Liquidity Constraints in the Resource Extraction Industry

by

Daniel Anthony LaGattuta

B.A. Mathematics and Political Science

New York University, 1991

Submitted to the Department of Economics

in partial fulfillment of the requirements for the degree of

Doctor of Philosophy

at the

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

February 1997

©Daniel Anthony LaGattuta, MCMXCVII. All rights reserved.

The author hereby grant to MIT permission to reproduce and distribute publicly paper and electronic copies of this thesis document in whole or in part, and to grant others the right to do so.

Author ....

Department of Economics
January 2, 1997

Certified by ....

David Scharfstein
Dai-Ichi Kangyo Bank Professor of Management
Thesis Supervisor

Certified by ....

Jeremy C. Stein
J. C. Penney Professor of Management
Thesis Supervisor

Accepted by ....

Peter Temin
Elisha Gray II Professor of Economics
Chairman, Departmental Committee on Graduate Students

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

APR 15 1997

ARCHIVES

LIBRARIES

Contents

Acknowledgements

I would like to thank my parents, without whose support, both moral and financial, this thesis would not have been possible.

I also would like to thank my advisors, Professor David Scharfstein and Professor Jeremy Stein. Their help was critical in the successful completion of my dissertation. Also, I am very grateful for Professor Acemoglu's willingness to help, which was essential to me finishing in a timely manner.

Finally, I would like to thank all my friends here at M.I.T. who helped to make life here more than just an academic experience. In particular, I would like to thank Walter Toshi Baily and Eric Lindblad whose good friendship I will always remember.

Liquidity Constraints in the Resource Extraction Industry

by

Daniel Anthony LaGattuta

Submitted to the Department of Economics

on January 2, 1997, in partial fulfillment of the

requirements for the degree of

Doctor of Philosophy

Abstract

This thesis investigates three topics in corporate finance. The first and second chapters explore the role of liquidity constraints in the natural resource extraction industry. The first chapter focuses on the production decisions of OPEC members while the second chapter focuses on the production decisions of oil and gas firms. The third chapter diverges from the first two chapters and instead examines the informational role of special dividends.

The first chapter examines how the decision of a cartel member to deviate from agreed upon production quotas is influenced by that country's financial situation. Cartel members can experience short term gains by overproducing; however, they risk the breakdown of the cartel with negative consequences for long term profits. A model is constructed which shows that the more financially constrained a country is, the more likely it will cheat on agreed upon production quotas since the short-term benefits exceed the long-term costs of compliance. This model is empirically tested using production and financial data from OPEC members.

The second chapter also explores the role of liquidity constraints in the production decisions of natural resource extractors, but this time for firms. A model is constructed showing that firms facing financial difficulties have an incentive to move planned production from the future to the present. This model is then empirically tested for firms in the oil and gas industry.

The third chapter is about liquidity issues, though not about natural resources. In this chapter, I examine the role of special dividends as a means of distributing cash. I find that the stockmarket reacts particularly

favorably to firms announcing special dividends who also have poor investment opportunities. This provides evidence supporting the views, proposed by Easterbrook(1984) and Jensen (1986) that dividends are a way for managers to commit to not spending free cash flow on bad investments.

David Scharfstein

Dai-Ichi Kangyo Bank Professor of Management

Thesis Supervisor

Jeremy C. Stein

J. C. Penney Professor of Management

Thesis Supervisor

Chapter 1

Financial Constraints and the Production Decisions of OPEC Countries

1.1 Introduction

Much of the world's natural resources are under government control. Perhaps the leading example is oil, in which the Organization of Petroleum Exporting Countries (OPEC) controls more than a third of of world production. Copper and tin are other examples in which national governments control production through outright ownership of production facilities or indirect control of private companies.

This chapter examines whether the same sort of financial constraints that affect a private company's natural resource production policy also affect a country's production policy. We analyze this issue by looking at the production decisions of countries in the OPEC cartel. As is well known, OPEC allocates production quotas for each of its eleven members. At certain times, however, countries have produced more than their allotted quotas. We examine whether countries under greater financial pressure — for example those with large external debt obligations relative to gross national product — are more prone to exceed their quotas. One would expect financially constrained countries to have the greatest incentive to exceed their quota because the shadow value of funds in the short run is relatively high; it is more costly for these countries to defer profits by continuing to collude.

There is some anecdotal evidence that the more financially constrained countries are more prone to cheat. For example, in 1995, Venezuela was facing financial hardship. Its foreign exchange reserves had fallen, and it had substantial foreign debt payments due. The Venezuelan economy was heavily dependent on its petroleum sector which accounted for 22 percent of GDP and 45 percent of government revenues. Venezuela was also one of OPEC's largest cheaters that year. According to Frank Freisinger of The Economist Intelligence Unit, "Venezuela can't afford not to overproduce." (Wilson, 1995).

Section 2 of this chapter formalized this idea in a model of a cartel when the cartel members also face financial constraints. Section 3 describes the oil production and financial data from the OPEC countries and Section 4 uses these data to examine my hypothesis that the most financially constrained countries are the biggest cheaters. Section 5 concludes the chapter.

1.2 Model

In this section, I model the incentive factors that shows how different factors can affect the propensity for a cartel member to produce over their allotted quota. The basic model is one of a collusive duopoly in which two producers play a Repeated Prisoner's Dilemma game. The producers have the choice of cooperating and sharing monopoly profits or not cooperating and producing the Cournot outcome. If one producer deviates while the other producer still cooperates, the deviating producer will earn profits above monopoly profits for one period, but then will face a Cournot equilibrium from then onward. As is standard in models of this sort, for a high enough discount factor, the cooperation equilibrium can be maintained.

Each country produces a quantity of output, $Q_j, j = 1, 2$. The inverse demand curve for petroleum market is linear and given by:

$$P = a - bQ_T \tag{1.1}$$

where total production is:

$$Q_T = Q_1 + Q_2$$

and

$$a, b > 0$$

The countries face a constant marginal cost of production, c. If the two countries split monopoly profits equally, they will each produce an output level of:

$$Q_1^M = Q_2^M = \frac{a-c}{4b} \tag{1.2}$$

This will yield a monopoly price of:

$$P^M = \frac{a+c}{2} \tag{1.3}$$

and monopoly profits for each country of:

$$\pi_1^M = \pi_2^M = \frac{(a-c)^2}{8b} = \pi^M \tag{1.4}$$

Now, if one country deviates from the collusive monopoly outcome, then its optimal production, given that the other country continues to produce its share of monopoly production, is:

$$Q^{CH} = \frac{3(a-c)}{8b} \tag{1.5}$$

Since the other country's production remains unchanged, total industry production is:

$$Q_T^{CH} = \frac{5(a-c)}{8b} \tag{1.6}$$

yielding a price of:

$$P^{CH} = \frac{3a+5c}{8} \tag{1.7}$$

Profits for the cheaters and the non-cheaters are:

$$\pi^{CH} = \frac{9(a-c)^2}{64b} = \pi^{CH} \tag{1.8}$$

and

$$\pi^{NC} = \frac{3(a-c)^2}{32b} = \pi^{NC}, \tag{1.9}$$

respectively.

If one country cheats, the two countries play a Cournot game in each subsequent round of the game. This gives production levels, prices, and profits of:

$$Q_1^{CO} = Q_2^{CO} = \frac{a-c}{3b} \tag{1.10}$$

$$P^{CO} = \frac{a+2c}{3}$$

$$\pi_1^{CO} = \pi_2^{CO} = \frac{(a-c)^2}{9b} = \pi_T^{CO} \tag{1.11}$$

One can show that there will be no incentive to cheat if the countries have a high enough discount factor. Let δ_j equal the discount factor for country j. It is assumed to be exogenous and country specific. The discount factor measures the extent to which governments value income today relative to the future. Countries with low discount factors (high discount rates) place relatively higher weights on income today. As we argue below, one reason that δ may vary across countries is that some countries may be under greater financial pressure and hence place a greater value on current income.

In a Repeated Prisoner's dilemma, where the punishment is permanent, the producers will not cheat when the discounted value of cooperating forever is greater than the value of cheating for one period and being punished forever afterwards. To maintain the collusive solution, the discount factor must satisfy the following inequality:

$$\pi^M \geq \pi^{CH}(1-\delta_j) + \pi^{CO}\delta_j \tag{1.12}$$

The monopolist outcome can be maintained for all $\delta_j \geq \delta^*$,where:

$$\delta^* = \frac{\pi^{CH} - \pi^M}{\pi^{CH} - \pi^{CO}} \tag{1.13}$$

If $\delta_j < \delta^*$, the collusive monopoly outcome cannot be sustained.

One simple way to model the impact of financial constraints is to suppose that financially constrained countries have a low δ. Low δ countries will then have an incentive to deviate from the collusive outcome.

Another way to model financial constraints is to introduce debt into the model. The presence of debt may raise the likelihood that a producer will want to cheat. If a government has a high level of foreign debt, it might want to generate short term revenue through overproduction to avert a financial crisis. Another possibility is that a country may be heavily dependent on oil revenue for imports and if it does not increase exports, it will be forced to impose austerity measures. A government may prefer to borrow from world markets instead of violating their agreed quota agreements. But countries in financial straits are also countries that have difficulty borrowing in the first place. Overproducing petroleum to generate more revenue may be their best option to avoid financial crisis.

For example, suppose a government has some short term debt, D, due in the upcoming period. Let this level of debt be greater than the country's monopoly profits, $D > \pi^M$. Also, let the short term debt be less than the profits when a country cheats, $\pi^{CH} > D$. When a country has a shortfall in revenue, it faces some financial penalty, F, which can be thought of as a bankruptcy cost, the high cost of an outside loan, or the political cost of austerity measures. A government will now not want to cheat when:

$$(\pi^M - D - F)(1 - \delta_j) + \pi^M \delta_j > (\pi^{CH} - D)(1 - \delta_j) + \pi^{CO}\delta_j \tag{1.14}$$

This gives a new cutoff for the discount factor:

$$\delta^{**} = \frac{\pi^{CH} - \pi^M + F}{\pi^{CH} - \pi^{CO} + F} > \delta^* \tag{1.15}$$

The government now needs a higher discount factor to be willing to continue to abide by the quotas. This required discount factor also rises with the fine:

$$\frac{\partial \delta^{**}}{\partial F} = \frac{\pi^M - \pi^{CO}}{(\pi^{CH} - \pi^{CO} + F)^2} > 0 \tag{1.16}$$

The level of petroleum prices should also have an effect on whether countries adhere to an OPEC agreement. When prices are low, the oil producers should be facing greater financial difficulties than when the price is high. This should cause cheating to become more rampant. When the price is high, cheating should become rarer because the producer states would have enough income without resorting to cheating. This would give the commodity a pro-cyclical markup. I examined this effect by seeing how the incentive to cheat varies with demand (and hence prices) as measured by a, the intercept of the linear demand equation. One can show, however, that in the basic model without debt, there is no effect on the incentive to cheat:

$$\frac{\partial \delta^*}{\partial a} = 0 \tag{1.17}$$

This result follows from the fact that an increase in demand raises the monopoly, cheating, and Cournot profits proportionately, so that the incentive to cheat does not increase.

When debt is added to this model, this is changed. We assume that the producer once again has short term debt, D. The countries also face a financial penalty, F, when there is a shortfall. A value of D is chosen such that at the original value of a, $\pi^{CH} > D$ and $\pi^{M} < D$.

The necessary condition to maintain the cartel becomes:

$$(\pi^M - D - F)(1-\delta) + \pi^M \delta > (\pi^{CH} - D)(1-\delta) + \pi^{CO}\delta \tag{1.18}$$

or

$$\delta^* = \frac{\pi^{CH} - \pi^M + F}{\pi^{CH} - \pi^{CO} + F} \tag{1.19}$$

Now, one can show that $\frac{\partial \delta^*}{\partial a} < 0$. When demand increases, the discount factor needed to get cooperation falls. Debt makes a country more likely to cheat, but the effect diminishes in good times. Low prices and debt can cause producers to find themselves strapped for cash and more willing to deviate. With high prices, the countries may generate enough earnings to avoid financial penalties without without resorting to cheating.

Rotemberg and Saloner (1986) showed that markups can be counter-cyclical. Their model had the assumption that shocks to demand were mean reverting. If demand is low today, the payoff from cheating falls while future cooperation will yield high benefits. If the demand is high today, cheating will yield high payoffs today and future payoffs are expected to be low. This makes cheating more likely in periods of high prices. In my model, demand shocks are permanent and not mean reverting. A low demand period is not more likely to be followed by a high demand period and a high demand period is not more likely to be followed by a period of low demand. If those assumptions were placed into the model, it would make the model more complex and the net effects would be ambiguous.

The propensity to overproduce among members of OPEC should also be expected to depend on their size relative to the global market for petroleum. This is because large producers have a larger effect on the price of the commodity. A 1% increase in production for a large producer will have a more depressing effect on world prices than a 1% increase by a small producer. The greater the price elasticity of demand for a producer, the less likely they will want to overproduce because the lower prices will reduce the gains from cheating.

A country like Saudi Arabia, which usually pumps about a quarter of OPEC output, would have a very depressing effect on global oil prices if it increased production significantly. Countries like Ecuador, which have a very small share of the world's petroleum production, know that an increase in production will not lower world crude prices much. Large producers may also not want to overproduce because the disruptions to the market of large scale producers overproducing might trigger the breakdown of the cartel. If a small producer cheats, the other cartel members may be less inclined to want to end cooperation since prices are still relatively high.

How would an increase in the quota of a country change its incentive to cheat? If we move away from the earlier model to a situation where firms have production capacity, k_i, and quota, q_i, one can calculate the new cooperation, cheating and Cournot profits. This allows one to calculate the cutoff discount factor for firms, δ^* as a function of quota size. One can differentiate δ^* by the country' assigned production quota, q_j to get:

$$\frac{\partial \delta_j^*}{\partial q_i} = \frac{-bk_j((a - bQ_T - c_i)(K_T - Q_T + k_i - q_i) - bk_j(k_j(a - b(Q_T + k_j - q_j) - c_j) - q_j(a - bQ_T - c_j)))}{(b(K_T - Q_T - k_i + q_i))^2} < 0 \tag{1.20}$$

When a country's production is large relative to that of other countries, it will have less of an incentive to overproduce. It's larger size has a greater effect on price so that the benefits to overproducing decrease.

Another factor that might encourage a country to increase production is the presence of spare capacity. Many OPEC countries have large quantities of spare capacity. Most would maximize their earnings if they produced up to full capacity, because of their low marginal costs. The more capacity relative to their assigned quotas can give producers a greater incentive to cheat. On the other hand, a country with little or no spare capacity cannot increase their production enough in the short term to make cheating payoff.

In this modified model, the ratio of the quota assigned to a producer, q_j to total production capacity, k_j, is u_j.

$$u_i = \frac{q_i}{k_i} \tag{1.21}$$

Total industry capacity is K_T and total industry quotas are Q_T where:

$$\sum_{j=1}^{n} k_j = K_T \quad and \quad \sum_{j=1}^{n} q_j = Q_T \tag{1.22}$$

When the cartel holds, profits for producers are:

$$\pi_j^M = q_j(a - bQ_T - c_j) \tag{1.23}$$

When one country cheats while the other countries maintain their quotas, the cheating country earns a profit of:

$$\pi_j^{CH} = k_j(a - b(Q_T + k_j - q_j) - c_j) \tag{1.24}$$

After one country cheats, the cartel breaks down and all countries produce at full capacity giving each producer profits of:

$$\pi_j^{FC} = k_j(a - bK_T - c_j) \tag{1.25}$$

To maintain the cartel, countries need a discount factor, δ_j, such that:

$$\pi_j^M > \pi_j^{CH}(1 - \delta) + \pi_j^{FC}\delta_j \tag{1.26}$$

The new cutoff discount factor becomes:

$$\delta^* = \frac{k_j(a - b(Q_T + k_j - q_j) - c_j) - q_j(a - bQ_T - c_j)}{k_j(a - b(Q_T + k_j - q_j) - c_j) - k_j(a - bK_T - c_j)} = \frac{k_j(a - b(Q_T + k_j - q_j) - c_j) - q_j(a - bQ_T - c_j)}{k_j b(K_T - Q_T - k_j + q_j)} \tag{1.27}$$

Or in terms of u_j:

$$\delta_j^* = \frac{(a - b(Q_T + k_j - q_j) - c_j) - u_j(a - bQ_T - c_j)}{(a - b(Q_T + k_j - q_j) - c_j) - (a - bK_T - c_j)} = \frac{(a - b(Q_T + k_j(1 - u_j) - c_j) - u_j(a - bQ_T - c_j)}{b(K_T - Q_T - k_j(1 - u_j))} \tag{1.28}$$

As a firm has less spare capacity, u_j rises, a firm will be less likely to want to cheat:

$$\frac{\partial \delta_j^*}{\partial u_j} = \frac{(-a + b(k_j + Q_T) + c_j)b(K_T - Q_T - k_j(1 - u_j)) - bk_j(a - b(Q_T + k_j(1 - u_j) - c_j - u_j(a - bQ_T - c_j))}{(b(K_T - Q_T - k_i(1 - u_j)))^2} \tag{1.29}$$

or

$$\frac{\partial \delta_j^*}{\partial u_j} = \frac{(K_T - Q_T)(b(Q_T + k_j) - a + c_j)}{(b(K_T - Q_T - k_i(1 - u_j)))^2} < 0 \quad if \quad a - (b(Q_T + k_j) - c_j) < 0$$

As a country is given a quota closer to production capacity, it will become less likely to want to cheat. It will not need as high a discount factor for the producer to want to maintain production at the assigned quota. This holds true as as long as that country does not have such a large capacity so as to drive the price to below zero.

As the quota of a country is increased, the country becomes less likely to want to cheat and produce at full capacity. The benefit to cheating diminishes because profits cannot be increased enough in the cheating period to make up for the loss of profits in the punishment periods.

A country will also have a greater incentive to cheat if other countries are cheating as well. While, the OPEC cartel does not break down when only one member cheats, if cheating gets too large, there could be a breakdown of the cartel. Profits could become too small for the countries that still maintain their quotas to continue to want to do so. If other countries increase their production, a firm will see their discount factor cutoff rise. While in the previous model, Q_T was total industry quota, let it now represent total industry production when there is still some cooperation. As total industry production increases, the cutoff for the discount factor changes by:

$$\frac{\partial \delta_j^*}{\partial Q_T} = \frac{bk(k_i - q_i)(a - b(K_T + q) - c_j))}{(b(K_T - Q_T - k_i + q_i)))^2} > 0 \tag{1.30}$$

When other countries cheat so as to raise total industry production, the net benefits to not deviating decrease even if your departure from quota is the trigger that brings down the cartel. A higher discount factor would be needed to help sustain a cartel when other members are cheating.

These are not all the factors that can affect a country's propensity to overproduce. A country with a lower marginal cost will benefit more from cheating than a country with higher marginal costs since the low prices during the punishment phase would be less harmful. The size of a country's reserves can also have an effect on the propensity of a producer to cheat. Larger reserves mean a country has longer horizons and is more willing to cooperate. On the other hand, countries with large reserves will not want to have prices maintained at a high level because that will hurt the long term demand for their product. Also, firms with few reserves are taking away production from the near future when they increase production while firms with a lot of a resource reduce production in the far future. Because of discounting, it is more costly for a firm with small reserves to boost production through cheating. The net effect of reserve size is therefore ambiguous. Varying marginal costs and firm size will not be examined in this paper but can be included in further studies of this topic.

Finally, discount factors do not have to be the same for all countries. One could try to categorize countries by how forward looking their leaders are. Leaders of stable countries would be expected to pursue policies that are more forward looking than those of governments that are unstable. A military dictator may need to generate income for his subjects today to prevent dissent, while a Gulf monarch may feel more secure of his position because tradition protects him. Given two countries with the same financial characteristics, one insecure leader may want to cheat, while a secure leader may want to abide by their production quota because of their different discount rates.

Overall, these models predict that one will find more cheating in cartels when members have high short term debt commitments, a low quota relative to production capacity, low prices, a small size relative to the market, and when other members are cheating.

1.3 Data

The production levels of OPEC countries are set at meetings of the oil ministers of the OPEC countries which are held every few months. Strict production quotas were originally put into place in March 1983, at which time overall OPEC production was set at 17.5 million barrels a day. Quotas were changed several times over the next decade and a half. At the time of the March 1983 agreement, OPEC consisted of 13 members: : Algeria, Ecuador, Gabon, Indonesia, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudia Arabia, the United Arab Emirates, and Venezuela.

From March 1983 until September 1985, when the OPEC production quota agreements collapsed, Saudi Arabia played the role of the swing producer within OPEC. Though the Saudis were nominally given a quota of 5 million b/d in March 1983 and 4.353 million b/d in November 1984, their actual role was to adjust their production downward if other countries overproduced. The goal was to keep total OPEC production below a predetermined level so as to keep prices high. Cheating was so widespread by the end of 1985 that Saudi Arabia was forced to cut its production from its agreed level of 5 million b/d in 1983 to 2.2 million b/d in August 1985.

The strains of being the swing producer were so great that Saudi Arabia decided that it would be better off producing at full capacity, even at the lower prices this would generate. In the fall of 1985, the Saudis decided to pursue this high production strategy and abandoned its quota. The other OPEC countries had no option but to ignore their quotas as well. The price of oil collapsed from over $24 dollars a barrel to under $10 a barrel in a period of only a few months.

By August 1986, total OPEC production had risen from 16 million b/d in the fall of 1985 to over 21 million b/d. Saudi Arabia had seen the largest increase by tripling its production so that the Saudis were generating more revenue than before, even at the new low prices. By August 1986, the OPEC countries began to return to quotas but without Saudi Arabia as the swing producer. Quotas were changed again in December 1986 and January 1987. OPEC's total production was lowered to 15.8 million b/d.

One of the problems facing OPEC was that its share of the world oil market decreased in the 1980's. Demand during this period was fairly flat and non-OPEC production was rising. OPEC's high price strategy of the 1970's and early 1980's encouraged consumers to use petroleum more sparingly, and it encouraged non-OPEC producers to increase their exploration for oil. As a result, OPEC shifted its strategy to one of keeping prices at more moderate levels. The quota agreements of the late 1980's reflect this shift in strategy: In July, 1987, the total production quota was raised to 16.6 million b/d. It was then raised to 18.5 million b/d in, to 19.5 million b/d in July 1989, to 22.1 million b/d in January 1990 and finally in July 1990 to 22.5 million b/d.

Despite the increase in allowances for the member nations, quotas were violated frequently over this period. Griffin and Neilson (1994) claim that the Saudis were playing a tit-for-tat game with the other OPEC players. When the other countries violated their quotas, Saudi Arabia was more likely to respond with an increase as well. Saudi Arabia took on the role of punisher rather than swing producer.

Right before the Gulf War, Kuwait had become one of the larger cheaters. Iraq's decision to invade Kuwait in August of 1990 may have been partially motivated by the desire to punish Kuwait for cheating on their quotas. After the July 1990 agreement, Saddam Hussein sent his troops across the border into Kuwait. Petroleum was effectively shut off to world markets from both Kuwait and Iraq. The response of the other OPEC countries was to boost production. Some of these OPEC members, most notably Saudi Arabia, were closely allied with the alliance that was attempting to oust Saddam Hussein from Kuwait. It was not in the interest of Saudi Arabia's allies to have a terrible oil shock. It also would not have been good in the long run for OPEC because another bad price shock would have reduced the long run demand for petroleum. By December, 1990, OPEC production had returned to the 23.5 million b/d seen before the invasion. Most of this was due to Saudi Arabia increasing its production from 5.3 million b/d to 8.4 million b/d. The other

OPEC countries also increased their production but not by the same magnitude. Quotas were effectively abandoned during the period of the war.

After the Gulf War, with a recession beginning in the West, world oil demand slackened and there was once again a glut. OPEC found itself unable to reinstate quotas when the fighting ended. With Kuwait rapidly resuming petroleum production and the fear that the U.N. might allow Iraq to return soon to the market, OPEC was in disarray. It was not until December, 1992 that new quotas were finally put into place with total production set at 24.5 million b/d. Ecuador decided it would be better off not being a part of this agreement and withdrew from OPEC. In March 1993, total production was reduced to 23.5 million b/d. In October 1993, total production quotas were raised back to 24.5 million b/d and in June 1996 they were raised again to 25 million. The last quota agreement excluded Gabon which had stopped paying OPEC dues at the end of 1994. It is interesting to note that the two countries which left OPEC were also the smallest producers in the cartel. As small producers, they could not influence world prices and could better serve their interests by an expansion of their production.

The period that will be examined in this paper will be the time when the quotas were in effect. This is from March 1983 through September 1985, from December 1986 through July 1990, and December 1992 through July 1996. During the other periods of time, quotas were either non-existent or not meaningful. Cheating can only be examined when the quotas were generally being obeyed. Only when production quotas were meaningful can overproduction be meaningful.

Production quota information and production data can be found in the Petroleum Intelligence Weekly, the Petroleum Economist, the OPEC bulletin, and the Middle Eastern Economic Survey. The data on the quotas were consistent between the different journals. However, production estimates varied between these different sources. This is because the countries generally misreport their own production. In particular, countries which are cheating are not likely to want to admit this but instead will underreport production. It is in the interest of each OPEC member to pretend they are maintaining quotas when they are actually overproducing. The outside observers are therefore estimating what they believe to be the actual production level rather than observing it directly.

The OPEC Bulletin from 1990 onwards gives production estimates compiled from a variety of these outside secondary sources. I use this production data from the OPEC Bulletin for the period after 1990. For the period before 1990, I averaged the production levels found in The Petroleum Intelligence Weekly and The Petroleum Economist. Both quotas and production levels were measured in thousands of barrels per day.

Figure 1 shows the total OPEC production levels and the total OPEC quotas for the period of interest. Overproduction depends on how much they are producing over quota. The statistic that I have used to measure overproduction is the percentage that production is over quota for each country in each period of time. I used quarterly data on quotas and production to calculate this. Figure 2 shows overproduction as a percentage of quotas for OPEC as a whole. Overproduction seems to have been the biggest problem during the middle period from 1986 to 1990.

The empirical analysis included regressions of the overproduction variable ran against various independent variables. I used both OLS regressions as well as robust regressions to take into account of the high variance in the overproduction numbers. Only a few of the overproduction data points were removed because they were outliers. Nigeria in the third quarter of 1994 was excluded due to a strike that caused a temporarily large dip in production and Ecuador in the second quarter of 1987 was also excluded for a similar temporary collapse in petroleum production. Data points for Saudi Arabia were removed for the period before 1986 because of the Saudi role as a swing producer. It did not really have a quota during that period so it could not really overproduce. Iraq was also removed from the period after the Gulf War since its production was limited by United Nations' sanctions. Kuwait was removed for the period immediately after the Gulf War because production was well below its allotted quota because all its wells were not on line yet. This left 422 quarters of overproduction data.

The data was grouped into two periods. The first period was pre-1986 when the price of petroleum was very high in real terms and the second period was from 1986 onwards when the real price of oil was much lower. The second period actually has a two year gap because of the Gulf War but the period on both sides of the Gulf War were characterized by low prices. The real price of oil in $1992 can be seen in Figure 3. The average price of petroleum was $33.47 per barrel in 1992 dollars during the first period and less than half that price, at $15.32, during the second period. There were 120 quarters of data in the pre-1986 period and

320 quarters in the period after 1986.

The model developed in the previous section predicted that several factors can affect the decision of a producer in a cartel to cheat. One of these is the presence of spare capacity. The existence of spare capacity is necessary for a country to increase production as well as an incentive to increase production. Production capacity levels used here were found in the Oil and Gas Journal as well as the International Energy Statistics Sourcebook.

My model predicts that countries with financial constraints in the near term would be more likely to want to overproduce. I use the ratio of external debt service to GNP to proxy for short term financial constraints. External debt service to GNP is the sum of payments, both interest and principal repayments, on short and long term debt divided by GNP. Data on debt service is taken from the World Bank Debt Tables. The GNP numbers came from World Bank data as well.

Another prediction from my model is that larger producers should be more willing to stick to their quotas than small producers. I use the quota level of a country to proxy for a producer's size relative to the world market for petroleum. Also, cheating should be more likely when other producers are cheating. To measure the level of cheating, I calculated the percentage by which actual production exceeds allotted quotas for all other producers. A summary of the data used in this chapter can be found in Table 1 at the end of this chapter.

1.4 Empirical Results

To test my hypothesis, it is necessary to demonstrate that countries that are financially constrained are more likely to go over their assigned quotas than countries that are not financially constrained. In order to show this, I regressed overproduction against factors from my model that are expected to influence the decision to overproduce, including some that proxy for liquidity constraints. The dependent variable in these regressions is overproduction, defined as the percentage over the assigned quota that a country produces. In the first set of regressions, this is regressed against two independent variables, $UTIL$ and $DEBTSERV$.

As shown in the model section, a country that has a quota assignment close to its capacity level has less of an incentive to overproduce. The variable used to represent this capacity constraint, $UTIL$, is defined as the country's quota divided by the country's capacity. As this approaches 1, all capacity is being used to meet the quota so that there is little room to overproduce. $UTIL$ is predicted to be negatively correlated with overproduction.

In my model, countries that have larger short term obligations are more likely to overproduce. The variable, $DEBTSERV$, which is equal to a country's external debt service to GNP ratio, was used to proxy for this. $DEBTSERV$ would be expected to be positively correlated with a country's overproduction.

Table 2 displays the results for OLS regressions with $UTIL$ and $DEBTSERV$. The table is broken down into a period with all the data and two subperiods, pre-1986 and post-1986. The decision to split the sample into there two sub-periods was motivated by the fact that prices were significantly higher in the earlier period than the latter period and because during the first period, Saudi Arabia behaved as a swing producer. Since prices were lower in the second period, one would expect financial constraints to have a greater effect on production decisions then, than in the pre-1986 period.

During the whole period and the post-1986 period, there is a statistically significant negative coefficient on $UTIL$ as predicted, while in the pre-1986 period, the coefficient is insignificant. The coefficient on $DEBTSERV$ is positive and significant in the entire period and in the post-1986 as the model also predicted. For the pre-1986 period, the coefficient is positive but not quite significant. The explanatory power of these regressions is also much lower in the pre-1986 period than the post-1986 period. These OLS regressions are found to be consistent with the predictions of my model. Also, $DEBTSERV$'s significance increases when $UTIL$ is also included showing that financial constraints affect production more after capacity constraints are taken into account.

In the next set of regressions, I added country dummy variables to take into account fixed effects. Table 3 shows the results of these regressions. By including the fixed effects, the coefficient on $UTIL$ becomes negative and significant for all the regressions which is consistent with the model. Also, the $DEBTSERV$ variable is positive, though only significant during the later period. The reason why the coefficient's significance decreases with the inclusion of dummy variables is due to the fact that $DEBTSERV$ varies little over time for individual firms. When $DEBTSERV$ is regressed against country dummies, the country dummies can explain 72% of the variation in this ratio. By including these dummies, they are bound to reduce the effect of *DEBTSERV* somewhat.

A potential problem with these fixed effects regressions is heteroskedasticity between different countries in the data set. This can lead to coefficients showing significance when they should not. Consistent standard errors can be estimated using Huber's formula for individual-level data even if there is heteroskedasticity. Using the STATA routine for applying Huber's formula, I found only minor changes in the t-statistics of the regressions in Table 2 and Table 3. I was also concerned that a few outliers might be driving the regression results. The regressions in Table 2 and Table 3 were rerun using robust regressions. Only small changes were found showing that the results are robust.

According to my model, other variables that should affect the propensity of countries to overproduce are the size of the producer and whether or not other countries are overproducing. Larger producers should have less incentive to cheat since their cheating will have a greater effect on the price. I used the quota level in thousands of barrels a day to represent the variable for the size of a country in world markets, *SIZE*. My model also predicted that widespread cheating on the part of other producers should lead to more cheating for that producer. The variable representing other countries cheating, *OTHCHEAT*, is the percentage overproduction of all the other countries combined. Table 4 shows the results of OLS regressions with these variables added to the regressions shown in Table 2.

The coefficient on the *SIZE* variable is significantly negative which is consistent with the model. Larger producers overproduce less than smaller ones. The coefficient on *OTHCHEAT* is significantly positive in the whole period and in the second period. In the first period, it is negative, but insignificant. The absence of a positive coefficient in the earlier period may be due to Saudi Arabia's role as a swing producer. When other countries cheated, it was expected that Saudi Arabia would reduce production accordingly. This would reduce the incentive to overproduce when countries observed other countries overproducing.

Table 5 displays the same regressions as Table 4, but with country dummies to take into account fixed effects. The only notable things about including firm dummies is that *SIZE* lose its significance. Since country size is relatively constant over time, the inclusion of country dummies reduces the explanatory power of the *SIZE* variable.

I also checked the robustness of the regressions in Table 4 and Table 5. The only difference is that the coefficient on $DEBTSERV$ loses significance in the post-1986 regression of Table 4.

One reason why the coefficient on the debt service to GNP ratio is not higher, is because there might be a strong correlation between $UTIL$ and $DEBTSERV$. If my hypothesis is correct, countries that are financially constrained should be expected to cheat more than those that are not financially constrained. If OPEC's oil ministers realized this, they should be willing to give debt constrained countries larger quotas relative to their production capacity compared with other countries. That will help to preserve compliance within the cartel.

To test whether the ratio of quotas to production capacity was higher for countries more debt constrained, I regressed $UTIL$ against $DEBTSERV$ for the quarters where quotas were changed. The results are in Table 6. We see here that there is a strong positive correlation between the two. The effect is much stronger in the period before 1986, probably because the industry had more overcapacity than in the later period.

Countries that are producing close to full capacity will be unable to increase production much more even if they want to do so. This means that as $UTIL$ increases the coefficient on $DEBTSERV$ should fall. For example, if a country was running at 100% of capacity, the coefficient on $DEBTSERV$ should be zero because debt cannot increase production. To take this effect into account, I included an interaction variable, $UTILDEBT$, that multiplies the $UTIL$ and the $DEBTSERV$, in the next set of regressions. The coefficient on $UTILDEBT$ is expected to be negative because less sparecapacity should reduce the effect of financial constraints on production desisions.

Table 7 shows the results of an OLS regression of overproduction against $UTIL$, $DEBTSERV$ and the interaction variable, $UTILDEBT$. The coefficient on the interaction variable is significantly negative and the coefficient on $DEBTSERV$ is significantly positive for all periods. The adjusted R^2 is significantly higher in the second period as compared with the first period.

In Table 8, the regressions in Table 7 were rerun with country dummy variables to take into account fixed effects. The results showed a loss of significance on the liquidity variable in the post-1986 period. When a robust regression was run, the coefficients were found to be the right sign and significant again. However, when heteroskedasticity is taken into account, the results do change. The t-statistics on $DEBTSERV$ and

UTILDEBT become larger in the pre-1986 period, but lose significance in the post-1986 period. The loss of significance is is due to the presence of a few countries overproducing very large quantities.

I was concerned that my regressions were underestimating the effects of capacity constraints. For example, a firm running at 90% capacity can raise production by 11%, but a firm running at 50% capacity can boost output by 100%. Thus, one would not expect the effects of *UTIL* on overproduction to be linear. I decided to create a new variable, $UTIL^2$ to take into account the non-linear effects of capacity constraints. The coefficient on $UTIL^2$ would be expected to be positive since the effect of excess capacity decreases as utilization rises.

Table 9 displays the regressions when this term is included. We see that the coefficient on *DEBTSERV* is significantly positive in all periods and the coefficient on *UTILDEBT* is significantly negative in all periods as predicted. This time, when heteroskedasticity is taken into consideration, the coefficients remain significant.

Table 10 adds dummies to the regressions in Table 9 to take into account fixed effects. While the liquidity variables lose significance for the period as a whole, *DEBTSERV* is significantly positive in both sub-periods and *UTILDEBT* is significantly negative in both sub-periods. The results did not change significantly when they were checked for robustness. When the effects of heteroskedasticity were included this time, the significance of the coefficients did not change.

I redid the regressions in the previous four tables using *SIZE* and *OTHCHEAT* with the other independent variables. There was no significant change in the results.

I also investigated how the the oil price and overproduction decisions interacted. One would expect that when the price is low, debt constrained countries might be more tempted to cheat. I included in an OLS regression a variable for the real price of oil, *PRICE*, and a cross term for real price times *DEBTSERV*, *DSPRICE*. The results are displayed in Table 11. The coefficient on price is significantly negative and the cross term is significantly positive when the entire sample is viewed together. The largest differences in price occur between the periods before and after 1986 so that the price variable is probably proxying more for differences between periods than anything else. When the sample is broken down between the two periods, the terms using pnce loses significance.

The coefficient on *DEBTSERV* is significantly positive in the second period and the coefficient on *UTILDEBT* is significantly negative in all periods. When robust regressions are used, that does not change. However, price and the interaction of financial constraints with price are shown to not be significant factors in deciding how much to overproduce when the price differences are small (as they are within each sub-period).

Finally, I reran the basic regressions with time dummies. For each quarter represented, there was a dummy included in the OLS regressions of overproduction on *UTIL*, *DEBTSERV*, and *UTILDEBT*. The results from these regressions are in Table 12. When the time dummies are included, there is almost no effect on the financial coefficients. I also redid this with annual dummies which resulted in no real changes.

1.5 Conclusion

The financial constraints that cartel members face are important factors in their decision to produce at either their assigned quota or to overproduce above that quota. In this chapter, it was shown theoretically that a producer with a large debt obligation in the short run, a large market share, or a lot of spare capacity is more inclined to cheat than other firms. And, a producer is more likely to cheat when other producers were cheating.

The empirical results generally support the model's predictions. First, countries with considerable excess capacity are more likely to overproduce than those with little spare capacity. Second, countries with a large debt service to GNP ratio are more likely to cheat. Third, large producers are reluctant to cheat and finally, a country is more likely to cheat when other firms are cheating.

The results show that financial constraints generally have a greater explanatory power in the post-1986 period. This is consistent with the idea that in low price periods, financial constraints will have a greater effect on production decisions than high price periods.

The propensity of debt constrained producers in a cartel to cheat is certainly underestimated in this chapter. It was shown that countries with more debt service are given relatively large quotas which reduced their incentives to cheat. If quotas, as a percentage of production capacity, had been the same thoughout the cartel, one would have expected to see more widespread cheating on the part of debt constrained producers.

The results of this chapter have implications for other cartelized industries. Prices for commodities produced by cartels should be expected to be more volatile when the cartel members are financially constrained. More debt means there will be more production during times of low prices keeping prices down. When prices are high, cooperation becomes more likely to be maintained so that prices remain high. This would make these prices become more pro-cyclical as the industry becomes more leveraged.

Table 1			
Summary Statistics			
Variables	Mean	Mean	Mean
	Total Period	Before 1986	1986 and After
OVERPRODUCTION	.100	.073	.110
	(.196)	(.073)	(.213)
UTIL	.712	.594	.756
	(.185)	(.198)	(.159)
UTILDEBT	.040	.038	.041
	(.033)	(.030)	(.035)
DEBTSERV	.053	.057	.052
	.(036)	(.030)	(.035)
SIZE	1544	1016	1741
	(1494)	(611)	(1669)
OTHCHEAT	.064	.004	.086
	(.087)	(.051)	(.087)
Number of Observations	442	120	322

Notes: This table reports the summary statistics of the data analyzed in this paper. *OVERPRODUCTION* is the percentage crude production is above a country's quota that they produce. *UTIL* is the percentage of production capacity that can be produced under the quota. *UTILDEBT* is the crossproduct of *UTIL* and *DEBTSERV*. *DEBTSERV* is the ratio of external debt service to *GNP*. *SIZE* is the size of a country's quota in thousands of barrels a day. *OTHCHEAT* is the percentage above quota that all other members of OPEC are producing for that quarter.

Table 2									
Variable	Total Period			Before 1986			After 1986		
	1	2	3	4	5	6	7	8	9
UTIL		-.298	-.349		.079	-.013		-.663	-.741
		(-6.15)	(-6.78)		(1.23)	(-0.14)		(-10.21)	(-10.96)
DEBTSERV	.104		.744	.854		.913	-.023		1.001
	(0.40)		(2.78)	(1.97)		(1.53)	(-0.07)		(3.51)
Constant	.094	.312	.308	.024	.026	.028	.111	.611	.618
	(5.58)	(8.75)	(8.70)	(0.87)	(0.65)	(1.53)	(5.47)	(12.18)	(12.52)
Adjusted. R^2	-.002	.077	.187	.024	.004	.015	-.003	.243	.269
Number of Obs.	442	442	442	120	120	120	322	322	322

$$\frac{QP_{it}-QT_{it}}{QT_{it}} = \alpha + \beta_1 UTIL_{it} + \beta_2 DEBTSERV_{it} + \epsilon_{it}$$

UTIL is the fraction of the country's production capacity that is part of the quota.

DEBTSERV is the ratio of the country's debt service to GNP

Table 3									
Variable	Total Period			Before 1986			After 1986		
	1	2	3	4	5	6	7	8	9
UTIL		-.198	-.203		-.805	-.779	-.658		-.653
		(-3.43)	(-3.52)		(-3.74)	(-3.56)		(-8.45)	(-8.49)
DEBTSERV	.622		.711	1.301		.700	1.989		1.879
	(1.37)		(1.58)	(1.27)		(.071)	(2.89)		(3.03)
Constant	.183	.390	.327	.207	.976	.891	-.015	.642	.457
	(3.26)	(6.93)	(4.74)	(2.12)	(5.52)	(4.17)	(-0.18)	(8.96)	(4.88)
Adjusted. R^2	.212	.230	.233	.488	.541	.538	.272	.393	.409
Number of Obs.	442	442	442	120	120	120	322	322	322

$$\frac{QP_{it}-QT_{it}}{QT_{it}} = \alpha + \beta_1 D_j + ... + \beta_{13} D_j + \beta_{14} UTIL_{it} + \beta 15 DEBTSERV_{it} + \epsilon_{it}$$

UTIL is the fraction of the country's production capacity that is part of the quota.

DEBTSERV is the ratio of the country's debt service to GNP.

Country dummy variables, D_j, are included.

Table 4			
Variable	Total Period	Before 1986	After 1986
UTIL	-.318	-.017	-.662
	(-6.24)	(-.20)	(-9.24)
DEBTSERV	.463	-.477	.699
	(1.64)	(-0.77)	(2.73)
SIZE	-.000016	-.00010	-.000012
	(-2.60)	(-4.26)	(-1.81)
OTHCHEAT	.539	-.306	.294
	(5.46)	(-1.32)	(2.41)
Constant	.292	.217	.569
	(8.26)	(3.72)	(10.30)
Adjusted. R^2	.180	.148	.286
Number of Observations	442	120	322

$$\frac{QP_{it}-QT_{it}}{QT_{it}} = \alpha + \beta_1 UTIL_{it} + \beta 2 DEBTSERV_{it} + \beta_3 SIZE_{it} + \beta_4 OTHCHEAT_{it} + \epsilon_{it}$$

UTIL is the fraction of the country's production capacity that is part of the quota.

DEBTSERV is the ratio of the country's debt service to GNP.

SIZE is the size of the firm measured in production in thousands of barrels per day.

OTHCHEAT is the percentage over quota of the other firms from the previous quarter.

Table 5			
Variable	Total Period	Before 1986	After 1986
UTIL	-.140	-.886	-.500
	(-1.92)	(-3.36)	(-4.80)
DEBTSERV	.664	.665	1.93
	(1.54)	(0.66)	(3.17)
SIZE	-.000023	.00022	-.000001
	(-1.17)	(0.84)	(-0.37)
OTHCHEAT	.570	-.025	.436
	(6.16)	(-0.13)	(3.79)
Constant	.223	.940	.288
	(4.79)	(4.12)	(2.72)
Adjusted. R^2	.302	.533	.407
Number of Observations	442	120	322

$$\frac{QP_{it}-QT_{it}}{QT_{it}} = \alpha + \beta_1 D_j + \ldots + \beta_{13} D_j + \beta_{14} + \beta_{15} UTIL_{it} + \beta_{16} DEBTSERV_{it} + \beta_{17} SIZE_{it} + \beta_{18} OTHCHEAT_{it} + \epsilon_{it}$$

UTIL is the fraction of the country's production capacity that is part of the quota.

DEBTSERV is the ratio of the country's debt service to GNP.

SIZE is the size of the country's quota in thousands of barrels per day.

OTHCHEAT is the percentage over quota of the other firms from the previous quarter.

Table 6			
Variable	Total Period	Before 1986	After 1986
DEBTSERV	2.117	4.835	1.795
	(5.07)	(4.24)	(4.37)
Constant	.602	.332	.648
	(21.79)	(4.71)	(23.51)
Adjusted. R^2	.168	.425	.156
Number of Observations	123	24	99

$$UTIL_{it} = \alpha + \beta_1 DEBTSERV_{it} + \epsilon_{it}$$

$UTIL$ is the fraction of the country's production capacity that is part of the quota.

$DEBTSERV$ is the ratio of the country's debt service to GNP.

Table 7			
Variable	Total Period	Before 1986	After 1986
UTIL	-.176	.458	-.530
	(-1.75)	(2.40)	(-4.22)
UTILDEBT	-3.612	-6.894	-4.730
	(-1.99)	(-2.75)	(-1.99)
DEBTSERV	3.679	5.298	4.947
	(2.46)	(3.12)	(2.47)
Constant	.174	-.241	.449
	(2.30)	(-2.29)	(4.56)
Adjusted. R^2	.097	.068	.276
Number of Observations	442	120	322

$$\frac{QP_{it}-QT_{it}}{QT_{it}} = \alpha + \beta_1 UTIL_{it} + \beta_2 UTILDEBT_{it} + \beta_3 DEBTSERV_{it} + \epsilon_{it}$$

$UTIL$ is the fraction of the country's production capacity that is part of the quota.

$UTILDEBT$ is the cross product of $UTIL$ and $DEBTSERV$.

$DEBTSERV$ is the ratio of the country's debt service to GNP.

Table 8			
Variable	Total Period	Before 1986	After 1986
UTIL	-.170	-.244	-.527
	(-1.63)	(-0.67)	(-3.23)
UTILDEBT	-.757	-6.782	-2.774
	(-0.39)	(-1.81)	(-0.88)
DEBTSERV	1.370	5.838	4.450
	(0.77)	(1.94)	(1.49)
Constant	.294	-.114	.181
	(2.64)	(-1.92)	(1.62)
Adjusted. R^2	.231	.548	.408
Number of Observations	442	120	322

$$\frac{QP_{it}-QT_{it}}{QT_{it}} = \alpha + \beta_1 D_j + \ldots + \beta_{13} D_j + \beta_{14} UTIL_{it} + \beta_{15} UTILDEBT_{it} + \beta_{16} DEBTSERV_{it} + \epsilon_{it}$$

$UTIL$ is the fraction of the country's production capacity that is part of the quota.

$UTILDEBT$ is the cross product of $UTIL$ and $DEBTSERV$.

$DEBTSERV$ is the ratio of the country's debt service to GNP.

Country dummy variables, D_j, are included.

Table 9			
Variable	Total Period	Before 1986	After 1986
$UTIL$	-.356	.468	-3.234
	(-0.96)	(1.03)	(-6.72)
$UTIL^2$	.146	-.009	2.146
	(0.50)	(-0.02)	(5.80)
$UTILDEBT$	-3.890	-6.863	-10.513
	(-2.05)	(-2.38)	(-4.25)
$DEBTSERV$	3.873	5.283	9.429
	(2.50)	(2.89)	(4.58)
Constant	.224	-.244	1.218
	(1.80)	(-1.69)	(7.50)
Adjusted. R^2	.096	.060	.343
Number of Observations	442	120	322

$$\frac{QP_{it}-QT_{it}}{QT_{it}} = \alpha + \beta_1 UTIL_{it} + \beta_2 UTIL_{it}^2 + \beta_3 UTILDEBT_{it} + \beta_4 DEBTSERV_{it} + \epsilon_{it}$$

$UTIL$ is the fraction of the country's production capacity that is part of the quota.

$UTIL^2$ is the fraction of the country's production capacity that is part of the quota squared.

$UTILDEBT$ is the cross product of $UTIL$ and $DEBTSERV$.

$DEBTSERV$ is the ratio of the country's debt service to GNP.

Table 10			
Variable	Total Period	Before 1986	After 1986
UTIL	.564	-.534	-2.866
	(1.28)	(-0.42)	(-4.94)
$UTIL^2$	-.596	.206	1.888
	(-1.72)	(0.24)	(4.19)
UTILDEBT	.541	-6.920	-8.172
	(0.26)	(-1.82)	(-2.45)
DEBTSERV	.589	5.995	8.144
	(0.32)	(1.94)	(2.67)
Constant	.066	.581	1.029
	(0.39)	(1.17)	(4.06)
Adjusted. R^2	.235	.544	.438
Number of Observations	442	120	322

$$\frac{QP_{it}-QT_{it}}{QT_{it}} =$$

$$\alpha+\alpha+\beta_1 D_j+\ldots+\beta_{13}D_j+\beta_{14}UTIL_{it}+\beta_{15}UTIL_{it}+\beta_{16}UTIL^2_{it}+\beta_{17}UTILDEBT_{it}+\beta_{18}DEBTSERV_{it}+\epsilon_{it}$$

UTIL is the fraction of the country's production capacity that is part of the quota.

UTILDEBT is the cross product of *UTIL* and *DEBTSERV*.

DEBTSERV is the ratio of the country's debt service to GNP.

Country dummy variables, D_j, are included.

Table 11			
Variable	Total Period	Before 1986	After 1986
UTIL	-.408	.509	-.504
	(-3.64)	(2.89)	(-3.73)
UTILDEBT	-1.789	-7.076	-4.485
	(-0.99)	(-3.08)	(-1.82)
DEBTSERV	.134	15.236	4.188
	(0.08)	(2.20)	(1.38)
PRICE	-1.208	.676	-.480
	(-4.82)	(0.49)	(-1.03)
DSPRICE	11.628	-34.578	2.031
	(3.26)	(-1.65)	(0.18)
SIZE	-.00002	-.00011	-.00013
	(-3.24)	(-4.68)	(-2.05)
OTHCHEAT	.376	-.025	.294
	(3.63)	(-0.09)	(2.40)
Constant	.580	-.288	.560
	(5.12)	(-0.63)	(3.11)
Adjusted. R^2	.209	.233	.293
Number of Observations	442	120	322

$$\frac{QP_{it}-QT_{it}}{QT_{it}} = \alpha + \beta_1 UTIL_{it} + \beta_2 UTILDEBT_{it} + \beta_3 DEBTSERV_{it} + \beta_4 PRICE_t + \beta_5 DSPRICE_{it} + \beta_6 SIZE_{it} + \beta_7 OTHCHEAT_{it} + \epsilon_{it}$$

$UTIL$ is the fraction of the country's production capacity that is part of the quota.

$UTILDEBT$ is the cross product of $UTIL$ and $DEBTSERV$.

$DEBTSERV$ is the ratio of the country's debt service to GNP.

$PRICE$ is the real price of a barrel of crude oil in 1992 dollars.

$DSPRICE$ is the cross product of $PRICE$ and $DEBTSERV$.

$SIZE$ is the size of the country's quota in thousands of barrels per day.

$OTHCHEAT$ is the percentage over quota of the other firms from the previous quarter.

Table 12			
Variable	Total Period	Before 1986	After 1986
UTIL	.301	.548	-.652
	(2.93)	(2.76)	(-5.39)
UTILDEBT	-3.612	-7.434	-7.432
	(-2.17)	(-2.89)	(-3.27)
DEBTSERV	4.025	5.285	7.438
	(2.80)	(3.06)	(3.85)
Constant	.288	-0.233	.564
	(3.00)	(-2.06)	(5.20)
Adjusted. R^2	.097	.046	.393
Number of Observations	442	120	322

$$\frac{QP_{it}-QT_{it}}{QT_{it}} =$$

$$\alpha + \beta_1 UTIL_{it} + \beta_2 UTILDEBT_{it} + \beta_3 DEBTSERV_{it} + \beta_4 SIZE_{it} + \beta_5 OTHCHEAT_{it} + t_1 + t_2 + ... + t_{48} + \epsilon_{it}$$

$UTIL$ is the fraction of the country's production capacity that is part of the quota.

$UTILDEBT$ is the cross product of $UTIL$ and $DEBTSERV$.

$DEBTSERV$ is the ratio of the country's debt service to GNP.

$SIZE$ is the size of the country's quota in thousands of barrels per day.

$OTHCHEAT$ is the percentage over quota of the other firms from the previous quarter.

Period dummy variables, t_j, are included.

Figure 1.1 - OPEC Production and Quotas

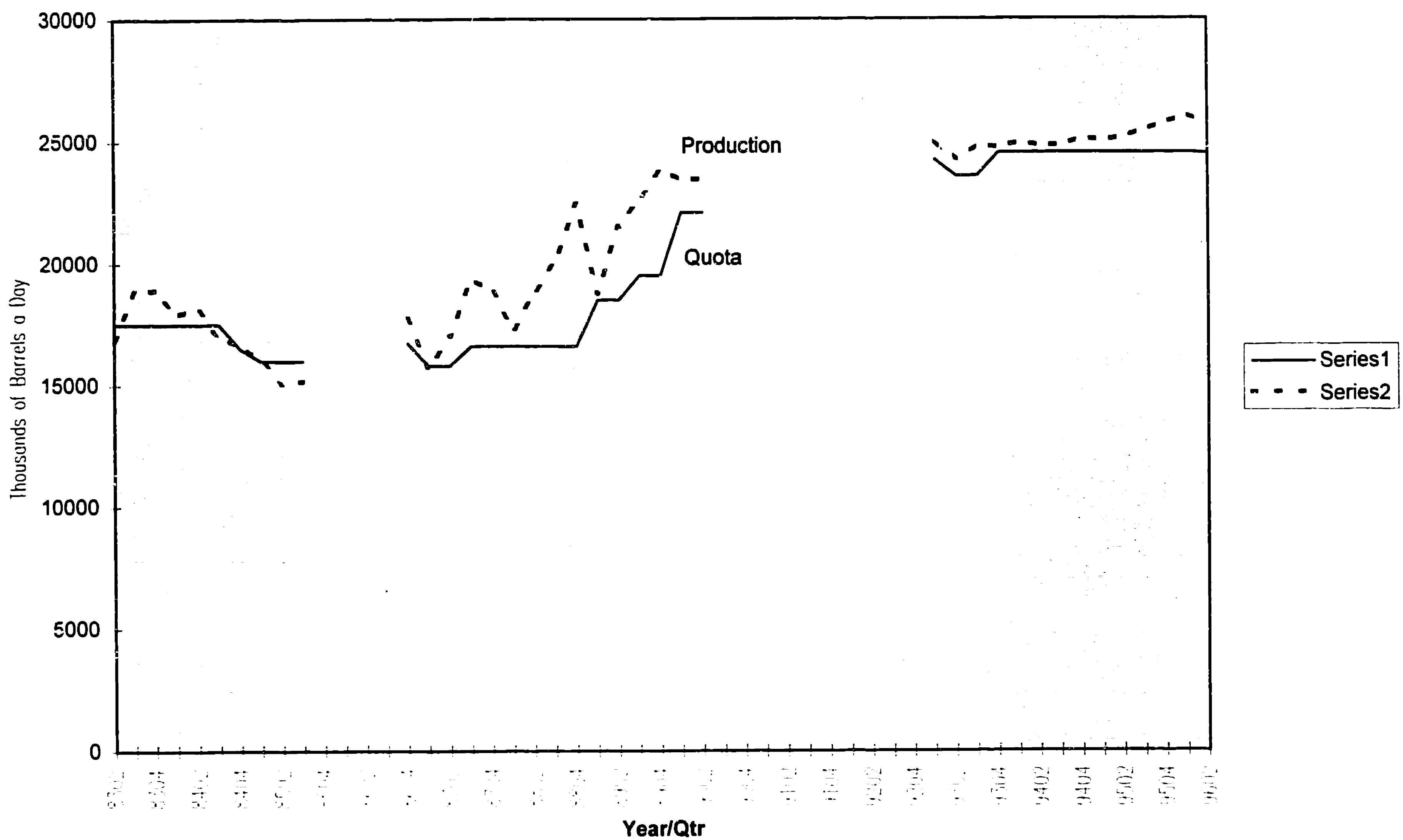


Figure 1.2 -Opec Overproduction

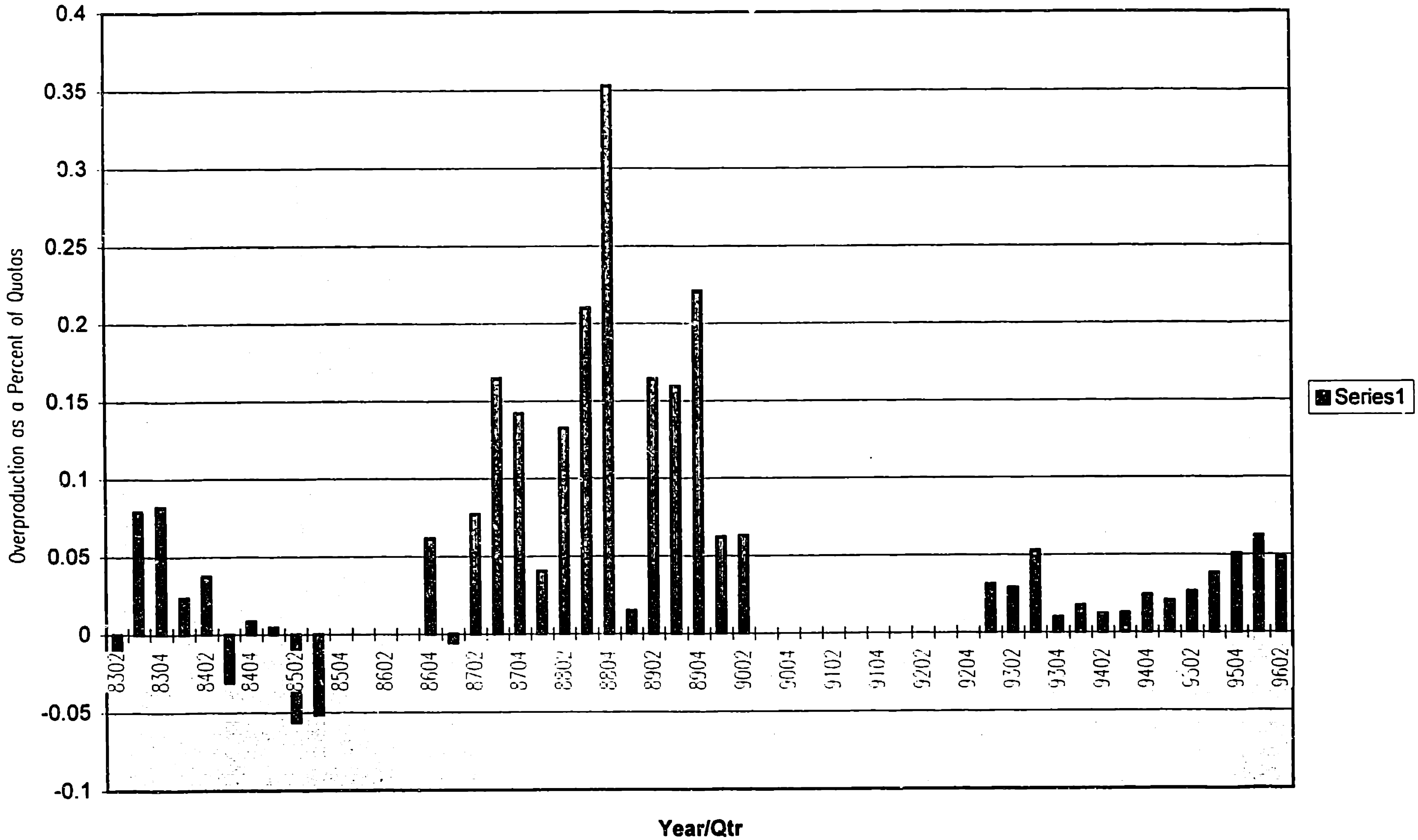


Figure 1.3 - Price of Oil

Bibliography

Fudenberg and Tirole. *Game Theory* , Cambridge: MIT Press, 1991.

Griffin, James M. and Neilson, William. "The 1985-86 Oil Price Collapse and Afterwards," *Economic Inquiry*, 32, 4, October 1994, pp. 543-561.

Rotemberg, Julio J. and Woodford, Michael. "Markups and the Business Cycle," *NBER Macroeconomics Annual 1991*, Cambridge: MIT Press, 1991, pp. 63-129.

Rotemberg, Julio J. and Saloner, Garth. "A Supergame-Theoretic Model of Price Wars during Booms." *American Economic Review*, 76, 3, June 1986, pp. 390-407.

Wilson, Peter. "Venezuela's Go-It-Alone Policy," *Bloomsberg Business News*, 1995.

Chapter 2

Financial Constraints and the Production Decisions of Oil and Gas Companies

2.1 Introduction

In this chapter, I examine the effect of financial constraints on the production decisions of oil and gas companies. I argue that financially constrained firms may want to produce in excess of the quantity implied by the classic Hotelling Rule governing extraction of an exhaustible natural resource. The Hotelling Rule states that the present discounted value of marginal profits should be equalized across periods. However, financially constrained firms will place greater value on short-run profits than on long-run profits leading them to deviate from this rule.

Firms that are involved in natural resource extraction often find themselves in financial difficulties when the price of the commodity they extract falls. The response of firms to this drop in price does not just depend on the commodity price and the firms' costs of production but also on their capital structure. All firms have some fixed commitments that they must pay out each period. These can include interest payments, dividends, or just the fixed costs of operating the firm. In normal years, these fixed cash payments can be paid through the normal cash flow of the corporations. However, in a year with low commodity prices, these cash flows might not be enough to cover these payments. To generate this needed extra cash, a firm may want to borrow from an outside source. However, external borrowing may not be a good option or even a possible option at this time because the firm is in financial straits from the low commodity price. Lenders might not want to extend further credit to a firm in a poor financial position.

Instead, these liquidity constrained firms may try to raise the cash internally. Some ways to do this might be by reducing capital expenditure (Lamont, 1994). Others might try to reduce R&D spending (Long and Ravenscraft, 1993). Still others, might try to raise extra cash by changing production decisions. A firm could do this by postponing the shutdown of a mine or a well (Mello and Parsons, 1992).

Firms involved in exhaustible natural resource extraction have to be concerned not only with the value from present production, but also with the loss in value from depleting a non-renewable resource. The Hotelling Rule from standard microeconomic theory shows how firms should extract a non-renewable resource. This rule states that a firm should extract the resource in such a way that in each period, the price minus the marginal cost of the last unit extracted is equal to the discounted price minus the marginal cost of the last unit extracted for all periods. Or, algebraically:

$$P_{t+1} - MC_{t+1} = (P_t - MC_t)(1 + r) \tag{2.1}$$

If a firm followed this rule, it would maximize the present value of the natural resource that is extracted. There is some evidence that firms may actual follow this rule from a paper by Upton and Miller (1985).

In the Hotelling model, price is always greater than the marginal cost of extraction. This means that a firm is not maximizing its present earnings. A firm could increase short term earnings by increasing output until marginal costs are equal to price. This would not normally be an optimal policy because increasing production today reduces the resource in the ground thereby reducing the value of future earnings. However, if a firm needed to raise extra cash in the short term, then it might become beneficial to deviate from

Hotelling's Rule and increase production until price equals marginal cost. Optimal production decisions are therefore a function of the financial situation of a firm as well as its costs and the price of the commodity.

In this chapter, I construct a model of the agency costs of debt on a natural resource extractor in section 2. I test this model empirically using oil and gas firm data in section 3. The chapter concludes in section 4.

2.2 Model

2.2.1 Firm Level

Firm i can produce a natural resource in period 1 and period 2. It has a total amount of resource, x_i. Production in period t, for $t = 1, 2$, is given by x_{it} where

$$x_{i1} + x_{i2} \leq x_i \tag{2.2}$$

Firms face a price of p_1 in period 1 and in period 2 they face a price of p_{2H} with probability q and a price of p_{2L} with probability $1 - q$. Firms have a discount factor, β. They also have extraction costs with a rising marginal cost, $\frac{1}{2}cx_{it}^2$. This gives firm i a cash flow in period 1 of:

$$CF_{i1} = (p_1 x_{i1} - \frac{1}{2}cx_{i1}^2) \tag{2.3}$$

In period 2, the firm has an expected cash flow of

$$E(CF_{i2}) = E(p_2 x_{i2} - \frac{1}{2}cx_{i2}^2)) \tag{2.4}$$

In period 1, the firm sees the price and chooses an output level x_{i1} and in period 2, the firm sees the new price and chooses a level of output, x_{i2}. Differentiating 2.4, after the state has been observed, with respect to x_{i2} yields $x_{i2} = P_2/c$. This will be the solution provided $x_i - x_{i1} > x_{i2}$. If not, second period production is equal to $x_i - x_{i1}$. Therefore, second period production is:

$$min(x_i - x_{i1}, \frac{P_2}{c}) \tag{2.5}$$

Thus, the problem in period 1 is to choose a production level x_{i1} to maximize:

$$(p_1 x_{i1} - \frac{1}{2} c x_{i1}^2) + \beta E(CF_{i2}) \tag{2.6}$$

There are three possible cases. In the first case, firms will have depleted all their resource at the end of the second period. In the second case, they will only want to do this when the second period price is high. In the third case, firms will produce up to where price equals marginal cost so that the marginal profit from producing is zero and there is some of the resource still in the ground at the end of the second period.

For the sake of brevity, this section only examines the first case. In this case, the firm will extract all remaining output in both the high and low states of the second period. The firm's optimal policy is to set equal marginal profits in the first period and the discounted expected marginal profits from the second period.

$$P_1 - c x_{i1} = \beta(E(P_2) - c x_{i2}) \tag{2.7}$$

This gives production levels of:

$$\begin{aligned} x_{i1} &= \frac{p_1 - \beta(E(p_2) - c x_i)}{c(1+\beta)} \\ x_{i2} &= \frac{\beta E(p_2) + c x_i - p_1}{c(1+\beta)} \end{aligned} \tag{2.8}$$

After solving for the optimal production policy of a firm without debt, debt was added to the model to show the effects of liquidity constraints on production policy. In this model, a firm has two debt payments, D_{i1} and D_{i2}, that must be paid in periods 1 and 2 respectively. If a firm expects to have enough cash flow to cover all these debt repayments, then debt will not have any effect on production. However, if a firm does not generate enough cash flow to cover debt payments in the first period, it can borrow from an outside creditor to cover its first period shortfall and repay this bridge loan with interest rate, R, in the second period. The value of the firm in the first period becomes:

$$V_i = \beta(-(1+R)(CF_{i1} - D_{i1}) + (E(CF_{i2}) - D_{i2})) \tag{2.9}$$

The term multiplying first period cash flow is $(1+R)\beta$. The larger this term is, the greater the return on production in the first period is relative to the return on production in the second period. As borrowing costs, R, rise, firms will have a greater incentive to shift production from the second period to the first period.

The problem for the firm can be made greater if the firm faces bankruptcy risk in the second period. If a firm faces bankruptcy in the low state, the outside creditor must ask for a higher interest rate to compensate for this extra risk. A lender would be willing to lend a firm the first period shortfall, $D_{i1} - CF_{i1}$, if the lending rate, R, satisfies the equation:

$$(q(D_{i1} - CF_{i1})(1+R) + (1-q)(CF_{i2} - D_{i2})^{+} \geq (D_{i1} - CF_{i1})(1+r) \tag{2.10}$$

or

$$R \geq \frac{1+r}{q} - \frac{(1-q)(CF_{i2} - D_{i2})^{+}}{q(D_{i1} - CF_{i1})} - 1$$

where

$$(CF_{i2} - D_{i2})^{+} = max(0, CF_{i2} - D_{i2})$$

An increase in debt in either period raises the interest rate, R, that the firm uses to borrow even further. This raises the return on first period production relative to second period production.

Changes in the demand for the commodity influence production decisions through changing the financial constraints of a firm. An increase in demand in the first period or the second period raises cash flows, thereby reducing the value of R. This means that when demand is low, a firm is more likely to want to increase present production than when demand is high.

Bankruptcy risk also has a second effect on production. Since a firm only earns profits in the high state of the second period, it now has to set equal the marginal profit in the first period with the marginal profit from the high state in the second period:

$$(1 + R)\beta(P_1 - cx_{i1}) = q\beta(P_{2H} - cx_{i2H}) \tag{2.11}$$

The reduction in the marginal profit in the second period means that more production should be shifted to the first period:

$$\begin{aligned} x_{i1} &= \frac{p_1(1+R) - qp_{2H} + cqx_i}{c(1+R) + cq} \\ x_{i2} &= \frac{qp_{2H} + c(1+R)x_i - p_1(1+R)}{c(1+R) + cq} \end{aligned} \tag{2.12}$$

To conclude, debt has several effects on firm production. The higher the outside borrowing costs, the more valuable production is in the first period relative to the second period. If debt increases bankruptcy risk in the low state, a firm will have even higher borrowing costs increasing the value further of shifting production to the first period. Also, shareholders only earn income in the high state in the second period reducing the marginal profit of second period production. In response to this, they will want to further boost first period production.

This two period model can also be extended to a multi-period model. If a firm is financially constrained for the next several periods, production will shift from later periods to those financially constrained periods. A multi-period model is a more realistic model for the real world decisions of firm as natural resource extractors have reserves that last many years. They also have financial commitments, like long term debt, that last for several periods. However, by adding more periods, the algebraic solutions become exceedingly long and complex.

2.2.2 Industry Level

If debt causes a firm to overproduce, can it cause overproduction for a whole industry? Normally, an industry that faces a bad demand shock would find the companies in that industry reducing output in response to the lower demand. If the firms in the industry are reluctant to reduce production because the firms have liquidity constraints, then total industry production will not decrease as much as before. This makes the industry supply curve more inelastic when the industry is leveraged than when the industry is not leveraged.

A simple model of a natural resource industry has a demand curve that is a linear function of industry output. Price is a function of total industry output, Q_I such that:

$$P = a - bQ_I \tag{2.13}$$

Firms know the demand level, (a_1, b_1), in period 1. and have an expected demand level in period 2, (a_2, b_2)

There are also a large number of homogenous firms, n, such that each firm's individual production does not have an effect on price. Total production is $Q_I = qn$.

To solve for the industry equilibrium, I first solved for the debt free industry equilibrium. When there is no debt, three more equations are added to the original firm level model:

$$P_1 = a_1 - b_2 qn \tag{2.14}$$
$$P_{2L} = a_{2L} - b_{2L} qn$$
$$P_{2H} = a_{2H} - b_{2H} qn$$

Once again, there are 3 possible cases. The first case has firms depleting all of their resource by the end of the second period. The second case only has the industry depleting its reserve during the high state of the second period. The third case never has depletion of the resource. I will again focus only on the first case.

In the first case, the firms deplete all of their remaining resource in the last period. They will therefore want to set the discounted expected marginal profit in the second period equal to the marginal profit in the first period. This will give a production level in the two periods for each firm of:

$$x_{i1} = \frac{a_1 - \beta E(a_2) + \beta(E(b_2)n + c)x_i}{b_1 n + c + \beta(E(b_2)n + c)} \tag{2.15}$$
$$x_{i2} = \frac{-a_1 + \beta E(a_2) + (b_1 n + c)x_i}{b_1 n + c + \beta(E(b_2)n + c)}$$

The prices in period 1 and 2 become:

$$P_1 = a_1 - b_1 \frac{n(a_1 - \beta(E(a_2) - (E(b_2)n + c)x_i))}{b_1 n + c + \beta(E(b_2)n + c)} \tag{2.16}$$
$$P_{2j} = a_{2j} - b_{2j} \frac{n(-a_1 + \beta(E(a_2) - (b_1 n + c)x_i))}{b_1 n + c + \beta(E(b_2)n + c)}$$
$$for \quad j = L, H$$

Debt will now be added to this model. Firms again need a bridge loan in period 1 at interest rate R to cover a shortfall in earnings. The higher the cost of external borrowing, the higher the rate of return on first period production relative to second period production.

If firms go bankrupt during the low state of period 2, then even more production will be shifted to the first period. Outside creditors also have to increase the interest rate that they lend to creditors because of this bankruptcy risk.

Bankruptcy risk has another effect on production. Since firms only earn profits in the high state in the second period, they have a lower expected marginal profit in the second period. Firms now set equal the marginal profit in the first period with this lower marginal profit in the second period. This gives production for an individual firm in an industry equilibrium of:

$$x_{i1} = \frac{a_1(1+R) - qa_{2H} + q(b_{2H}n + c)x_i}{(1+R)(b_1 n + c) + q(b_{2H}n + c)} \tag{2.17}$$
$$x_{i2} = \frac{-a_1(1+R) + qa_{2H} + (b_1 n + c)(1+R)x_i}{(1+R)(b_1 n + c) + q(b_{2H}n + c)}$$

The prices in period 1 and 2 become:

$$P_1 = a_1 - b_1 n \frac{a_1(1+R) - qa_{2H} + q(b_{2H}n + c)x_i}{(1+R)(b_1 n + c) + q(b_{2H}n + c)} \tag{2.18}$$
$$P_{2j} = a_{2j} - b_{2j} n \frac{-a_1(1+R) + qa_{2H} + (b_1 n + c)(1+R)x_i}{(1+R)(b_1 n + c) + q(b_{2H}n + c)}$$
$$for \quad j = L, H$$

Debt has several effects on the industry equilibrium. It raises the borrowing costs of the firms in the industry because of bankruptcy risk. These higher interest rates will lead to an increase in the value of production in the first period compared with production in the second period. The possibility of bankruptcy in the second period lowers the expected profits on second period production. This will also lead to a shift in production from the second period to the first period.

In the industry equilibrium, this will have the effect of lowering prices in the first period and raising them in the second period as supply is shifted from the second period to the first period. There is some negative feedback in this model because the price in the second period rises relative to that in the first period thereby reducing the incentive to shift even more production to the first period.

The expectation of low demand in the second period can shift production to the present when there is debt. When the probability of the low state increases, the firms are more likely to go bankrupt. This expectation decreases the price in the first period as more output is shifted to the first period.

This model also shows that a leveraged industry has a more inelastic supply curve in period 1 than an industry without debt. In a high state demand state, no firms have bankruptcy risk. But when demand falls far enough, the leveraged firms might find themselves acquiring some risk of bankruptcy as well as being forced to borrow from outside markets. They will not want to have as low a first period production as non-leveraged firms so that production will fall less for leveraged firms as for non-leveraged firms. Thus, the elasticity of industry supply curves will decline as industry leverage rises.

2.3 Empirical Data from Firms

In this section, I test the hypothesis that natural resource extractors that are liquidity constrained will have an abnormally higher rate of production. The industry that I examine is the oil and gas industry. This industry was selected because of the large number of firms with both financial and production data available. Oil and gas are usually physically located at the same sites so that these two commodities are often produced by the same firms. Also, the prices of these two commodities usually move in similar directions since they are both substitutes for each other in energy markets. Normally, when there are large swings in price of one of these commodities, the other commodity will show a similarly large move.

The cost of oil and gas production comes in two parts. First, there is the exploration and development of oil and gas fields. After these initial investments, production costs are incurred, known as lifting costs, to bring the commodity up to the surface. In 1992, the lifting cost per barrel of oil equivalent in the United States was $4.62. This is equivalent to the marginal cost in my model.

Marginal costs vary across fields and wells depending on the characteristics of those wells. Offshore platforms and wells in remote locations often have significantly higher operating costs. Different methods of production also generate different costs. For example, new fields have enough pressure so that the oil will come to the surface more or less on its own. When the pressure runs low, secondary production of oil can be generated by pumping down water to generate more pressure but at a higher cost. These heterogeneous lifting costs in the oil and gas industry are needed to generate a rising marginal cost curve for firms. Ideally, one would like to have a lifting cost profile for all the firms, but that information is not easily obtained.

Production data for oil and gas companies were taken from the Oil & Gas Journal Databook. This book is published annually and has a list of the 300 largest U.S. based oil and gas producers. Data were available for the period between 1984 and 1993. Not every company was listed in every year. Many very small producers only showed up in a handful of years so they were excluded from the dataset. Other firms vanished because of mergers and were only available for part of this period.

The source for financial data on the companies comes from the COMPUSTAT database. This database did not have all the companies that I found in the Oil and Gas Journal Databook. Some of the firms were not public and therefore were unavailable. Others just were not covered because they were too small.

During the period examined, 1984 – 1993, there were large swings in the price of oil and gas. The largest change was a drop in the price of oil and gas in the period of early 1986. The companies that were finally selected had production data that was continuous from 1984 through 1994. I found 78 public U.S. companies with 11 years worth of production data. This gave me ten years worth of production changes.

To test my hypothesis, I examine the relationship between production decisions and financial variables. The best dependent variable would be one that showed the deviation from a firm's optimal production if there were no liquidity constraints. However, I cannot directly observe a firm's optimal production level against which production can be compared. Instead, I look at the change in production from the previous year. A firm that became liquidity constrained would be expected to be more likely have increasing production, than one that is not liquidity constrained. Thus, for the dependent variable, I use the percentage change in a firm's production from the previous year.

One problem with using the percentage change in production is that it has a high variance. If production started from a low base in the previous year, there might be a relatively large jump in production the next year. I removed data points when production fell by more than 80% or rose by more than 250%.

As proxies for financial constraints - the key independent variables - I use firm size, bond ratings, and leverage. Small firms, those with low bond ratings, and those with high leverage are more likely to be financially constrained. These measures of financial constraints have been widely used in the literature. See, for example, Gertler and Gilchrist, Kashyap, Lamont and Stein, and Sharpe.

One difficulty using size as a proxy for financial constraints is that large firms have more flexibility in their production choices. Large firms have more oil production sites giving them more options to adjust production. Small firms, with few production sites, would have more difficulty adjusting production. But while production changes for small firms would be expected to be larger than for larger firms, the average change should not be different. For size, I used a dummy variable, $SIZE$, set equal to 1 for firms with nominal assets above $500 million. The regressions were robust to variations in this cutoff point.

Another measure of liquidity that was used was the debt to asset ratio of a firm. Firms with a high debt to asset ratio have to pay out a larger share of their cash flow to creditors than other firms. This means firms have more fixed commitments to worry about in each period. However, using this alone is misleading. Many firms have a high debt to assets ratio because they have made investments to expand production. It takes capital to develop new oil fields so that highly indebted firms would be expected have rising production regardless of market conditions. After that debt is assumed, it will be paid off as the field ages so that one should find firms with old fields having falling production and a low debt to asset ratio. To take into account the fact that debt is acquired for the purpose of increasing output, I have also included a term for the change in the debt to asset ratio. This variable will be used to separate the effects of a firm's leverage from the change in leverage.

Firms that have to pay most of their cash flow out in interest payments should also be more liquidity constrained. $LQ1$ is a variable which is equal to interest payments over cash flow plus interest payments. This ratio will fall between 0 and 1 when both cash flow and interest payments are positive. If interest payments are negative, this will be 0. For negative cash flow, this number will be greater than 1. I truncate this variable so that for all values greater than 2 are changed to 2. I use this ratio to try to capture how much of the firm's cash flow is needed to service its debts.

I include the nominal price changes of oil and gas among the independent variables. When the price of a commodity falls, production of that commodity is usually expected to decline as well. However, this effect is expected to be dampened for those firms with financial constraints.

I also created an interaction variable between the change in price and $LQ1$. When the price falls and a firm is liquidity constrained, the model predicts that production would be higher than otherwise so that the coefficient on the interaction variable should be a negative coefficient.

Table 1a and Table 1b report the results of a regression of production changes on variables representing a firm's financial constraints for natural gas and liquids (petroleum) production respectively:

$$\frac{\Delta q_{t,t-1}}{q_{t-1}} = \beta_0 + \beta_1 X_{t-1,i} + \epsilon_{it}$$

where $X_{t-1,1}$ are the various liquidity variables included that might affect production decisions. Regression 1 in both tables runs the change in production of firms against the size dummy for the firm, $SIZE$, the change in the debt to assets ratio $\Delta DT/AT$, the debt to asset ratio for the firm, DT/AT, and the percentage change in the price of the commodity $\Delta P/P$.

For both gas and liquid production, large firms decrease production relative to small firms. This may be because small firms tend to be fast growing while large firms are mature and grow more slowly. Production also rises with increases in a firm's leverage. This was predicted since firms that are developing new fields will have higher debt than firms that own mature fields.

The more interesting finding is that the coefficient on the debt to asset level is positive for both gas and liquids though it was only significant for liquids. A positive coefficient is consistent with the model. Price changes alone have no effect on production decisions for liquids but they are significantly negative for gas. This is the opposite of what one might expect if firms were not financially constrained; an increase in price should increase production. The results, however, suggest that the effects of financial constraints could be so great that a drop in price - and hence an increase in financial constraints - actually raises production.

The second regression in Table 1a and Table 1b include the liquidity variable $LQ1$. The coefficient on $LQ1$ is positive for both commodities as expected, but it is not significant. When an interaction term between price and $LQ1$ is added in regression 3, the coefficient on the interaction term is negative as the model predicts. Production increases when firms are liquidity constrained and there is a price drop. However, it is only significant in the regression for gas. Regression 4 instruments the variables on the lagged values of $LQ1$ since

$LQ1$ might be highly correlated with present production. The $LQ1$ coefficient becomes significantly positive in the case for gas but the interaction term, though still negative, is no longer statistically significant. In the liquids case, the cross term becomes significantly negative though the coefficient on the liquidity variable remains insignificant. Overall, Table 1a and Table 1b show that change in production is negatively affected by a firm's size, and is positively affected by the increase and level of the firm's leverage. Firms that are more liquidity constrained are more likely to increase production and this effect is increased when prices drop.

Tables 2a and 2b show the results of another set of regressions. Two new variables are used to proxy for firm liquidity. The first variable is a dummy variable, $LQ2$, which takes the value 1 for firms in the top quintile of the ratio of (Interest Payments + Short Term Debt - Cash and Marketable Securities - Cash Flow)/Assets and zero otherwise. The ratio signifies the amount of money that a firm must pay to creditors in one year minus the amount it has available. $LQ3$ is a similar measure except that the ratio is (Interest Payments + Short Term Debt - Cash and Marketable Securities)/Assets. I also include an interaction variable between the liquidity dummies and the changes in price.

Six regressions were run for both gas and liquids. All included a firm size dummy, the change in the debt to asset ratio, the debt to asset ratio, and the change in price as independent variables. The first regression also included the cross term between $LQ2$ and the change in price, the second regression includes the $LQ2$ dummy variable and the third regression had both. The fourth through sixth regression repeated these three regressions substituting $LQ3$ for $LQ2$. In all the regressions, for both commodities, the size dummy variable is negative and statistically significant, and the change in the debt to asset ratio is positive and statistically significant. The level of the debt to asset ratio has a positive coefficient in all the regressions, but is only significant for liquids.

In all these regressions, the cross term between the change in price and the liquidity dummies is negative and statistically significant. This provides evidence that firms that are the most financially constrained are more likely to increase production during a drop in prices and less likely to increase production during a price rise. The supply curve of the debt constrained firms becomes more inelastic, which is consistent with the model. The coefficients on the liquidity dummies, $LQ2$ and $LQ3$, are positive but not significant, suggesting that liquidity is only a problem when combined with falling prices.

Overall, Tables 1 and 2 show that liquidity constraints, combined with a fall in prices, lead to higher production than otherwise. However, these models only explain a small fraction of the variation in production changes with the adjusted R^2's only around .05.

The next set of regressions splits the sample into the years when the price of the commodities were high and the years when they were low. The dependent variable is once again the percentage change in production. The independent variables include a size dummy, $SIZE$. I also included an interest coverage ratio, $COVR$. $COVR$ is defined as the ratio of interest payments + short term debt to cash and equivalents plus net income, or what needs to be paid out divided by what is available. The reason for splitting the sample into years of high and low prices is because if liquidity constraints matter, they should have a greater effect in low price years.

The results of these regressions are in Tables 3a and 3b. The cutoff price for natural gas is \$1.90 per 1000 cubic feet and the cutoff price for petroleum years is \$18 per barrel. The tables show that when the prices of natural gas and liquids are high, the coefficients on the liquidity variable, $COVR$, in both regressions are statistically insignificant. However, in low price years, the coefficient is positive and statistically significant, indicating that more constrained firms increase their production relative to less constrained firms.

Tables 4a and 4b uses alternative measures of financial constraints: the debt to sales ratio, $DEBT/SALES$ and a dummy variable set equal to 1 when Standard and Poor's rates a firm's senior debt to proxy for liquidity constraints. The results were reported for only the low price years and all years since the regressions had no explanatory power in the high price years. In the entire sample, firms with no debt rating and a high debt to sales ratio, increase production relative to rated firms and those with low leverage. In the low price years, the coefficients on these variables increase as well as the adjusted R^2.

Tables 5a and 5b have redone the regressions in Tables 4a and Table 4b with the inclusion of firm dummy variables to take into account fixed effects. These regressions show that the coefficients on the debt rating dummy and $DEBT/SALES$ lose their significance. Part of the reason for this might be because the liquidity variables do not vary much for the individual firm during the decade examined. If these variable are more or less constant, then firm dummies would be proxying for these variables.

Tables 6a and 6b examine production behavior depending on whether a firm is profitable or not. I used firms where there was production data for several years as well as for those with complete data. The average year to year production change for the firms is listed in Table 6a and Table 6b. For the firms that are losing money, production of both commodities increases while for profitable firms, production on average decreases. The difference between the production behavior of these two types of firms is statistically significant.

The sample was also split between low and high price years. During the low price years, there is an even larger gap between the strategies of profitable and unprofitable firms. In the high priced years, there is no significant difference in production strategy between both types of firms. This is consistent with my model where firms need a short term bridge loan. When prices are low, firms cannot easily obtain outside credit and will want to move production to the present to increase short term cash flow.

Table 7 shows the regressions of the percentage change of the production of liquid on the percentage change of the production of gas and the cash flow to assets ratio. The reason for including the production change in natural gas as one of the independent variables is to include some of the non-financial factors that may be affecting production. Since both products are frequently produced at the same fields, this will help to proxy for site related factors. Also, marginal costs in liquids production are more important so that if production decisions are being affected by financial factors, one would expect them to be higher for liquid production.

The change in the production of natural gas has a large and significant positive coefficient. Firms that are increasing natural gas also are usually increasing liquid production. The coefficient on the cash flow to assets ratio is negative and significant for all years and for the low price years. Firms with lower cash flows tend to increase production more than those with high cash flows when prices are low. When prices are high, cash flow is unrelated to production decisions.

Table 8 shows robust versions of the regressions in Table 7. This was to see whether the large variance in some of the variables has an effect on the results. The robust regressions gave very similar results to those in Table 7 except that the t-statistics were larger.

Finally, I checked to see if the heteroskedasticity between individual firms was driving the results in Table 7. Using Huber's formula and grouping the data by firm, new t-statistics were generated which were higher for the cash flow to asset ratio during low price years. Overall, I found there to be a negative correlation between cash flow and changes in the production of liquids when firms are faced with low prices.

2.4 Conclusion

Firms are often faced with precommitments to pay out cash in times when the market for their product is depressed. Several papers mentioned in the introduction have explored how this could lead firms to deviate from efficient policies when faced with financial constraints. In this chapter, we examined the hypothesis that natural resource producers will try to increase production or at least decrease production less when faced with low prices and liquidity constraints. The model showed that liquidity constrained firms will produce more than they otherwise would at a given price.

Mello and Parsons' theoretical paper showed that leveraged firms with constant production costs and fixed opening and closing costs would be more reluctant to close a production site when prices are low than debt free firms. Production decreases in our data could have been from closing a site, reducing production at some sites, or some combination. Since the production data only included total production and not the changes in the number of sites, these different effects cannot be separated in this chapter. Nonetheless, the empirical evidence in this paper shows that firms with liquidity constraints and falling or low prices will either increase production or reduce production less than non-constrained firms. To the extent that financial constraints are important in an industry, one would expect industry supply to become more inelastic.

Stronger results might have been found had the marginal cost profile of oil and gas producers been readily available. Future research in this field would include that information if and when that data becomes accessible.

Finally, looking at other resource extraction industries might prove fruitful. Though there are far fewer firms to study, the theory suggests that the effects of liquidity constraints would be greater for them. There is more flexibility with production in the mining industries than in the petroleum industry. Mines are more labor intensive and it is relatively easier to add extra shifts and boost production. Marginal costs play a greater role in production decisions so that the effect outlined in this model would be expected to be stronger.

Table 1a				
Natural Gas				
	1	2	3	4
$SIZE$	-.111	-.093	-.092	-.036
	(-3.36)	(-2.71)	(-2.68)	(-0.96)
$\Delta DT/AT$	.449	.466	.467	.671
	(2.90)	(2.99)	(3.01)	(4.34)
DT/AT	.109	.096	.092	-.053
	(1.34)	(1.18)	(1.14)	(-0.61)
$\Delta P/P$	-.376	-.323	.074	-.165
	(-2.04)	(-1.74)	(0.30)	(-0.66)
$LQ1$		.060	.016	.188
		(1.29)	(0.32)	(1.96)
$(\Delta P/P) * LQ1$			-1.280	-.860
			(-2.45)	(-1.42)
$CONSTANT$	.071	.048	.064	.017
	(2.36)	(1.38)	(1.79)	(0.36)
N	565	557	557	424
$Adj.R^2$	.04	.04	.05	

$$\frac{q_{i,t}-q_{i,t-1}}{q_{i,t-1}} =$$

$$\alpha + \beta_1 SIZE_{i,t-1} + \beta_2 \Delta DT/AT_{i,t-1} + \beta_3 DT/AT_{i,t-1} + \beta_4 \Delta P/P_{i,t} + \beta_5 LQ1_{i,t-1} + \beta_6 \Delta P/P * LQ1_{i,t-1} + \epsilon_{it}$$

Regression 1-3 are OLS regressions of changes in production of natural gas on the lagged independent variables. $SIZE$ is a size dummy variable, $\Delta DT/AT$ is the change in the debt to assets ratio, DT/AT is the debt to assets ratio, $\Delta P/P$ is the change in price and $LQ1$ is the liquidity variable. Regression 4 instruments the variables on the lagged value of $LQ1$

t-statistics are in parentheses

Table 1b				
Liquids				
	1	2	3	4
$SIZE$	-.102	-.085	-.085	-.050
	(-3.09)	(-2.45)	(-2.45)	(-1.25)
$\Delta DT/AT$	.566	.564	.554	.557
	(3.44)	(3.41)	(3.34)	(3.12)
DT/AT	.179	.146	.146	-.032
	(2.20)	(1.81)	(1.80)	(-0.34)
$\Delta P/P$	-.049	-.049	.008	.029
	(-0.71)	(-0.71)	(0.09)	(0.29)
$LQ1$		.070	.070	.056
		(1.48)	(1.47)	(0.60)
$(\Delta P/P) * LQ1$			-.172	-.430
			(-0.88)	(-1.99)
$CONSTANT$	.094	.073	.075	.100
	(3.19)	(2.11)	(2.16)	(2.18)
N	562	553	553	425
$Adj.R^2$	.04	.04	.04	

$$\frac{q_{i,t}-q_{i,t-1}}{q_{i,t-1}} =$$

$$\alpha + \beta_1 SIZE_{i,t-1} + \beta_2 \Delta DT/AT_{i,t-1} + \beta_3 DT/AT_{i,t-1} + \beta_4 \Delta P/P_{i,t} + \beta_5 LQ1_{i,t-1} + \beta_6 \Delta P/P * LQ1_{i,t-1} + \epsilon_{it}$$

Regression 1-3 are OLS regressions of changes in production of liquids on the lagged independent variables. $SIZE$ is a size dummy variable, $\Delta DT/AT$ is the change in the debt to assets ratio, DT/AT is the debt to assets ratio, $\Delta P/P$ is the change in price and $LQ1$ is the liquidity variable. Regression 4 instruments the variables on the lagged value of $LQ1$

t-statistics are in parentheses

Table 2a						
Natural Gas						
	1	2	3	4	5	6
$SIZE$	-.098	-.092	-.091	-0.99	-.101	-.093
	(-2.96)	(-2.62)	(-2.62)	(-3.01)	(-2.66)	(-2.66)
$\Delta DT/AT$	.463	.472	.471	.465	.473	.473
	(3.00)	(3.04)	(3.04)	(3.02)	(3.04)	(3.05)
DT/AT	.120	.117	.122	.118	.097	.120
	(1.49)	(1.44)	(1.52)	(1.47)	(1.14)	(1.49)
$\Delta P/P$	-.160	-.389	-.183	-.158	-.327	-.182
	(-0.80)	(-2.11)	(-0.90)	(-0.79)	(-2.01)	(-0.89)
$LQ2, LQ3$		.067	.027		.063	.027
		(1.58)	(0.59)		(1.55)	(0.60)
$(\Delta P/P) * LQ2, LQ3$	-1.25		-1.14	-1.21		-1.10
	(-2.81)		(-2.40)	(-2.77)		(-2.35)
$CONSTANT$	.063	.048	.055	.064	.046	.055
	(2.11)	(1.44)	(1.64)	(2.14)	(1.41)	(1.66)
N	565	565	565	565	565	565
$Adj.R^2$	.05	.04	.05	.05	.04	.05

$$\frac{q_{i,t} - q_{i,t-1}}{q_{i,t-1}} =$$

$$\alpha + \beta_1 SIZE_{i,t-1} + \beta_2 \Delta DT/AT_{i,t-1} + \beta_3 DT/AT_{i,t-1} + \beta_4 \Delta P/P_{i,t} + \beta_5 LQ2,3_{i,t-1} + \beta_6 \Delta P/PLQ1_{i,t-1} + \epsilon_{it}$$

$SIZE$ is a size dummy variable, $\Delta DT/AT$ is the change in the debt to assets ratio, DT/AT is the debt to assets ratio, $\Delta P/P$ is the change in price and $LQ2$ and $LQ3$ liquidity variable.

Regressions 1-6 are OLS regressions of gas production changes against these independent variables.

$LQ2$ is a dummy variable for firms in the top quintile of the ratio of (Interest Payments + Short Term Debt - Cash and Marketable Securities - Cash Flow)/Assets

$LQ3$ is a dummy variable for firm in the top quintile of the ration (Interest Payments + Short Term Debt - Cash and Marketable Securities)/Assets

t-statistics are in parentheses

Table 2b						
Liquids						
	1	2	3	4	5	6
$SIZE$	-.101	-.095	-.095	-.102	-.085	-.096
	(-3.07)	(-2.71)	(-2.71)	(-3.09)	(-2.51)	(-2.75)
$\Delta DT/AT$	.548	.573	.555	.553	.547	.559
	(3.34)	(3.48)	(3.37)	(3.38)	(3.19)	(3.41)
DT/AT	.186	.181	.189	.187	.211	.190
	(2.31)	(2.24)	(2.34)	(2.33)	(2.34)	(2.35)
$\Delta P/P$	.022	-.052	-.389	.033	-.043	.030
	(0.29)	(-0.76)	(-2.11)	(0.44)	(-0.84)	(0.39)
$LQ2, LQ3$		.026	.023		.024	.020
		(0.60)	(0.54)		(0.58)	(0.46)
$(\Delta P/P) * LQ2.LQ3$	-.351		-.348	-.406		-.402
	(-2.07)		(-2.05)	(-2.41)		(-2.38)
$CONSTANT$	.094	.085	.086	.093	.083	.086
	(3.19)	(2.59)	(2.62)	(3.16)	(2.47)	(2.63)
N	562	562	562	562	562	562
$Adj.R^2$	.05	.04	.05	.05	.04	.05

$$\frac{q_{i,t}-q_{i,t-1}}{q_{i,t-1}} =$$

$$\alpha + \beta_1 SIZE_{i,t-1} + \beta_2 \Delta DT/AT_{i,t-1} + \beta_3 DT/AT_{i,t-1} + \beta_4 \Delta P/P_{i,t} + \beta_5 LQ2,3_{i,t-1} + \beta_6 \Delta P/PLQ1_{i,t-1} + \epsilon_{it}$$

$SIZE$ is a size dummy variable, $\Delta DT/AT$ is the change in tne debt to assets ratio, DT/AT is the debt to assets ratio, $\Delta P/P$ is the change in price and $LQ2$ and $LQ3$ liquidity variable.

Regressions 1-6 are OLS regressions of liquid production changes against these independent variables.

$LQ2$ is a dummy variable for firms in the top quintile of the ratio of (Interest Payments + Short Term Debt - Cash and Marketable Securities - Cash Flow)/Assets

$LQ3$ is a dummy variable for firm in the top quintile of the ration (Interest Payments + Short Term Debt - Cash and Marketable Securities)/Assets

t-statistics are in parentheses

Table 3a			
Natural Gas			
	All Years	Years when $P < \$1.90$	Years when $P > \$1.90$
$SIZE$	-.104	-.132	-.045
	(-3.18)	(-3.61)	(-0.69)
$COVR$	.058	.077	.017
	(3.10)	(3.69)	(0.46)
$CONSTANT$	.079	.078	.080
	(3.37)	(7.02)	(1.68)
$Adj R^2$	.03	.06	-.00
N	550	371	179

$$\frac{q_{i,t}-q_{i,t-1}}{q_{i,t-1}} = \alpha + \beta_1 SIZE_{i,t-1} + \beta_2 COVRi, t-1 + \epsilon_{it}$$

The regressions in this table are OLS regressions where the change in the production of gas is regressed against a size dummy, $SIZE$ and an interest coverage variable, $COVR$. It is broken down by low and high price years.

Table 3b			
Liquids			
	All Years	Years when $P < \$18$	Years when $P > \$18$
$SIZE$	-.096	-.118	-.044
	(-2.89)	(-2.92)	(-0.77)
$COVR$	.078	.090	.057
	(4.13)	(3.91)	(1.75)
$CONSTANT$	.098	.125	.037
	(4.19)	(4.44)	(0.90)
$Adj R^2$	.04	.06	-.01
N	546	369	177

$$\frac{q_{i,t}-q_{i,t-1}}{q_{i,t-1}} = \alpha + \beta_1 SIZE_{i,t-1} + \beta_2 COVRi, t-1 + \epsilon_{it}$$

The regressions in this table are OLS regressions where the change in the production of liquids is regressed against a size dummy, $SIZE$ and an interest coverage variable, $COVR$. It is broken down by low and high price years.

Table 4a						
Natural Gas						
	ALL YEARS			YEARS WHEN P < \$1.71		
	1	2	3	4	5	6
DEBT/SALES	.042		.039	.077		.119
	(2.08)		(1.98)	(3.17)		(3.09)
S&PSr.DebtDummy		-.116	-.112		-.133	-.127
		(-2.68)	(-2.61)		(-2.85)	(-2.77)
CONSTANT	.077	.162	.131	.058	.177	.074
	(2.93)	(5.47)	(3.93)	(1.97)	(5.57)	(3.26)
$Adj.R^2$	.01	.01	.02	.03	.03	.05
N	495	495	495	310	310	310

$\frac{\Delta q_{t,t-1}}{q_{t-1}} = \alpha + \beta_1 DEBT/SALES_{t-1,i} + S\&PRATING_{i,t-1} + \epsilon_{it}$

The regressions in this table are OLS regressions where the change in the production of gas is regressed against the debt to sales ratio, *DEBT/SALES* and a dummy variable equal to 1 when Standard & Poor's rates a firm's senior debt, *S&PSr.DebtDummy*. It is broken down by all years and years when the price of natural gas is less than \$1.71 per 1,000 cubic feet.

Table 4b						
Liquids						
	ALL YEARS			YEARS WHEN $P < \$18$		
	1	2	3	4	5	6
DEBT/SALES	.042		.042	.048		.046
	(2.22)		(2.17)	(2.58)		(2.50)
S&PSr.DebtDummy		-.057	-.053		-.082	-.077
		(-1.37)	(-1.28)		(-1.80)	(-1.69)
CONSTANT	.060	.118	.085	.021	.098	.085
	(2.39)	(4.15)	(2.67)	(0.77)	(3.13)	(1.67)
$Adj.R^2$	.01	.00	.01	.02	.01	.02
N	495	495	495	310	310	310

$\frac{\Delta q_{t,t-1}}{q_{t-1}} = \alpha + \beta_1 DEBT/SALES_{t-1,i} + S\&PRATING_{i,t-1} + \epsilon_{it}$

The regressions in this table are OLS regressions where the change in the production of liquids is regressed against the debt to sales ratio, *DEBT/SALES* and a dummy variable equal to 1 when Standard & Poor's rates a firm's senior debt, *S&PSr.DebtDummy*. It is broken down by all years and years when the price of a barrel of oil is less than $18.

Table 5a			
Natural Gas			
	ALL YEARS	YEARS WHEN $P < \$1.71$	YEARS WHEN $P > \$1.71$
	1	2	3
$DEBT/SALES$	0.15	.190	.078
	(0.55)	(0.40)	(1.17)
$S\&PSr.DebtDummy$	-.047	-.217	-0.75
	(-0.18)	(-0.86)	(-0.13)
$CONSTANT$	.029	.196	-.002
	(0.15)	(1.06)	(-0.01)
$Adj.R^2$	.11	.18	.07
N	495	310	185

$$\frac{\Delta q_{i,t-1}}{q_{t-1}} = \alpha + \beta_1 DEBT/SALES_{t-1,i} + S\&PRATING_{i,t-1} + \beta_3 D_1 + .. + \beta_{N+2} D_N + \epsilon_{it}$$

The regressions in this table are OLS regressions where the change in the production of gas is regressed against the debt to sales ratio, $DEBT/SALES$,a dummy variable equal to 1 when Standard & Poor's rates a firm's senior debt, $S\&PSr.DebtDummy$, and N firm dummy variables. It is broken down by low and high price years.

Table 5b			
Liquids			
	ALL YEARS	YEARS WHEN $P < \$18$	YEARS WHEN $P > \$18$
	1	2	3
$DEBT/SALES$	0.32	-.005	.097
	(1.25)	(-0.22)	(0.98)
$S\&PSr.DebtDummy$	-.139	.050	.282
	(-0.59)	(0.83)	(0.57)
$CONSTANT$	.014	-.083	-.189
	(0.08)	(-0.49)	(-.048)
$Adj.R^2$	.09	.18	.07
N	495	310	185

$$\frac{\Delta q_{t,t-1}}{q_{t-1}} = \alpha + \beta_1 DEBT/SALES_{t-1,i} + S\&PRATING_{i,t-1} + \beta_3 D_1 + .. + \beta_{N+2} D_N + \epsilon_{it}$$

The regressions in this table are OLS regressions where the change in the production of liquids is regressed against the debt to sales ratio, $DEBT/SALES$,a dummy variable equal to 1 when Standard & Poor's rates a firm's senior debt, $S\&PSr.DebtDummy$, and N firm dummy variables. It is broken down by low and high price years.

Table 6a						
Gas						
	All Prices	N	Price < $1.90	N	Price> $1.90	N
All	-.040 (.319)	1408	-.052 (.356)	639	-.030 (.284)	769
Cash Flow is Positive	-.048 (.294)	1217	-.067 (.316)	534	-0.032 (.275)	683
Cash Flow is Negative	.008 (.442)	191	.026 (.507)	105	-.014 (.349)	86
Combined Difference T-test	2.25		2.47		0.56	

Mean of the percentage change in gas production. Standard errors are in parentheses. The firms are broken down by low and high price years and by whether or not a firm has a positive cash flow.

Table 6b						
Liquids						
	All Prices	N	Price < $18	N	Price> $18	N
All	-.006 (.334)	1243	.000 (.342)	974	-.029 (.300)	269
Cash Flow is Positive	-.024 (.315)	1071	-.020 (.320)	825	-.036 (.295)	246
Cash Flow is Negative	.103 (.419)	172	.111 (.429)	149	.0483 (.350)	23
Combined Difference T-test	4.66		4.35		1.29	

Mean of the percentage change in liquids production. Standard errors are in parentheses. The firms are broken down by low and high price years and by whether or not a firm has a positive cash flow.

Table 7									
Liquids									
	ALL YEARS YEARS			YEARS WHEN $P < \$18$			YEARS WHEN $P > \$18$		
	1	2	3	4	5	6	7	8	9
$\frac{\Delta GAS}{GAS}$	.398		.397	.424		.421	.352		.353
	(16.56)		(16.63)	(14.52)		(14.52)	(8.50)		(8.50)
$CASHFLOW/ASSETS$		-.191	-.189		-.206	-.182		.038	-.074
		(-3.35)	(-3.64)		(-3.34)	(-3.27)		(0.23)	(-0.49)
$CONSTANT$	-.002	-.006	.012	.017	.007	.028	-.048	-.057	-.040
	(-0.30)	(-0.59)	(1.27)	(1.70)	(0.59)	(14.49)	(-3.27)	(-2.51)	(-1.93)
$Adj.R^2$	.171	.008	.179	.181	.011	.190	.159	-.003	.157
N	1,327	1,327	1,327	948	948	948	379	379	379

$$\frac{\Delta q_{t,t-1}}{q_{t-1}} = \alpha + \beta_1 \Delta Gas_{t,t-1}/Gas_{i,t-1} + \beta_2 CASHFLOW/ASSETS_{i,t-1} + \epsilon_{i,t}$$

The regressions in this table are OLS regressions where the change in the production of liquids is regressed against the change in the production of gas and the cash flow to assets ratio. The table is broken down by low and high price years.

Table 8									
Liquids									
	ALL YEARS YEARS			YEARS WHEN $P < \$18$			YEARS WHEN $P > \$18$		
	1	2	3	4	5	6	7	8	9
$\frac{\Delta GAS}{GAS}$	.427		.426	.442		.442	.411		.413
	(21.83)		(21.96)	(19.05)		(19.22)	(11.38)		(11.39)
$CASHFLOW/ASSETS$		-.184	-.182		-.191	-.182		-.114	-.111
		(-3.97)	(-4.33)		(-3.85)	(-4.12)		(-0.81)	(-0.83)
$CONSTANT$	-.010	-.008	.004	.005	-.001	.018	-.047	-.031	-.036
	(-1.55)	(-0.95)	(0.59)	(0.61)	(-0.07)	(2.19)	(-3.70)	(-1.61)	(-1.97)
N	1,327	1,327	1,327	948	948	948	379	379	379

$$\frac{\Delta q_{t,t-1}}{q_{t-1}} = \alpha + \beta_1 \Delta Gas_{t,t-1}/Gas_{i,t-1} + \beta_2 CASHFLOW/ASSETS_{i,t-1} + \epsilon_{i,t}$$

The regressions in this table are robust regressions where the change in the production of liquids is regressed against the change in the production of gas and the cash flow to assets ratio. The table is broken down by low and high price years.

Bibliography

Brennan, Michael and Schwartz, Eduardo S. 1985. "Evaluating Natural Resource Investments." *Journal of Business*, 58, 2, April 1985, pp. 135-157.

Gibson, Rajna and Schwartz, Eduardo. "Stochastic Convenience Yield and the Pricing of Oil Contingent Claims.",*Journal of Finance.*, July, 1990 pp. 959-976.

Hull, John C. *Options, Futures, and Other Derivative Securities*, Upper Saddle River: Prentice Hall N.J., 1993.

Lamont, Owen. "Corporate Finance and Macroeconomics," *Dissertation* , M.I.T., 1994.

Levhari, David and Pindyck, Robert. "The Pricing of Durable Exhaustible Resources," *Quarterly Journal of Economics*, 96, 3, August 1981, pp. 365-377.

Long, William and Ravenscraft, David. "LBO's , Debt and R+D.", *Bureau of the Census Center for Economic Studies Discussion Paper*, February 1993.

Mello, Antonio S. and Parsons, John E. "Measuring the Agency Cost of Debt," *Journal of Finance*, 47, 5, December 1992, pp. 1887-1904.

Miller,M. and Upton,C. "A Test of the Hotelling Valuation Principle," *Journal of Political Economy* , 93, 1, February 1985, pp. 1-25.

Oil and Gas Journal Databook, Tulsa, OK: PennWell Publishing Co, 1986-1995.

Pindyck, Robert. "Optimal Production of an Exhaustible Resource when Price is Exogenous and Stochastic", *Scandinavian Journal of Economics*, 83, 2, 1981, pp. 277-88

Pindyck, Robert. "Uncertainty and exhaustible resource markets", *Journal of Political Economy*, 88, 6, December 1980, pp. 1203-1225.

Pindyck, Robert and Dixit, Avinash. *Investment Under Uncertainty*, Princeton University Press, 1994.

U.S. Department of Energy. *Performance Profiles of Major Energy Producers*, Washington, DC: Office of Energy Markets and End Use, 1995.

Chapter 3

Why Do Firms Pay Special Dividends?

3.1 Introduction

This final chapter is a study on the role special dividends play in the distribution of cash by firms. Firms have a variety of means by which cash can be disbursed to stockholders. Regular dividends are by far the most important means of distributing cash. Share repurchases are another means; indeed during the 1980's, this became an increasingly important way of distributing cash. Both of these methods have received considerable attention from researchers. This chapter considers a third means of distributing cash to shareholders through the issuance of special dividends, which have received considerably less attention.

Special dividends are one time cash disbursements. Extra dividends are also one time cash disbursements but are paid at the same time as a regular dividend. Since special and extra dividends are not expected to be repeated, they are more like share repurchases than quarterly dividends.

In this paper, we will characterize the types of firms that issue special dividends and investigate the information that these dividends convey by looking at the excess returns of stocks around the announcement of a special dividend.

There have been other papers written in the last few years that have looked at the relationship of the excess returns on stocks around an event to the financial characteristics of the firm. Healy and Palepu (1988) show that firms which initiate dividend payments have positive earnings changes. Subsequent earnings changes were related to the dividend announcement returns. Lang and Litzenberger (1989) looked at dividend changes during the period of 1979-1984. They showed that the stock's positive excess returns after dividend increases were larger and that the stock's negative excess returns after dividend cuts were were also larger when firms had a low Tobin's Q. Firms with a low Tobin's Q have less internal investment opportunity. Free cash flow theory predicts that firms that distribute cash to shareholders that cannot be used productively internally should be rewarded more than those that have good internal investments. The gain in stock price was .3% when dividends were increased for those firms that had a high Tobin's Q and .8% for those with a low Tobin's Q. When there was a dividend decrease, firms with a high Tobin's Q did better, a decline of −.3%, than those with a low Tobin's Q, a decline of −2.7%. Both the size and the significance of the change in stock price grows when Q is less than one. In this paper, we will examine whether this phenomenon also occurs for special dividends.

The reaction to other types of cash distributions are also dependent on a firm's internal investment opportunities. In Vafeas and Joy (1995), open market repurchases are shown to increase shareholder gains if Q is low. Firms with high free cash flow and a low Tobin's Q had the highest gains in the period around the announcement event. Howe, He, and Kao (1992) looked at tender offer repurchases as well as special dividends. They found no significant difference between high and low Q firms. However, their sample was small. They had only 60 events for special dividends which may have explained their insignificant results.

This chapter will also look at the firm's capital structure at the time of the issuance of special dividends. Firms that have become underleveraged for one reason or another could use a special dividend to move towards a more optimal capital structure.

3.2 Data

A list of special dividend issues is obtained from the CRSP data file. Special and extra dividends have distribution code number 1272. The events extracted with this code match the *Wall Street Journal Index* dates for special dividends usually within a window of two days. The period that is examined is the 33 years between 1962 and 1994. A subset of 684 special dividends events from 1986 to 1993 is also examined more closely because there was quarterly financial data available from the issuing firms. These were firms where it was possible to match the CRSP data on stock returns to COMPUSTAT data on income statements and balance sheets.

The search through CRSP generated a list of 6,501 special dividends. These special dividends were issued by 2,184 different firms. The firm with the most special dividends issued 66. The bulk of the firms issued far fewer. The left hand side of Table 1 shows the breakdown of the number of special dividends issued per firm. Almost half of the firms extracted in the search issued only one special dividend during the period examined and only slightly more than 5% gave out 10 or more.

When special dividends are issued in close succession to each other, shareholders might come to expect them. Thus, the stock price reaction to the announcement of a special dividend might be less than it otherwise would be because it is less of a surprise. If one excludes the special dividends that come within 2 years of a previous special dividend, we are left with 2,655 special dividends from 2,178 different firms. On the right hand side of Table 1, we see the breakdown of special dividends when they are separated by more than two years from the previous special dividend. By excluding firms that issue more than one special dividend within two years, we eliminate many of these firms that issued multiple special dividends so that over 90% of the events were from firms that issued only one special dividend during this period.

Table 2 shows how many of the events were the first special dividend for the firms examined, how many were the second dividend of the firms examined, and so on. The left hand side of Table 2 shows the breakdown for all events and the right hand for events spaced at least 2 years apart. Only a third of all special dividend events are the first for firms issuing them, while over eighty percent are the first issue when the more restrictive sample is considered.

Special dividends were issued in every year in the period selected. Figure 1 shows the number of events by year of issuance. There does seem to be a small increase in the frequency of special dividends over time. However, when broken down between those firms that have quarterly dividends and those that do not, there is a sharp rise in the number of firms without quarterly dividends that issue special dividends over the past decade.

The value of a special dividend may be affected by whether or not the firm issues regular dividends. If a firm is already distributing cash on a regular basis, a special dividend might seem like a less important signal to the financial markets than it is for a firm that is not normally distributing cash. On the other hand, giving out extra cash on top of a quarterly dividend might be seen as a better signal because it shows that the firm can afford to do so. Table 3 shows the breakdown of firms with regular quarterly dividends and no regular quarterly dividends that issue special dividends. On the left hand side, the breakdown is shown for all special dividend events and on the right hand side, for those events for which there is quarterly COMPUSTAT data. A little over 70% of special dividend issues are by firms already issuing quarterly dividends.

Another important characteristic of special dividends is the size of the special dividend relative to the stock price. The Special Dividend/Share Price ratio, SPD_{it}, is calculated from the price two days before the announcement date so as to avoid the announcement interfering with the price. Table 4 shows a summary of this payout ratio. The payout ratio is larger for firms without quarterly dividends than those with quarterly dividends. This makes sense since firms with regular dividends are already dispensing cash to shareholders. In addition, given that there are fixed costs of processing a dividend, a firm that is not regularly paying a dividend (and therefore not already bearing this cost) would need to make a relatively large payment to make it worthwhile.

The mean of the payout ratio is 1.9% for the full sample and 4.9% for the COMPUSTAT subsample. However, the median is much lower: it is just .69% for the full sample and .84% for the COMPUSTAT subsample. This is because most firms give out very small special dividends with a few large ones bringing up the average. If one excludes the firms without quarterly dividends, the median increases to nearly 1 percent for the entire sample.

A breakdown of the payout ratio is given in Table 5 for the entire sample and for the subsample with financial data. From Table 5, it can be seen that the majority of special dividend payouts are small amounts. The firms with financial data also have much larger payout ratios than the firms in the entire dataset. Part of this has to do with the fact that there was an increase in the payout ratio over time and the events with financial data were later than the average event. For example, the size of the distribution increased from under 1 percent for the period before 1975 to 2.5 percent for the period after 1975.

3.2.1 Special Dividends and the Financial Characteristics of Issuing Firms

Firms which issue special dividends have different financial characteristics than other firms. Table 6 and Table 7 show the change in various financial statistics of a firm surrounding a special dividend issue in the period from 1986 to 1993. Issuing firms show an increase in assets and market value over the years following a special dividend. However, operating profits and sales do not display any increasing trend. Capital expenditures also don't show any sustained rise though research and development spending does rise.

One motivation for a firm to issue a special dividend is that it might have more cash on hand than is optimal. A firm with too little cash would seem like an unlikely candidate for issuing a special dividend. A firm that has very little debt might find itself underleveraged. Issuing a special dividend would allow it to increase its leverage. On the other hand, a firm that is already highly leveraged would only make its situation more precarious by distributing more cash to shareholders.

The data confirm this expectation. Firms that issue a special dividend between 1962 and 1991 have an average cash and liquid assets to total assets ratio equal to 14.8% compared with 11.2% for all COMPUSTAT firms from the industrial file. The average total debt to total assets ratio for the same sample period was 12.3% compared with 21.3% for all firms. In every year between 1962 and 1991, the average firm that issue special dividends have more liquid assets and less debt than other firms. The special dividends can be viewed as an attempt by a firm to return to a better capital structure.

A way to confirm this hypothesis is to see whether firms with a higher cash to assets ratio issue larger special dividends than other firms which issue special dividends. Also, firms with a low leverage would be expected to pay out larger dividends than those with a high leverage. However, there is no significant difference in the size of the firm's special dividend payout ratio between high cash and low cash firms or between high leveraged and low leveraged firms.

3.2.2 Excess Returns

In this section, I examine the informational content of a special dividend issue. I start by calculating the excess returns around the announcement of a special dividend. The excess return, ER_{it} for firm i is given by:

$$ER_{it} = RET_{it} - MR_{it}$$

where MR_{it} is the market return during a five day window around the event using equally-weighted CRSP data and RET_{it} is the return on the stock for the same period using stock returns from CRSP data. One can also adjust the excess returns by the firm's beta.

$$ER_{it} = RET_{it} - \beta_{it}(MR_{it} - r_{ft}) - r_{ft}$$

The β used in the above equation is estimated from the daily returns of the firm for the year before the event. The variable, r_{ft}, is the risk free interest rate during the month of the event.

There was only enough daily data on CRSP to generate betas for a subset of 5,388 events. Table 8a shows the excess returns for the full sample and for the COMPUSTAT subsample. On the left hand side are all events and the right hand side events are the events with quarterly COMPUSTAT data. The entire sample had a mean excess return of 2.3%. The excess returns averaged 2.1% percent for firm with quarterly dividends and 2.9% for firms without quarterly dividends. The difference between these means is statistically significant. If one looks at events in the later period where there is financial data, the excess return is 2.7% and the difference between the returns of firms without quarterly dividends is still significantly higher than it is for firms without quarterly dividends.

In Table 8b, the beta adjusted excess returns are displayed. The same patterns hold but the excess returns increase slightly. These excess returns can be compared to the excess returns for dividends initiations in Thaler, Michaely, and Womack(1994). In that sample, the announcement of dividend initiations is followed by excess returns of 3.5%. The smaller effect found in this study may be because they are not expected to be repeated while regular dividends are. Even though the average quarterly dividend is less in value than the average special dividend, it is worth more because a firm has implicitly promised to repeat it.

The payout ratio effects the excess returns around a special dividend event. To see this effect, the excess return around an event was regressed against the firm's payout ratio. In the first regression in Table 9, the estimated coefficient of the payout ratio is positive and statistically significant. The results for the much smaller sample of firms with quarterly COMPUSTAT data are similar (see column 4).

To examine the effect of outliers, I used a robust regression. The results are in column 2 of Table 9 and do not change much from that of the first regression. The same is true for the fifth regression of Table 9 which was a robust regression using only the smaller sample of firms with quarterly COMPUSTAT data. Not much changes when robust regressions are used.

Finally, to take into account the effects of large special dividends, a variable for the square of the payout ratio was added, SPD^2. This was included because one should not expect a linear relation between the payout ratio and excess returns. For example, while a payout ratio of 10% is ten times larger than one of 1%, one would not expect ten times the excess return. Outliers where the payout ratio was above 1 were also removed. Column 3 in Table 9 shows the results of this OLS regression for all events and column 6 shows this for the smaller sample of firms. The results of these regressions show that the payout ratio has a significant positive coefficient but the square of the payout ratio has a significant negative coefficient. Excess returns increase with the payout ratio but with diminishing returns.

3.2.3 Free Cash Flow and Excess Returns

In this section, I investigate whether special dividends play a role in limiting managerial discretion in investment spending. Lang and Litzenberger have found some evidence along these lines for regular dividends. They discovered that the stock price response to the announcement of a dividend increase was greater for firms with more free cash flow and worse investment opportunities. Regular dividends are valued because they limit the ability of management to invest in negative net present value investments.

Does this phenomena also extend to firms that issue special dividends? Firms that pay out larger special dividends might be expected to have larger excess returns when the firm has free cash flow that cannot be used efficiently internally. To examine this possibility, one can use Tobin's Q to measure the firm's investment opportunities. Ideally, one would want to measure marginal Q - the marginal value of an extra dollar of investment. However, this is impossible to observe. As a crude proxy, I use the ratio of the market value of the firm to the book value of its assets. This is a close cousin to average Tobin's Q but differs from it in that I do not adjust the book value of assets for changes in depreciation and inflation. However, this adjustment is unlikely to impact the results (See Kaplan and Zingales (1996)). The data to generate the market and book values were extracted from annual COMPUSTAT data. For simplicity, I will call this ratio Q.

Firms were divided into two groups: those with Q greater than 1 and those with Q less than 1. The excess return around the event dates for these two groups of firms is compared in Table 10a and Table 10b. Table 10a shows the excess returns for all firms that had Q data. The low Q firms had an average return of 3.4% compared with 2.1% for the high Q firms. Table 10b shows the beta-adjusted returns for those firms from the COMPUSTAT subsample. The average excess returns for the low Q firms was 4.0% compared with 2.6% for the high Q firms. The difference is statistically significant for the whole sample of firms, and nearly significant in the small sample.

In the subsample of events with quarterly COMPUSTAT data, the payout ratio is lower in the low Q firms than in the high Q firms. Since, it has already been shown that firms that pay out more have higher excess returns than those that distribute less, this difference could explain the lack of significance in the subsample.

To separate the effect of Q from the effects of other variables, I added to the regressions in Table 9 a dummy variable equal to 1 for firms with $Q > 1$. The first column in Table 11 reports the results of an OLS regression with the payout ratio and the Q dummy. The coefficient of the Q dummy is negative and statistically significant. Column 4 repeats the regression for the subsample with quarterly COMPUSTAT data. A similar result is found for this regression.

In the second and fifth columns of Table 11, a robust regression was used to take into account the effect of outliers. In these regressions, the coefficient on the Q dummy loses significance. Part of the reason for this is that firms with high payout ratios can distort the outcome. To take this into account, a variable equal to the square of the payout ratio was added to an OLS regression when the payout ratio was less than 1. The results are shown in columns 3 and 6. The coefficient on Q is negative and statistically significant when using the entire sample. By including both the payout ratio and the Q dummy in the same regression, the significance of the Q dummy improves.

Table 12 redoes the regressions in Table 11 but with the inclusion of interaction variables between the Q dummies and SPD and SPD^2. The coefficient on the cross term between SPD and the Q dummy is significantly negative in all six regressions. As firms with low Q increase their payout ratio, they get a larger excess return than firms with a high Q. The coefficient of the cross term between the dummy variable and SPD^2 is positive which means that this effect diminishes for very large payouts. Outside investors reward firms that issue special dividends more when the firms have a low Q. Shareholders are rewarded when the special dividend size increases and even more so for low Q firms that increase special dividends.

The market reaction to special dividends might also be dependent on the capital structure of a firm. Firms with excess cash or low leverage may be below their optimal leverage ratio. By issuing a special dividend, they can help bring their firm closer to their target level.

Ideally, one would like to be able to observe a firm's optimal capital structure. Firms that are further below the optimum are more likely to issue special dividends. However, the optimal capital structure is clearly not observable. Instead, I argue that firms that see a big drop in leverage are more likely to be below their optimum. Thus, I calculate the change in the capital structure from 5 quarters before the event to one quarter before the event.

The first capital structure measure I examine is the ratio of cash and liquid assets to total assets. I divide firms into two groups: those firms with an increase in this ratio and those with a decrease. Of the 499 events with data, 261 had an increase in cash to assets and 238 saw a decrease in the cash to assets ratio between the time of 5 quarters before the event to 1 quarter before the event. Table 13a shows the payout ratios and the excess returns for these groups. Firms that had an increase in cash to assets had significantly higher returns than those firms that showed a decrease, 4.2% versus 2.3%. If the firms that had a rising level of cash to assets had a significantly higher payout ratio, that could explain this difference. However, the payout ratio of firms that increase their cash to assets is insignificantly different from the payout ratio of firms that show a decrease in cash to assets.

This effect is further increased if one breaks down firms into those with low and high Q ratios. Table 13b shows the payout ratio and excess returns for firms with a Q below 1 and Table 13c shows the payout ratio and excess returns for firms with a Q above 1. In both cases, there is no significant difference in the payout ratios between firms whose cash to asset ratio increases and those that have decreases. However, the excess returns are different for low and high Q firms. In Table 13b, we see that the excess returns are significantly higher for firms with a rising cash to assets ratio, 6.7%, than for those with a falling cash to assets ratio, 1.3%. The results in Table 13c are quite different. For high Q firms, there is no significant difference between firms with a rising cash to asset ratio and those with a falling ratio. The market reacts favorably to firms that dispense cash to shareholders through special dividends. This reaction is even more positive when firms have few good internal investment opportunities and rising amounts of cash in company coffers. This lends support to Jensen's free cash flow theory.

Another capital structure variable that can be affected by a firm issuing a special dividend is the debt to assets ratio. By issuing a special dividend, a firm becomes more leveraged than before. To determine whether or not a firm is underleveraged, the leverage ratio from 1 quarter before the event was compared with that from a year before that quarter. Firms that had an increase in leverage gave smaller payouts than firms that showed a decrease in leverage, 6.9% versus 3.7%. However, the excess returns show no significant difference between firms that increase their leverage and those that do not.

Once again firms were broken down by whether or not they had a high or low Q. Firms with a low debt to asset ratio and a low Q would be expected to have the highest excess returns when distributing cash. However, these firms do not have significantly higher excess returns than other firms. Firms do seem to use the special dividend to move towards a more optimal leverage since the payout ratio is higher for firms with a falling leverage but debt alone does not seem to affect excess returns.

One reason for this result might be that special dividends will have less of an effect on a leverage ratio than on a firm's cash to asset ratio because the average leverage ratio is higher than the average cash to assets ratio. The average leverage of the firms sampled here is 32 percent which is nearly double that of the cash to asset ratio, 17 percent. Another reason why the debt to asset ratio has less of an effect is that the problem for a firm is not too much equity but too much equity in the form of cash.

Also, if one looks at net leverage, debt minus cash divided by assets, similar results are found. Net leverage changes have no effect when Q is high, but when Q is low, firms with an increase in net leverage see higher excess returns after a special dividend announcement.

Finally, if firms are dispensing cash through special dividends to alleviate free cash flow problems, firms that give out more cash should be expected to be investing less. Firms were split into two groups, those which had a capital expenditures to asset ratio of more than 5 percent in the year following the special dividend and those that had less than 5 percent. The payout ratio of the firms with high capital expenditures was 4.8% but for firms with low capital expenses, the payout ratios averaged 9.3%. The difference in means between these two groups is statistically significant. Firms that distribute large special dividends are not planning on high capital expenditures. Managers do not want to dispense cash to shareholders if they expect to use it on internal investments in the near future.

3.3 Conclusion

Firms that issue one time special or extra dividends experience significant excess returns around their announcement date averaging 2.3%. The announcement effect is heavily affected by the size of the special dividend relative to the stock price. A larger payout raises the excess returns but with diminishing effects. But, more importantly, the payout has a much greater positive effect on the excess returns of the firms when they have poor investment opportunities. This provides evidence in support of Jensen's Free Cash flow model.

Firms that issue special dividends tend to have more cash and liquid assets and less debt than other firms. While this capital structure may be preferred by the management because the firm has fewer financial constraints, this would be viewed unfavorably by shareholders who would worry about managers misallocating funds. Investors would consider a more optimal capital structure to be one with more leverage and less cash on hand. Special dividends can move a firm closer to that more optimal capital structure and this move is rewarded by excess returns.

The evidence is consistent with this view. Firms that have been moving away from their optimal capital structure by accumulating too much cash are rewarded more when they issue a special dividend. This effect is increased for low Q firms indicating that investors are particularly concerned about what firms will do with their cash when they have few investment opportunities. Firms that plan on large capital expenditures give out smaller special dividends than other firms suggesting that firms prefer to use internal funds when they invest.

Table 1				
	All	Events	Events 2	Yrs. Apart
No. of Special Dividends	No. of Firms	Percent	No. of Firms	Percent
1	1,072	49.08	1,976	90.73
2	380	17.40	125	5.74
3	218	9.98	24	1.10
4	133	6.09	26	1.19
5	88	4.03	10	0.46
6	64	2.93	2	0.09
7	48	2.20	1	0.04
8	35	1.60	4	0.18
9	29	1.33	6	0.28
10+	117	5.36	4	0.18

The first sets of columns has the number of firms that issued that many special dividends. The second set of columns includes only the firms with at least a two year gap between special dividends.

Table 2				
	All	Events	Events 2	Yrs. Apart
No. of the Special Dividend	No. of Events	Percentage	No. of Events	Percentage
1	2,184	33.59	2,184	82.26
2	1,112	17.11	208	7.83
3	732	11.26	83	3.13
4	514	7.91	59	2.22
5	381	5.86	33	1.24
6	293	4.51	23	0.87
7	229	3.52	13	0.49
8	181	2.78	11	0.41
9	146	2.25	10	0.38
10+	636	11.21	31	1.17

The first sets of columns has the number of special dividends that are the first, second, etc. issued by a particular firm. In the second set of columns, only the firms with at least a two year gap between special dividends are included.

Table 3				
	All	Events	Subsample with	Financial Data
Quarterly Dividends	No. of Events	Percent	No. of Events	Percent
Yes	4,705	72.37	486	71.16
No	1,796	27.63	486	28.84

Shows number of firms with and without quarterly dividends in the first two columns and the same in the last two for the firms where there is quarterly COMPUSTAT data

Table 4				
	All	Events	Subsample with	Financial Data
	SPD_{it}	No. of Events	SPD	No. of Events
All	.0190 (.0762)	6,427	.0458 (.1784)	684
If Quarterly Dividends	.0141 (.0475)	4,652	.0836 (.0628)	486
If No Quarterly Dividends	.0318 (.1219)	1,775	.0304 (.1668)	198
Difference T-Test	(8.38)		(3.57)	

SPD is the ratio of the special dividend to the pre-announcement price of the stock. The left hand side represents all events and the right hand side includes the events where is quarterly COMPUSTAT data.

Table 5				
	All	Events	Financial Data	Subsample
Less than .5%	2,577	39.96	265	40.90
Between .5% and 1%	1,596	24.75	120	17.54
Between 1% and 2%	1,242	19.26	114	16.67
Between 2% and 3%	407	6.31	44	6.43
Between 3% and 5%	303	4.70	42	6.14
Between 5% and 10%	154	2.39	38	5.56
Between 10% and 20%	79	1.22	24	3.51
Between 20% and 50%	60	0.93	26	3.80
Greater than 50%	31	0.48	11	1.61
Total	6,449	100	684	100
Median	.69%		.84%	

The special dividend events are broken down by the payout ratio for all events and for the events where there is quarterly COMPUSTAT data.

Table 6				
	Year Prior	Year of Event	Years After Event	Two Years After Event
Total Assets	678	726	771	829
	(5280)	(5885)	(6187)	(6931)
Sales	445	474	515	510
	(2062)	(2166)	(2544)	(2273)
Market Value	298.99	363.04	393.22	
	(675.8)	(912.3)	(990.8)	
Operating Profits Bef. Depreciation	56.86	60.42	60.67	56.44
	(283)	(263)	(278)	(240)
Capital Expenditures	53.77	53.40	63.79	67.95
	(322.52)	(294.10)	(398.93)	(438.64)
R&D	1.27	2.28	2.65	2.78
	(12.66)	(18.86)	(19.74)	[illegible]19)

Mean in nominal dollars with standard deviations in parentheses.

Table 7				
	Year Prior	Year of Event	Years After Event	Two Years After Event
Operating Profit Before	.149	.161	.153	.134
Depreciation/Assets	(.167)	(.256)	(.260)	(.171)
Capital Expenditures/Assets	.120	.123	.122	.115
	(.123)	(.120)	(.124)	(.123)
$R\&D$/Assets	.0056	.0070	.0085	.0088
	(.0274)	(.0277)	(.0284)	(.0267)

These ratios are calculated for the year before, the year of the event, the year after and two years after the event.

Table 8a								
	All	Events			Subsample	With	Financial	Data
	Mean	Std. Dev.	T-Test	N	Mean	Std. Dev.	T-Test	N
ER_{it}	.0230	.0725	25.39	6,420	.0268	.0889	7.87	683
ER_{it} if divs.	.0209	.0612	23.24	4,648	.0190	.0820	5.12	486
ER_{it} if no divs.	.0285	.0957	12.52	1,772	.0458	.1018	6.32	197
Combined Difference T-Test			3.75				3.60	

This table shows the excess returns for all events on the left and the excess returns for events where there is quarterly financial data on the right.

Table 8b								
	All	Events			Subsample	With	Financial	Data
	Mean.	Std Dev.	T-Test	N	Mean	Std. Dev.	T-Test	N
ER_{it}	.0239	.0733	23.90	5,388	.0277	.0883	8.15	674
ER_{it} if divs.	.0213	.0610	21.90	3,939	.0205	.0812	5.54	480
ER_{it} if no divs.	.0308	.0989	11.86	1,449	.0456	.1022	6.21	194
Combined Difference T-Test			4.24				3.36	

This table shows the beta-adjusted excess returns for all events on the left and the beta-adjusted excess returns for events where there is quarterly financial data on the right.

Table 9						
Regression	1	2	3	4	5	6
SPD	.2422	.3193	.7761	.1802	.0510	.5663
	(21.11)	(44.57)	(21.62)	(10.21)	(5.58)	(8.71)
SPD^2			-.8033			-.5292
			(-13.78)			(-5.13)
$CONSTANT$	.0183	.0085	.0116	.0194	.0090	.0101
	(20.34)	(15.19)	(12.04)	(5.93)	(5.35)	(3.27)
Adj. R^2	.065		.093	.133		.154
N	6,442	6,442	6,438	674	674	672

$$ER_{it} = \alpha + \beta_1 + \beta_1 SPD + \beta_2 SPD^2 + \epsilon_{it}$$

Regressions 1-3 are regressions of the excess returns for all events against the payout ratio, SPD and the payout ratio squared, SPD^2. Regressions 1 and 3 are OLS and regression 2 is a robust regression.

Regressions 4-6 are regressions of the beta-adjusted excess returns for the events with quarterly COMPUSTAT data against the payout ratio, SPD and the payout ratio squared, SPD^2. Regressions 4 and 6 are OLS and regression 5 is a robust regression.

Table 10a				
	Mean	Std Dev	T-Test	N
ER_{it}	.0272	.0813	21.03	3,964
ER_{it} if $Q > 1$	.0205	.0635	14.40	1,995
ER_{it} if $Q < 1$	.0340	.0956	15.76	1,969
Combined Difference			5.24	

The excess returns for all events are split into two groups where Q is known. There is a significant difference between the means of the two subsamples.

Table 10b				
	Mean	Std Dev	T-Test	N
ER_{it}	.0321	.0989	8.15	508
ER_{it} if $Q > 1$	.0264	.0746	6.16	301
ER_{it} if $Q < 1$	.0401	.1252	4.81	213
Combined Difference			1.56	

The excess returns, adjusted by beta for events with quarterly financial data are split into two groups where Q is known. There is a significant difference between the means of the two subsamples.

Table 11						
Regression	1	2	3	4	5	6
$Q > 1$	-.0130	-.0020	-.0104	-.0157	.0515	-.0073
	(-5.23)	(-1.28)	(-4.38)	(-1.90)	(1.13)	(-1.02)
SPD	.2265	.3065	.7306	.1726	.0510	.5100
	(17.20)	(36.75)	(16.45)	(8.66)	(4.62)	(6.65)
SPD^2			-.7263			-.4532
			(-10.40)			(-3.80)
$CONSTANT$	.0283	.0123	.0197	.0319	.0089	.0171
	(15.79)	(10.84)	(10.68)	(4.99)	(2.50)	(2.88)
Adj. R^2	.075		.100	.130		.132
N	3,979	3,979	3,975	508	508	506

$$ER_{it} = \alpha + \beta_1 + Q_{DUMMY} + \beta_2 SPD + \beta_3 SPD^2 + \epsilon_{it}$$

Regressions 1-3 are regressions of the excess returns for all events against a dummy variable equal to 1 when Q is greater than 1, the payout ratio, SPD and the payout ratio squared, SPD^2. Regressions 1 and 3 are OLS and regression 2 is a robust regression.

Regressions 4-6 are regressions of the beta-adjusted excess returns for the events with quarterly COMPUSTAT data against a dummy variable equal to 1 when Q is greater than 1, the payout ratio, SPD and the payout ratio squared, SPD^2. Regressions 4 and 6 are OLS and regression 5 is a robust regression.

Table 12						
Regression	1	2	3	4	5	6
$Q > 1$	-.0059	-.0003	-.0032	-.0065	.0139	.0052
	(-2.34)	(-0.17)	(-1.20)	(-2.38)	(2.80)	(0.62)
SPD	.4223	.3441	.9475	.4718	.5742	.9287
	(18.72)	(23.73)	(15.40)	(18.61)	(21.18)	(6.62)
SPD^2			-.9677			-1.353
			(-9.94)			(-4.86)
$Q > 1 * SPD$	-.2929	-.1544	-.4483	-.3619	-.5228	-.5679
	(-10.62)	(-8.71)	(-5.07)	(-11.96)	(-17.52)	(-3.34)
$Q > 1 * SPD^2$			.5122			1.130
			(3.68)			(3.63)
$CONSTANT$	.0234	.0118	.0157	.0235	.0002	.0077
	(12.82)	(10.08)	(7.98)	(12.03)	(0.06)	(1.16)
Adj. R^2	.101		.107	.109		.151
N	3,979	3,979	3,975	508	508	506

$$ER_{it} = \alpha + \beta_1 + Q_{DUMMY} + \beta_2 SPD + \beta_3 SPD^2 + \beta_4 Q_{DUMMY} SPD + \beta_5 Q_{DUMMY} SPD^2 + \epsilon_{it}$$

Regressions 1-3 are regressions of the excess returns for all events against a dummy variable equal to 1 when Q is greater than 1, the payout ratio, SPD, the payout ratio squared, SPD^2, and cross terms between the dummy variables and the payout ratios. Regressions 1 and 3 are OLS and regression 2 is a robust regression.

Regressions 4-6 are regressions of the beta-adjusted excess returns for the events with quarterly COMPUSTAT data against a dummy variable equal to 1 when Q is greater than 1, the payout ratio, SPD, the payout ratio squared, SPD^2, and cross terms between the dummy variable and the payout ratios. Regressions 4 and 6 are OLS and regression 5 is a robust regression.

Table 13a							
	All Firms	N	Firms w/ Falling Cash/Assets	N	Firms w/ Rising Cash/Assets	N	T-Test of Difference
SPD	.059 (.205)	506	.051 (.130)	244	.062 (.256)	262	0.59
ER	.033 (.099)	499	.023 (.080)	238	.042 (.114)	261	2.08

This shows the payout ratio, SPD, and the excess returns, ER, broken into groups based on whether or not the firm had a rise in cash to assets in the year before the event.

Table 13b							
	All Firms	N	Firms w/ Falling Cash/Assets	N	Firms w/ Rising Cash/Assets	N	T-Test of Difference
SPD	.051 (.133)	206	.044 (.104)	102	.057 (.156)	104	0.70
ER	.041 (.124)	203	.013 (.076)	100	.067 (.156)	103	3.10

This shows the payout ratio, SPD, and the excess returns, ER, broken into groups based on whether or not the firm had a rise in cash to assets in the year before the event when Q is less than one.

Table 13c							
	All Firms	N	Firms w/ Falling Cash/Assets	N	Firms w/ Rising Cash/Assets	N	T-Test of Difference
SPD	.060 (.241)	298	.057 (.147)	141	.064 (.305)	157	0.74
ER	.027 (.074)	294	.030 (.082)	137	.024 (.069)	157	-0.26

This shows the payout ratio, SPD, and the excess returns, ER, broken into groups based on whether or not the firm had a rise in cash to assets in the year before the event when Q is greater than 1.

Figure 3.1 - Number of Special Dividend Events

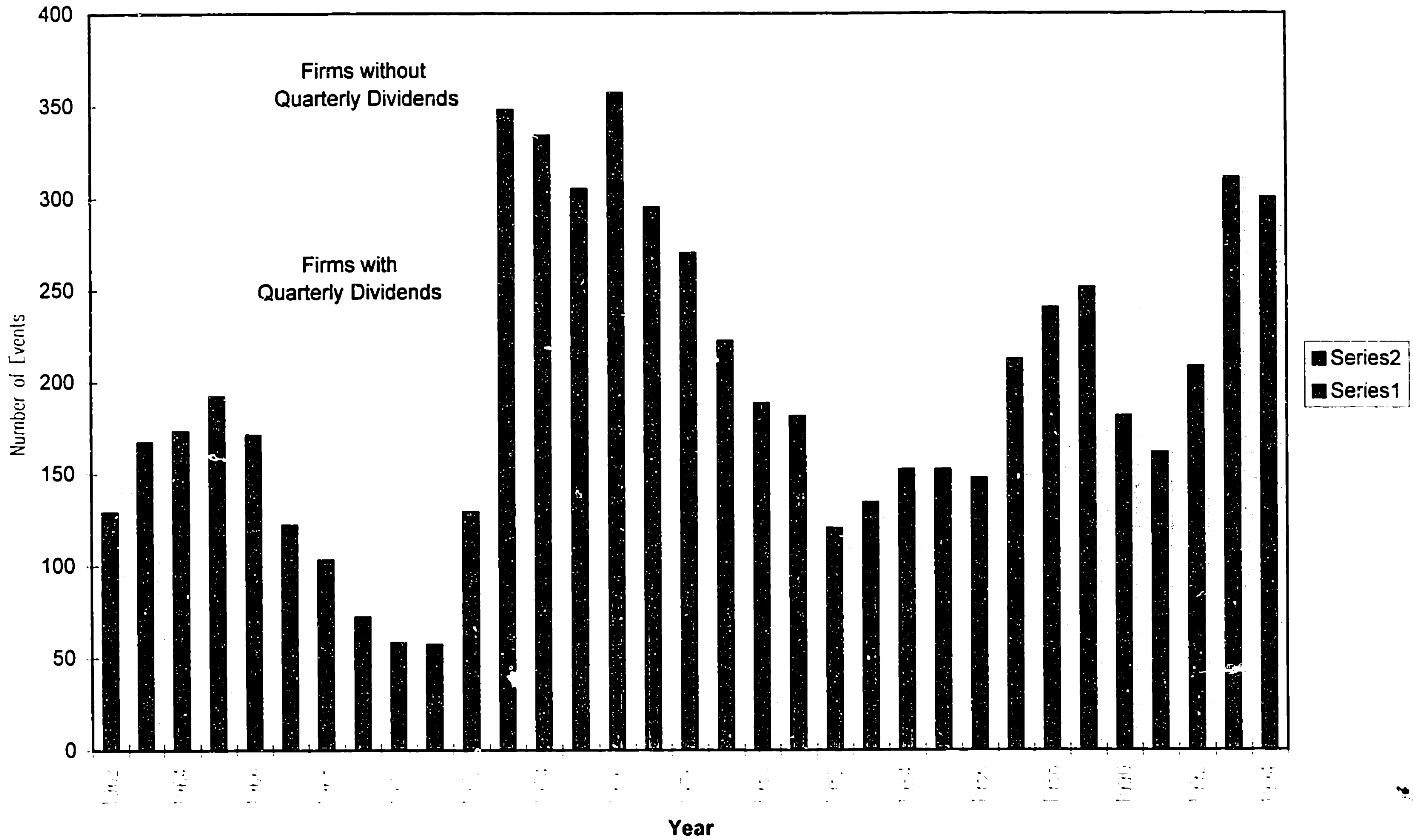
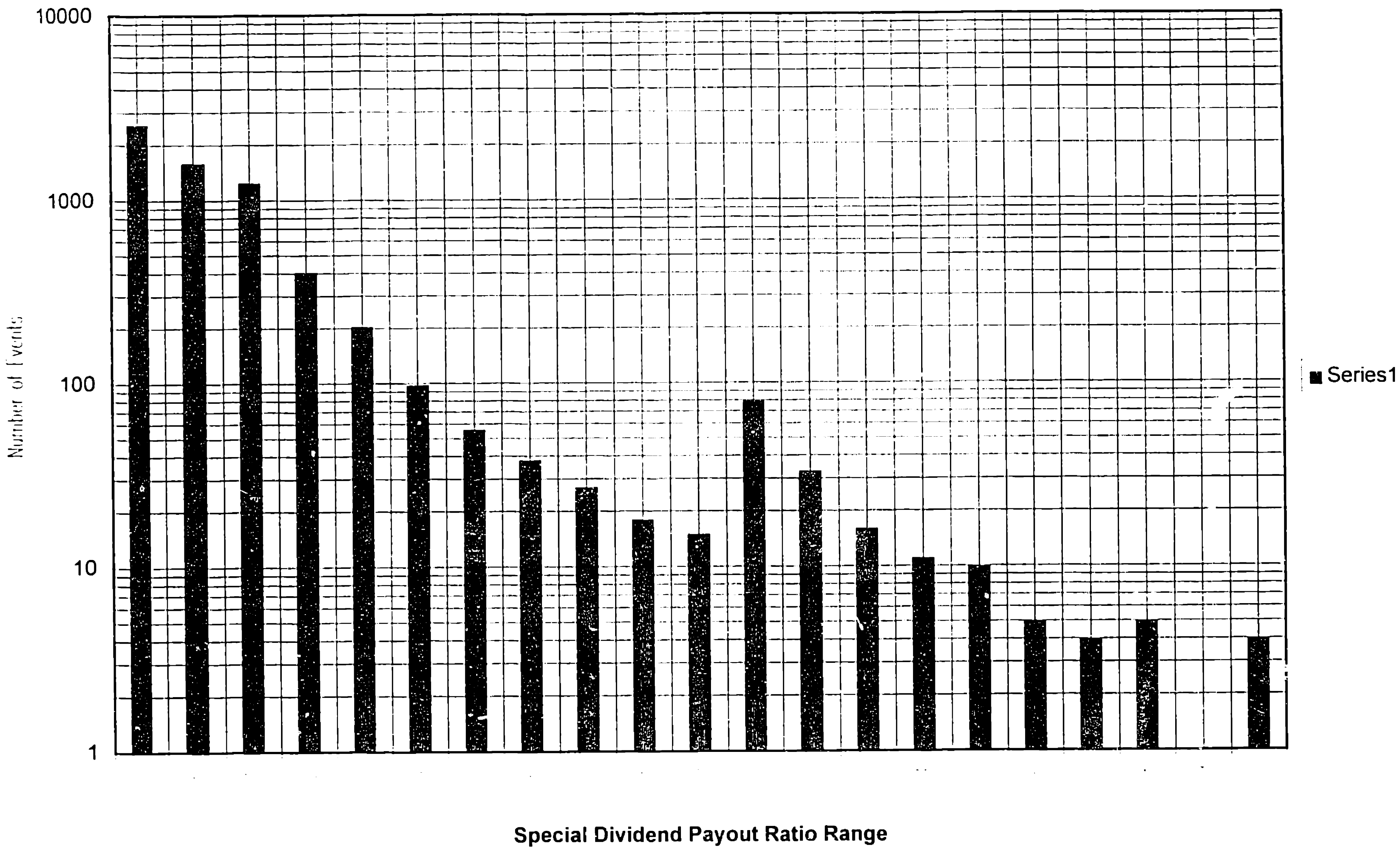


Figure 3.2 - Distribution of Payout Ratios



3.4 Bibliography

Bradley, Michael, Jarrell, Gregg A. and Kim, E. Han. "On the Existence of an Optimal Capital Structure: Theory and Evidence," *Journal of Finance*, 39, 3, July 1984, pp. 857-78.

Brennan, Michael J. and Thakor, Anjan. "Shareholder Preferences and Dividend Policy," *Journal of Finance*, 45, 4, September 1990, pp. 993-1018.

DeAngelo, Harry and DeAngelo, "Dividend Policy and Financial Distress: An Empirical Investigation of Troubled NYSE Firms," *Journal of Finance*, 45 ,5, December 1990, pp. 1415-31.

Eades, Kenneth M. "Empirical Evidence on Dividends as a Signal of Firm Value," *Journal of Financial and Quantitative Analysis*, 17, 4 ,November 1982, pp. 471-500.

Easterbrook, Frank H. "Two Agency-Cost Explanations of Dividends," *American Economic Review*, 74, 4, September 1984, pp. 650-59.

Healy, Paul M. and Palepu, Krishna G. "Earnings Information Conveyed by Dividend Initiations and Omissions," *Journal of Financial Economics*, 21, 2, September 1988 , pp. 149-75.

Howe, Keith M., He Jia and Kao, G. Wenchi. "One-Time Cash Flow Announcements and Free Cash-Flow Theory: Share Repurchases and Special Dividends," *Journal of Finance*, 47, 5, December 1992, pp. 1963-75.

Kaplan, Steven N. and Zingales, Luigi. "Do Financing Constraints Explain Why Investment is Correlated with Cash Flow?" *NBER Working Paper*, No. 5267, 1995.

Jensen, Michael. "Agency Costs of Free Cash Flow, Corporate Finance, and Takeovers," *American Economic Review*, 76, 2, May, 1986, pp.323-29.

Joy, Maurice and Vafeas, Nikos O. "Open Market Share Repurchases and the Free Cash Flow Hypothesis," *Economics Letters* , 48,3-4, June 1995, pp. 405-410.

Kalay, Avner "Signalling, Information Content, and the Reluctance to Cut Dividends," *Journal of Financial and Quantitative Analysis* , 15, 4, November, 1980, pp. 855-869.

Lang, Larry H. P. and Litzenberger, Robert H. "Dividend Announcements: Cash Flow Signalling vs. Free Cash Flow Hypothesis?" *Journal of Financial Economics*, 24, 1, September 1989, pp. 181-91.

Ofer, Aharon R. and Thakor, Anjan V. "A Theory of Stock Price Responses to Alternative Corporate

Cash Disbursement Methods: Stock Repurchases and Dividends," *Journal of Finance* , 42, 2, June, 1987, pp. 365-394.

Thaler R., Michaely, R., and Womack, K. "Price Reactions to Dividend Initiations and Omissions:Overreaction or Drift?" *Journal of Finance*, 50, 2, June 1995, pp. 573-608.