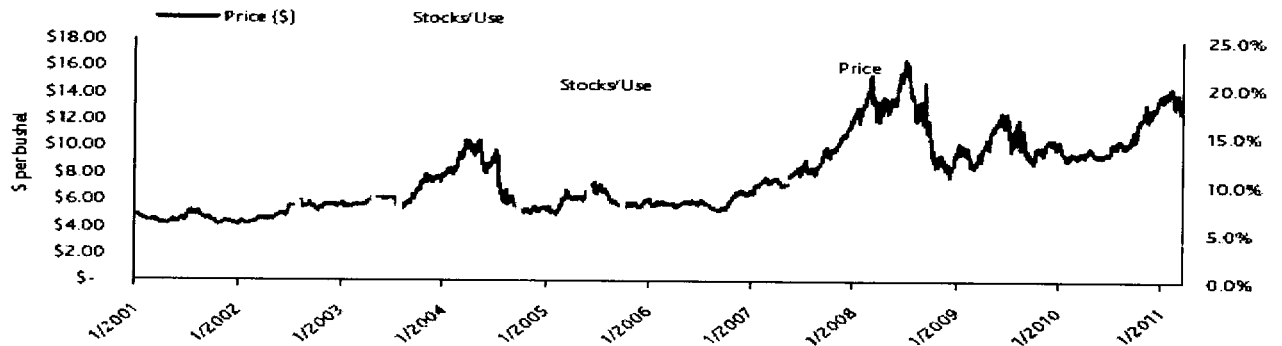
3.A - Corn

Corn Prices and Stocks/Use Ratio



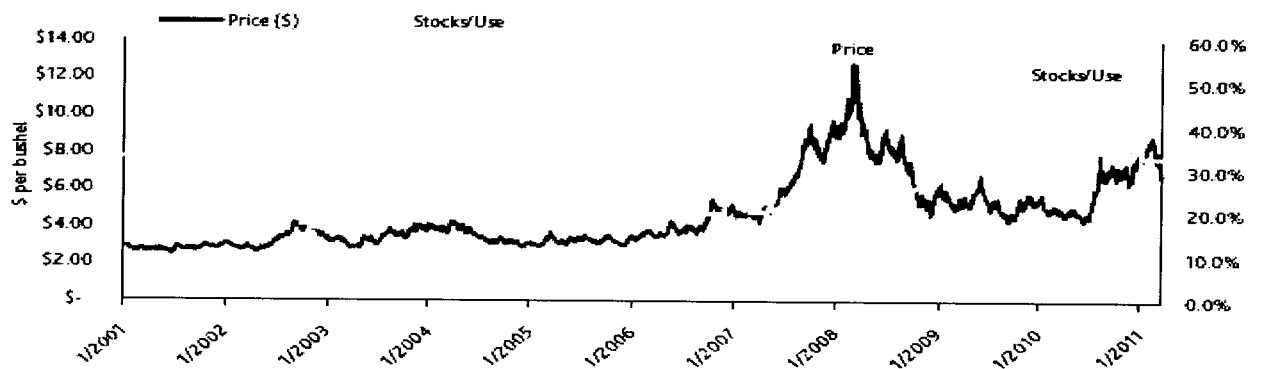
3.B - Soybean

Soybean Prices and Stocks/Use Ratio



3.C - Wheat

Wheat Prices and Stocks/Use Ratio



Source: Moody's investors Services

In Figure 3.a, above, we see the price increase for corn beginning just before 2007 with peaks at 7.35\$ per bushel and ranged at a low of 3\$ per bushel within a year. The stocks to use ratios are consistently low since 2006, hovering around 5% of total demand, given previous trends prior to 2007, which settled at above 20% of total demand and are continuing along down this path. This indicates that corn prices are likely to remain high above 5\$ per bushel where, according to Moody's Investor Services (2011), average historical data reveals stock to use ratios situated around 15- 20 percent. The demand for corn

has increased as China increased the quantity of corn it was importing in the second half of 2010 (Moody's, 2011). This happened since the corn yield that China was producing was no longer sufficient to sustain their population's growing demand for higher calorie consumption and protein demand.

"Disturbances to food production resulting from poor economic conditions, widespread poverty, civil war, inappropriate food pricing policies and logistical constraints contribute significantly to the problem [of the food crisis]" (Roy et al., 2006, page 5). Beside all of these issues facing the production of food, there has also been a significant increase in the demand for food due to a growing population. With estimated projections of 7.5 billion people by 2020 and 9 billion people by 2050 (Roy et al., 2006), the demand for food is growing faster than its production. Given that the increase in the population will be located in 93 developing countries, which together make up more than 60% of the world fertilizer market (Moody's, 2011), the demand for cheap food will be of increasing importance. This will be especially significant since the largest growth in consumption is expected in the Sub-Saharan African region (Roy et al., 2006).

East and South-east Asia, which are expected to have the smallest consumption growth, represent the largest bulk of the world's population (Roy et al., 2006). China, for example, has a population that well surpasses population of other nations and although its growth has been negative since the introduction of their one-child policy, currently they represent 18.8 percent of the world's population (CIA, 2011). Since the implementation of the Green Revolution over the past few decades, their incomes and standard of living has increased substantially. Thus, their demand for food has increased in both quantity and quality. They now demand a high calorie intake as well as a higher share of protein consumption, estimated to be 30 kg/capita/year by 2020 (Roy et al., 2006). The increased demand for protein has put strains on the production for cereal grains used in fodder used to feed animals, such as

corn soybeans and wheat to name a few. Fodder needed to produce a kilogram of beef, entails 7kg of feed. Additionally, to produce a kilogram of pork, 4 kg of feed is required, and 2 kg is required for poultry (Mack, 2011).

Global population growth figures become more alarming when one considers that the global supply of arable agricultural land is fixed. "Although demand for food will increase as population increases, the area of cultivated land will not increase significantly" (USGS, 1999, page 1), which means the available land per capita is decreasing. This implies that increasing agricultural production will have to be delivered through means of higher crop yields. The world's "limits of food production reveals that a much greater number of people than the expected equilibrium population (of about 10 000 million) could be supplied with sufficient food" (Roy et al., 2006, page 8). That is, global production *can* supply a growing population, especially with gains that have been made in agricultural production such as irrigation, fertilizer and high yielding variety (HYV) seeds. The problem is that the agricultural progress has not been uniformly achieved across all regions, especially when the distribution of the population growth does not correspond to the achievements made in agricultural production (Roy et al., 2006). Elevated global food prices will keep demand and prices for fertilizers strong over the next two or three years, at least, as predicted by Moody's (2011).

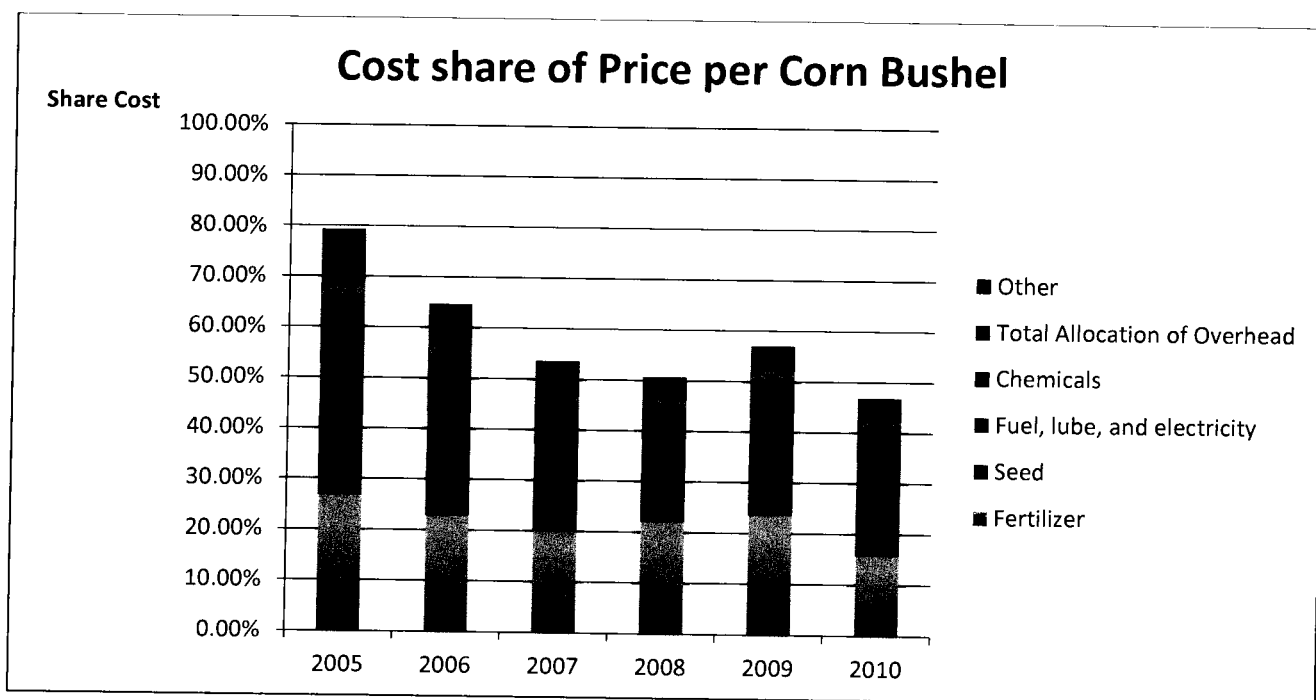
When food prices increase, a farmer has an incentive to produce more food, and more efficiently to generate more profit. The elasticity of gross revenue from crop production with respect to the value of modern inputs, such as fertilizer, HYV seeds and irrigation, is estimated to be 0.46 in Kilimanjaro and 0.14 in Ruvuma, two regions in the Republic of Tanzania, and south of Ethiopia respectively. According to Christiaensen and Demery, modern input use is more widespread in Kilimanjaro where nearly 80 percent of the farmers had used fertilizer in the previous year, compared with 50 percent in Ruvuma

(2007). They also found that with the effect of other green revolution products, "...the elasticity of the value of cereal output in Ethiopia with respect to fertilizer use is estimated at 0.12" (Chritiaensen and Demery, 2007, page.58).

3.1.2.2. Farming Costs

The cost of production is an important issue to farmers and appears to be a large source of tension between farmers and fertilizer producers (House of Commons, 2010). For farmers the higher the cost share of production (specifically the ratio of the unit cost of production to the revenue generated by the unit produced), the riskier it is for the farmer to be in business.

Figure 5 – Cost Share of Price per corn Bushel



Source: USDA, <http://www.ers.usda.gov/data/costsandreturns/testpick.htm>

Other Costs include Custom Operations, Repairs, Purchased Irrigation Water and Interest paid on Operating Capital.

Total Allocation of Overhead includes hired labour, Capital recovery of machinery and equipment, Taxes and Insurance and General farm Overhead.

Farmers in the United States have felt the same tensions that Canadian farmers have experienced recently. In 2008, U.S. farmers saw the price of fertilizer increase by 65% which well surpassed price increases for other inputs such as fuel, seeds, chemicals that saw price increases of 43%, 30% and 3.8% respectively (Etter, 2008).

To understand the costs that Canadian farmers experience in their business, we will use the available data on farming costs from the USDA as a proxy to see what farmer's costs are over time in North America. As we can see below in Figure 5, since 2005 the total costs for production has decreased as farmers moved into 2010, yet the cost share of fertilizers to food prices has remained the same. Fertilizer cost share in U.S. cornfields represents approximately 20 percent of the bushel price on average in recent years. This is seen in Figure 5, where the cost share of each input per corn bushel is depicted as a percentage of the price of corn per bushel for each year between 2005 and 2010. The difference in percent of the 100 percent and total cost share represent the profit share for that year. Over the past five years we can see that profit for farmers has been increasing due to relative reductions in cost shares of all other costs to the price of food. This graph says that fertilizer is in fact the largest component of cost for a U.S. corn farmer. Investigation into farming costs in the U.S. corn industry between 1975 and 1995 results in the same findings that, 20 cents on every dollar spent on a corn bushel gets to fertilizer costs (United States Department of Agriculture, 2011). The relative fertilizer price also had the most variation compared to the other relative input prices, seeing highs of 25 percent of the price of a corn bushel and lows of 15 percent of that price.

High input costs are risky for farmers because they must invest into the costs of production before a payoff is realized. For an American farmer that has access to insurance in case of bad weather and can afford the high relative cost of fertilizer, the risk is considerably low. In regions such as Ethiopia, that lack

proper credit markets, the high relative price of fertilizer is risky business, since if there is bad weather and a crop is lost, the returns to cover the high relative cost of fertilizer might not be seen. When living in poverty, this loss can be devastating. This in turn leads farmers to procrastinate when purchasing fertilizer and generally become adverse to purchasing it (Croppenstedt, Demeke and Meschi, 2003; Duflo, Kremer and Robinson, 2010; Zerfu and Larson, 2010).

3.1.2.3. Substitutes and Complements

Substitutes

The substitutes offered for fertilizers can help define the product and its market. Very broadly speaking fertilizers have been expressed as substitute for land and all else equal, "one would expect high fertilizer consumption to develop in land-short, labour abundant agricultural economies" (Heisey and Norton, 2007, page 2743). Other broader forms of substitutes for fertilizer include field fallowing, where farmers move crops to another field to allow nutrients to build up in the soil again for optimal use. In an analysis of farmers in western Kenya, half performed this task on only 10%-50% of their crops, which is high for a densely populated area (Franzel, Shephard and Ndufa, 1997). This technique works well in farms that have low labour to land ratios, since if the farmer fallows his crops, the breakeven return to compensate for the lost season is only 21 percent of the new long rain yields (Franzel, et al., 1997). The reason why the compensation for the lost season of crop is so low is because of the savings on labour costs while fallowing the fields included with the additional 21 percent covers the opportunity cost of fallowing the field. Compared to chemical fertilizers, this technique is limited and output is still dependant on the rain outcomes. Chemical fertilizers can be tailor made to suite the natural soil deficiencies of the regions, whereas fallowing fields does not guarantee any particular level of nutrient.

The only close substitute for potash is manure as an organic fertilizer, which are low- potassium – content sources. As mentioned earlier, organic fertilizers tend to have a low concentration of nutrients (Roy et al., 2006). Another main distinction between these fertilizers and Potash fertilizers is that manure can only be transported over short distances to remain profitable for producers (USGS, 1999). Organic fertilizer is a poor substitute for chemical fertilizers since their quality is not guaranteed and it has a shorter shelf life. The role that organic fertilizers play in crop production is difficult to determine since, as a source of waste, it is difficult to measure its use among farmers relative to that of chemical fertilizers.

Complements

With the introduction of the Green Revolution to developing countries, farmers saw increased returns due to the use of their new inputs. This technology that the Green revolution brought was proper farming techniques and understanding of how these high return yielding inputs such as irrigation, HYV seeds and fertilizer work together to maximize yield outputs. Introducing the proper complements to farmers increased the demand for all three inputs. Thus as a complement “fertilizer use is considerably higher for HYVs than it is for so-called ‘farmers’ varieties, and higher on irrigated than on rain fed land” (Heisey and Norton, 2007, page 2756). In this Green Revolution input package, HYV seeds are most likely sought after by the farmer if there is considerable financial restraint, since without the seeds there are no crops, hence no return. Whereas if a farmer needs to cut expenses and opts for just the seeds and no fertilizer then, returns to yields can be expected but not necessarily maximized.

3.1.2.4. Risk

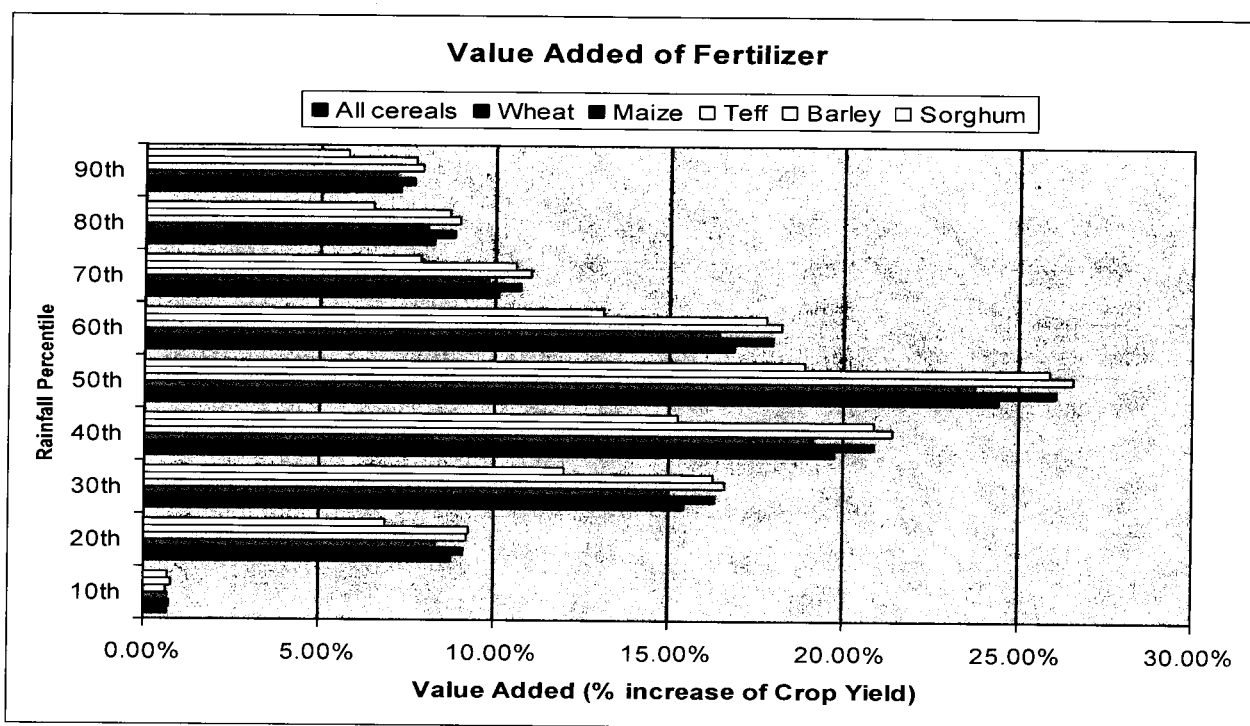
Risk is an important factor behind the farmer’s demand for fertilizer. Due to shocks such as extreme weather conditions, there is uncertainty in the success of a crop at the beginning of the season. Farmers

will not see any returns on their investments into the inputs until the crops can be harvested and sold. Most farmers in developed and some developing nations opt for irrigation systems in order to avoid this risk. Although for the 2.6 million farmers living in rural poverty, this option may not always be available to all farmers. Making an investment into costly inputs like fertilizer can be a difficult decision given such a risk. Although, as shown in Figure 7, fertilizer can increase the crop value at every level of rain fall, if the cost of fertilizer is more than its added value, then there is no incentive to purchase the modern input. Economic cost of choosing not to use potash leads to plants that are left more susceptible to diseases and stress due to drought, reducing the production capacity of the crops (Roy et al., 2006). Given this benefit of potassium fertilizers, the graph in Figure 7 includes only nitrogen and phosphate fertilizers, since these are the only fertilizers used in Ethiopia. In this figure, the 10th percentile of rain demonstrates a miniscule return to fertilizer relative to the 90th percentile where the return is similar to the 20th percentile. This means that the 10th percentile of rain (i.e. a drought) is the most devastating shock to crops in the Ethiopian region. Thus there is a large potential for potassium fertilizer application in these soils given their benefits to plants under drought circumstances. If the shock of a drought is large enough to significantly reduce the return so that costs are no longer covered, the farmer risks having to take a loss of his initial investment into the needed inputs. If the price of potash fertilizer is too high, then this technology becomes too risky of an investment to use, despite its potential, since the increased costs give the farmer a smaller window to generate profits.

Risk seems to have more of an impact on poorer households, like those in Ethiopia, which tend to engage in "... risk avoidance in the face of incomplete credit and insurance markets" (Dercon and Christiaensen, 2010, page 1). This means that a farmer that is so close to the brink of poverty and suffers one loss, falls into poverty. The cost to poorer farmers to take on the risk of buying fertilizer can in some

cases mean the difference between eating and not eating. This is one of the main reasons that fertilizer is not adopted in some countries where poverty is a serious issue.

Figure 7 – Value Added for Fertilizer Use in Ethiopia



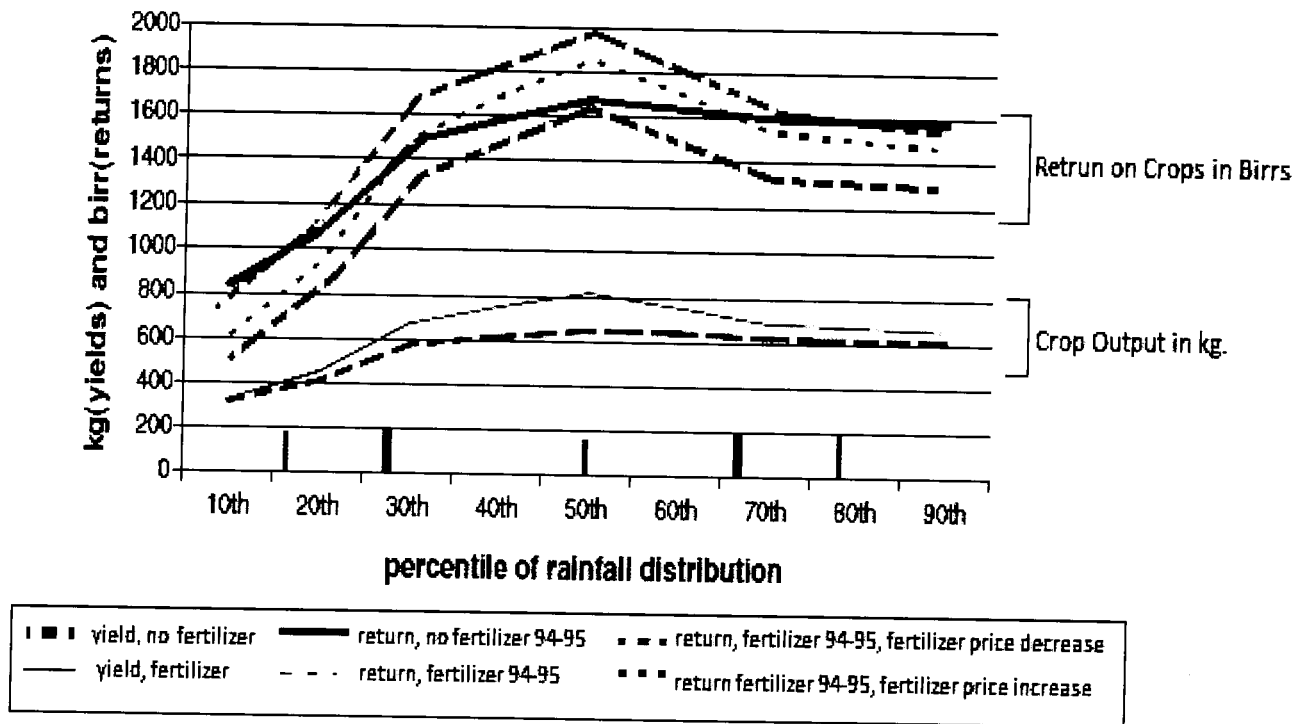
Note: Fertilizer used in Ethiopia includes only Nitrogen and Phosphorus based Fertilizers.

Source: Dercon and Christiaensen, 2010

This risk adversity among poor farmers leads to situations of poverty traps. Dercon and Christiaensen discuss this issue and describe that farmers in poverty cannot ensure their consumption against random shocks to their household income and will tend towards low risk activities that will yield lower returns (2010). Farmers then become limited in future fertilizer use due to their low returns not being substantial enough to afford future fertilizer. In turn, this leads them to low returns on crops in the future. This cycle continues and makes agricultural growth a difficult hurdle for impoverished farmers.

Farmers that have moderate to high risk thresholds and are lucky enough to afford fertilizers in the next season will generate greater returns due to the fertilizer. Unfortunately, once these farmers have a bad season (either a flood or a drought depending on the region) resulting in unsustainable crop yields, combined with high fertilizers prices the value added by fertilizer may not be sufficient to cover its own cost. The farmers then fall back into the poverty trap. This implies that, depending on fertilizer prices, farmers have a certain window of profit opportunity, which is represented in Figure 8.

Figure 8 – Fertilizer Use and Weather Uncertainty in Ethiopia



Source: Driven from Dercon & Christiaensen, 2010

In this figure, we have the distribution of rainfall on the x-axis and the yield/returns, similar to figure 7, generated by the agricultural production in Ethiopia for the y-axis. This graph shows two cases; the first

is when the farmer uses fertilizer (nitrogen and phosphorus) and the second is when the farmer does not use fertilizer. The two bottom horizontal lines represent the crop yields.

The top line is the yield when fertilizer is used and it is everywhere above the line below it when fertilizer is not used, indicating that for every level of rainfall the output using fertilizer is always greater than the crop output when not using fertilizer. This is exactly what is revealed in the previous Figure 7. The top four horizontal lines show something very interesting. The solid thick line represents the returns (profits that are a function of the crop output price and the crops input price, specifically fertilizer in this case) on the harvest when fertilizer is not used. The line with small dots that crosses the thicker solid line at the 30th and 70th percentile is the return on the crop harvest when fertilizer is used. This dotted line is not everywhere above the solid black line, specifically the returns are worthwhile in the 10th -20th and 70th -90th percentile of rainfall. Conversely, fertilizer is only profitable when the rainfall is between the 30th -60th percentiles. This is the farmer's window for fertilizer profitability, indicated by the two vertical black lines on the x-axis.

Let's consider what happens when the price of fertilizer decreases. When the costs for a farmer decreases, then their revenue increases, meaning an upward shift everywhere on the returns line, this is indicated by the line with the dashes that is everywhere above the small dotted line. When the price of fertilizer goes down, the window of profitability opens for the farmer. The two outer vertical lines on the x-axis in the 20th and 80th percentile indicate this window, since these are the points when using fertilizer is more profitable than not using fertilizer. If the price of fertilizer were to increase, costs would go up and profit would decrease. This is indicated by the line with dashes that is everywhere below all lines of return in Figure 8. In this particular instance, the price has increased enough to close the window of profitability and fertilizer is no longer seen as an option for the farmer.

3.2. Fertilizer Supply

According to Bloomberg analysts, this year's industry data reveals that the potash inventory levels are at 26 percent, their lowest rates in the last five years (Toovey, 2011). The supply of potash fertilizer depends on where the reserves are, who controls the production of the reserves and how much it costs to extract and transport the mineral. These factors contribute to establishing the bargaining power of the firms, which will help determine the price that follows the equilibrium quantity. Given the recent spikes in food prices and hence an increase in the demand for fertilizer, one would expect, based on the law of supply, that the supply of potash fertilizer would increase in response to the increased price. Instead, there have been limited movements in the past five years towards opening new mines. This section will focus specifically on the production and supply of potash fertilizer and will talk about nitrogen and phosphorus fertilizers in relation to potash fertilizer.

3.2.1. Potash Reserves and Resources

The distribution of the mineral is an important feature, since it will define who will produce it and ultimately the potential level of market power concentration. This limitation implies that not just anyone can simply decide to enter the potash fertilizer market, producing potash requires access to the material, which may be more difficult to obtain in some jurisdictions than others. Establishing ownership over reserves can create a barrier for other firms to enter the potash fertilizer market, making potash a difficult commodity to obtain and a rare resource.

The world has a current estimate of 250 billion metric tons of potash mineral resources, measured by the U.S. Geological Survey (2011b). The global stock of potash resources is a "concentration of the mineral within the Earth's crust such that it is in a form and amount that economic extraction from the concentration is currently or potentially feasible" (USGS, 2011a, page 193). Their demonstrated or

inferred deposits measure potash resources. Demonstrated potash deposits are ones that can generate samples with assurance of continuity between two potash deposits. Inferred deposits, however, are estimates of potash sites that possess geological evidence of their existence but are not supported by samples or measurements.

This establishes the identified resources. Relative to potash, by the FAO's estimates, there are only 10 000 million tonnes of phosphorus reserves found on land (Roy et al., 2006). There are inferred deposits within the oceans, but no attempts to access them have been made. With less than 200 years of reserves left to meet the current demands (assuming it remains constant), phosphate is considered a rare mineral compared to potash.

A potash reserve is a dynamic measure based on the inflows of newly discovered reserves and outflows of production. As a component of the reserve base, which includes all demonstrated deposits, reserves are concentration of the potash mineral that are at the time of determination, economically feasible to mine. In other words, reserves can also represent the working inventory of the supply of a potash mining company that is economically extractable. This does not restrict the definition of reserves that include deposits that are in or will be in production, but any deposit that is economically recoverable. The recoverability of the inventories is limited by costs of production, taxes, output prices, and will be developed to a business' needs or their geographic limit. In most recent measurements by the USGS, the world has 9.5 billion metric tons of potash reserves; this can be seen in Table 1 above. These reserves are distributed among 13 countries and 3 of those 13 countries account for nearly 90% of global reserves. This implies that there is a heavy concentration in the ownership of deposits among countries.

Table 1 – Global Potash Reserves by Country

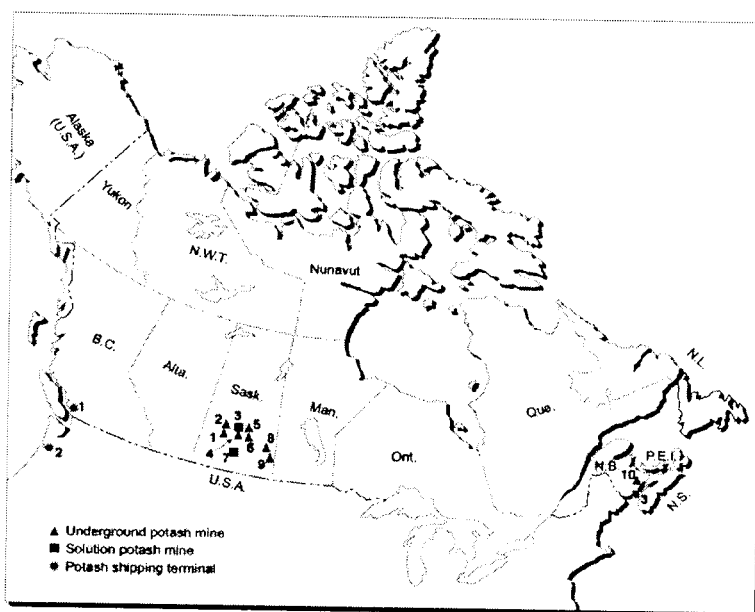
Global Reserves by Country in 2009	
Country	Reserves in Thousand Metric Tons of K₂O
United States	130,000
Belarus	750,000
Brazil	300,000
Canada	4,400,000
Chile	70,000
China	210,000
Germany	150,000
Israel	540,000
Jordan	540,000
Russia	3,300,000
Spain	20,000
Ukraine	25,000
United Kingdom	22,000
Other countries	50,000
World total (rounded)	9,500,000

Source: US Geological Survey, Mineral Commodity Summaries

Based on this figure, it is estimated that globally in 2010, only 0.35 percent of the world's potential potash reserves was produced. Owing the world's largest deposits, Canadians are only estimated to be extracting 0.21 percent of their 4.4 billion metric tons of reserves annually. A map of Canada's reserves utilized for potash production can be seen in Figure 9 below. This means that there is a large potential

for mining development, especially in Canadian reserves. Total investments in Canadian potash reached a new high after 2002, due to a new tax incentive program to increase potash mine capacity by the NDP Saskatchewan government to encourage the industry's potential (Saskatchewan Chamber of Commerce, 2011). In a five year period, between 2004 and 2009, the Saskatchewan potash industry increased its capital expenditures nine-fold, due to tax holidays and capital write offs for the industry.

Figure 9 – Canadian Potash Mines

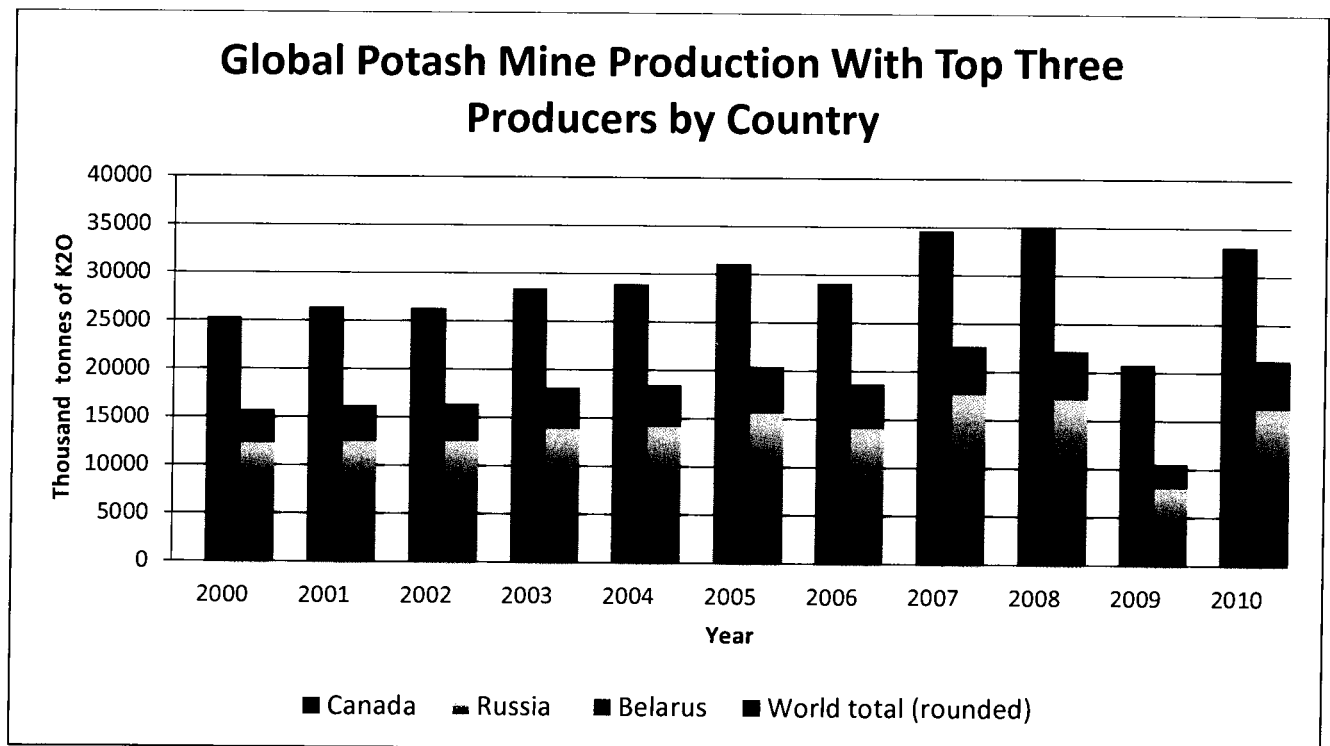


Source: Natural Resource Canada

Potash, due to this tax incentive, has increased in popularity for many mining investors, including junior potash producers. In addition to this, recent valuations of the mineral in Canada's most recent potash contract with China, settling prices 17 percent above the last contract and 20\$/ton above what was expected by most analysts (Reuters, June 29, 2011), it would be difficult to see investors lose sight of mining the mineral. In other words, potash is a hot commodity.

With some of the world's largest deposits, it is clear that Canada has led the way over the past ten years, with approximately 20 percent of world production. Russia's share of production is roughly the same as Canada's, at 17 percent. Along with Belarus, these three countries contributed 50 percent of the global supply of potash in 2009. After a large cut in global production following the recession, these three countries reached their lowest production share combined. The upper limits of their combined production share are closer to 60 percent, which can be seen over the course of the decade.

Figure 10 – Global Potash Mine Production with Top Three Producers by Country



Source: USGS Geological Survey, Mineral Commodity Summaries

These three countries seem to respond the most to changes in demand when looking at Figure 10. It is a fair assumption that demand absorbs all production in equilibrium, so we could look at global production as equal to global demand. Suppose for a moment that each country is itself a firm. If we

look back at 2009, the production share for the top three countries dropped to a low of 50%. With the recession that occurred the previous year, the corresponding demand for fertilizer dropped in 2009. This caused a significant contraction among all three producers indicating that they are sensitive to global fluctuations, while the rest of the world relatively maintained constant production unaffected by global demand. The rest of the world is measured by the difference between the world total and the sum of the three countries. This gap displayed on top of the stacked bars is representative of all other global producers and its magnitude of production between in 2008 to 2009 is relatively constant. When examining the global production data minus the top three producers, the rest of the world produced a total of approximately 9 mmt (million metric tons) of potash, stabilized at 10mmt, then in 2007 and 2008 jumped to 12mmt at most. Excluding the top three producers the global production changed on average by 2 percent per year. Total production grew at an average rate of 5 percent per year and the top three averaged a growth rate of 9 percent per year. This implies that all major variation is mainly due to these three large countries, Canada, Russia and Belarus. That is, everyone else seems almost unaffected by market fluctuations. These three countries have the greatest influence on the global supply of potash. This suggests that in essence, the industry is a three-country oligopoly, based on the distribution of the mineral reserves. Mother Nature did not take into account market shares as the deposits formed.

In spite of Belarus, China measures up to be the world's third largest producer accounting for approximately 15 percent of the world's supply of potash. Although China's global production is very high, none of this supply reaches the world market since, as mentioned earlier China is a net importer of this mineral for potash fertilizer and food production. The only countries estimated to increase production shares in 2010 are Canada, Belarus, Russia, Germany and Jordan.

Given such large production shares and the evidence of an oligopoly, the concentration of the distribution of this resource could tell us something about the level of market power in this industry. The HHI (Herfindahl-Hirschman Index),

$$HHI = \sum_{i \in X} s_i^2$$

can measure the level of concentration of market shares over the past decade, where X is the set of countries producing potash and s is a county's share of production in a particular year. Below, Table 2 lists the countries that produced potash and their market shares in 2000, 2005 and 2010. The calculation for HHI in 2000 is:

$$HHI_{2000} = 0.0514^2 + 0.1344^2 + 0.0138^2 + 0.3399^2 + 0.0009^2 + 0.0099^2 + 0.1347^2 + 0.0676^2 + 0.0439^2 + 0.1462^2 + 0.0206^2 + 0.0012^2 + 0.0237^2$$

$$HHI_{2000} = 0.1836$$

Table 2 – Production Shares over the Past Decade

Country	Year		
	2000	2005	2010
United States	0.0514	0.0386	0.0576
Belarus	0.1344	0.1543	0.1515
Brazil	0.0138	0.013	0.0121
Canada	0.3399	0.3254	0.2879
Chile	0.0009	0.0119	0.0212
China	0.0099	0.0193	0.0909
Germany	0.1347	0.1158	0.0909
Israel	0.0676	0.0662	0.0636
Jordan	0.0439	0.0395	0.0364
Russia	0.1462	0.1768	0.02061
Spain	0.0206	0.0161	0.0121
Ukraine	0.0012	0.0021	0.0004
United Kingdom	0.0237	0.0193	0.0121
HHI	0.184	0.183	0.174

Source: US Geological Survey, Mineral Commodity Summaries

Using this ratio, the average HHI over the past decade is 0.173. At the bottom of Table 2 the HHI for each year is given using the equation above. This gauge between 0 and 1 is used as an indicator of the level of competition. Using data from each year between 2000 to 2010, a ratio of 0.173 reflects the market, on average, is moderately concentrated. After the recession 2009 experienced an increase in concentration of approximately 20 percent but quickly returned to below its initial position the following year. This indicated a short increase in market power and a decrease in competition in 2009.

Together Canada, Russia and Belarus own 88 percent of the world's reserves and presently produce at least 50 percent of the world's supply of potash. Between the three countries, their estimated production will increase by nearly 65 percent in 2010 according to the U.S. Geological Survey (2011b). There is a large potential for expansion among these countries. These estimates suggest that Canadian, Russian and Belarusian policies may have a large influence over the market for potash.

3.2.2. Production

3.2.2.1. A Brief History

In the mid 1960's, Saskatchewan had a known potash deposit, that had substantial potential for production. Unfortunately, due to its complex formation, extraction was costly, making it an unattractive investment. Eventually the technology was developed, which made these deposits economically feasible to extract. Under the control of the Canadian government, the Potash Corporation of Saskatchewan was founded. New Mexico, a potash producer at that time, became worried that Saskatchewan's vast supplies would flood the market with this new development. Threats of a trade war between Canada and the U.S. emerged in the political spectrum.

To avoid this the Governor of New Mexico, David Cargo, and the Saskatchewan premier, Ross Thatcher, met to brainstorm solutions that would halt trade wars building between Canada and the U.S. before they would begin. The conclusive solution was to set production quotas for all firms in order to maintain low prices stable. This solution is based on a similar program used by New Mexico on its oil and gas industry. Canpotex, a North American potash distributor, was created soon after the quotas were announced and was in place only to sell to potash markets outside North America. North American potash producers were required to join up with the distributor or risk losing their production quotas.

In 1975, Saskatchewan Premier Allan Blakeney put up 50 percent of the Potash Corporation of Saskatchewan production under a Crown Corporation; Potash Corp. In the early 1980s, privatization of several Crown corporations were underway, which included Potash Corp. Canpotex, meanwhile faced its first defaulter of production quotas, Saskterra Fertilizers Ltd. In an attempt to pull out and undercut its fellow member, its competition was cut short and was bought out by Potash Corp.

In an effort to promote the product, Canpotex saw China as a large potential consumer of potash. In a three year campaign, “[officials] fanned out across the country, educating farmers and government bureaucrats about the benefits of potash” (Waldie, 2010). Eventually China became one of Canpotex’s largest buyers of potash, just as Canpotex had envisioned.

By 1991, the collapse of the Soviet Union brought a new international competitor to the scene. Russia and Belarus had large deposits which were sold to private entrepreneurs. This led to the creation of producers, Uralkali and Belaruskali, as well as a common distributor, Belarusian Potash Corp (BPC) with similar structure as the North American potash industry. BPC had an edge on transportation as it sat next to a major consumer, China. With increased competition on the international market, North

American producers consolidated and by 1994 only three remained in North America: Potash Corp., Mosaic and Agrium. To match the competition Canpotex invested into its infrastructure to reduce transportation costs. The system was built to carry far more than what was then being produced. This ensured all deliveries made it to China, as well as timely delivery by expanding its shipping terminals to Prince Rupert, B.C., reducing the shipping distance between Canada and China over the Pacific Ocean. As of today, four more players have become involved in this expanding market, Russian-based Silvit, Germany's K + S Group, Israel Chemicals Ltd. and Arab Potash Co. of Jordan (Waldie, 2010).

3.2.2.2. Mining

Planning to develop a mine, in general, will consider the thickness and depth at which the potash may be found as well as the profitability based on the cost of "extracting and marketing the material in a given economy at a given time" (USGS, 2011a, page 193). A big consideration that an investor might examine when looking into developing a mine is the profitability of a project. Three important aspects in the profitability of a project for an investor are what to invest into, when to invest and where to invest.

In choosing what to invest into, there are two common methods used to mine potash. In North America, two methods are widely used to mine for potash (Darst, 1991). The first method, which is the most common form of potash mining used in western Canada, is to extract the ore from deposits by sinking shafts down the deposit, extract and haul up the mineral for refining at the earth's surface. The second method used for potash extraction employs the idea that potash is a water-soluble substance; hence, this method is called solution mining. Instead of installing a shaft into the ground, solution mining injects the deposit with water through a well. This process turns the deposit into a solution which is brought to the surface through another well, much like pumping oil out of the ground. There

the solution can be returned to its normal state by evaporating the water. This method is a cheaper option relative to the first one, since solution mining is much less capital intensive. In Canada, there are only two solution mines, one located in New Brunswick and the other in Saskatchewan. To produce the final product of potassium chloride (KCl) or MOP, the salt rocks must be grinded and heated to remove the unwanted components. The potassium chloride then crystalizes as it cools (Roy et al., 2006). Two other forms of mines that can be considered by an investor are either a greenfield mine or a brown field mine. A greenfield mine is a new development on a reserve that requires infrastructural instalments, whereas a brownfield mine is a mine development over an existing abandoned mine. The difference in cost between the two is the infrastructural cost. This cost represents approximately 60 percent of the capital cost of a greenfield potash mine. The savings found in a brownfield mine represent \$1200 per tonne infrastructural investment (PotashCorp, 2011).

When considering where to invest, Canada possess many great attributes, such as political stability and proper installed infrastructure (Mack, 2011). Outside of Canada, by comparison, a number of projects in Africa, such as the Allana project situated in Ethiopia, have very interesting potential but face significant obstacles with respect to social infrastructure, including a lack of access to rail, water, power and ports. Political barriers also cause many issues in limiting access to ports for chain partners as well as producers involved in the mining process. Regardless, these deposits are under development for extraction, but due to its constraints the normal 7-year timeline it takes for a mine to reach production, can become extended significantly. "In an ideal world, you want a large potash resource located close to a large source of end demand with good infrastructure already in place and a stable geopolitical environment" (Mack, 2011). This means that the level of investment required for a potash mine requires a serious commitment that could very well run for several decades. If this is so, then strategic planning

on where to develop a mine can have a large impact over the long term profitability and returns on the investment. Currently, Saskatchewan and Brazil satisfy these considerations for developing a mine.

If a potash investor is considering when to invest, as a profit maximizer timing can be everything. When potash prices reach a threshold that guarantee return to cover the cost of the initial investment, investors have a profitability window. If the cost is too high and the price of potash will not generate the returns necessary to be profitable, this will inhibit mine expansion. Since the timeline for a potash mine is longer than that of a nitrogen or phosphate mine, there is a higher risk in potash expansion. To reduce the risk and boost confidence in a potash investments, there needs to be stability in potash price to ensure adequate returns.

Despite all the risks faced by a potash investor, mine expansions by Potash Corp. have shown to have a multiplier effect for the economy of Saskatchewan. This is a great benefit to the economy and the producer since they both fuel each other. Estimated by the Saskatchewan's Chamber of Commerce, the multiplier has an impact on the Saskatchewan economy by a factor of 1.8 times for an investment into mine expansion (2011). In other words, for every dollar spent, the economy benefits 0.80\$. For a greenfield development that costs \$3 billion, this investment will translate to \$2.4 billion added to the Saskatchewan economy. Relative to Canada's GDP, the potash industry feeds the surrounding Saskatchewan economy by purchasing a variety of goods and services from local businesses. The amendment made to the tax and royalty system to encourage new expansion, exempted any new mine development. Until these changes, the development of a mine will not be subject to a base tax or profit tax that sells tonnes in excess of 2001 and 2002 averages (Saskatchewan Chamber of Commerce, 2011).

3.2.2.3. *Capacity*

In the previous sections, we have seen that the market for potash fertilizer, based on national ownership of the potash deposit, is moderately concentrated and that over the history of the industry only a few players have engaged in the market, making it a duopoly. Market shares among firms that are currently in production demonstrate the same story. In a recent analysis of the fertilizer market performed by Moody's Investor Services, it was suggested that the market was highly concentrated (2011).

The capacity of the potash industry or a firm represents the upper limit of output of reserves given the potential of the capital installed and at a particular deposit. Additionally, the percentage of the production or operational rate of capacity by a firm, facility or industry represents the volume of production in a given period, as a percentage of the upper limit of production volume given all of the fixed and variable inputs produced within the same period. Increasing the supply of potash by a firm can happen by either increasing the rate of operational capacity or by building more mines, adding to the production capacity.

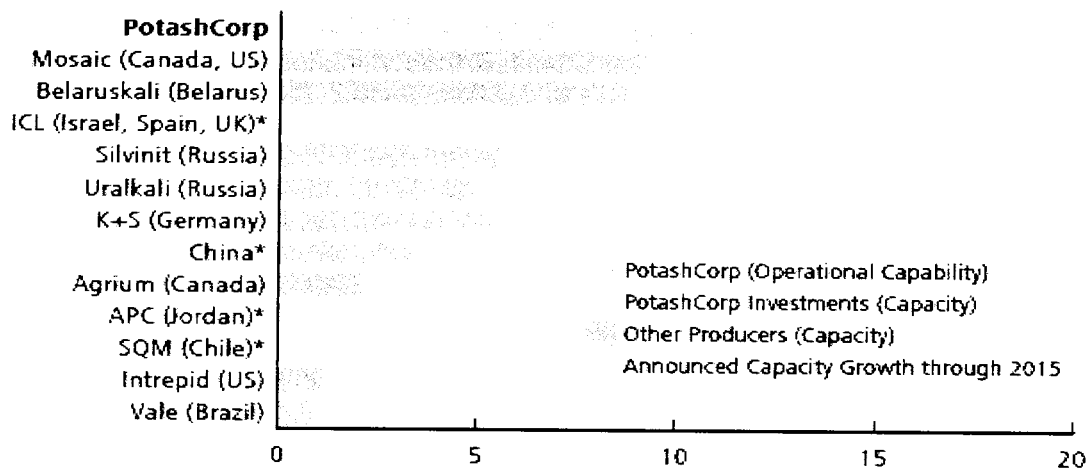
The operational rate of capacity of a firm or industry gives an idea about the short run flexibility of a market to supply more potash. In the short run, supply is normally said to be inelastic for most commercial products, since it is difficult to increase the upper limit of capacity by building new facilities in a short time period. Mining potash in the short run follows this idea, since building a potash mine does not yield immediate production. Thus, in the short run supply depends on the current operational rate of capacity. For example, suppose a potash mining facility is currently at 100 percent operational capacity, then it is operating at the maximum production that is expected of the facility. If the demand for potash were to increase, the supply will remain roughly the same since the facility cannot do much

more in the short run to increase its extraction rate. On the other hand suppose that a facility operating at 50 percent production capacity and the demand were to increase, they have the short run flexibility of increasing supply in response to the change in demand.

Figure 11 – World Producer Profile

World Potash Producer Profile

Million Tonnes KCl – 2009 to 2015



* PotashCorp Investments: ICL (14%), APC (28%), SQM (32%) and Sinofer (22%)

Note: PotashCorp based on operational capability (what we could physically produce) while competitor capacity is stated nameplate, which may exceed operational capability.

Source: Fertecon, British Sulphur, IFA, PotashCorp

The mining capacity of some major companies in the market is shown in Figure 11 above. Here we see that Saskatchewan's Potash Corp is a major player as was mentioned with an operational capability of over 10 mmt. With further plans to expand capacity domestically and internationally, Potash Corporation is the leading producer in potash. Mosaic is second largest producer worldwide, operating out of Saskatchewan and into the state of Montana. The third largest contributor to the Canadian potash supply is Agrium, but worldwide this company has the ninth largest capacity and helps define the top six along with Russian companies in global capacity. In Table 2, we see the profile list of companies

with their respective operational rate of capacity in 2010, as estimated by the analysts at Moody's Investor Services. In the production of potash, we see that the two largest Canadian producers have the lowest operational rate of capacity. Relative to the potash production by PCS and Mosaic, the operational rate of capacity in the production of nitrogen and phosphate fertilizers are at much higher rates. This implies that the quantity supplied for these fertilizers is quite high, with less flexibility to increase supply. That is, the quantity produced in the potash fertilizer market has more variability compared with nitrogen and phosphorus fertilizer supply, especially when considering PCS and Mosaic.

Table 2 – Producer Profile Capacity Utilization, 2010

Company	Operational Rate of Capacity (%)		
	Potash	Ammonia	Phosphate
PCS	73.64%	97.14%	83.33%
Mosaic	50.00%	-	81.82%
Agrium	87.80%	82.35%	90.91%
K+SAG	85.71%	90.00%	-
Compass Minerals International	97.33%	-	-
SQM	86.67%	-	-
CF Industries	-	77.08%	85.63%
Yara International ASA	-	91.69%	93.75%
QAFCO's	-	100.00%	-
JSC Acron's	-	88.24%	N/A

Source: Moody's Investors Service

According to the Potash Corporation's CEO, Bill Doyle, "[meeting] the world's growing demand will be one of the biggest challenges in our industry in the years ahead," (Toovey, 2011). He forecasts an "era of tight supply/demand fundamentals" (Toovey, 2011) for the potash market, and expects potash production will be maxed out in the next few years. That is the potash production will be reaching 100% of its capacity. In a recent report released by Moody's Investors Services, current potash production is at 80 percent of its capacity, as of 2011.

From these figures we can see that the majority of the new capacity that will be added to the market will be made by some of the major producers. By increasing their share ownership of the resources and holding back on the supply of production, potash becomes a scarce resource to the fertilizer and agricultural market. There will be capacity added by new entrants that are expected to hit the market in 2015, increasing competition (Moody's, 2011). The influx of new entrants into the potash market could be due to the higher prices currently seen in potash. As discussed earlier, the higher potash prices offer a quicker return on the investment of a new potash mine, which now seems more appealing and less risky for entering firms. High potash prices have provided incumbent firms with the incentive to increase their capacity through mine development. This new competition is not expected to change market shares (at most a 5% drop for the top producers), making the change in concentration negligible (Moody's, 2011).

In the fertilizer industry, new facility expansion is expected for the production of nitrogen fertilizers. According to Moody's Investors Services, this will not place any significant impact on the price for nitrogen fertilizers in the next few years (Moody's, 2011). For the capacity of phosphorous, the new Ma'aden plant in Saudi Arabia is the largest phosphate facility ever built. It has a capacity to produce 1.5 million tonnes of phosphoric acid and 3 million metric tons of DAP, one of the main phosphate

fertilizers. Such figures would account for more than 4% of global capacity and will begin to bring down the price of phosphate fertilizer once production hits the market (Moody's, 2011).

3.2.3. Distribution and transportation

A major player in the distribution of the potash industry is Canpotex. As discussed in this industry's history, Canpotex provides distribution services for almost all of North American potash producers. They also played a large role in helping China become a major potash consumer. This company has faced a lot of criticism in the past and present (Van Geyn, 2011; Waldie, 2010).

These common services provided by Canpotex allow the two smaller corporations (namely, Mosaic and Agrium) to remain as competitors due to PSC large industry's capacity supply and its ability to achieve economies of scale. Suppose, if the other two producers (Agrium and Mosaic) were to operate through their own distributors, their supply would not be large enough to achieve the same economies of scale as compared to Potash Corp due to available capacity. This would imply that on the world market, faced with higher costs, Mosaic and Agrium would most likely have to demand a higher price through their distributors to cover their costs. With many farmers looking to minimize their costs, they will most likely opt for the cheaper potash fertilizer (i.e., PotashCorp), sinking the other two producers out of business. This results in an overall lower supply of potash fertilizer, forcing prices up even further. When bearing in mind the cost structure and the varying levels of capacity amongst firms, the value for a firm like Canpotex can be understood.

Having a firm specialize in this section of the supply chain also helps to reduce costs. Again, as mentioned before in the brief history, an example of reduced transportation costs played a key factor for Canpotex in keeping China as a loyal customer during the rise of Russian potash. The cost of

transportation can make a big difference in the level of affordability of fertilizer for the farmer depending on his location. Farmers that are landlocked (much like those in Ethiopia) tend to be at a large disadvantage for importing large bulky sacks of fertilizer. Transportation will only be worthwhile financially for farmers if they import large volumes since that will reduce the per bag cost of transportation. An example from Jaret Anderson, a fertilizer industry analyst at Salman Partners, demonstrates just how costly fertilizer can be due to transportation costs, representing about 35 percent of the price per ton of potash, if a mine development is not near to its end point of demand. Here he shows the transportation costs to Brazil:

“A potash supplier in Saskatchewan, such as Potash Corp or Mosaic, is likely to face transportation costs of \$35/ton to move its product from Saskatchewan to the port in Vancouver. To move the product to Brazil another \$35/ton via ship from Vancouver to the port in Brazil, and to get the fertilizer inland, another \$80-\$115/ton to move the product from the port in Brazil to the inland location where the fertilizer blenders actually need the product. The total cost of end-to-end transportation is somewhere between \$150 and \$185/ton” (Mack, 2011).

Current prices being around \$500 per tonne, transportation can represent up to 40 percent of the price paid by farmers at their gate. With Canpotex and BPS as the two distributors that produce at least 50 percent of the world’s resources, the market for potash fertilizers effectively becomes a duopoly. This in turn affects the options of transport costs that farmers can choose, ultimately reducing the bargaining power of the farmers.

3.2.4. Issues in Competition

3.2.4.1. Competition Strategies

Based on the history, the structure of the market appears to be based on capacity setting tendencies, which are driven by the demand for fertilizer. The game, in which this sequence plays out, can be either a Cournot or Bertrand competition. In 1983, Kreps and Scheinkman offer a relationship between Cournot and Bertrand like competition among firms that apply to the mining industry. The strategy that

a firm chooses (either Cournot or Bertrand) is usually said to have different effects on the market's equilibrium price. Kreps and Scheinkman, on the other hand, show that in the mining industry this is not the case. Kreps and Scheinkman say that, assuming profit maximization, firms will set the production capacity in a Cournot fashion for any given deposit. This production is then brought to the market in the second stage, where firms can observe the output of other companies and in a Bertrand-like competition, prices will be determined in the market based on marginal costs (Kreps and Scheinkman, 1983). Theoretically, in the long run potash mining companies will compete like capacity setting competitors and in the short run the price will be set through Bertrand competitive methods. These authors conclude that regardless of Bertrand price competition, outcomes will still be identical to the Cournot quantity competition.

The potash industry resembles this game structure, but based on the history of this industry, market quantities supplied are pre-determined by artificially set quotas and not the other firm's reaction functions. This differentiates the potash industry from the strategy model. According to Besanko and Braeutigam, the Cournot and Bertrand competition have yet another distinction in which the mining sector behaves like Cournot competitors. Miners take the output of their other competitors as given and assume that "competitors will instantly match any price change [a] firm makes so that they can keep their sales volume constant" (Besanko and Braeutigam, 2005, pg 495). This implies that prices can be adjusted quickly in the mining industry, whereas production can take longer to adjust. This will be investigated further in the next section.

3.2.4.2. *International Cartel*

The domestic supply for Canadian farmers only constitutes a small portion of the potash production, while the intended majority of production is for the international market. The reason why the potash

market is heavily lured to the international trade realm is because this is where the bulk of their profits come from which is guaranteed by their presence as a cartel. "PCS and Canpotex have traditionally adjusted production to make sure the market for potash does not become over supplied" (Moody's, 2011, page 6). This is demonstrated by their low operational rate of capacity. Part IV of the Competition Act in Canada states:

"(1)Every person commits an offence who, with a competitor of that person with respect to a product , conspires, agrees or arranges...(c)to fix, maintain, control, prevent, lessen or eliminate the production or supply of the product" (1985, page 52).

This collusive behaviour would be illegal domestically, but by utilizing an exemption for the export market, which can be found in the Canadian *Competition Act* section 45(5), the issue is avoided. The exemption states that:

"(5)No person shall be convicted of an offence under subsection (1) in respect of a conspiracy, agreement or arrangement that relates only to the export of products from Canada..." (1985, page 52).

By way of the exemption in the Competition Act of Canada, their cartel operations are performed legally through their international distributors. This means that the quantities of potash fertilizers are set, produced for the demand. For example, Canpotex is a distributor of potash fertilizers, owned by Potash Corp, Mosaic and Agrium potash producers. These producers fix their total supply on the international market. For them, this regulates and stabilizes the industry prices.

There has also been evidence of cartel like behaviour from the Potash Corporation of Saskatchewan. Korol and Larivière (1998) found that at the end of the 1980's, the United States prompted an anti-dumping action against PCS. Acting as a residual supplier, PCS would supply cheap fertilizer to US

consumers, choking profits of U.S. fertilizer producers. PCS reacted by increasing their price accordingly and all the other Saskatchewan producers followed with the same price increase. This indicates that although there may not be any formal cartel, fertilizer producers (especially Canadians) watch each other's pricing as signals to move prices together. "[The] low capacity utilization rate of PCS in comparison to other Canadian potash producers throughout this period suggests that PCS used their market power to restrict supply to the market in order to keep prices above what they would be otherwise" (Korol and Larivière, 1998).

In an interview with Chuck Childers, who ran Potash Corp. from 1987 to 1999, Mr. Childers stated "controlling the supply is a necessary evil in the fertilizer business" (Waldie, 2010). It is necessary in this business, again due to the difference in the economies of scales reached by each producer, which was also discussed as the reasons of the duopoly distribution chain. Going back to Figure 11 and Table 2, PCS has the largest production capacity followed by Mosaic, implying that they are better able to achieve economies of scale. Compared to Agrium, they have low operational rate of capacity. If all these firms were to compete with each other in a Cournot fashion, the operational rates of capacity would be higher than what is seen in Table 2. Followed by a more aggressive Bertrand strategy once the firms reached the market, Potash Corp. would reach economies of scale to undercut everyone in the market. They would get all the demand since the capacity is difficult to expand in the short run (that is, the upper limit of production) for this homogenous product that comes with asymmetric costs for firms. The result would leave Potash Corp. standing on its own to carry the market supply since the other firms would most likely sink and go out of business. The market would have a lower aggregate supply of potash fertilizer, putting further upward pressure on potash fertilizer prices. Whether this justification is the reason for the exemption, or something else, it is a legal action that the producers can use to

maximize their profits. As Childers said, "Not using a cartel when it's legal doesn't make much sense, does it" (Waldie, 2010) ?

3.2.4.3. Barriers to Entry

Allowing more competitors onto the Canadian potash production market, would be a viable way to increase the supply of potash without encountering conflicts of market dominance. Entry into the market for junior potash producers is very difficult. When potash fertilizer prices began to increase in 2010, normally the law of supply says that the quantity supplied will increase as well in response to price increases. Since 2006, there were no immediate moves to increase the quantity supply of potash. As discussed earlier, mining potash ore is a lengthy and costly task, indicating the first obstacle to entry for junior potash producers. "High capital costs and long lead times (7-10 years) highlight the economic risks associated with developing new greenfield capacity" (PotashCorp, 2010b, page 5). Given the comparative risk in potash fertilizer investment, compared to nitrogen or phosphate, potash fertilizer prices must stay high and stable long enough to ensure adequate recovery of investment compared to other mining initiatives in fertilizer. In other words, volatile in potassium prices that leave investors unsure as to whether the investment can be made back in the long run make the resource an unattractive investment.

In January 2010, the Saskatchewan government recognized this and implemented amendments to the potash tax system to encourage new entrants into the industry. These amendments were used in effect to remove barriers such as unfair competitive advantages compared to the incumbent firms in the industry (Saskatchewan Chamber of Commerce, 2011). When K+S AG, a German potash producer bought Potash One, (located in Saskatchewan) to produce a 2.7 million metric tonne solution mine, it has been the only foreign firm that has progressed the furthest through the approval process of the

Saskatchewan government (Moody's, 2011). The project bought by the German company in 2010 is expected to hit production by 2015. Contracts are another source of barriers to entry into the international potash fertilizer industry. Contracts, offered by potash producers, allow them to tie up their customers for a certain amount of time. This in effect reduces the flexibility of customers to choose the lowest prices around.

3.3. Fertilizer Prices

Since the producers of potash are few in number relative to the number of farmers that demand potash fertilizer, the producers will have greater bargaining power on potash fertilizer prices. Even at a local level, market fertilizer prices are driven by international trends, where China and India possess a large influence over the consumer bargaining power (Bain, 2009) and North America drives supply. Although we can expect future expansion in the capacity to produce fertilizer, markets are quick to absorb the new capacity that becomes available over the years, leaving very little, if any excess supply. Existing producers that normally restrain supply from the international market will bring this additional capacity to the market (Moody's, 2011).

In Potash fertilizer, contracts create the framework for international prices. Contracts stabilise potash prices, which subject potash prices to its long-term trends. In the short-run, this makes prices slow to react to market changes and producers keep a tight rein on supply in order to stay in sync with demand to avoid situations of excess supply and drop in prices. This keeps prices relatively stable allowing potash mining investors to keep confidence in their returns.

More recently, we can see (figure 13.A) that potash prices increased close to 500 percent from their initial value in less than a year. According to Potash Corps' CEO Bill Doyle "potash supplies [are] so tight,

and the demand [is] so high... there is a fundamental shift occurring in the potash market, with purchasers more willing to come to the table and settle long-term contracts to meet their pressing need" (Toovey, 2011). If this is the case, it indicates that the consumers expect potash fertilizer prices to continue rising in the future. This means that consumers are then willing to settle for a long-term contract and lock in potash prices, in an attempt to avoid higher future prices, despite the recent influx of new producers.

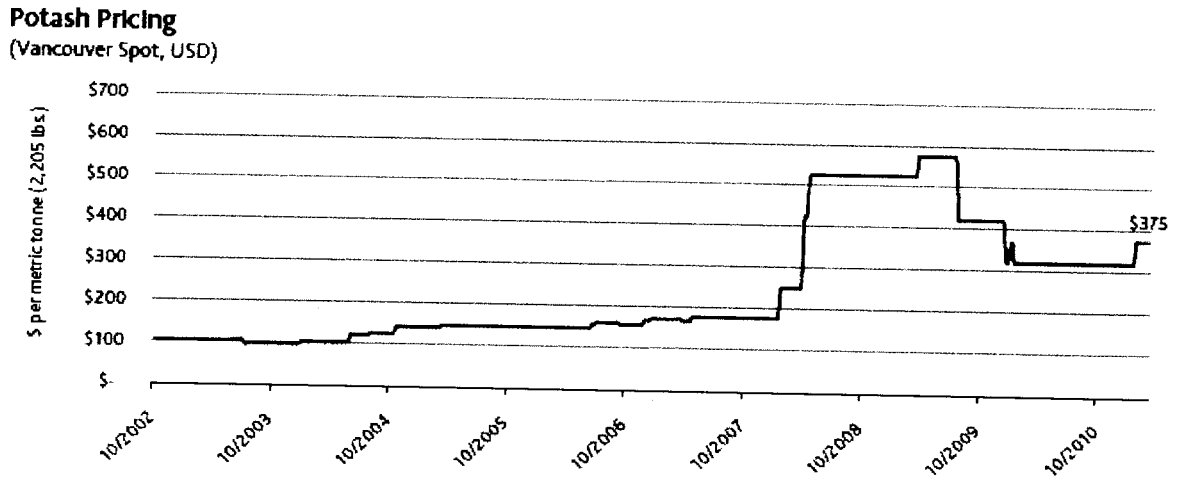
Potash prices were relatively stable up until the beginning of 2008, where the price jumped and increased almost three-fold, but dipped down again the end of 2009 and plateaued at approximately 150\$ above the price of potash before 2007. In comparison to Figure 13.b, the price of ammonia fertilizer is much more volatile, relative to the block like movements in the price of potash. According to the investigation into fertilizer prices by Agriculture Canada mentioned earlier, they found price volatility to be a healthy symptom of price competition since it means that prices are subject to the forces of supply and demand (Korol and Larivière, 1998). On the other hand, this does not mean that a lack of volatility as seen in figure 13.a, implies anti-competitive behaviour.

In contrast, the price for ammonia fertilizer follows a similar long run trend to potash, yet it experiences more volatile fluctuations in price. This indicates that there is greater price competition among other widely used fertilizers, but in the long run fertilizers are subject to the demand.

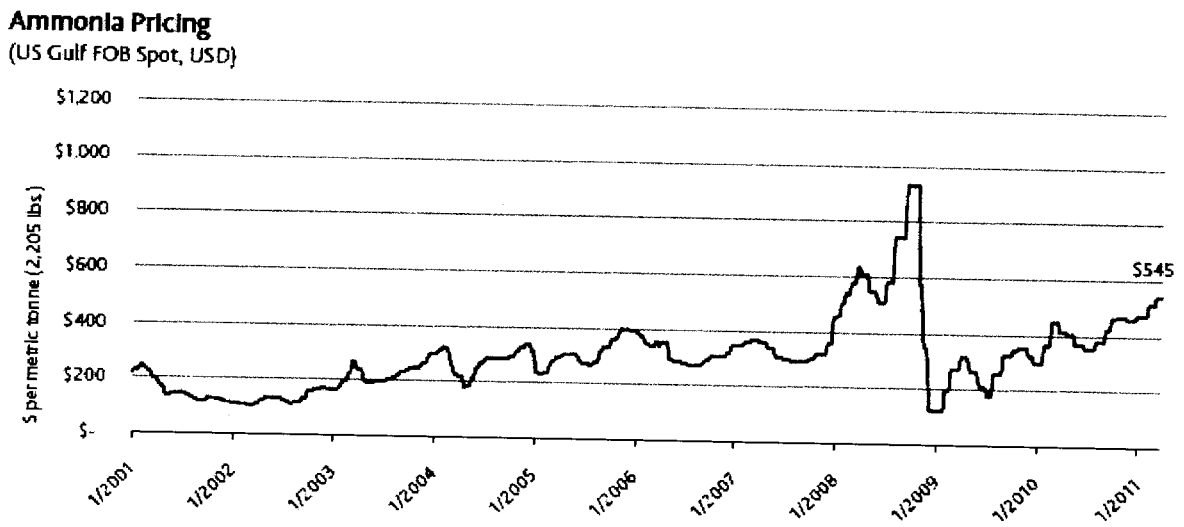
After surveying the economic literature and analysing data sets from the fertilizer industry, Korol and Larivière (1998) found that fertilizer prices in North America were subject to the forces of supply and demand (the majority of the forces that affected demand were from offshore). In particular, the potash fertilizer industry is characterised by controlled supplies, in contrast to nitrogen and phosphate fertilizers. Notably, the largest producer of fertilizer (not just potassium fertilizer), the Potash

Figure 13 – Fertilizer Pricing

13A. Potash Fertilizer Pricing



13B. Ammonia Fertilizer Pricing

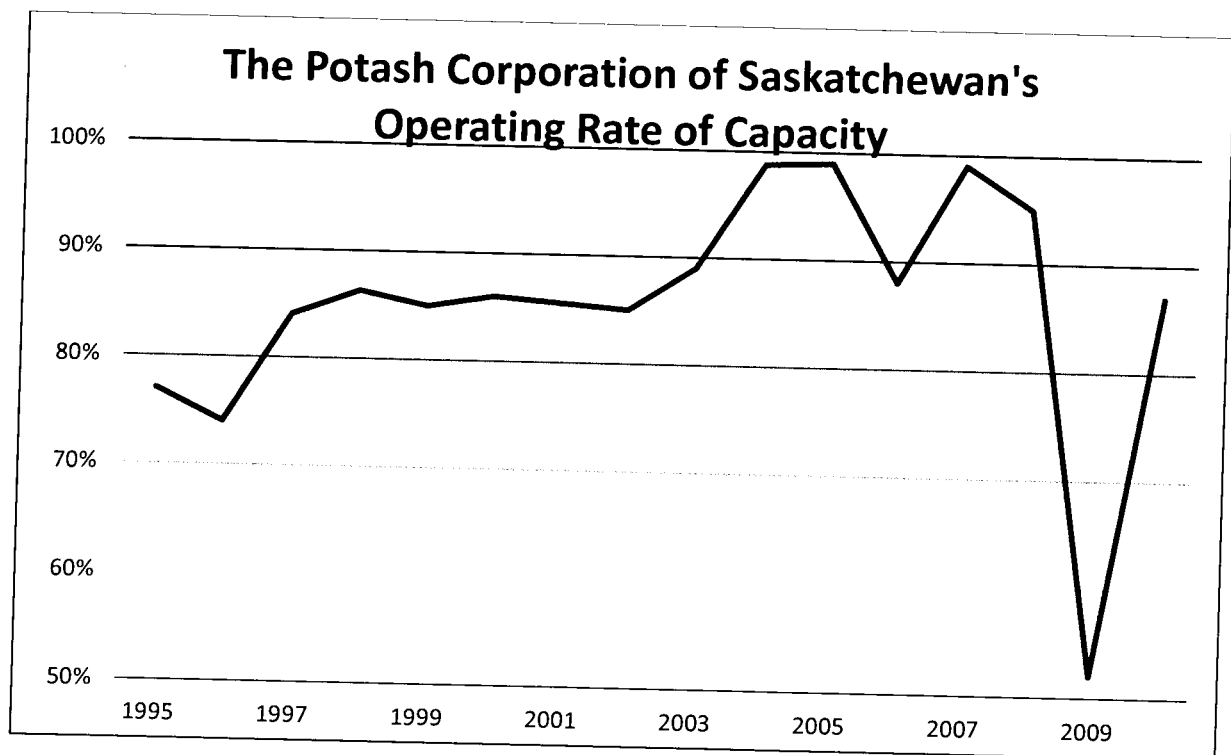


Source: Moody's Investor services, 2011

Corporation of Saskatchewan (PCS), holds this excess potash supply. Relative to other North American fertilizer producers, PCS keeps a large portion of their capacity idle.

With nitrogen (commonly known and sold as ammonium fertilizer) prices encountering the same peak during the end of 2008 that increased almost five-fold, also fell quickly before the beginning of 2009, almost 10 months before potash prices fell. At the end of 2009, nitrogen prices dropped to levels that had not been seen since 2002. On the other hand potash prices dropped, but still remained well above the prices seen before 2007. When considering this fact combined with the global drop in production values (approximately a 75% drop in global production) seen in Figure 10, which based on the discussion for that analysis the top three producers (Canpotex – representing Canada) made the most significant drop in production.

Figure 14 – Operating Rate of Capacity



Source: Recreated from Potash Corporation of Saskatchewan's Presentation on global Fertilizer, 2011

In figure 13A, this comparison suggests that the Vancouver spot price (i.e. Canpotex's selling price) was low but still above prices seen before 2007, yet the production was at its lowest level in at least a decade. The PCS further illustrates this in light of Figure 14 (recreated from their presentations) that shows their cut in capacity use in 2009, which reduced the impact of dropping prices by leaving the supply "tight". In other words for a profit maximizing firm to cut production levels in 2009 to the lowest in over a decade, even though prices remained well above the prices prior to 2006 is counter intuitive since it implies that PCS was not maximizing their revenue. A possible reason for this inconsistency could be due to maintenance, since in Figure 14, the years prior to this cut in production, PCS was operating at almost full capacity to supply the growing demand.

4. Poverty Analysis

The agricultural sector plays a role in economic development, such that it can "supply cheap food and low wage labour to the modern sector" (Dethier and Effenberger, 2011, page 6). Although the agricultural sector has always been characterized by low productivity and consequently growth, when the it becomes more productive, it increases its ability to supply cheap food to the modern sector.

Industrialization has been seen as the driving force behind any economic development, but Dethier and Effenberger (2011) find that the agricultural sector feeds and nourishes the modern sector. Although this idea is largely disputed, Johnston and Mellor (1961) account for agriculture's importance through a production and consumption linkage. That is to say, the agricultural sector supplies material inputs to the non-agricultural sector and demands input from the modern sector. Due to higher productivity, consumption also increases when income increases. Singer (1979) also expressed that agricultural productivity would initiate industrialization, but it was conditional that there are mainly small to

medium sized farmers, since larger agricultural producers will weaken the production and consumption linkages by importing required inputs to productions.

In the presence of risk, increasing the supply of potash fertilizer could be a creditable means of development for poorer agricultural farmers since there would be "...substantial synergies in complementing interventions that foster access to credit with interventions that help households cope with shocks" (Dercon and Christiaensen, 2010, page 2). A drop in potash prices would reduce farmer liability to credit agencies, reducing the risk for lenders, thus providing more access to farmers. A drop in the potash prices would encourage more potash fertilizer usage, which will provide resilience to crops when presented with droughts, which is common in Africa, as well as larger crop growth to insure consumption for the household. An interesting study would be to evaluate Figure 8 with potash in the mix, since the figure presented here only using nitrogen and phosphorus fertilizers. Based on the information presented in this paper, the data suggests that the left side of the crop yield curve with potash fertilizer would increase, since potash results in better yields even in times of drought.

Let's suppose there are no barriers to this market solution and that there was immediate incentive to open another mine. Based on all of this information found in the Industrial analysis, we can deduce that the cost of opening a greenfield solution mine by any junior potash producer is approximately 2.5-3\$ billion dollars. This would produce an extra 2 million tonnes of Potash per year. This has the potential to increase the global supply of potash fertilizer by 10 percent.

After 2004, Canada saw an increase in the total operational capability due to the tax incentive programs launched by the provincial government to build more mines, and demand quickly absorbed this extra supply by 2007 (PotashCorp., 2011). Once a mine is operating at full capacity, the major international

consumers will absorb the extra 2mmt, assuming consumption remains at the same concentration levels. This implies that fertilizer use will increase by 10 percent. In regions such as Ethiopia, extra fertilizer can improve yields significantly based on the current low application rates of fertilizer. Based on the cereal output and fertilizer application elasticity of 0.12 estimated by Demery and Christiaensen (2007), a 10 percent increase in the use of fertilizer would increase the output of cereal production by 1.2 percent. Christiansen and Demery (2007) also estimate that increasing the per capita growth in agriculture by one percent can reduce poverty 1.6 times more than the same one percent per capita growth in any other sector. This means that if cereal production were to increase by 1.2 percent then, poverty is reduced 1.92 times more than the growth of any other sector. Also, based on some other of their estimates, a ten percent increase in nitrogen and phosphorus fertilizer consumption in this region can lead to a 0.2 percent increase in consumption, according to a fertilizer to consumption elasticity of 0.02 (Christiaensen and Demery, 2007). This is actually a much more significant estimate, rather than estimating the change in price, since the vast majority of the poor are found in rural regions depending on agriculture as a source of livelihood, which in most cases they are barely able to provide for themselves, especially in times of drought.

5. Conclusions

The impact that the recent food crisis has had on many areas inflicted with drought, has essentially escalated the problems of starvation and malnutrition for the people who live there. In an effort to determine whether there is anything Canada can do to alleviate poverty, the goal of this paper is to examine whether opening another potash mine could have any effective result on potash prices. By examining the role that fertilizer supply has on poverty, by means of a marginal potash mine, two effects were found to benefit both consumer and producers of agriculture by increasing fertilizer supply. By

reducing fertilizer prices the window (or likelihood) of profitability would grow for local farmers in the SSA.

The second benefit deals with the main problem in the food crisis. Being that access is a big issue especially during droughts (Sen, 1981), making potash available to farmers will provide them with a beneficial nutrient for crops when experiencing drought. Since 80 percent of the population in SSA depend on agriculture, by adding potash to their crops we could potentially increase food access to people through agricultural production. Access to food is the biggest challenge that SSA faces today. When people in poverty are exposed to droughts, like what is seen in the Horn of Africa, the crop yields are significantly reduced, limiting their access to food. They are also left with virtually no income to purchase available food that becomes further out of reach due to skyrocketing prices. Increasing and ensuring a farmer's crop yield through means of potash fertilizer seems to show great potential as a poverty aid, when compared to any other alternative form of aid.

This paper finds that the marginal potash mine constructed in Canada can increase consumption in the Ethiopian area by at least 0.2 percent. This has a potential of being a substantial increase in consumption and access to food. This entails little downside to Canada. Although the price for potash may decrease, reducing government revenues through taxes (this is made even more insignificant by means of tax holidays in the Canadian Industry), the Saskatchewan Chamber of Commerce themselves found that investment into a mine will contribute for the local economy with a multiplier effect of 1.8. This implies business opportunities and jobs for the Saskatchewan economy. Potash could be a source to save many lives and provide jobs. It deserves further studies on the effects that it can have on Ethiopian soils and the windows of profitability.

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