Corporate Finance and Macroeconomics

by

Owen A. Lamont

B.A., Economics and Government, Oberlin College (1988)

Submitted to the Department of Economics
in partial fulfillment of the requirements for the degree of

Doctor of Philosophy in Economics

at the

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

May 1994

Author ....
Department of Economics
May 5, 1994

Certified by ....
Olivier Jean Blanchard
Professor of Economics
Thesis Supervisor

Certified by ....
Jeremy C. Stein
Professor of Finance
Thesis Supervisor

Accepted by ....
Olivier Jean Blanchard
Department Committee on Graduate Studies

Corporate Finance and Macroeconomics

by

Owen A. Lamont

Submitted to the Department of Economics
on May 18, 1994, in partial fulfillment of the
requirements for the degree of
Doctor of Philosophy in Economics

Abstract

Chapter 1

One way in which corporate financial structure affects macroeconomic performance is by creating debt overhang. Debt overhang occurs when existing debt deters new investment because the benefits from new investment will go to the existing creditors, not to the new investors. If the economy is booming, debt overhang will not bind because the returns to investing are high. If the economy is stagnant, debt overhang will bind because the returns to investing are low. As a result, high levels of debt can create multiple expectational equilibria in which "animal spirits" determine economy activity. We also show that, despite the costs of debt from deterring investment, it might still be individually rational for corporations to have high debt levels.

Chapter 2

Using data from the 1986 oil price decrease, we examine the capital expenditures of the non-oil subsidiaries of oil companies, compared to a control group of similar units owned by firms less affected by oil. We test the joint hypothesis that 1) a decrease in cash flow and collateral decreases investment, holding fixed the profitability of investment, and 2) the finance costs of different parts of the same corporation are interdependent. The results support this joint hypothesis: oil companies significantly reduced their non-oil investment compared to the control group.

Chapter 3

We test whether the time-series positive correlation of inflation and relative price variability is also present in a cross-section of US cities. We find this correlation to be a robust empirical regularity: cities which have higher than average inflation also have higher than average relative price dispersion, ceteris paribus. This result holds for different periods of time, different classes of goods, and (surprisingly) across different time horizons. Our results suggest that at least part of the relationship between inflation and relative price variability cannot be explained by monetary factors.

Thesis Supervisor: Olivier Jean Blanchard
Title: Professor of Economics

Thesis Supervisor: Jeremy C. Stein
Title: Professor of Finance

Acknowledgments

I wish to thank my teachers, classmates, officemates, and colleagues for all they have tried to teach me in the past four years. Special thanks goes to my employers (Rudi Dornbusch), coauthors (Guy Debelle, Anil Kashyap, and Peter Klibanoff), and advisors (Olivier Blanchard and Jeremy Stein). Financial support was generously provided by National Science Foundation and the Alfred P. Sloan Foundation. Emotional support was generously provided by Elizabeth Bernier.

Dedication

This work is dedicated to the memory of Winston S. Churchill.

Contents

List of Tables

0.1 Introduction

A long tradition in macroeconomics, including Irving Fisher's (1933) debt-deflation theory, identifies debt burdens and price movements as important parts of the business cycle. The past two decades have seen significant progress in the field of corporate finance and the economics of information; these new concepts and techniques are gradually being applied to macroeconomic analysis. As part of this ongoing research program on the interaction of financial structure and aggregate fluctuations, this thesis explores three related topics: the effect of "debt overhang" on aggregate investment; the effect of changes in financial slack on firm investment; and the relationship between inflation and relative price dispersion.

One topic of current interest is the effect of capital structure on corporate investment. Chapter 1, "Corporate Debt Overhang and Macroeconomic Equilibrium," is a theoretical paper on how a well-recognized partial equilibrium phenomenon - debt overhang - might have important general equilibrium implications. Debt overhang creates a threshold level that investment returns must meet in order to be feasible. This forward-looking constraint can increase the interdependence of firms' investment behavior in models where firms make complementary goods. If the debt levels are high enough, debt overhang can amplify existing complementarities to create multiple rational expectations equilibria, in which beliefs are self-fulfilling.

In the case of debt overhang, a firm may be unable to attract external funds even if it is profitable for the firm to invest. This is an example of situation where capital market imperfections raise the cost of external funds relative to internal funds. More generally, a variety of capital market imperfections might cause firm investment to be sensitive to "financial slack," broadly defined, including internal liquidity or collateralizable assets. Chapter 2, "Financial Constraints and Investment: Evidence from Internal Capital Markets", is an empirical examination of the effect of cash flow and collateral values on corporate investment. The main innovation of this paper is that it is able to isolate shocks to cash flow and collateral values which are not positively associated with the profitability of investing.

Chapter 3, "Inflation and Relative Price Variability" pursues a similar strategy of attempting to establish an empirical relationship by looking at an old question from a new vantage point. A central question in macroeconomics is the extent to which inflation and the money supply can effect the real economy. A variety of macroeconomic models imply that inflation can cause relative price variability. Like the correlation between cash flow and investment at the firm level, the correlation between inflation and relative price variability at the national level is a strong empirical regularity. But the correlation does not imply causation, since the same driving forces may be affecting both variables. This chapter, coauthored with Guy Debelle, examines inflation and relative price variability at the *city* level in the US. The virtue of this approach is that since different cities do not have different monetary policies, the results cannot be driven by endogenous monetary policy.

Chapter 1

Corporate Debt Overhang and Macroeconomic Equilibrium

1.1 Introduction

According to conventional wisdom, the 1990-91 recession had (at least) two special features. The first was that the debt levels of households, firms, and governments were unusually high going into the recession, and that these debts retarded the recovery.[1] The second was that the Gulf War shock to business and consumer confidence helped trigger the recession.[2] Are these two features related? In this paper, we present a model in which corporate debt overhang can create multiple equilibria in which expectations determine economic activity.

The basic idea is simple. Debt overhang occurs when existing debt deters new investment because the benefits from new investment will go to the existing creditors, not to the new investors. Thus debt overhang creates a threshold value for investment returns; below this threshold, the firm cannot attract funds and thus cannot invest. If the economy is booming, debt overhang will not bind because the returns to investing are high. If the economy is stagnant, debt overhang will bind because the returns to

[1] A 1992 survey of professional forecasters found debt was cited as the most important factor for the macroeconomic outlook. See Carlson (1993).

[2] See, for example, Blanchard (1993).

investment are low.

For those unfamiliar with debt overhang, consider an example. Suppose a firm has 100 dollars in debt, due next year, but will have an income of only 80. Thus without further action, the company will be bankrupt next year. Suppose also that this firm needs to raise funds to finance an investment project that will cost 5 today and yield 15 next year. For simplicity, suppose the interest rate is zero, so that the project has a net present value (NPV) today of 10. If the existing creditors are first in line for the payout of the firm, then no outside investors will be willing to supply 5 to the firm since the benefit will go to the original creditors (who will have their payoff increased to 95) while the new investors will receive nothing. If, in contrast, the project yields 30 next year (so that it has a NPV of 25), the firm will be able to invest since it can now promise the new investors 10 next year in return for 5 today. This example generalizes into a simple rule: investment is only financially possible if the net present value of investing is greater than the debt overhang. The innovation of this paper is to embed this standard rule into a general equilibrium framework where firms' investments are "strategic complements" (as defined by Cooper and John (1988)), so that the net present value of investing depends on whether other firms are investing.

Our model is inspired by Irving Fisher's classic "Debt-deflation" theory (1933) although price changes are not required in our story about recessions.[3] The insight we try to formalize in this model is that balance sheet constraints are essentially a general equilibrium problem. According to Fisher, recessions originate in "Mild *Gloom* and Shock to *confidence*,"[4] which suddenly make existing debt levels burdensome. The enduring empirical relevance of the Fisherian financial mechanism is documented by Eckstein and Sinai (1986), who place balance sheet deterioration at the heart of the business cycle.

Our model departs in several ways from the existing literature on financial factors

[3]Shleifer and Vishny's recent (1992) work on asset sales and debt capacity suggests one way to incorporate Fisher's emphasis on asset deflation into a modern corporate finance framework. We leave this subject for future research.

[4]his emphasis

in macroeconomics.[5] First, imperfect information is not a part of the overhang story. Second, the source of shocks is animal spirits, not productivity or monetary policy. Third, unlike much (but not all) of the literature, financial intermediaries play no role. Last, our model depends crucially on the existence of many agents who cannot coordinate their actions optimally.

For example, the assumptions used and results derived are quite different from those in Bernanke and Gertler (1989). In their model, costly state verification creates a wedge between the costs of internal and external finance, so that productivity shocks that increase internal funds (and therefore decrease borrowing needs) lead to an amplifying increase in investment. In our model, in contrast, investment is driven not by current cash flow, but rather by future expected cash flow, so that the same level of debt can be either a debt overhang or not an overhang, depending on self-fulfilling macroeconomic expectations.[6] Gertler (1992) also presents a stylized concept of debt overhang, but aggregate fluctuations are again driven by productivity shocks, not by pure animal spirits as in our model.

The overhang model also has somewhat different real world implications. Existing theory and empirical work focuses on bank lending and on a distinct set of firms that are likely to be financially constrained: small firms with limited access to credit markets.[7] Debt overhang, in comparison, also affects large, public firms that are heavily indebted.

Our model shares with existing models the feature that balance sheet variables matter, and that the cost of external funds is countercyclical. In our model, the countercyclicality of the cost of funds is extreme: if a recession is expected, no external funds can be raised (and thus the cost of funds is infinite).

Our strategy is to first find the macroeconomic implications of a certain financial structure, taking that structure as given, and then to show why that financial structure is optimal for an individual firm, taking the macroeconomy as given. We take

[5] Surveyed by Gertler (1988)

[6] As in Bernanke-Gertler, in our model investment would increase with internal funds in some equilibria, but we focus on a 2-period model in which internal funds are fixed in the first period.

[7] This literature is surveyed by Kashyap and Stein (1992).

our macroeconomic framework from Kiyotaki (1988), in order to show that financial structure can have the same effect as increasing returns to scale technology, and thus connect the corporate finance literature to the New Keynesian literature on increasing returns to scale and coordination failures.[8]

We take our financial structure from Hart and Moore (1990) and Myers (1977). Myers showed how debt overhang might distort investment decisions, while Hart and Moore used this distortion as a bonding device to control empire-building managers. In our exposition, we first assume that managers are efficient value-maximizers, and derive their behavior. We then use this optimal behavior as a benchmark in analyzing empire-building managers.

In Section 1.2 we present the model in the case with no debt. In Section 1.3 we assume the existence of senior debt, and show how it might create multiple equilibria. Section 1.4 shows that, in certain circumstances, the financial structure we assumed might in fact be optimal from the point of view of the firm's owners, and perhaps socially optimal as well. We briefly speculate about inflation and debt in Section 1.5, and offer concluding remarks in the last section.

1.2 The equilibrium without overhang

We use a simplified version of Kiyotaki (1988). We retain his basic setup but drop his assumptions of an increasing returns to scale technology and a labor supply that is elastic up to a threshold, which generate multiple equilibria. Thus in our version, in the absence of a debt overhang, there is a unique rational expectations equilibrium. Like Kiyotaki, we use a mainly graphical analysis.

There are two periods (date 1 and date 2). In each period, m firms use capital and labor to produce output, with m large and fixed.[9] The firms' products are imperfect substitutes, so that there is monopolistic competition in the product market; the labor and financial markets, in contrast, are perfectly competitive. In the first period,

[8] See Cooper and John (1988) and Weitzman (1982).

[9] We include labor in the model so that the firms will have wage costs that reduce their income or cash flow, forcing them to seek external funds from the capital market.

firms invest in productive capital, which determines the second period capital stock. Households consume and provide labor in each period, and in the first period they save. There is no uncertainty about tastes or technology in either period.

The next few subsections describe the results for the case without debt overhang, taken largely from Kiyotaki.

1.2.1 Households

We normalize the number of households to be equal to the number of firms, m. Each household is identical and the representative household has a very simple utility function:

$$U(C, C') = C + \frac{1}{\delta}C' \tag{1.1}$$

where we use primes to denote second period values. We assume that consumption today and tomorrow are perfect substitutes in order to force the interest rate to be fixed in equilibrium; this allows us to abstract from changes in interest rates in the analysis.[10] Households wish to consume many goods, so that C is the Dixit-Stiglitz CES consumption index:

$$C = m^{-\beta}(\sum_{j=1}^{m} C_j^{\frac{1}{1+\beta}})^{1+\beta}$$

$$\beta > 0$$

with C_j representing the consumption of the jth product.

Households are initially endowed with ownership of an equal portion of all financial obligations of all the firms. They are also endowed with one unit of labor services each period, which they offer inelastically to employers. Thus their budget constraint is

$$E + \frac{1}{R}E' = W + \frac{1}{R}W' + V \tag{1.2}$$

[10] We choose this specific structure of preferences only as a simplification. The results we present below are robust to more general intertemporal preferences as long as the interest-elasticity of savings is sufficiently high. See Kiyotaki for more detail.

where $E = \sum_{j=1}^{m} C_j p_j$ is the total consumption expenditure, p_j is the price of the jth product, W and R are the nominal wage and gross interest rate, and V is the average nominal value of all firms in date 1. Prices are measured in some arbitrary unit of account; in this model, only relative prices have meaning and the absolute price level is indeterminate.

The maximization problem produces the standard consumption function and related price index, P:

$$C_j = (\frac{p_j}{P})^{\frac{-(1+\beta)}{\beta}} E/(mP) \tag{1.3}$$

$$P = (\frac{1}{m}\sum_{j=1}^{m} p_j^{-1/\beta})^{-\beta} \tag{1.4}$$

$$C = E/P \tag{1.5}$$

so that the budget constraint can be re-written in real terms as:

$$C + \frac{1}{r}C' = w + (\frac{1}{r})w' + \frac{V}{P} \tag{1.6}$$

where $r = PR/P'$ is the real gross interest rate and $w = W/P$ is the real wage.[11]

1.2.2 Firms

We assume firms create their products using an constant returns to scale Cobb-Douglas technology, which is identical across firms and across periods:

$$y = k^{\lambda} l^{1-\lambda} \tag{1.7}$$

$$y' = k'^{\lambda} l'^{1-\lambda} \tag{1.8}$$

[11]This paper uses lower case letters to denote firm-level variables and uppercase letters to denote aggregate per firm levels. We follow tradition, however, in denoting the real wage and real interest rate using lower case letters; since these are aggregate variables there should be no confusion.

$$0 \leq \lambda \leq 1$$

Where k is the firm's capital stock, l is labor, y is output, and where we have suppressed the j subscript since all firms are identical. The firm is born with capital k at the date 1. It can then choose to increase its capital stock by investing $i \geq 0$ at date 1; date 2 capital stock is $k' = k + i$. After production in date 2, capital stock depreciates entirely and is worthless. To keep the algebra simple and symmetric, we assume that the firm's investment i must be composed of investment (i_j) in many different goods:

$$i = m^{-\beta}(\sum_{j=1}^{m} i_j^{\frac{1}{1+\beta}})^{1+\beta} \tag{1.9}$$

$$i_j \geq 0 \tag{1.10}$$

$$i \geq 0 \tag{1.11}$$

Now define real aggregate demand at date 1 as:

$$Y = (\sum_{j=1}^{m}(C_j + I_j)p_j)/(mP) \tag{1.12}$$

so that Y is aggregate demand per firm, while y is the production of an individual firm. Similarly, we will use k and l to denote the capital and labor of an individual firm, while K and L denote total capital and labor per firm (with $L = 1$ a necessary equilibrium condition).

Each firm takes the pricing, investment, and production actions of the other firms as given, so that an individual firm is small enough that it does not affect Y or P. Thus each firm faces a downward sloping demand curve in each period:

$$y = (p/P)^{-(1+\beta)/\beta}Y \tag{1.13}$$

$$y' = (p'/P')^{-(1+\beta)/\beta}Y' \tag{1.14}$$

We assume that managers choose prices, labor and investment so as to maximize firm value (V) at date 1, taking as given the interest rate, aggregate prices, and aggregate demand:

$$V = py - Wl - Pi + \frac{1}{R}(p'y' - W'l') \tag{1.15}$$

$$i \geq 0 \tag{1.16}$$

We will later discuss dropping the assumption that managers maximize value.[12] Note that Equation 1.15 is the standard assumption in macroeconomics, and would holds in our Modigliani-Miller world of no agency problems, no asymmetric information, no taxes, and no costs to financial distress. To invest i, the firm can (as usual) issue debt, equity, or any other financial security.

The first order conditions from the firm's optimization problem are:

$$\frac{p}{P} l^{-\lambda} k^{\lambda} (1 - \lambda) = (1 + \beta) w \tag{1.17}$$

$$\frac{p'}{P'} l'^{-\lambda} k'^{\lambda} (1 - \lambda) = (1 + \beta) w' \tag{1.18}$$

$$r(1 + \beta) \geq \frac{p'}{P'} \lambda (k + i)^{\lambda - 1} l'^{1 - \lambda} \tag{1.19}$$

with (1.19) holding with equality if i is greater than zero.

The first order conditions and the demand curve give the firm's investment as a function of second period aggregate output, interest rates, and wages:

$$k'^{*} = max[k, (\frac{\lambda}{r(1 + \beta)})^{\frac{\lambda + \beta}{\beta}} (\frac{1 - \lambda}{(1 + \beta) w'})^{\frac{1 - \lambda}{\beta}} Y'] \tag{1.20}$$

We look only for symmetric equilibria in which pricing, production, and investment are the same for all firms. Imposing that $p = P$, $p' = P'$, and using the aggregated first order condition for labor, and condition that $L = 1$, real wages in each period are determined by that period's capital stock:

$$w = \frac{1 - \lambda}{1 + \beta} K^{\lambda} \tag{1.21}$$

[12] In this section and the next, we use the words "manager" and "firm" interchangeably.

$$w' = \frac{1-\lambda}{1+\beta} K'^{\lambda} \tag{1.22}$$

Plugging in real wages, we can rewrite (1.20) as

$$k'^{*} = max[k, (\frac{\lambda}{r(1+\beta)})^{\frac{\lambda+\beta}{\beta}} Y'^{\frac{\lambda+\beta-1}{\beta}}] \tag{1.23}$$

This gives the investment demand of an individual firm, given that all other firms are in an symmetric equilibrium producing Y'. Equation 1.23 is the aggregate investment function, $i^{*}[Y', r]$ or equivalently $k'^{*}[Y', r]$. We consider only the case where $\beta > 1 - \lambda$ so that investment is increasing in date 2 aggregate demand.

1.2.3 Second period equilibrium

Aggregating the production function (Equation 1.8) and imposing that aggregate labor supply per firm is one, we find that in equilibrium the aggregate production function at date 2 is:

$$Y' = K'^{\lambda} \tag{1.24}$$

This equation and the investment function (1.23) are shown in Figure 1. The vertical axis shows the aggregate per firm output and demand at date 2, while the horizontal axis shows the aggregate per firm capital stock at date 2, K'. The K'^{*} line shows, for a given expected date 2 aggregate demand, the capital stock that would be chosen by each firm. In equilibrium, $K'^{*} = K$, and so the intersection of the two curves shows the equilibrium capital stock and aggregate demand at date 2. Since the production function is concave in K' while the investment function is concave in Y', there is a unique equilibrium for any given set of parameters and preferences.

Clearly, market equilibrium requires that the real rate of interest be equal to the discount rate:

$$r = \delta \tag{1.25}$$

As can be seen from Equation 1.23, increases in r cause decreases in desired investment. If r is high enough, the production function and desired investment line do not intersect to the right of the initial capital stock k, and there is zero investment. We restrict our attention to the more interesting case where r (equivalently, δ) is low enough so that the production function and investment function intersect to the right of k, and there is positive investment.[13] In what follows, we shall refer to point E, the equilibrium of Figure 1, as the "unconstrained equilibrium".

1.3 The equilibria with overhang

We now consider how the economy might change if firms have financial obligations, and start by describing the legal institutions in the economy. Financial obligations come in two basic types, equity and debt, and debt is further subdivided according to seniority (junior and senior) and date due (date 1 and 2). Creditors at date n have first claim to the payouts of the firm at date n, and if the income of the firm at date n is insufficient to pay creditors, the firm is liquidated and the creditors are paid off in order of seniority. "Senior debt" gives the senior creditors priority in collecting the value of the firm. For example, suppose a firm has senior debt d', due at date 2, and pays out x at date 2, where both x and d' are denominated using the same measure of value. Since the firm's capital stock vanishes in date 2, x must be equal to the income of the firm in date 2, plus any savings the firm might have leftover from date 1.[14] Then senior creditors have the right to the first d' units paid out at date 2, so that the senior creditors receive $min(x, d')$. The junior debt holders and equity holders divide up the remaining value, $max(0, x - min(x, d'))$, similarly. We (realistically) assume further that the senior debt is accompanied by a legally binding constraint that the firm cannot issue additional senior debt so as to dilute the senior creditors' claims.[15]

There is no hidden information and no uncertainty, and all claims can be legally enforced. So, for example, the firm must pay all its debt obligations if it is able to

[13] Thus we restrict attention to the case the $K' > K$.

[14] We assume that wages are paid prior to debt repayment, so that income is revenue minus labor costs.

[15] Standard calculations shows that allowing *pari passu* debt issuance, so that new investors can have claims equal to (but not more senior than) the existing creditors, reduces but does not eliminate the debt overhang problem.

do so; it cannot claim poverty and then funnel the money to the shareholders or to the managers. Note that in our set-up, date 1 claims are paid before date 2 claims, so even if the date 2 claimants are "senior" creditors and the date 1 claimants are "junior", the date 1 claimants are paid at date 1 if the funds are then available, even if it is known with certainty that the firm will not be able to meet its obligations at date 2.

The last major assumption about financial structure we make is that renegotiation of senior debt is impossible. A number of papers have examined the (partial equilibrium) case when renegotiation is possible; see Hart and Moore (1989) and Gertner and Scharfstein (1990). In the real world, renegotiation is always possible, so the choice between senior debt and junior debt is perhaps less stark. But most public debt in the United States has widely dispersed ownership, and current law makes renegotiation difficult, expensive, and time-consuming because of the problems inherent in negotiation between many agents with different interests (e.g. free rider and hold-out problems).

Now assume that the firms are born with financial obligations in addition to capital stock. Specifically, we assume that the firm comes into the world with debt due in the first period, d, and senior debt due in the second period, d' (for simplicity, we assume there is initially no junior debt due at date 2). We assume that these debts are denominated in units of aggregate output, so that the firm must pay Pd in date 1 and $P'd'$ in date 2. This ensures that the aggregate price levels (P and P') will continue to be economically meaningless; only relative prices matter.[16]

We also assume that

$$Pd \leq py - Wl \tag{1.26}$$

so that the firm is able to service its debt at date 1.

Consider a manager who wants to invest i in date 1. Every i must fall into one of

[16] In section 1.5 we briefly discuss allowing the nominal price level to matter.

three categories. First, it may be that

$$Pi \leq py - Pd - Wl \tag{1.27}$$

so that the investment can be financed entirely out of internal funds.

If the inequality in (1.27) is not satisfied, then the firm needs to raise $Pi - py + Wl + Pd$ worth of external funds by selling securities. If the firm is able to invest i, then it will have income of $p'(k+i)^{\lambda}l'^{1-\lambda} - W'l'$ at date 2. We know that the senior creditors will receive the first $P'd'$ of firm income at date 2. Therefore the most the firm will be able to promise to any new investors at date 2 will be $max[0, p'(k+i)^{\lambda}l'^{1-\lambda} - W'l' - P'd']$. Since new investment will only be forthcoming if the firm is able to pay the market rate of return on new securities, we have the "overhang constraint" in nominal terms:

$$\frac{1}{R}(p'(k+i)^{\lambda}l'^{1-\lambda} - W'l' - P'd') \geq Pi - py + Wl + Pd \tag{1.28}$$

The left hand side of this equation is the net present value of the firm after subtracting payment to the senior creditors; the right-hand side is the amount the firm needs to borrow in order to invest i. If i satisfies (1.28) then it is feasible. If i satisfies neither (1.27) nor (1.28), then it is not feasible. Thus we can group all potential i into three categories: feasible via internal funds; feasible via external funds but not internal funds; or not feasible.

We continue to assume that managers maximize the net present value of the firm (which is equivalent, assuming the firm does not go bankrupt, to maximizing the value accruing to the equity-holders). Bankruptcy costs are zero. So even if bankruptcy is certain next period, we assume the managers will still invest to maximize value (minimize loss), as long as they can obtain the funds to do so.

The manager now seeks to maximize:

$$V^N = py - Pi - Wl + \frac{1}{R}(p'y' - W'l' - P'd') - Pd \tag{1.29}$$

$$i \geq 0 \tag{1.30}$$

with the additional constraints that if $i > 0$, either the internal funds constraint (1.27) or the overhang constraint (1.28) or both must be satisfied. We have added an N to this V to denote the net worth of the company (so that this value is different from the V in the previous section).

The first step in solving this maximization problem is to see when the unconstrained firm's investment, $i^*[Y', r]$ from section 1.2, satisfies the internal funds and/or the overhang constraint. Clearly, in the first period, the profit maximizing output and labor input are the same as in the unconstrained case, so that $p = P$, $l = 1$, and the internal funds constraint can be written in real terms:

INTERNAL FUNDS CONSTRAINT (II)

$$k' \leq k + k^{\lambda}\frac{\beta + \lambda}{1 + \beta} - d \tag{1.31}$$

If k'^* satisfies the real internal funds constraint (1.31) and maximizes (1.15) then clearly k'^* is the solution to (1.29) as well. Note that, even if $d = 0$ so that there is no debt burden in the first period, the internal funds constraint might still bind, depending on the share of revenue paid out to capital and labor.

The overhang constraint is more complicated. Using the demand curve and the first order condition for labor, we can write it in real terms:

$$\frac{1}{r}[Y'^{\frac{\beta}{1+\beta}}(y')^{\frac{1}{1+\beta}}\frac{\beta + \lambda}{1 + \beta} - rk'] \geq d + \frac{d'}{r} - k - k^{\lambda}\frac{\beta + \lambda}{1 + \beta} \tag{1.32}$$

Plugging in for the optimal k'^* and using the production function and the formula for equilibrium real wages, we derive:

OVERHANG CONSTRAINT (OO)

$$k'^* \geq \frac{\lambda}{\beta}[d + \frac{d'}{r} - k - k^{\lambda}\frac{\beta + \lambda}{1 + \beta}] \tag{1.33}$$

If i^* solves the problem facing the unconstrained firm, program 1.15, and satisfies the real overhang constraint (1.33) then it solves program 1.29.

If $i^*[Y', r] > 0$ satisfies neither the overhang nor the internal funds constraint, then the firm should simply invest all its internal funds, since the first-order condition (1.19) is not satisfied and the marginal productivity of capital is decreasing in k.

The effects of these two constraints is shown in Figure 2. The vertical II line shows the internal funds constraint (1.31). To the left of II (which corresponds on the vertical axis to the area labeled Region 1), the investment function of the firm with debt and the firm without debt are the same. To the right of II, the firm does not have sufficient internal funds to finance investment. The vertical OO line shows the overhang constraint (1.33). To the left of OO, the investment that an unconstrained firm would make has insufficient NPV to permit the overhung firm to repay any new investors. To the right of OO (which corresponds to Region 3 on the vertical axis), the investment function of the firm with debt and the firm without debt are the same. Between the OO and II lines (Region 2), the firm with debt can only invest its internal funds. The shaded line in Figure 2 shows the resultant investment function of the overhung firm.

The financial constraints make firms' investments much more sensitive to expected aggregate demand at date 2. If aggregate demand at date 2 isn't in Region 3, the firm is unable to attract any external funds, since the K'^{*} line is to the left of the OO line.

Does the debt change the nature of the possible equilibria? It depends on the positions of the II and OO lines, which are determined by the amounts of date 1 and date 2 debt. In Figure 2, there is a unique equilibrium where the overhang constraint doesn't bind. The same unique macroeconomic investment equilibrium (point E) would also result if firms have no debt. But if the debt burden is high enough, as in Figure 3, there are two equilibria: the pessimistic low-investment equilibrium (point L), and the optimistic high-investment equilibrium (point E). The key is whether the II and OO lines are far enough apart so that when all firms are investing their internal funds (as at L), the aggregate date 2 capital stock is still not enough to create an aggregate demand that causes desired capital to exceed the overhang constraint.

Debt can also force us into the low-investment equilibrium. If the OO line were to the right of the unconstrained equilibrium (to the right of point E), then investment in excess of internal funds would never take place.

This setup produces comparative static results that clarify the traditional intuition about the effects of debt on the macroeconomy. Loosely, we might think of the current debt d as corresponding to the debt service burden facing firms, while the next period's debt d' corresponds to the "financial inflexibility" of firms.[17] In order for debt to matter to the economy, it must be true that there is both 1) a low level of current cash flow after paying current debt obligations, and 2) financial structure is relatively inflexible, so that firms cannot respond nimbly to a change in business conditions. There are discrete thresholds of d and d', below which the economy is in the unique, unconstrained, "optimistic" equilibrium. High, overhanging d' makes the pessimistic equilibrium possible. And given that we are in a situation like Figure 3, so that the pessimistic equilibrium can occur, high debt service burdens relative to cash flow (higher d) make the potential recession more severe.

It is obvious that in the pessimistic equilibrium, everyone would be better off if the firms could renegotiate with their creditors at date 1. With frictionless capital markets, capitalists would want to buy all the firm's securities in date 1 and, say, engineer an all-equity firm that could invest optimally. Here, we have simply assumed that such renegotiation is impossible. In the real world, this renegotiation is possible, but takes time; thus one can imagine an extension of this model into a multiperiod framework in which renegotiation rigidities cause a temporary recession, which ends once financial structures are altered. In the real world, we observe substitution of equity for debt when corporations become overindebted. In the recent recession and in the 1974-5 recession (which was also accompanied by high corporate debt levels), equity issuance surged immediately after the downturn, as corporations replaced debt with equity. To the extent that these real-world restructurings take time, then, the model presented here represents the onset of a recession.

Since in the pessimistic equilibrium, senior debt prevents the firm from investing optimally, why would firms ever issue senior debt? In the next section we take up

[17]More generally, d can be seen (for comparative statics purposes) as representing all factors that reduce internal cash flow, for example, raw materials costs.

this issue.

1.4 Financial structure design

The discussion so far suggests that debt can have potentially large costs for individual firms. Why then do firms choose to issue (senior) debt? This is an open question in the corporate finance literature. In this section, we focus on a specific explanation of the benefits of debt, an explanation that is far from universally accepted. Our basic point is to provide an example showing how firms weigh the costs and benefits of issuing debt. Whatever the true explanation for corporate financing decisions, it seems clear that firms do not internalize the potential *macroeconomic* consequences of their individual capital structure decisions.

We now drop the assumption that managers maximize value, and instead assume that managers maximize k', subject to the overhang and internal funds constraints. Increased capital is assumed to provide perks, prestige, or power to the manager. Such empire-building managers would, if they were able, seek to borrow infinite amounts at date 1 and default at date 2.

We assume further that, once the managers arrive at date 2 and can no longer affect k', they are willing to choose prices and labor input at date 2 to maximize profits. Clearly, managers will maximize date 1 income on their own, since it furthers their interest by creating cash flow with which to invest. Thus we can continue to focus on symmetric equilibria in which the prices and quantities (but not investment) of each manager maximize within-period profits.

Based on the analysis in the previous section, it's easy to determine the behavior of this empire-builder. Empire-builders always invest as much as they can. Suppose we are in an environment like Figures 2 or 3. Clearly, the minimum the empire-builder would ever invest is given by the internal funds constraint (1.31). The maximum the empire-builder can invest is determined by the overhang constraint. The nominal overhang constraint (1.28) can be rewritten in real terms (without plugging in for k'^* as in (1.33)) as:

$$\frac{1}{r}[Y'^{\frac{(\lambda+\beta)}{(1+\beta)(\lambda+\beta)}} k'^{\frac{\lambda}{\beta+\lambda}} \frac{\beta+\lambda}{1+\beta} - rk'] \geq d + \frac{d'}{r} - k - k^{\lambda}\frac{\beta+\lambda}{1+\beta} \tag{1.34}$$

We can draw the effects of constraint (1.34) using the OO line and the desired capital k'^* of the value-maximizing firm. When the OO line and the k'^* line intersect (at point A in Figure 4), we know that k'^* is the only k' that can satisfy (1.34), since (1.33) just holds, so that at this Y' the most the empire-builders can invest is k'^*. Inspection of (1.34) shows that the left-hand side is increasing in Y', while we know that the empire-builders will choose a k' higher than k'^* if given a chance; thus, to the right of the OO line, the empire-builder's $k'[Y', r]$ must lie to the right of the k'^* line. The shaded line in Figure 4 shows the investment of the empire-builders. The OO line determines how much the empire-builders are able to invest, so that each different OO line anchors a different "empire-builder's investment" line.

Another way of describing the empire-builders behavior (subject to financial constraints) is to say that the managers will always exhaust the full value of the firm in order to obtain external financing, giving everything to the new investors and preserving nothing for the existing equity-holders. Thus (to the right of the OO line) the empire-builder's investment line shows $V^N = 0$.

With empire-building managers, multiple equilibria can occur for exactly the same reasons as with the value-maximizing managers. Figure 5 shows high (H) and low (L) investment equilibria.

Now we are ready to consider optimal financial structure. In the previous section we assumed that firms came into the world at date 1 with an endowment of capital and financial structure. We now assume that financial structure is determined at date 0 (prior to date 1). We continue to assume that a fixed number of firms come into the world with a given endowment of capital, k.

The set-up is a simplified version of Hart-Moore (1990), and can be justified as follows.[18] At date 0, the firms have no debt but are owned outright by, say, one individual (the "owner"). The owner is unable to manage the firm and must

[18] See also Hart (1991).

hire a manager; further, this manager is an insatiable empire-builder and cannot be controlled by any incentive system (all managers are identical). Once installed, managers can never be fired. Managers consume nothing in either period and supply no raw labor.

At date 0 the owner wants to design the financial structure so as to maximize the value of the firm, taking into account the financial structure designs of all the other owners. Once again we look for symmetric equilibria only. The owner has two tools, the OO and II lines, and one basic goal: to force the manager's investment to conform as closely as possible to the k'^* line, which shows optimal investment.

We now make a crucial assumption: if the financial structure chosen by owners at date 0 is such that at date 1, multiple equilibria are possible, then *which* equilibrium is to be chosen at date 1 is not known at date 0. This assumption means that there are two different types of equilibria, one at date 0 and one at date 1. At date 0 there is a symmetric financial structure equilibrium, in which all owners choose the same financial structure. At date 1, there is a symmetric investment equilibrium, in which all managers choose the same investment. We do not specify how the investment equilibrium is chosen at date 1; it may be based on the outcome of a sunspot variable. If so, the sunspot variable is not revealed until date 1, after the financial structure is determined.

This assumption ensures that, if multiple investment equilibria are possible, the owner doesn't know which Y' at date 2 will emerge. Whatever the process for determining the outcome, we assume that if two investment equilibria are possible, at date 0 agents believe that with probability q the pessimistic equilibrium will occur and with probability $1 - q$ the optimistic equilibrium will occur. We also assume a (realistic) market failure: "straight" debt and equity are the only existing financial securities.[19] Thus, for example, the firm cannot issue state-contingent debt which is canceled in the event of a recession but which retains priority in a boom.[20]

[19]Also, we assume that debt is non-negative. This assures that firms cannot set d negative such that the firm somehow automatically receives cash with which to invest at date 1. In other words, we assume that firms can be born with financial liabilities but not financial assets

[20]Hart-Moore (1990) show that, in a set-up similar to this one, simple debt/equity structures are

This sequence of actions and information creates two externalities. The first, non-standard externality occurs at date 0, when owners design financial structure without taking into account its effect on the financial structure equilibrium, possibly creating multiple equilibria. The second, standard aggregate demand externality occurs at date 1, when managers choose investment without taking into account its effect on the investment equilibrium.

In what follows, we do not attempt to characterize all the possible financial structure equilibria; instead, we focus only on the issues involving possible macroeconomic multiple equilibria. Although we will not explore these issues, we note here that the framework presented can accommodate several different concerns the owners have when choosing their firms' financial structure. For example, in the spirit of Jensen (1986), owners might want to move their II lines leftward, so that the managers are forced to disgorge free cash flow at date 1.[21]

Consider the actions of an individual owner, given that all the other owners have chosen security structures such that the aggregate economy has two equilibria as in Figure 6. Suppose that Figure 6 depicts the situation in which all other owners have set $d = 0$ (so that the II line is determined only by the wages the firm must pay at date 1, and cannot be moved farther to the right by changing the financial structure) and have set d' such that the OO line goes through the unconstrained equilibrium. Here the OO and II lines represent the financial structure of all other firms; the choice of the individual owner is where to put her own II and OO lines, given that aggregate demand will either be at point L or point E. If the individual owner sets her firm's d' such that her OO line is to the right of the aggregate OO line, then the firm will always be overhung and can only invest internal funds (which is suboptimal) in both equilibria. If any individual owner sets her OO line slightly to the left of the aggregate OO line, her manager will overinvest in the optimistic equilibrium, and in

in fact optimal and more exotic contingent claims are not necessary.

[21]This might be the case if, for example, when $d = 0$, the II line is to the right of point E, In that case, the owners would want to set the II and OO lines so that they both go through point E. This effectively forces the manager to invest optimally. In the next paragraph, in contrast, we consider the case where (even if $d = 0$) the II line is already to the left of point E).

the pessimistic equilibrium will still invest internal funds. If the owner sets d' low enough so that in the pessimistic equilibrium the overhang constraint just binds (so that the firm's OO line goes through point B in Figure 6), then the manager will overinvest in the optimistic equilibrium but invest optimally (i.e. it will invest the amount indicated by point B on the k'^* line) in the pessimistic equilibrium.

Thus the owner faces a clear trade-off: set debt high and invest optimally in good times but underinvest in bad times, or set debt low, and invest optimally in bad times but overinvest in good times. If q, the probability of recession, is low enough, the owner will choose the former, and so the situation in Figure 6 is an equilibrium in financial structure. Thus we get the result that debt-related pessimistic equilibria can only occur if they are unexpected when financial structure is chosen at date 0.[22] This confirms Fisher's conjecture that "I fancy that over-confidence seldom does any great harm except when, as, and if, it beguiles its victims into debt."

Are multiple investment equilibria inevitable? The answer depends on the process which determines whether the high or low investment equilibrium is chosen. A financial structure which does not create multiple investment equilibria at date 1 may not be a financial structure equilibrium at date 0. Suppose all owners set d' low enough so that if all firms were investing their internal funds, the overhang constraint is satisfied with equality, so that only the high investment equilibrium can occur (this is shown in Figure 7). This could never be a financial structure equilibrium at date 0, since each individual owner would then want to move his own OO line to the right (to a position between E and H) to prevent inevitable overinvestment. The fact that Figure 7 is not an equilibrium is due to the externality in the financial structure design process.

If q, which is completely arbitrary, is low enough, then the situation in Figure 6 may be socially optimal even if it allows recessions to occur.[23] If q is high (so that if a recession is possible, it usually occurs) then the situation in Figure 7 might be

[22] "Unexpected" at date 0 in the sense that they are low probability events. Of course, at date 1 a symmetric rational expectations equilibrium is chosen, so that if the pessimistic equilibrium occurs it is expected with probability one at date 1.

[23] With apologies to managerial readers, here we use the term "socially optimal" to indicate the maximization of a social welfare function that does not include managers.

socially preferred though impossible to achieve.

1.5 Inflation

We have assumed debt is indexed to the price level; this is not the case in the real world (why this is so is beyond the scope of this paper).[24] If debt is not indexed, our model has the traditional and obvious feature that the central bank can inflate away any debt overhang, and thus prevent the pessimistic equilibria from ever occurring.[25] The central bank need only announce that, in the event of the pessimistic equilibrium, it will boost the price level high enough so that all firms can pay their nominal debts; thus the low investment equilibrium could never take place because overhang could never bind.

Friedman (1986) argues that this debt-induced "no-recession monetary policy" is in fact a major consideration for the Federal Reserve, so that a cost of overindebtedness is increased inflation. The no-recession policy suggests another way in which the financial structure might be chosen such that pessimistic equilibria are possible. If at date 0, owners believe that the Fed will adopt this rule, so that the probability of a recession is zero, they will be more likely to choose high debt. If their belief turns out to be false (perhaps because the Fed is unable to control the money supply and thus unable to commit to inflating at date 1), then the likelihood of recession is increased.

1.6 Conclusion

We have presented an example of a simple economy in which balance sheet variables help determine the course of the macroeconomy. Although this particular economy has very specific and stylized features, it seems likely that the basic conclusions would survive a more general formalization. Here, we use monopolistic competition to make

[24] One model of money and prices under monopolistic competition is Blanchard and Kiyotaki [1987].

[25] Conversely, the central bank might be able to force the economy into the pessimistic equilibrium by deflating and thus pushing the OO line rightward; of course, we have not specified the date 0 expectations about the central bank that would allow this to occur.

firms interdependent, and principal-agent problems to make senior debt a desirable financial structure. But other reasons for the interdependencies of firms and for the existence of debt might well lead to similar conclusions.

The strength of the model is that it formalizes aspects of traditional intuition about debt and the economy, and makes precise one channel by which debt can make the economy "more vulnerable" to recession, even an economy dominated by large, public companies. Even if one does not believe the explanation for debt offered in Section 1.4, the multiple equilibria presented in Section 1.3 might still be a good description of a debt-related recession, given that debt exists in the real world.

One weakness of the model, as currently formulated, is that it relies too heavily on the possibility of mass bankruptcy.[26] A more sophisticated model could probably obtain similar results by using a subtler concept of overhang, closer to the original Myers (1977) article, based on an increased probability of bankruptcy and default (the present model does retain the virtue of simplicity, however).

Future theoretical work might focus on natural extensions of the model. One would be the incorporation of money and prices into the framework, to capture the true Fisherian debt-deflation process. Another would be allow for other standard corporate finance motivations for firms to issue debt, perhaps allowing for heterogeneity across firms.

[26]The 1990-91 recession saw historically unprecedented level of bankruptcy, but many firms which seemed unlikely to go bankrupt still cut investment and cited their high debt levels as an explanation.

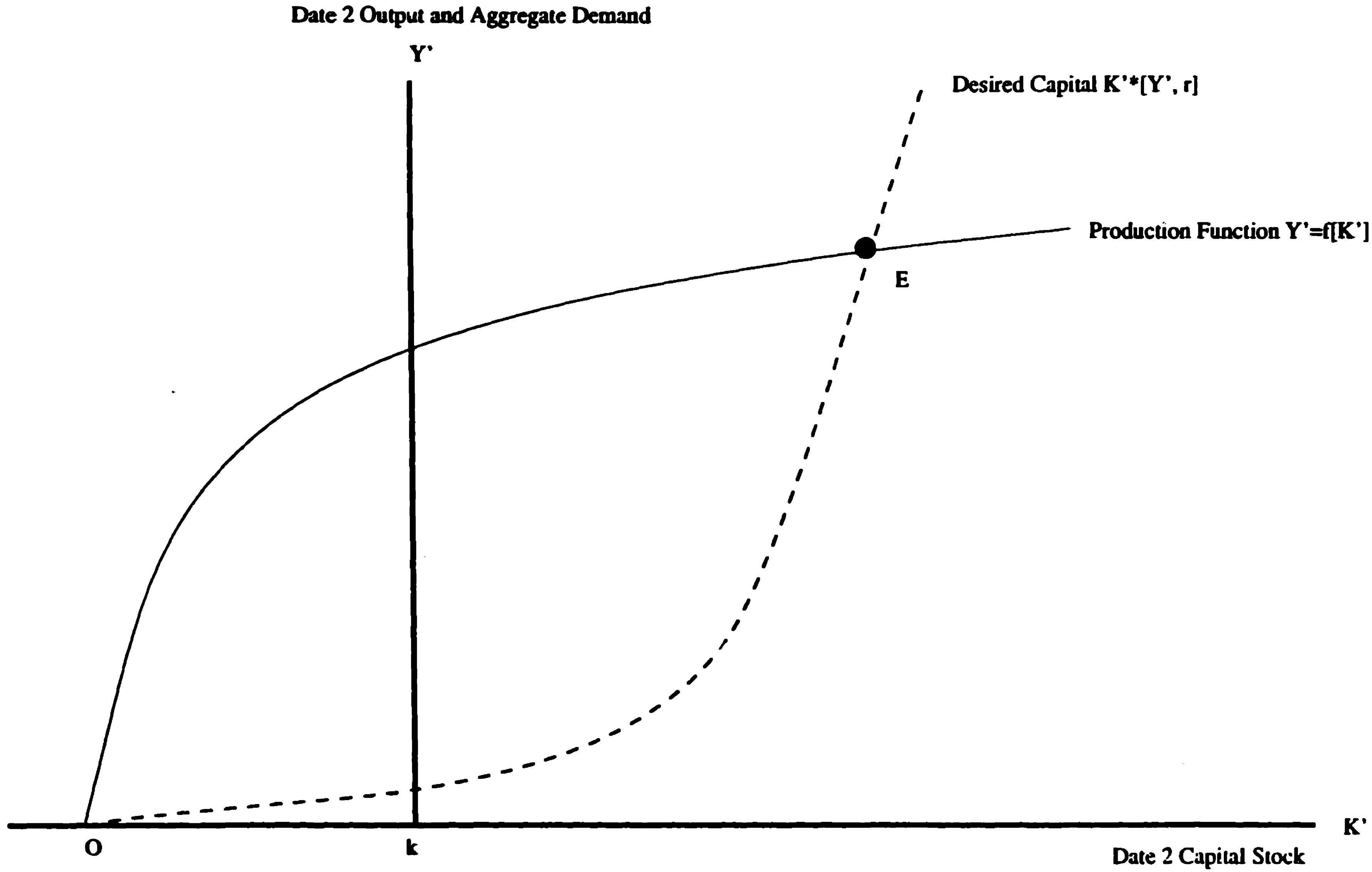


FIGURE 1 : The Unconstrained Equilibrium

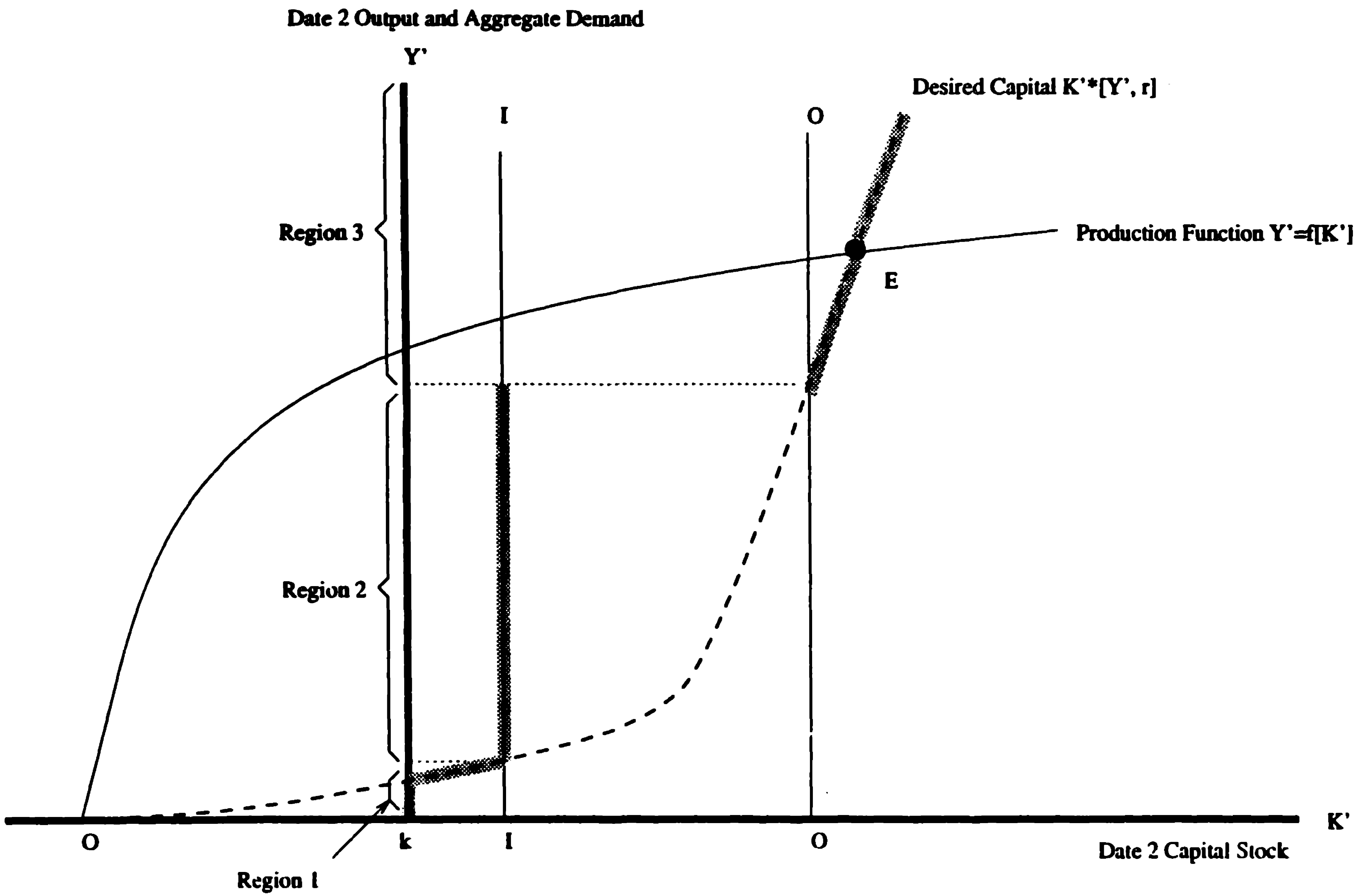


FIGURE 2: The Internal Funds and Overhang Constraints

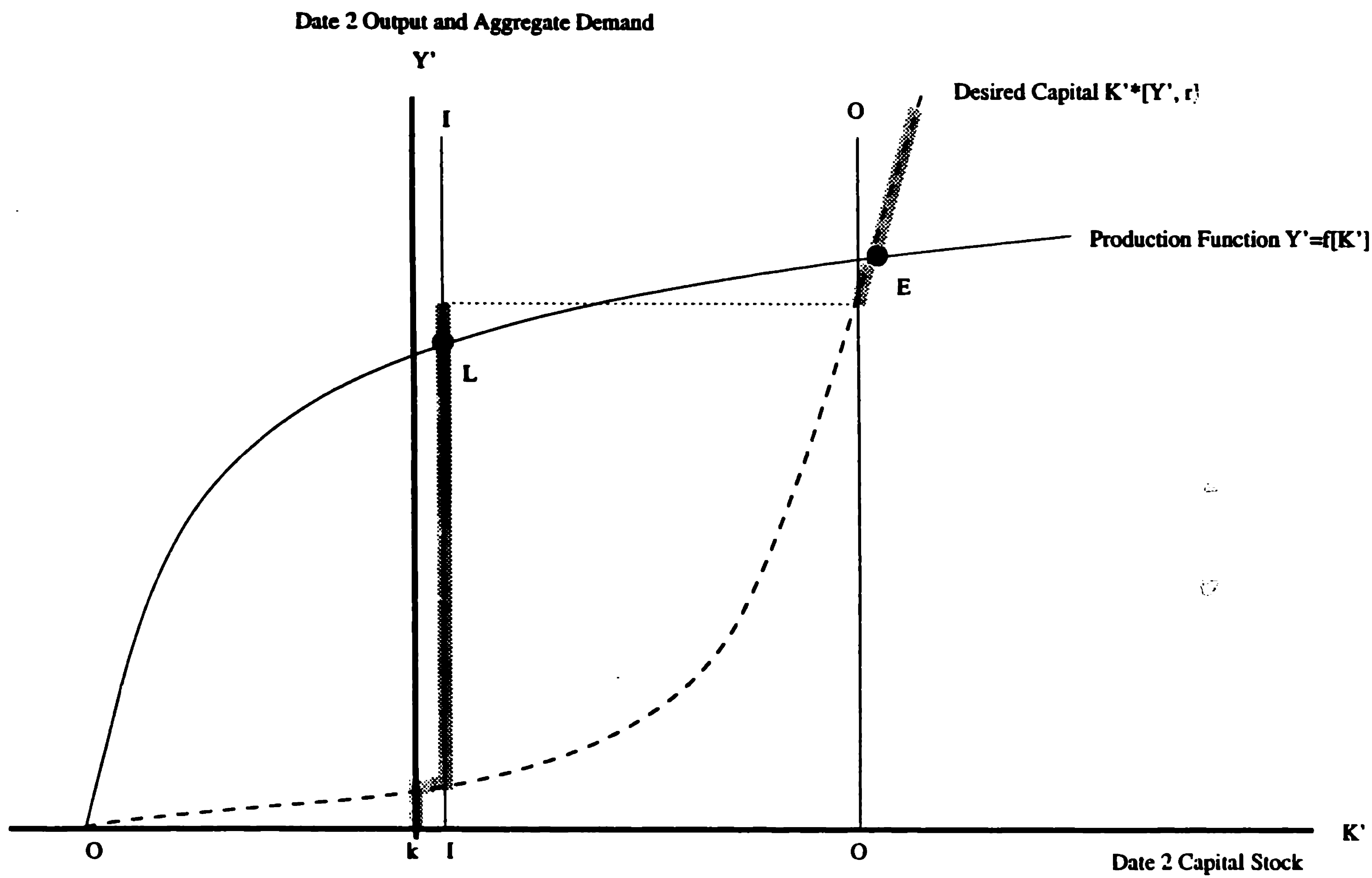


FIGURE 3: Financial Constraints Create Multiple Equilibria

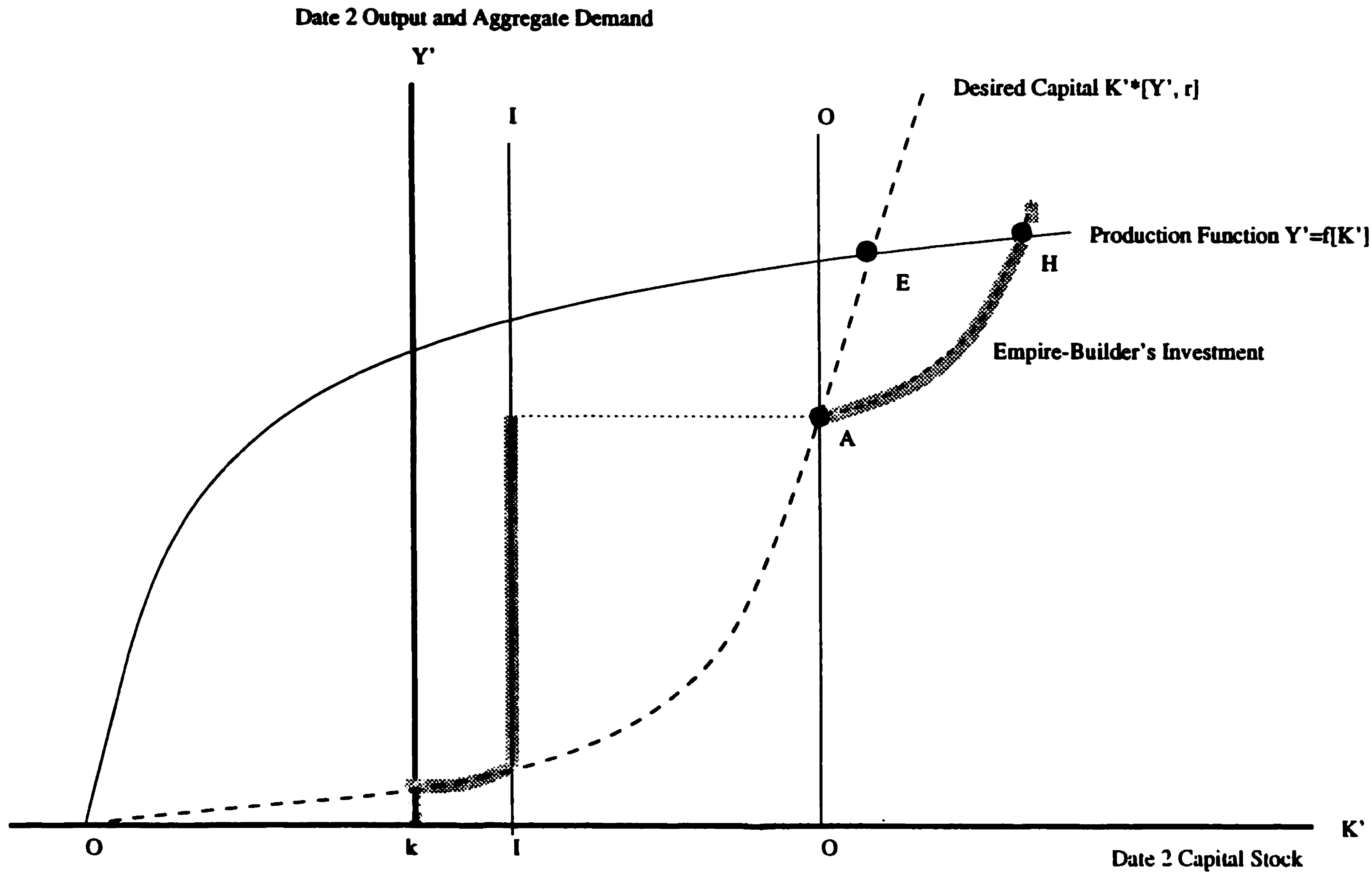


FIGURE 4: Empire-Builder's Investment

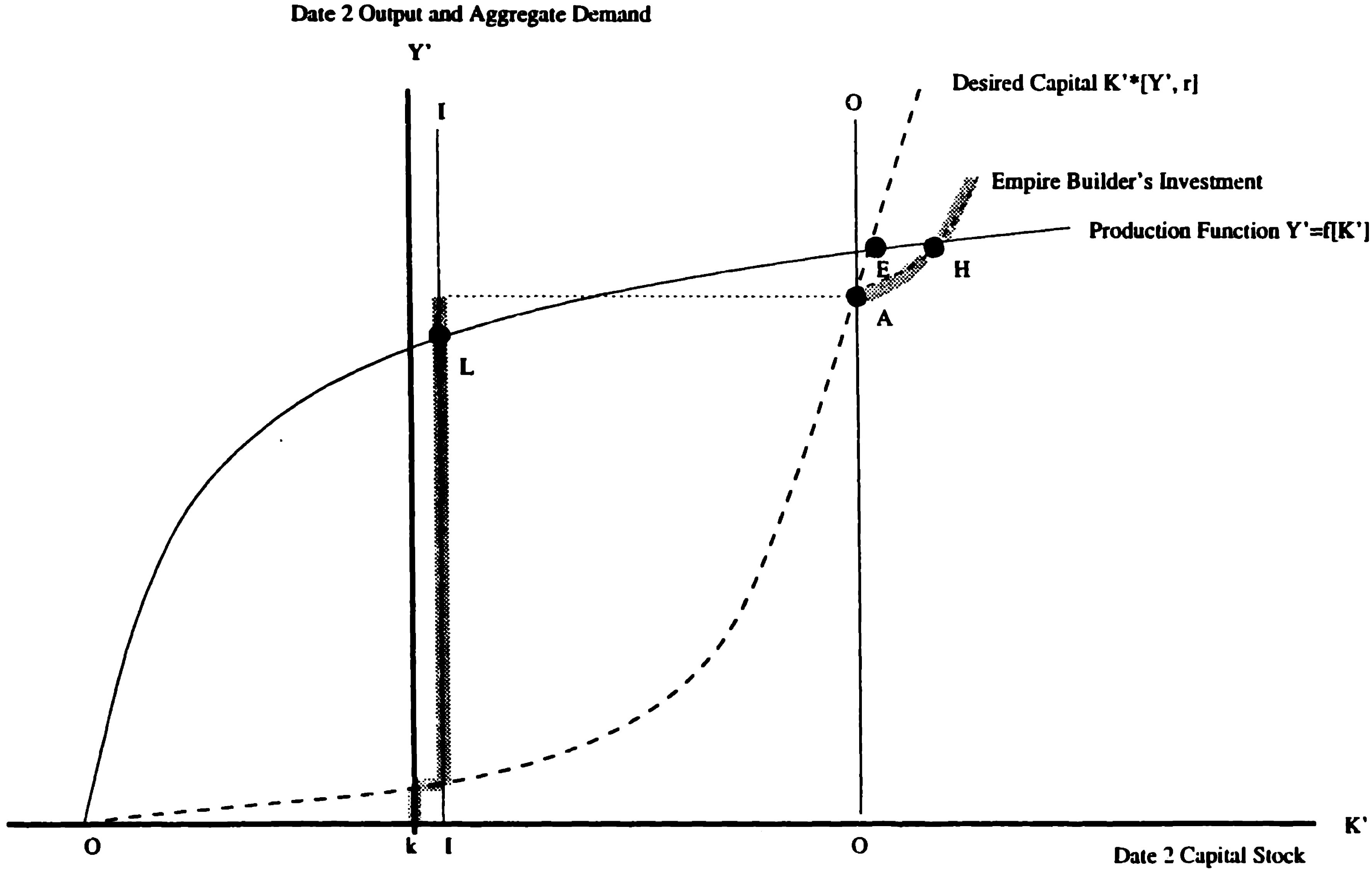


FIGURE 5: Multiple Equilibria with Empire-Builders and Over-Investment

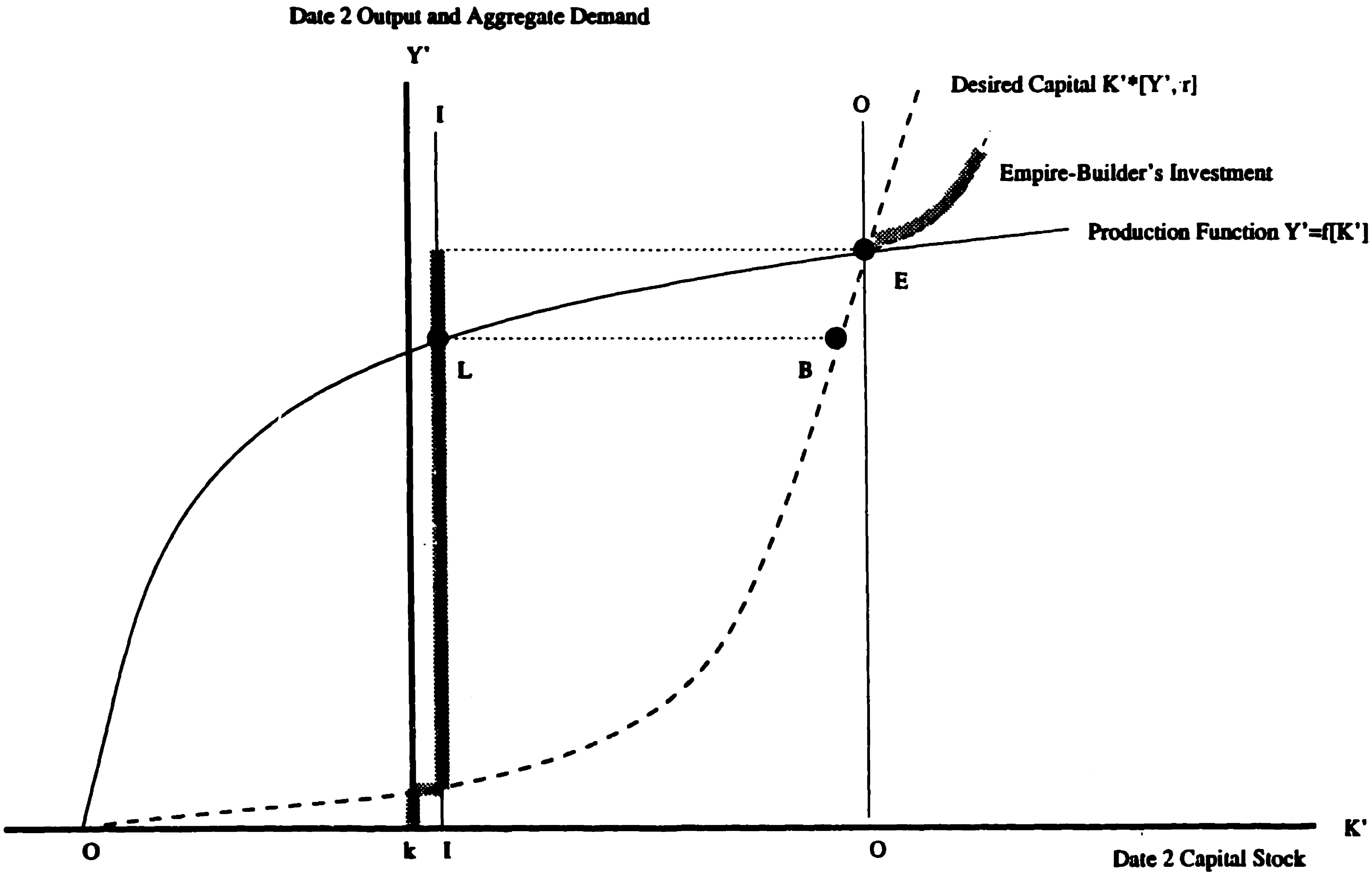


FIGURE 6: Multiple Equilibria with Empire-Builders but No Over-Investment

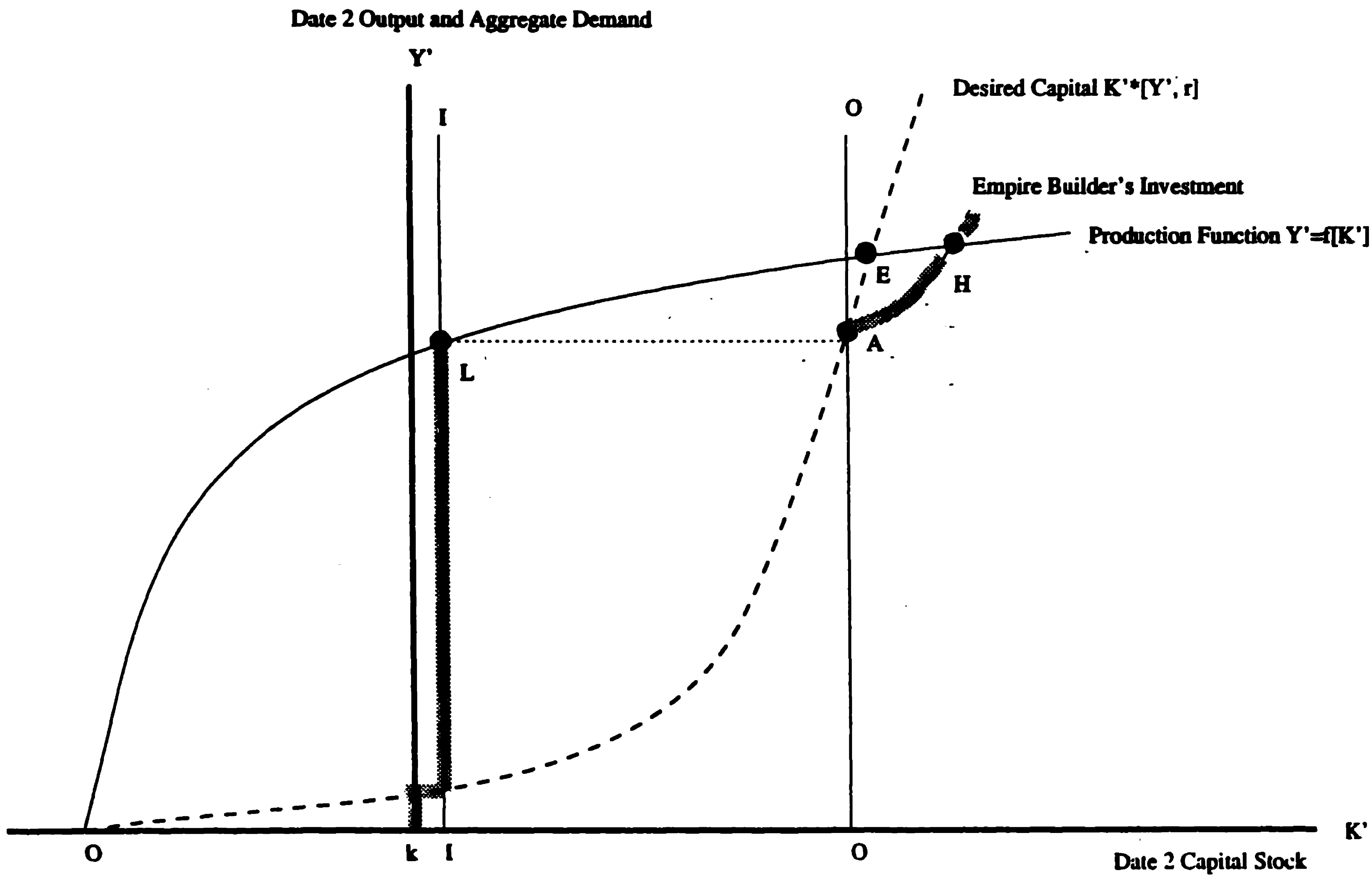


FIGURE 7: Not a Financial Structure Equilibrium

Chapter 2

Financial Constraints and investment: Evidence from internal capital markets

2.1 Introduction

Suppose that a company's cash flow or collateral value falls, but the profitability of its investment opportunities stays constant (or rises). Would this company reduce its investment? In this paper I try to answer this question by examining how different parts of the same firm reacted to the 1986 oil price decline, which reduced the cash flow and collateral value of oil firms. Using the Compustat database, I identify a group of firms which have corporate segments both in the oil extraction industry and in non-oil industries, where "non-oil" is defined as an industry with profits that are not (positively) correlated with the price of oil. I then test the hypothesis: do large cash flow/collateral value decreases to a corporation's *oil* segment decrease investment in its *non-oil* segment?

I focus on the 1986 oil shock, in which oil prices fell by 50 percent, because this dramatic economic event seems unambiguously exogenous to any individual firm.[1]

[1]Baily (1993) also uses the 1986 oil shock as an identifying assumption to examine imperfect capital markets.

Looking within firms, rather than across firms, I test the joint hypothesis that 1) the oil shock affected the costs of finance for oil segments, and 2) the cost of finance in the oil segment affected the cost of finance in the non-oil segment of the company. This joint hypothesis would be true if both external capital markets were imperfect (so that liquidity matters for investment) and if internal capital markets allocated capital within firms (so that the different parts of the firm are interdependent). It is of interest both to macroeconomics (because investment is an important part of the business cycle) and corporate finance (because the financing of investment is a central purpose of corporate capital structure).

I begin by discussing the two parts of the joint hypothesis. I then describe the macroeconomic background, data, and sample selection issues. I perform several statistical tests with the data, examining medians, means, and regression coefficients. The empirical tests reject the null hypothesis, and I estimate that for every dollar that pre-tax oil cash flow falls, non-oil investment falls by at least ten cents.

2.1.1 Liquidity and Investment

A large literature in corporate finance and macroeconomics documents the relationship between liquidity and investment (see Fazzari, Hubbard and Petersen (1988); Hoshi, Kashyap, and Scharfstein (1991)). Although a strong correlation between cash (whether measured as a flow, a stock, or both) and investment is a well-documented fact, the causal connection between the two has been harder to establish, since both investment and cash flow are driven by underlying shocks to profitability. Existing studies have attempted to control for the profitability of investment by including a measure of Tobin's q in the estimated equation, but since current profitability may well be a better measure of the profitability of investment than stock market data, the estimated coefficients may be biased.

Since exogenous instruments for cash that are uncorrelated with the profitability of investment are difficult to find, researchers instead have focused on the examining the *differences* in cash-investment correlations between groups of firms hypothesized to have different dependence on internal finance. Studies typically use panel data on firms to estimate:

$$\frac{I}{K} = a + bQ + c\frac{CASH}{K} + YEARDUMMY + FIRMDUMMY \qquad (2.1)$$

where I is investment, K is capital stock, Q is Tobin's q, and $CASH$ is a measure of cash flow or cash stock. To test the hypothesis that two groups of firms face different finance constraints, the coefficient c on cash is compared across different firms, with firms categorized according to dividend payout ratios (Fazzari, Hubbard, and Petersen (1988)), bond rating (Kashyap, Lamont, and Stein (1992)), bank relationship (Baily (1993)), or membership in a Japanese keiretsu (Hoshi, Kashyap, and Scharfstein (1991)). Another test is to compare coefficient c across different time periods with different macroeconomic-credit conditions (Gertler and Hubbard (1988)).

However, looking at differences in cash-investment correlations may still be a less than perfect test. It may be that innovations in cash have different implications for the profitability of investment in small and large firms (Gilchrist and Himmelberg (1992)). Alternatively, it may be that q is more poorly measured for small firms (as noted in Poterba (1988)).

This paper takes a different route, and seeks to find an exogenous instrument for cash. By focusing on a small group of corporate units, I can unambiguously identify shocks to cash which are not correlated (or at least, not positively correlated) with the returns to investment. The basic idea is to find a natural experiment in which one can identify specific changes in the cost of finance. A similar strategy is used by Blanchard, Lopez-de-Silanes, and Shleifer (1993), who examine a small (eleven) group of firms that experience a cash windfall. In contrast, this study examines a somewhat larger group of firms that experience a cash shortfall, and compares their investment with a control group of similar companies that do not experience a cash shortfall.

The innovation in the present paper is the use of corporate *segment-level* data. In the United States, publicly-owned firms are required to report certain data disaggregated into corporate segments, with a segment for each different industry in which the company participates. The new data set used here brings new issues (both econometric and conceptual), and by focusing on the 1986 episode I chose a different balance in the tradeoff between sample size and econometric bias. Thus the data presented here is additional (rather than conclusive) evidence on the connection between finance costs and investment.

A simple perfect capital markets model implies that when a company's oil segment cash flow falls, the same company's non-oil segment should be unaffected if the net present value of non-oil investment is unaffected. An imperfect capital markets model implies, in contrast, that when financial constraints tighten, the shadow cost of investment rises for all projects, so that the amount of investment (ceteris paribus) falls for all divisions of the firm.

2.1.2 Internal capital markets

Internal capital markets are a major channel of capital allocation in modern industrial economies. In any firm, managers must allocate capital across different projects. External finance is sometimes earmarked for particular parts of the firm or secured by specific assets (e.g. project finance). Internal funds are usually more fungible, and finance the bulk of investment. For example, between 1981 and 1991, internal funds accounted for more than three quarters of capital outlays for U.S. nonfinancial corporations.

Internal capital markets may differ from external capital markets due to differences in information, incentives, asset specificity, or transactions costs (see Alchian (1969), Grossman and Hart (1986), and Gertner, Scharfstein, and Stein (1993)). Corporations may own multiple assets due to product market synergies, increases in managerial efficiency, or improvements in capital allocation.

These issues are not explored here; instead, I simply outline the hypothesis to be tested. The null hypothesis is that corporate segments operate as stand-alone units; there are no internal capital markets, and each segment finances its investment from its own internal finance or from external finance secured by its own collateral. Corporations operate multiple business for reasons of product market synergy, or because scarce managerial talent is best used supervising a wide range of activity.

The alternative hypothesis is that corporate segments are financially interdependent; internal capital markets function. Under this hypothesis, combining diverse businesses into a corporate whole would alter the investment and financing behavior of the component companies. Of course, it need not be true that the financing of the company is completely and perfectly integrated; that is, the possible imperfections of the external capital market may be mirrored in the internal capital market.

If different corporate segments are financially interdependent, then a financial shock to one segment affects the cost of finance in another segment. In the case of the oil shock, financial constraints may tighten in two related ways. First, the internal finance available to the company - its cash flow generated by oil - falls. Second, the value of the petroleum-related collateral owned by the company also falls, so external finance may be more difficult to obtain. The empirical tests implemented here do not attempt to discriminate between these two channels, and for the rest of this paper I focus only on oil cash flow, which is highly correlated with the value of oil-related collateral.

Note that internal capital markets may have macroeconomic implications. Existing macroeconomic research emphasizes the role of banks, securities markets, and other external capital markets in the transmission of business cycles. Internal capital markets (in diversified firms) also provide a channel through which shocks can be transmitted from one sector to another.

2.2 The Oil Shock of 1986

In late 1985, Saudi Arabia appeared to deliberately change its petroleum policy, and increased production. Figure 1 shows the result: crude oil prices responded dramatically, falling from $26.60 per barrel in December 1985 to $12.67 in April 1986. Table 2.1 shows the effect this plunge had on major US oil companies: profit rates for petroleum fell markedly. Table 2.1 also shows that oil and gas production was hit much harder than other petroleum-related segments. Therefore, this paper focuses largely on the shock to oil and gas production/extraction (as opposed to refining or transportation).

Evidence on whether the oil price crash was anticipated is mixed. On one hand, oil prices had been declining slowly in real terms throughout the mid-1980s and were weak in 1985, and many observers predicted a decline in oil prices due to OPEC's continuing internal turmoil. On the other hand, contemporary press accounts indicate that the depth and rapidity of the oil price decline surprised many participants.

Oil companies certainly dramatically altered their plans in the first quarter of 1986. According to a Department of Commerce survey conducted in October 1985, petroleum companies planned a 3.4 percent increase in (predominantly oil-related) capital expenditures in 1986 compared to 1985. By April, 1986, the same survey indicated a planned 24.4 percent fall in capital expenditures in 1986.[2] For the companies which comprise the dataset, downward revisions of total planned 1986 investment ranged from 20 percent (Unocal) to 51 percent (Homestake Mining Company).[3] Unfortunately, most companies did not report the industry details of their expected and revised 1986 investment plans, which would have been ideal for the hypothesis test in this paper.

For at least one company in the sample, company officials explicitly stated that they were cutting non-oil investment as a result of the oil price crash:

> Chevron Corp. cut its planned 1986 capital and exploratory budget by about 30 percent because of the plunge in oil prices...A Chevron spokesman said that spending cuts would be across the board and that no particular operations will bear the brunt. About 65 percent of the $3.5 billion budget will be spent on oil and gas exploration and production - about the same proportion as before the budget revision. Chevron also will cut spending for refining and marketing, oil and natural gas pipeline, minerals, chemicals, and shipping operations. (*Wall Street Journal* 3/14/86)

[2] In contrast, industries which are major consumers of petroleum and energy as inputs revised their projected investment upwards. The three most energy intensive manufacturing industries (chemicals, paper, and primary metals) all raised their projected 1986 capital spending between October and April, consistent with the fact that their investment returns rose as a result of the oil price decline.

[3] *Oil & Gas Journal*, 5/19/86.

Table 2.1: Profit Rates and Operating Statistics for Petroleum Companies, 1980-1990

Profit Rates for Lines of Business for FRS Petroleum Companies											
	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Consolidated	15.3	12.4	7.7	7.4	6.9	5.5	3.0	3.6	7.2	6.4	6.8
.Petroleum	19.2	16.6	12.5	11.3	10.4	10.5	5.5	6.2	7.3	6.7	9.5
..U.S. Petroleum	17.5	16.1	12.7	10.3	9.4	9.4	3.0	4.9	6.3	5.8	7.9
...Oil and Gas Production	20.9	20.2	14.0	11.3	10.8	9.5	0.8	4.1	2.8	2.9	8.5
...Refining/Marketing	9.8	4.4	6.0	4.8	0.3	6.5	4.5	2.9	14.7	11.5	5.2
...Pipelines	15.1	15.6	20.8	16.6	20.8	15.0	13.2	12.8	9.6	10.2	11.2
..Foreign Petroleum	23.0	17.7	11.8	14.1	13.3	13.8	12.8	9.5	9.9	8.7	12.5
...Oil and Gas Production	25.1	25.5	17.4	19.6	18.8	20.0	11.6	12.4	9.2	8.9	13.1
...Refining/Marketing	26.4	9.0	4.7	7.7	4.5	3.3	16.3	4.7	11.6	8.0	11.2
...International Marine	2.4	-1.1	-6.3	-13.2	-14.0	-19.0	5.3	-3.6	6.8	12.4	11.7
.Coal	5.6	6.1	4.4	5.0	6.2	4.6	2.7	5.1	6.7	5.0	3.3
.Nuclear and Other Energy	-0.7	-6.8	-5.2	0.5	-1.8	-8.4	-0.8	0.5	-2.5	-2.3	1.9
.Nonenergy	5.9	3.5	0.6	2.9	4.8	4.2	5.1	12.2	20.3	17.3	7.8
Operating Statistics for FRS Firms and for US Petroleum Industry											
Net Production (bil barrels)											
FRS companies	2.09	2.07	2.08	2.06	2.09	2.12	2.09	2.07	2.10	1.91	1.81
U.S. Industry	3.71	3.69	3.67	3.75	3.81	3.81	3.71	3.57	3.32	3.24	3.27
Refinery Output (mil barrels/day)											
FRS companies	12.22	11.28	10.63	10.38	11.00	10.92	11.46	11.71	12.03	11.41	11.31
U.S. Industry	15.35	14.66	14.01	13.69	14.27	14.19	14.93	15.09	15.43	15.65	15.91
Net Wells Completed											
Exploratory	926	1,159	625	513	597	539	258	356	224	363	347
Development	1,917	2,081	1,580	1,586	1,982	1,776	647	911	822	922	1,164

Notes: FRS companies are a set a major petroleum companies which are tracked by the Department of Energy's Financial Reporting System.

2.3 Data

For corporate segments that constitute at least 10 percent of total sales and which are in a different industry from the rest of the corporation, accounting standards require corporations to report five annual variables on a segment-level basis: sales, operating profit, capital expenditures, depreciation, and identifiable total assets. Operating profit is usually reported on a pre-tax basis. The Compustat database reports these five items, along with a pair of SIC codes, for each segment. After examining various documents supplied by the company, Compustat assigns a primary 4-digit SIC industry code to each segment, corresponding to the industry classification of the majority of the segment's sales. If the segment engages in business in more than one 4-digit industry, Compustat assigns a secondary SIC code for the next largest part of the segment.

Segment-level accounting data is far from perfect, and may well contain more noise than firm-level accounting data. In particular, firms must (perhaps arbitrarily) divide up overhead costs and assets which may provide benefits to more than one segment. I focus primarily on (appropriately normalized) *changes* in segment-level capital expenditure data, so that any noise that is constant over time (such as different accounting practices used by different firms) may be alleviated. Since the 1986 shock is quantitatively and economically very large, the size of the effect should be large enough to be discerned despite possible measurement errors in the data.

To gather a sample of firms likely to be affected by the oil price decrease of 1986, I extracted every firm which in 1985 had a segment with either primary or secondary SIC codes in the oil and gas extraction sector (2-digit SIC code 13).

I then selected those firms which had a *non-oil* segment, as identified by Compustat's SIC codes for the segment and using my own judgment about which industries were oil-related.[4] I restricted attention to segments which were not in the financial or services industries, as is standard.[5] I defined a non-oil industry as any industry which:

[4]A complete list of excluded industries is presented in the data appendix.

[5]i.e. those segments with primary SIC code less than 6000. This is standard because these industries have complex accounting variables.

was not involved in the extraction of or exploration for oil and gas (or byproducts of oil and gas extraction); did not primarily involve refining, transporting, or selling petroleum products; did not supply services or equipment to the oil and gas industry; and did not produce a product which was a substitute for petroleum.[6] This meant that, for example, in addition to excluding gas pipelines, retail gasoline distributors, and oilfield services, I also excluded: the coal and uranium industries; manufacturing of valves and other pipeline-related equipment; manufacturing of construction and mining equipment; and sulfur mining (since sulfur is sometimes produced as a byproduct of oil extraction). When in doubt, I excluded suspect industries.

I carefully checked the line-of-business descriptions of every segment, and excluded those which I judged likely to be adversely affected by the oil price shock, either because they provided services for the oil and gas extraction industry or operated in a region heavily dependent on oil (a complete list is given in the Data Appendix). For example: I excluded Rowan Companies "Aviation Operations" (a charter aircraft business) because after checking the company documents, I found it operated principally in two oil-related regions, Alaska and the Gulf of Mexico. I was happy to include as non-oil industries those which used oil as an input, since these segments were likely to receive an increase in profitability as a result of the decline in oil prices.

I then deleted segments with incomplete data for the 1985-6 period, segments from firms which in bankruptcy between 1985-6, segments whose segment name was "OTHER" (since I found these segments often contained only corporate overhead or discontinued operations data), segments which (according to Compustat footnotes) had significant merger and acquisition activity in 1985-6 (because these accounting events could distort the variables of interest), and segments which had anomalous accounting data in 1985 (I removed segments which reported zero depreciation and segments with 1985 capital expenditures greater than sales).

[6] We made one exception in deleting companies with an SIC code which indicated refining. Compustat assigned Fina, Inc.'s Chemicals segment a secondary SIC code indicating petroleum refining. After reading Fina's 1986 annual report and related documents, I did not agree with this classification, so I included this segment in the sample. Deleting this segment did not materially alter the results in this paper.

Last, because the resulting sample contained very small segments which seemed to have more volatile accounting data, I excluded all segments with 1985 sales of less than \$50 million, or identifiable assets or depreciation of less than \$5 million in 1985.

The resulting sample of diversified, multi-segment firms is shown in Table 2.2. These 43 firms have a total of 79 non-oil segments; a complete list of segments is given in Table II in the appendix. The main activity of most of these firms fell into one of five main areas: extracting, refining and distributing petroleum products; railroads; mining; chemicals; and miscellaneous manufacturing. Most of these firms are quite large (far larger than the average firm on Compustat). A standard result in the cash/investment literature is that liquidity matters less for large firms than for small firms. Fazzari, Hubbard, and Petersen, for example, find that small firms have much higher cash/investment correlations than large firms. Thus it may be difficult to reject the null hypothesis with this sample of firms.

2.3.1 Survivorship bias

There is likely a substantial survivorship bias in the data which decreases the ability to reject the null hypothesis even when it is false. Under the alternative hypothesis that the oil shock increased the cost of finance, financially constrained firms are likely to sell their non-oil segments.

The imperfect capital markets/financial constraints literature would predict that, as a result of the adverse cash flow shock of 1986, oil-dependent companies would *underinvest* in their non-oil subsidiaries. One way to mitigate this inefficiency, and at the same time raise cash, is for the firm to sell off some of its divisions (either to another company, to private investors, or to new stockholders). This is precisely what occurred in 1986. Figure 2 shows that non-energy asset disposals in companies tracked by the Department of Energy peaked in 1986.[7] This process decreases the sample size since this paper includes only non-oil divisions with continuous data; i.e. those that were owned by the same parent company in both 1985 and 1986.

[7]The sample of companies tracked by the DOE change over time, so this time series is affected by changes in composition.

Table 2.2: Firm Data

		Ex ante Oil dependence 1985 Oil Share		*Ex post* Oil Shock 1985-1986	Firm Size
	Company	Cash Flow	Sales	Change in Oil Cash Flow Normalized By Firm Sales	1985 Sales (mil $)
1	AMOCO CORP	0.81	0.15	-0.07	28,641
2	ASHLAND OIL INC	0.09	0.03	0.00	8,577
3	ATLANTIC RICHFIELD CO	0.74	0.47	-0.01	41,351
4	BURLINGTON NORTHERN	0.28	0.28	-0.02	8,775
5	CANADIAN NATIONAL	0.09	0.01	-0.00	3,572
6	CANADIAN PACIFIC	0.28	0.07	-0.01	10,964
7	CHEVRON CORP	1.01	0.94	-0.03	43,614
8	DEKALB ENERGY CO	0.77	0.28	-0.17	570
9	DOMTAR INC	0.02	0.00	-0.00	1,523
10	DU PONT	0.49	0.12	-0.04	29,483
11	DWG CORP	-0.01	0.05	NA	1,085
12	ETHYL CORP	0.04	0.02	-0.01	1,547
13	FINA INC	0.71	0.08	-0.05	2,409
14	FLUOR CORP	0.05	0.02	NA	4,168
15	GOODYEAR	0.02	0.00	0.00	9,585
16	GRACE (W.R.) & CO	0.28	0.10	-0.08	5,193
17	HOMESTAKE MINING	0.32	0.19	-0.06	333
18	IMCERA GROUP INC	0.11	0.03	NA	1,627
19	IMPERIAL CHEM INDS PLC	0.09	0.08	-0.01	15,191
20	IMPERIAL OIL LTD	0.49	0.09	-0.08	6,295
21	KANSAS CITY SOUTHERN	0.05	0.04	-0.00	455
22	KATY INDUSTRIES	0.09	0.11	-0.00	391
23	KERR-MCGEE CORP	0.57	0.16	-0.09	3,343
24	LITTON INDUSTRIES INC	0.34	0.29	-0.04	4,560
25	MOBIL CORP	0.94	0.83	-0.03	59,547
26	MONSANTO CO	0.07	0.03	NA	6,743
27	NOVA CORP OF ALBERTA	0.41	0.29	NA	2,393
28	OCCIDENTAL PETROLEUM	0.88	0.31	-0.09	15,479
29	PHILLIPS PETROLEUM CO	0.80	0.21	-0.11	15,582
30	PLACER DOME INC	0.43	0.27	-0.07	302
31	PS GROUP INC	-0.03	0.13	0.01	919
32	QUANTUM CHEMICAL CORP	0.20	0.13	0.02	2,289
33	RAYTHEON CO	0.03	0.05	-0.01	6,409
34	ROYAL DUTCH/SHELL GRP CO	0.82	0.19	-0.04	97,246
35	SANTA FE PACIFIC CORP	0.22	0.09	-0.02	6,438
36	SCHLUMBERGER LTD	0.94	0.65	-0.17	6,119
37	SOUTHDOWN INC	0.49	0.19	-0.05	326
38	TENNECO INC	0.57	0.10	-0.04	15,270
39	TEXAS INSTRUMENTS INC	0.05	0.08	-0.02	4,909
40	UNION PACIFIC CORP	0.41	0.48	-0.02	7,798
41	UNOCAL CORP	0.70	0.10	-0.02	11,318
42	USX CORP-CONSOLIDATED	0.78	0.52	-0.04	18,429
43	ZAPATA CORP	1.03	0.68	-0.12	289

Further, because the firms that were most constrained were the ones most likely to sell divisions, it may bias the results in favor of accepting the null hypothesis.

Major energy producers which sold off petrochemical operations in 1986 include Diamond Shamrock and Enron. Thus these two companies are not represented in our sample. Among the 26 oil-dependent companies which did make it into the sample, at least five discontinued large non-oil operations: Canadian Pacific (airlines and mining); Homestake Mining (silver mining); WR Grace (agricultural chemicals and restaurants); Mobil (paperboard and packaging); and USX Corp (chemicals). For some of these discontinued segments, I was able to find at least partial capital expenditure data in 1986 (with data coming either from the buyer or successor company, or from the original owner). In each case, this data indicated that capital expenditure decreased in 1986, consistent with the hypothesis that investment decreased due to the oil shock. For example, one of the firms in the sample, USX Corp (formerly US Steel) spun-off its chemical segment in October, 1986. The financial statements of the resultant entity, Aristech Chemical, show that capital expenditure fell between 1985 and 1986, when it was a unit of USX.

2.4 Results

I try to adhere to standard practice by using a dependent variable similar to the left hand side of equation (1). Since I focus mainly on the year 1986, I examine ΔI between 1985 and 1986 (which is identical to using fixed effect firm-specific dummy variables, as in equation (1), with two periods). Since I do not observe K for corporate segments, I normalize with 1985 segment sales, S_0.

The basic empirical strategy is to test the hypothesis in two ways. First, I impose few assumptions on the data, and look only at means and medians. Second, I come as close as possible to testing the standard equation (1) using oil cash flow and non-oil investment. However, with segment data it is impossible to observe Tobin's q for each segment, since individual corporate segments do not (usually) issue equity.[8] Because

[8] why this is so is explored in Holmstrom and Tirole (1993).

I cannot observe q, I pay particular attention to industry-adjusted data.

To be sure that the observed oil cash flow decrease is caused by an exogenous shock, and not by the firm's endogenous response to the shock, I look at both the *ex post* magnitude of the cash flow decrease in the oil segment in 1986, and the *ex ante* likelihood that a large decrease would occur. In looking at *ex ante* data, I use only information on the industry composition of the firm in 1985, to avoid the possibility that firms which had a large *ex post* decrease in oil cash flow in 1986 were firms with particularly inept managers.

2.4.1 *Ex ante* tests

From the 79 non-oil segments, I selected 40 which I judged, based on 1985 data alone, to be *oil-dependent*; that is, to have a high *ex ante* probability of receiving a large decrease in their oil cash flow (relative to their non-oil cash flow) in 1986. I classified firms as being oil-dependent if at least 25 percent of their cash flow in 1985 came from the oil and gas extraction industry (see the appendix for more details).

These forty segments are presented in Table 2.3. Chemicals and plastics is the largest single industry (with 17 segments) with railroad, mining, agriculture, and paper/lumber products also represented. Both the chemical/plastics and paper/lumber industries are heavy consumers of petroleum and energy products. As can be seen in Table 2.3, most of the non-oil segments experienced an increase in cash flow between 1985 and 1986, in sharp contrast to the performance of the oil industry. In particular, of the segments in industries that are intensive users of petroleum as an input (chemical/plastics and paper/lumber), all but one segment experienced an increase in cash flow, as input prices fell dramatically (the exception was Unocal chemicals, which produced predominantly agricultural chemicals).[9]

Table 2.4 presents means and medians for the (normalized) change in segment investment. Based on the evidence from Table 2.3, one might have expected capital expenditures to increase in 1986, since cash flow increased. In fact, Table 2.4 shows

[9]In 1986, chemical output prices fell as well, but petroleum feedstock prices fell more, leading to increase in profits despite a fall in revenue. This higher profitability lasted at least through 1987.

Table 2.3: Segment Data, Oil-Dependent Firms

	Company	Segment	$\frac{\Delta I}{S_0}$	$\frac{\Delta SEGCF}{S_0}$	Size (Mil $)
1	AMOCO CORP	CHEMICALS	0.04	0.06	2905
2	ATLANTIC RICHFIELD	SPEC & INT. CHEMICALS	0.01	0.01	2155
3	BURLINGTON NORTHERN	FOREST PRODUCTS	-0.01	0.04	258
4	BURLINGTON NORTHERN	RAILROAD	-0.07	-0.06	4098
5	CANADIAN PACIFIC LTD	FOREST PRODUCTS	0.02	0.02	1546
6	CANADIAN PACIFIC LTD	RAILROAD	-0.03	-0.01	2408
7	CHEVRON CORP	CHEMICALS	-0.02	0.05	2246
8	DEKALB ENERGY CO	AGRICULTURAL SEED	-0.03	-0.12	201
9	DU PONT	AG-IND. CHEMICALS	-0.01	0.11	3388
10	DU PONT	BIOMEDICAL PRODUCTS	0.01	0.05	1016
11	DU PONT	FIBERS	0.02	0.13	4483
12	DU PONT	INDUS.-CONS. PRODUCTS	0.00	-0.00	2780
13	DU PONT	POLYMER PRODUCTS	0.00	0.05	3379
14	FINA INC	CHEMICALS	-0.01	0.11	405
15	GRACE (W.R.) & CO	SPECIALTY BUSINESS	-0.01	0.01	787
16	GRACE (W.R.) & CO	SPECIALTY CHEMICALS	-0.01	0.01	2254
17	HOMESTAKE MINING	GOLD	-0.12	0.23	169
18	IMPERIAL OIL LTD	CHEMICALS	0.01	0.04	542
19	KERR-MCGEE CORP	CHEMICALS	-0.03	0.04	483
20	LITTON INDUSTRIES	ADV. ELECTRONIC	0.03	-0.05	1863
21	LITTON INDUSTRIES	MARINE ENGIN.	0.00	0.03	975
22	MOBIL CORP	CHEMICAL	-0.00	0.06	2266
23	MOBIL CORP	RETAIL MERCH.	-0.01	0.02	6073
24	NOVA CORP OF ALBERTA	PETROCHEMICALS	0.07	0.02	541
25	OCCIDENTAL PETROL.	AGRIBUSINESS	0.00	0.00	6510
26	OCCIDENTAL PETROL.	CHEMICALS	0.01	0.07	1621
27	PHILLIPS PETROLEUM	CHEMICALS	0.00	0.03	2266
28	PLACER DOME INC	MINING	0.02	0.07	221
29	ROYAL DUTCH/SHELL	CHEMICALS	-0.01	0.09	8583
30	SCHLUMBERGER LTD	MEASUREMENT	0.02	0.02	1619
31	SOUTHDOWN INC	CEMENT	-0.04	0.02	265
32	TENNECO INC	AUTOMOTIVE PARTS	0.02	0.05	1074
33	TENNECO INC	CHEMICAL	-0.01	0.04	841
34	TENNECO INC	PACKAGING	0.00	0.02	851
35	TENNECO INC	SHIPBUILDING	-0.02	-0.02	1801
36	UNION PACIFIC CORP	TRANSPORTATION	-0.04	0.07	3786
37	UNOCAL CORP	CHEMICALS	-0.03	-0.01	1217
38	UNOCAL CORP	METALS	-0.12	-0.07	129
39	USX CORP	STEEL	-0.02	-0.08	6263
40	ZAPATA CORP	MARINE PROTEIN	-0.11	0.14	93

Notes: $\frac{\Delta I}{S_0}$ and $\frac{\Delta SEGCF}{S_0}$ are the change in segment investment and cash flow, respectively, between 1985 and 1986, divided by segment sales in 1985.

Table 2.4: Raw data:oil-dependent firms, 1984-1987

	1984-85 (1)	1985-6 (2)	1986-7 (3)	1985-7 (4)	1984/5 - 86/7 (5)
No. of Obs.	31	40	40	40	31
Mean of $\frac{\Delta I}{S_0}$	0.77	-1.18	0.94	-0.23	-0.51
t-statistic	(1.91)	(1.96)	(2.01)	(0.27)	(0.70)
2-sided p-value	(.06)	(.05)	(.04)	(.79)	(.48)
Median of $\frac{\Delta I}{S_0}$	1.02	-0.61	0.55	0.07	0.19
Z-statistic	(2.94)	(1.52)	(1.84)	(0.07)	(0.30)
2-sided p-value	(.003)	(.13)	(.07)	(.95)	(.76)
number positive	23/31	16/40	24/40	20/40	13/31
2-sided p-value	(.01)	(.27)	(.27)	(1.00)	(.47)

Notes:

Dependent variable: $\frac{\Delta I}{S_0}$, where S_0 is segment sales in the first period. Expressed as percentage points. Mean: The t-statistic is calculated using White's robust standard errors. Median: The Z-statistic is the Wilcoxon signed-rank test, which tests the hypothesis that the observations are IID and symmetrically distributed around zero. Number positive: the 2-sided p-value is the probability of observing at most this number of positive or negative values, under the null hypothesis that the observations are independent and prob[positive]=.5.

Table 2.5: Industry-adjusted data:oil-dependent firms, 1985-1986

	Raw Data	Industry-Adjusted Data	
		Method 1	Method 2
	(1)	(2)	(3)
No. of Obs.	40	39	37
Mean of $\frac{\Delta I}{S_0}$	-1.18	-1.54	-1.56
t-statistic	(1.96)	(2.31)	(2.06)
2-sided p-value	(.05)	(.02)	(.04)
Median of $\frac{\Delta I}{S_0}$	-0.61	-1.02	-1.03
Z-statistic	(1.52)	(2.20)	(1.85)
2-sided p-value	(.13)	(.03)	(.07)
number positive	16/40	15/39	14/37
2-sided p-value	(.27)	(.20)	(.19)

Notes: See notes to Table 2.4. Industry-adjustment methods described in the text.

that just the opposite occurred: capital expenditures declined in 1986 for most of the 40 segments, with a mean and median decline of around one percent, compared to the 1985 level of the investment/sales ratio of around eight percent. In contrast, investment rose between 1984-5, prior to the oil price crash, and also rose in the year following the oil price crash. The recovery of oil-dependent firm's non-oil investment in 1987 helped erase some of the decline in 1986; thus the decline in investment was a relatively transitory phenomenon.

Table 2.5 presents industry-adjusted statistics, and displays some of the major results of this paper. Industry-adjustment is necessary to control for industry-wide changes in the profitability of investment. I tried two different methods of industry adjustment. Method 1, shown in column (2), is fairly standard in the corporate finance literature. For example, Kaplan (1989) uses an almost identical algorithm (except, as explained in the appendix, I use information about both the primary and secondary SIC industry codes assigned by Compustat). For each observation of $\frac{\Delta I}{S_0}$, I subtracted the median value of $\frac{\Delta I}{S_0}$ from a control group of Compustat segments which were in the same industry, but which were owned by companies which did not have an oil extraction segment. The algorithm for selecting the control group is detailed in the appendix; there were matches for 39 of the 40 observations.

Column (3) industry-adjusts with Method 2: I paired the observations with a single matching segment instead of with the industry median, and I matched observations along size as well as SIC code. Specifically, potential matches were required to have segment size (measured by 1985 sales) within 25 percent of the observation's size. If this produced more than one match, I picked the matching industry segment which provided the best size match. At this level of precision there were matches for 37 of the 40 observations.

Table 2.5 shows that, for both means and medians, industry-adjusted investment fell in 1986. For Method 1, both the mean and median fall are significant at the five percent level, and again equal to more than one percent of the investment/sales ratio. For Method 2, with a slightly smaller sample size and a matching technique that introduces more idiosyncratic noise, the estimated declines are the same size but with slightly lower confidence levels.[10] Following convention, the table reports two-sided p-values, although I am really trying to test a one-sided hypothesis; thus the p-values in the table are quite conservative.

2.4.2 Robustness checks

This section presents some basic robustness tests on the industry-adjusted results of column (2) in Table 2.5. First, I checked to see if the results were driven by any single observation. They weren't.[11] Next, Table 2.6 measures the dependent variables in a variety of different ways: column (2), looking at the change in the investment/sales ratio between 1985-6; column (3), normalizing by segment assets instead of sales; column (4), looking at the percent change in assets; column (5), normalizing by total firm sales (in each case I industry-adjusted by subtracting the control group's median of the appropriate variable). The results are consistent with Table 2.5: most of the

[10]Using a different definition of oil-dependent does not alter the qualitative conclusions. Looking only at the twenty-one segments whose companies have more than 50 percent (instead of 25) of 1985 cash flow coming from oil, the means and medians for 1985-6 in Table 2.5 are higher (around 2 percent) while the test statistics are about the same size.

[11]The lowest t-statistic for the mean in Table 2.5 column (2) that I could generate by throwing out a single observation was 2.03.

Table 2.6: Alternate Samples and Measures of Industry-Adjusted Change in Investment, 1985-6

	Alternate Measures					Alternate Samples	
	Baseline Sample					Firm Total	Bigger Sample
	$\frac{\Delta I}{S_0}$ (1)	$\Delta(\frac{I}{S})$ (2)	$\frac{\Delta I}{A_0}$ (3)	$\frac{\Delta I}{I_0}$ (4)	$\frac{\Delta I}{FS_0}$ (5)	$\frac{\Delta I}{S_0}$ (6)	$\frac{\Delta I}{S_0}$ (7)
No. of Obs.	39	39	39	39	39	25	92
Mean	-1.54	-1.68	-1.09	-6.34	-0.49	-1.62	-0.85
t-statistic	(2.31)	(2.53)	(2.26)	(0.48)	(2.00)	(1.92)	(1.91)
2-sided p-value	(.02)	(.01)	(.02)	(.63)	(.05)	(.06)	(.06)
Median	-1.02	-1.06	-1.32	-14.96	-0.09	-1.05	-0.18
Z-statistic	(2.20)	(2.75)	(2.20)	(2.20)	(2.29)	(1.79)	(1.46)
2-sided p-value	(.03)	(.01)	(.03)	(.03)	(.02)	(.07)	(.14)
number positive	15/39	13/39	15/39	15/39	15/39	8/25	48/92
2-sided p-value	(.20)	(.05)	(.20)	(.20)	(.20)	(.11)	(.75)

Notes:
All variables industry-adjusted with Method 1.
Dependent variables: $\frac{\Delta I}{S_0}$ as in Table 2.4. $\Delta(\frac{I}{S_0})$ is the change in the investment/sales ratio. A_0 is segment assets in 1985. $\frac{\Delta I}{I_0}$ is the percent change in investment. FS_0 is total firms sales in 1985. All variables are expressed as percentage points.
"Firm total" aggregates the industry-adjusted observations from Table 2.5 column (2) into firm totals, weighting by segment size.
"Bigger sample" includes a wider array of industries, and includes many oil-related industries excluded from the baseline sample.

test statistics reject the null hypothesis.

One problem with Table 2.5 is that different segments from the same company are not independent observations, so that test statistics calculated under an IID hypothesis are not correct. Therefore, column (6) of Table 2.6 aggregates the industry-adjusted observations of $\frac{\Delta I}{S_0}$ into firm totals, weighting each observation by segment sales. The results are essentially unchanged, with slightly lower significance levels.

Since I was worried by the judgmental way by which I defined "non-oil" industries, I also tried calculating basic sample statistics and regression results for a larger sample of corporate units. Rather than judging industries and segments, this sample simply includes all observations except industry segments which were coded as being in the oil extraction industry. This screening rule added 52 additicnal segments to the baseline sample, totalling 92 segments. The additional segments were mostly petroleum refining (22 segments), natural gas transmission and pipelines (13 segments), and coal mining (10 segments). As can be seen from Table 2.1, in 1986 profits fell for these industries in the US. The results using industry-adjusted data are shown in Table 2.6, and give a somewhat weaker rejection of the null hypothesis than the baseline sample (the unadjusted data, not shown, of course show a large decline in investment for these oil-dependent industries). Although both the mean and median changes in investment are still negative, the median decline is much lower and less significant.[12]

Another potential objection to the evidence in Table 2.5 is that the non-oil segment data may somehow be contaminated by the fact that the parent company also owns an oil exploration segment, despite the fact that I carefully screened the companies and read each segment's line-of-business description. For example, it could be that Burlington Northern's railroad division is more heavily involved in oil transportation compared to the control group of railroad divisions. There may be synergies between oil and non-oil segments (although it is difficult to imagine what they might be for, say, Mobil's Montgomery Ward retail division). Perhaps tax changes in this period affected oil companies more than other companies. Last, it could be that companies that own oil extraction segments also are regionally concentrated in oil-producing states.[13]

Although I cannot control for all of these factors, I can at least use a different control group that addresses some of these concerns. To provide a better control group, I used the firms from Table 2.2 which owned an oil segment but which were not oil-dependent (by my reckoning using *ex ante* data). I call these companies, which own 39 non-oil segments, ***not-oil-dependent oil companies.*** There is substantial overlap in the industries owned by oil-dependent and not-oil-dependent firms, with

[12]One important caveat is that I have not yet carefully checked the Compustat numbers for this larger sample for errors.

[13]Of course, this possible regional effect could work both ways. It could be that non-oil industries that sold their products nationally but were located in oil-related regions benefited, as wages, rents, and other business costs fell in those regions.

Table 2.7: Oil-dependent firms vs. not-oil-dependent firms: $\frac{\Delta I}{S_0}$ 1985-6

	Raw Data	Industry-Adjusted Data	
		Method 1	Method 2
	(1)	(2)	(3)
No. of Obs.	79	75	72
Mean of $\frac{\Delta I}{S_0}$	-2.41	-2.94	-3.51
t-statistic	(2.23)	(2.57)	(2.62)
2-sided p-value	(.03)	(.01)	(.01)
Median of $\frac{\Delta I}{S_0}$	-0.77	-0.70	-2.05
Z-statistic	(1.58)	(1.99)	(2.55)
2-sided p-value	(.11)	(.05)	(.01)

Notes:
Mean: the coefficient on the dummy variable for oil-dependent firms in a regression including only a dummy and a constant. Constant term not shown. White standard errors are used to construct the t-statistic. Median: the difference between the medians of the oil-dependent and not-oil-dependent sample. The Z-statistic is the Wilcoxon-rank sum test, which tests the hypothesis that the two samples have the same IID distribution. The reported 2-sided p-values are two sided. See also notes to Table 2.5.

both groups including chemicals, mining, railroads, and agriculture.[14] If there is some hidden dependence on oil in these industries, then one might expect it to be reflected in the segments owned by not-oil-dependent oil firms. Of course, this control group is only useful to the extent that the hidden dependence depends on the *existence* of an oil segment rather than its quantitative size. If there is some hidden synergy is a function of the size of the oil segment, I have no hope of controlling for it.

Table 2.7 shows evidence using both means and medians. Using the industry-adjusted data in Panel B, both the mean and the median change in investment were significantly lower for the oil-dependent oil firms compared to the not-oil-dependent oil firms.

Table 2.7 includes segments in a variety of industries, and there are some industries that are not common to both groups. A narrower test is to compare only those segments in the oil-dependent group which are in the same industry as segments in the control group of not-oil-dependent oil companies (although throwing away

[14]As can be seen in Table II in the appendix.

information in this manner reduces statistical power). Table 2.8 shows the set of 20 paired observations generated by matching segments from the two groups.

Table 2.8 is constructed as follows: Moving alphabetically down the list of segments in Table 2.3 owned by oil-dependent firms, I tried to find a industry match at the three-digit or higher level from the list of segments owned by not-oil-dependent firms from Table 2.2, following the algorithm of Method 1.[15] In cases where I found more than one match, I chose the one that was closest in size. Mechanically matching on industry codes in this manner produced fourteen paired observations; I judgmentally matched six more pairs with identical primary two-digit SIC codes.[16]

The results from Table 2.8 are striking. In only 4 of the 20 pairs does the oil-dependent firm's segment have a larger change in investment in 1986 compared to the not-oil-dependent firm's segment. If each pair had an equal (and independent) chance of being positive or negative, the (two-sided) probability of observing four or fewer would be .01. A Wilcoxon signed-ranks test rejects the hypothesis that the matched-pairs have the same distribution at the .05 (two-sided) level.

The matching in Table 2.8 seems quite precise. Among other good matches, I have two Canadian railroad segments, two US railroad segments, two defense electronic segments, and two makers of animal feed. Based on these matches, it seems hard to conclude that a failure to correctly match industries is the driving force behind the results.

Although Table 2.8 has only twenty pairs, the results are moderately robust to various alterations. For example, discarding the six two-digit pairs which were judgmentally matched, one can still reject the null hypothesis with reasonable confidence:

[15]I judgmentally excluded Monsanto's Low-Calorie Sweetener division from consideration as a match. It was coded 2869, miscellaneous organic chemicals. I did not think the fast-growing Nutrasweet division was a fair match for the commodity chemical divisions owned by oil companies. Including this segment as a match would make it easier to reject the null hypothesis.

[16]I paired two-digit matches by hand since I did not want to match, say, Imperial Chemical's pharmaceutical division with Shell's commodity chemical division. The rational for these judgmental matches was: 1) Mobil/Ethyl, shared a common four-digit SIC code; 2) Occidental/Imcera chemical, shared a common four-digit SIC code; 3) Occidental/Imcera agribusiness, seemed more similar than the other potential agribusiness match (Grace/Imcera); 4) Southdown/Domtar, both supplied construction industry; 5) Tenneco/Quantum, both involved in making detergent chemicals; 6) USX/Fluor, had identical pairs of two-digit primary and secondary SIC codes.

Table 2.8: Oil-dependent firms vs. not-oil-dependent firms: Paired Obs. of $\frac{\Delta I}{S_0}$

	Oil-dependent firm				Not-oil-dependent firm				Diff. in
	Firm	Segment	SIC Codes		Firm	Segment	SIC Codes		$\frac{\Delta I}{S_0}$
Four or Three Digit SIC Code Matches									
1	ARCO	CHEMICALS	2869	2865	ETHYL CORP	CHEMICALS	2869	2865	-0.02
2	BURLINGTON	RAILROAD	4011	6519	CANADIAN NATL	RAIL OP.	4011	4111	-0.01
3	CANADIAN PAC.	FOREST PROD.	2621	2421	DOMTAR	PULP/PAPER	2621	2611	-0.20
4	CANADIAN PAC.	RAILROAD	4011		CANADIAN NATL	RAILWAYS	4011		-.03
5	CHEVRON	CHEMICALS	2869	2865	IMPERIAL CHEM	IND. PROD.	2869	2812	-.01
6	DU PONT	AG./IND. CHEM	2879	2819	MONSANTO	CROP CHEM	2879	181	0.02
7	DU PONT	FIBERS	2824	2297	MONSANTO	CHEMICALS	2824	3080	0.03
8	DU PONT	POLYMERS	2821	3081	QUANTUM CHEM	PETROCHEM	2821	2869	-0.02
9	GRACE	SPEC. CHEM	2800	3086	ASHLAND OIL	CHEM	2800	5169	-0.00
10	LITTON	ADV. ELECTRON.	3812	3679	TEXAS INST.	DEF. ELECTRON.	3812		-0.01
11	TENNECO	PACKAGING	2631	3089	DOMTAR	PACKAGING	2631	5093	0.05
12	UNION PAC.	TRANS.	4011	4213	KANSAS CITY	TRANS.	4011	4213	-0.09
13	UNOCAL	CHEMICALS	2873	2999	IMPERIAL CHEM	AGRIC.	2873	2879	-0.01
14	ZAPATA	MARINE PROTEIN	2048	2077	MONSANTO	ANIMAL SCIENCES	2048		-0.14
Two Digit SIC Code Matches									
15	MOBIL	CHEMICAL	3081	2821	ETHYL	PLASTICS	3089	3081	-0.00
16	OCCIDENTAL	CHEMICAL	2812	2874	IMCERA	FERTILIZER	2874	1470	0.02
17	OCCIDENTAL	AGRIBUS.	2011	6512	IMCERA	ANIMAL PROD	2048	2834	-0.00
18	SOUTHDOWN	CEMENT	3241	6519	DOMTAR	CONSTR. MATL	2899	2841	-0.03
19	TENNECO	CHEMICAL	2819	2800	QUANTUM CHEM	OLEOCHEM	2899	2841	-0.03
20	USX CORP	STEEL	3312	1011	FLUOR CORP	METALS	3339	1000	-0.02

the (two-sided) probability of observing 3 or fewer positives/negatives from a sample of 14 is .06.[17]

One potential problem with the results from Table 2.8 is that the observations are not independent, since some companies have more than one segment represented (for example, Du Pont is responsible for two of the four positive observations). Therefore, moving alphabetically down the list in Table 2.8, I discarded any pairs in which either parent company appeared previously in the list. This left us with 11 observations, of which 2 were positive: the (two-sided) probability of this event is .1054. Repeating this in reverse alphabetical order left us with a different set of 11 pairs, of which zero were positive (probability: .00098).

2.4.3 Regression evidence

Table 2.9 uses the data on oil-dependence in a more continuous way. Instead of separating the observations into two groups, I regressed the entire sample of 79 segments on the share of oil extraction in the parent company's cash flow or sales. For both raw and industry-adjusted numbers, the data soundly reject the null hypothesis that the change in non-oil investment was unrelated to the parent firm's dependence on oil cash flow.

The coefficients in Table 2.9 imply that a firm with 50 percent of its cash flow in oil in 1985 would decrease its investment/sales ratio by about 2.5 percent in 1986, compared to a firm with no exposure to oil. In other words, investment falls by about one third of its 1985 level.

2.4.4 *Ex post* tests

This section presents regression evidence using the *ex post* cash flow shock suffered by the company in 1986. Here, I approach closest to estimating the standard equation

[17] Readers who may disagree with specific pairings from the set of 20 can use the following facts from the binomial distribution to arrive at conclusions: discarding one of the 16 negative observations, one still rejects the null hypothesis at the five percent level. Discarding three or fewer negative observations, one still rejects at the ten percent level.

Table 2.9: *Ex ante* regression evidence: $\frac{\Delta I}{S_0}$ 1985-6

	(1) Oil Cash Flow Share	(2) Oil Sales Share	No. of Obs.
Panel A: Raw Data			
Coefficient	-0.035		78
t-statistic	(2.02)		
2-sided p-value	(.04)		
Coefficient		-0.041	79
t-statistic		(1.78)	
2-sided p-value		(.07)	
Panel B: Industry-Adjusted Data, Method 1			
Coefficient	-0.047		74
t-statistic	(2.48)		
2-sided p-value	(.02)		
Coefficient		-0.048	75
t-statistic		(2.05)	
2-sided p-value		(.04)	
Panel C: Industry-Adjusted Data, Method 2			
Coefficient	-0.051		71
t-statistic	(2.37)		
2-sided p-value	(.02)		
Coefficient		-0.047	72
t-statistic		(1.80)	
2-sided p-value		(.07)	

Notes:

Dependent variable: $\frac{\Delta I}{S_0}$

Regressions include a constant term, not shown. T-statistics constructed with White standard errors. Oil shares: percent of total firm pre-tax operating cash flow and sales in 1985 coming from segments with primary or secondary SIC codes in oil and gas extraction industry (code 13). For cash flow, this excludes one company (Fluor Corp) which had negative firm cash flow in 1985. See also notes to Table 2.5.

(1), and I use panel data for the period 1985-7.[18] To compare oil and non-oil cash flows, I normalized all variables by total firm sales in 1985. I used the firm's oil cash flow relative to firm size, $\frac{OILCF}{FS_0}$, to measure the oil-dependence of the firm. Oil cash flow both measures the internal finance available to the firm, and provides a rough guide to the collateral value of the firm's oil segment. The non-oil segment's own cash flow relative to firm size, $\frac{SEGCF}{FS_0}$, both measures liquidity generated by the segment, and perhaps signals the profitability of the non-oil segment.

Using three years of data, Table 2.10 regresses the investment of the non-oil segments on their own cash flow, the oil segment's cash flow, and a set of segment and year dummies. In each case, the data reject the hypothesis that oil cash flow does not affect non-oil investment. Instead, I estimate that for every dollar that pre-tax oil cash flow falls, non-oil investment falls by 10 to 20 cents. I cannot reject the hypothesis that the oil cash flow and the non-oil cash flow have an identical affect on the non-oil segment's investment. Panel A, using raw data, is closest to the standard result of equation (1).

I tried running a variety of robustness checks on these results: instrumenting for $OILCF$ with the 1985 oil share; using only 1985-6 data (so the results are more comparable to Table 2.5; entering industry adjustment factors on the right hand side of the equation (instead of subtracting from the dependent variable); and using only manufacturing segments. In each case, the coefficient on $OILCF$ was around .1 to .2, usually with reasonable significance levels.

These results are comparable to existing estimates of equation (1). Using firm (not segment) data, Fazzari, Hubbard, and Petersen (1988) estimate a coefficient of .23 on cash flow for a similar group of companies 1970-1984.[19]

However, there are important differences between this regression and standard firm-level versions of equation (1). One difference is that, for consistency, in Panels B and C I have industry-adjusted both the non-oil investment and the non-oil cash flow. Thus the estimates on the segment's own cash flow are intended to capture only

[18]The Compustat data I was able to access had segment data only back to 1985.

[19]This estimate is for companies that pay high dividends. Most of the companies in the sample would fall into this category.

Table 2.10: *Ex post* regression evidence: $\frac{I}{FS_0}$ 1985-7

	(1) $\frac{OILCF}{FS_0}$	(2) $\frac{SEGCF}{FS_0}$	(3) $\frac{TOTALCF}{FS_0}$	No. of Obs.
Panel A: Raw Data				
Coefficient			0.138	195
t-statistic			(2.72)	
2-sided p-value			(.01)	
Coefficient	0.119	0.146		195
t-statistic	(2.14)	(2.00)		
2-sided p-value	(.03)	(.05)		
Panel B: Industry-Adjusted Data, Method 1				
Coefficient			0.070	184
t-statistic			(1.12)	
2-sided p-value			(.26)	
Coefficient	0.144	0.050		184
t-statistic	(2.30)	(0.41)		
2-sided p-value	(.02)	(.68)		
Panel C: Industry-Adjusted Data, Method 2				
Coefficient			0.143	168
t-statistic			(3.21)	
2-sided p-value			(.00)	
Coefficient	0.194	0.125		168
t-statistic	(2.09)	(1.65)		
2-sided p-value	(.04)	(.10)		

Notes:

Dependent variable: $\frac{I}{FS_0} = \frac{I}{S_0} * \frac{S_0}{FS_0}$

Regressions include a constant term, fixed-effects segment dummies, and year dummies, not shown. T-statistics constructed with White standard errors.

FS_0 is total firm sales in 1985. $OILCF$ and $SEGCF$ are pre-tax operating cash flow for the oil segment(s) (with primary or secondary SIC code in oil and gas extraction), and the individual segment, respectively.

The column (2) independent variable, $\frac{SEGCF}{FS_0}$, is industry-adjusted in Panels B and C.

$TOTALCF = OILCF + SEGCF$

the idiosyncratic component of the segment's cash flow. In Panels B and C this effect is estimated imprecisely (and in Panel B it seems a bit low).

The most significant departure from the existing literature is that the cash flow I observe is pre-tax operating income, since after-tax net income is not generally available. Thus $OILCF$ and $SEGCF$ do not represent true internal finance available to the firm. This problem may well be particularly acute for oil companies, for two reasons. First, US tax laws (which were changing or anticipated to change during this period) are a substantial factor in investment in capital-intensive industries like petroleum. Second, much of the income tax payment made by the large international oil companies in the sample was paid to foreign governments (e.g. Saudi Arabia). These payments to host countries were sometimes structured so as to ensure fixed profit margins for oil companies regardless of price. Thus, looking at pre-tax income would overstate the effect of the 1986 oil price crash for some companies.[20] Using after-tax income would decrease the magnitude of the cash flow variable, and thus increase the magnitude of the coefficients.

Another potential way that taxation might affect our ability to make inferences from the results is by affecting the cost of capital. Companies with lower profits (or losses) may loose certain tax benefits and thus face a higher after tax cost of capital. Thus the cash/investment correlation might reflect changes in the cost of finance due to the tax code, not financial market imperfections. This problem is also present in the existing literature using firm-level data. So while the use of segment data improves on the existing literature by avoiding the profitability signalling component of cash flow, it does not avoid the tax signalling component.

A problem more specific to the 1986 episode is that major tax legislation was passed during this period; this legislation contained several provisions with differing effects on the cost of capital (portions of the law were implemented in 1986, with the bulk of the effect in 1987). If tax reform raised the cost of capital for oil firms more than other firms, then it may be driving the results. It's worth noting that (according

[20]For example, Mobil (which did report both before- and after-tax segment income) had a fall in pretax oil income as shown in Table 2.2, but after-tax net oil income was essentially flat. Due to growth in chemicals and merchandising, Mobil's net income actually rose between 1985 and 1986.

to Table 2.5) investment revived in 1987, so that if the tax legislation is driving the results, for some reason the effect stopped in 1987.

2.5 Conclusion

I conclude, based on the responses of oil companies' non-oil segments, that large decreases in cash flow decrease investment. I confirm the findings from the literature on cash flow and investment: cash matters. Unfortunately, the sample size is fairly small, there are survivorship biases in the data, and the investigation is fairly limited in scope: therefore I feel confident only in testing relatively simple hypotheses. While statistical confidence levels are not extraordinarily high, they are moderately robust.

The sample of firms used in the paper include some of the largest corporations in the world. A common finding from the existing literature is that cash matters more for small firms than for large firms, perhaps because small firms have less access to financial markets. Thus if cash matters for the large, publicly-owned companies used in this study, it is likely to matter even more for other firms.

One issue not addressed here is the question of underinvestment versus overinvestment. The literature on imperfect capital markets suggests underinvestment (relative to what would take place in perfect capital markets) may result from costly external finance, so that the fall in oil cash flow may have resulted in (increased) underinvestment in non-oil activities. On the other hand, principal-agent models (such as Jensen (1986)) stress that managers may overinvest free cash flow, so that the fall in oil cash flows may have prevented wasteful expenditure. Indeed, the oil industry was often cited as a possible case of overinvestment and an example of the salutary effects of hostile takeovers on corporate discipline. Both the underinvestment and overinvestment approaches imply that when internal finance falls, investment falls.

I also conclude that corporate segments are interdependent, so that combining different firms into a corporate whole has real consequences. Issues in the theory of the firm emerge naturally from this empirical investigation.

I have not pinpointed the precise financial mechanism which caused non-oil segments to decrease investment when oil prices fell. The findings are consistent with a variety of possible ways to allocate capital within that the firm. On one hand, it could be that the firms treated cash flow as fungible from segment to segment, and subsidized the operations of ailing oil segments with cash flow from the non-oil segments. On the other hand, it could be that firms allowed individual segments to raise their own financing (either externally or internally), but external finance became less available to the non-oil segments because their parent company's collateral declined.

In principle, the approach used here can be used for many other episodes with financial shocks to diversified firms, for example exchange rate fluctuations (and other country-specific shocks for multinational firms), commodity price movements, and business cycles. Other types of evidence, for example the Census Bureau's plant-level database, would also be useful. Internal capital markets are an important channel of capital allocation; empirical work can shed light on how this channel operates.

Figure 1:Real Crude Oil Prices

1982 Dollars per Barrel

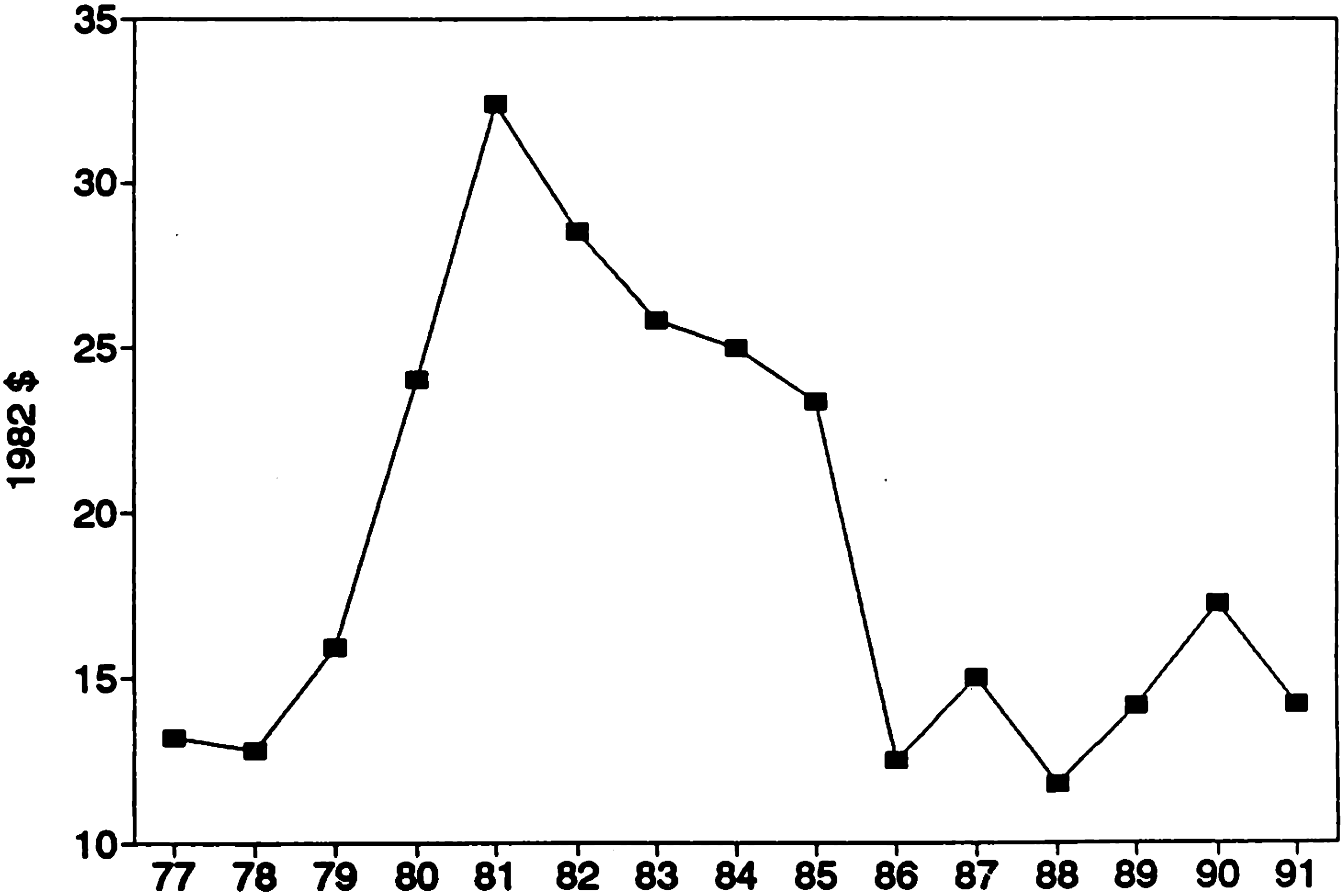
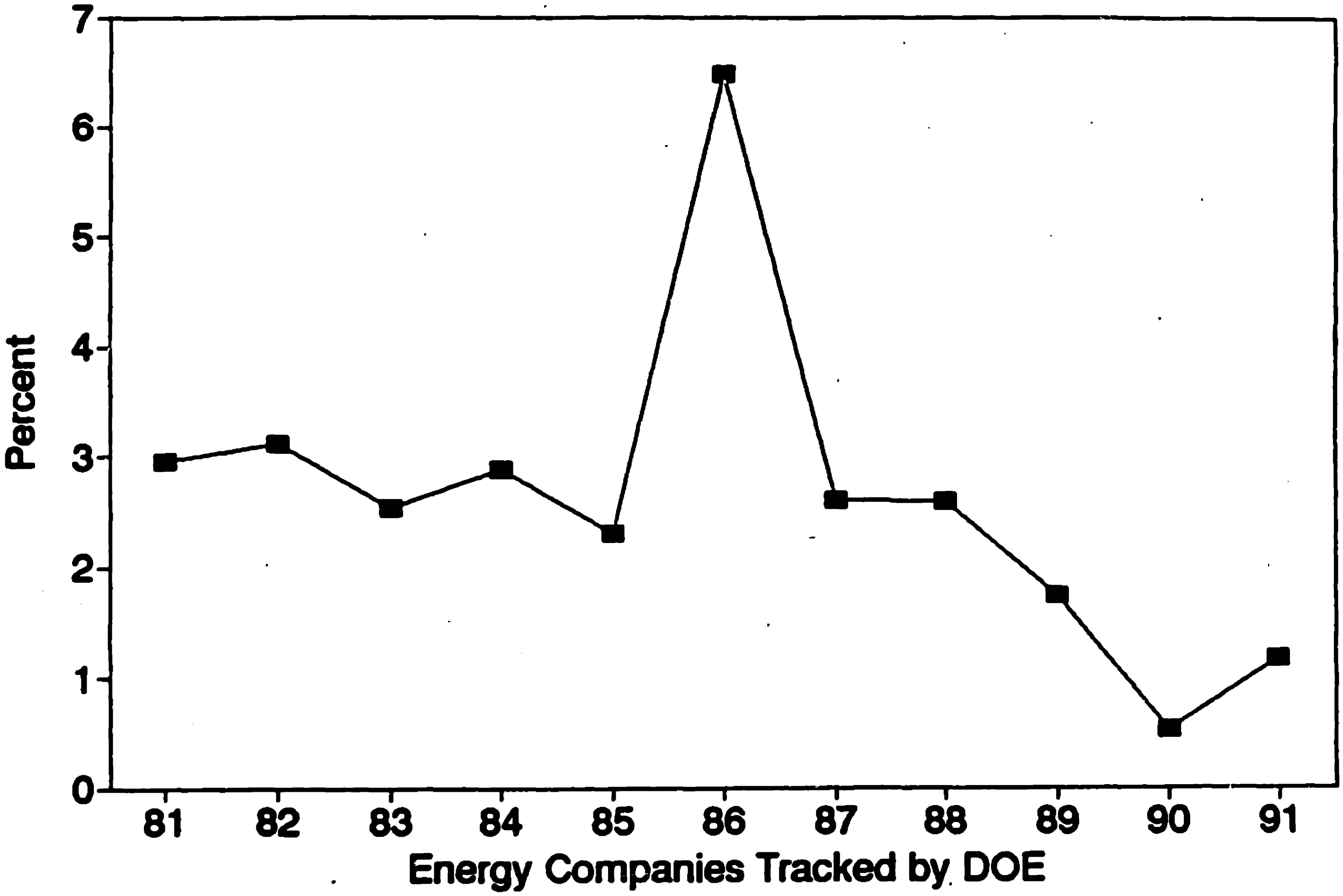


Figure 2: Nonenergy Asset Disposals

As a percent of net capital stock



Chapter 3

Inflation and relative price variability: Evidence from US Cities (Coauthored with Guy Debelle)

3.1 Introduction

Time series evidence suggests that inflation and relative price changes are strongly correlated, at least at moderate levels of inflation. A variety of theories can explain this correlation, but existing evidence is inconclusive about the causal mechanism that generates the observed facts. In this paper, we present new evidence on the relationship between inflation and relative price variability by examining a cross-section of US cities in the post-war period. The value of this approach is that it controls for nation-wide shocks, including changes in monetary policy and oil prices.

The movement of individual prices relative to the aggregate price level has been investigated at least since Mills' classic description of the US price system in 1927. Previous empirical work using time series data has found a positive relationship between relative price variability and inflation in different countries and in different inflationary environments.[1] This work has defined relative price variability as the standard deviation (or variance) of the rates of inflation of various categories of goods and services around the average consumer price inflation rate, that is, *inter-market* price variability. Graph 1 illustrates the standard result in the literature. It updates Figure 1 in Fischer (1981), plotting the US inflation rate (as measured by the private consumption deflator) against the variance of the inflation rates of its 12 major components.[2] A positive relationship between price variability within markets (*intra-market* price variability) and the level of inflation has also been found.[3]

Using data on annual consumer price inflation, we find that across US cities, the positive correlation between inflation and relative price variability is a robust empirical regularity. US cities which have inflation above the national average in a given year also have a higher degree of relative price variability. This relationship holds for different categories of goods and services, for different subperiods, and controlling for fixed city and year effects. These results are consistent with the existence of real price rigidity, but cannot easily be explained by other theories explaining the relationship.

The following section briefly discusses the theoretical underpinnings for the relationship between inflation and relative price variability. The third section summarises the existing empirical work, the fourth section presents our results, whilst the final section concludes.

3.2 Theories of Relative Price Variability

Fischer (1981) provides a useful summary of the theoretical links between inflation and relative price variability (RPV). The relationship between the two may be explained by the following, not necessarily mutually exclusive, theories, as summarised in Table

[1] Vining and Elwertowski (1976), Parks (1978), Fischer (1981) and (1982), Tommasi (1992), Lach and Tsiddon (1992)

[2] Fischer's graph ran until 1980. It is interesting to note that there is another peak in the variance at the time of the 1986 negative oil price shock, in addition to the two he found at the time of the 1973 and 1979 oil price shocks. Replotting this figure using the CPI rather than the private consumption deflator yields approximately the same picture.

[3] Lach and Tsiddon (1992), Van Hoomissen (1988), Domberger (1987). See also Reinsdorf (1992) who examines price *level* dispersion.

Table 3.1: Theoretical Implications

Theory	Exogenous factor	Aspect of Inflation associated with RPV
1. Imperfect Information	Monetary shocks	Unanticipated
2. Menu Costs	Inflation	Level
3. Real Price rigidity	Relative shocks	Level
4. Nominal Price rigidity	Relative shocks	Decreases with level
5. Govt policy	Policy	Changes in level
6. Monetary Accommodation	Real shocks	Level

Source: Fischer (1981) p387

Firstly, based on the framework of Lucas (1973) and Barro (1976), unanticipated changes in the money supply may cause changes in the price level in individual markets which are misperceived as being partly changes in relative prices. "A lack of full current information ... prevents individuals from dichotomizing unanticipated price movements into relative and absolute components."[4] Differing elasticities across markets will translate these misperceptions into actual changes in relative prices. Alternatively, the misperceptions could have more permanent effects if the individuals act on the imperfect information by, for example, investing in capital. Thus unanticipated movements in inflation in either direction should increase relative price variability.[5]

The second theory uses the presence of menu costs to generate a positive relationship between the level of inflation (anticipated or unanticipated) and relative price variability. In a model of price adjustment such as Sheshinki and Weiss (1977) where there is a fixed cost of price adjustment, an increase in inflation not only causes

[4]Barro 1976 p1

[5]Inflation uncertainty has often been associated empirically with the level of inflation. Okun (1971) found evidence of a positive association between the level of inflation and inflation variability. Ball (1992) presents a theoretical model linking inflation uncertainty to the level of inflation. In this model, unanticipated changes in the money stock will be larger on average, the higher the level of inflation, as the public is more unsure what the future actions of the monetary authority will be at higher levels of inflation. Thus combining the Ball and Barro/Lucas models could generate a positive relationship between the level of inflation and relative price variability.

prices to be adjusted more frequently but also widens the band over which prices are adjusted thus increasing relative price variability.[6] The menu-cost framework also provides a justification for the positive skew of the distribution of inflation rates discussed below.

However, this theory is probably more applicable to intra-market price variability than inter-market price variability. It may also break down in periods of extreme inflation when prices are indexed to a foreign currency or menu costs become insignificant. In such situations, relative price variability may disappear entirely in what Frenkel (1982) refers to as the "bells ring at noon" syndrome.[7] That is, relative price movements are swamped by the simultaneous upward adjustment in all prices.

Using a similar theoretical base, a number of models have linked inflation and relative price variability based on the content of price information available to consumers.[8] Tommasi (1992) argues that inflation reduces the value of consumers' price information, thus allowing firms to charge higher markups and increasing relative price variability. Conversely, Benabou (1988) argues that increased relative price variability induces consumers to search more, thus reducing markups.

Thirdly, downward price rigidities (real or nominal) may lead to increased relative price variability which generates inflation. That is, the relationship runs from relative price variability to inflation. If prices are inflexible downwards, then relative shocks will cause markets with excess demand to adjust prices upwards, but prices will remain unchanged in markets with excess supply. Thus the larger the relative shocks, the larger the relative price variability and the higher the inflation rate. The underlying assumption is that this process is accommodated by monetary policy. In a classical economy with constant expenditure shares, a rise in the price of one good should reduce income and hence demand for other goods, causing their prices to fall, so that the aggregate price level is unchanged.

---

[6] Caplin and Leahy (1991) present a similar model in which there is only output adjustment but no price adjustment for small shocks. However if the shocks are big enough, Caplin and Spulber (1987) show that the adjustment is all in the price.

[7] See Graham (1930) and De Gregorio, Giovanni and Wolf (1993)

[8] Benabou (1988), Van Hoomissen (1988), Tommasi(1992)

If there is only nominal rigidity, then as the rate of inflation increases, this relationship will become smaller. However, with real price rigidity, the relationship should persist with higher inflation. If prices were flexible, then the distribution of relative prices is g, and an increase in relative price variability results in the distribution f. Assume the average inflation rate is $\bar{\pi}$, real price rigidity in effect truncates the distribution to the left of $\bar{\pi}$: Firms receiving a positive shock increase their prices by more than $\bar{\pi}$ while other firms increase their prices by $\bar{\pi}$. Then clearly, holding $\bar{\pi}$ constant, an increase in relative price variability increases the observed average inflation rate.

Fourthly, differing short-run elasticities may also generate a relationship between relative price variability and inflation. In adjusting to a relative shock, if industries have different short run elasticities, the price changes in the two industries may not completely offset in the short run, resulting in a movement in the aggregate price level, even if the long run effect is neutral.

Fifthly, government policy actions may change the composition of final demand (and hence relative prices) and simultaneously affect the inflation rate. For instance, changes in real interest rates induced by fiscal policy may change the relative demand for durable and non-durable goods.

Finally, accommodating monetary policy in response to relative shocks will reduce the effect on output but at the expense of higher inflation. Hence, larger relative shocks and relative price movements will be associated with higher inflation.[9]

Our approach controls for nationwide effects such as monetary policy and thus excludes theories 5 and 6 as potential explanations. Furthermore, our examination of the relationship over longer time intervals is difficult to reconcile with theory 1. We do not reject these theories but argue that they cannot explain the relationships which we find.

[9]Taylor (1981) actually finds that increased accommodation reduces RPV, but this result is dependent on his definition of relative price variability and the overlapping contract structure.

3.3 Existing Empirical Results

The empirical literature on relative price variability and inflation dates back to Mills (1927) who provided a comprehensive survey of the US price system by examining the levels of and movements in wholesale price indexes and their components over the period 1890-1926. As part of his survey, Mills examined the relationship between shifts in the price level and changes in the degree of dispersion (defined as the standard deviation of relative prices). He found that "dispersion depends upon the violence of the price change, regardless of the direction," and determined a correlation coefficient of 0.614 between an index of dispersion and the absolute value of inflation.[10] Similar findings were also reported for France and Britain around the same period.[11] In explaining his results, Mills appears to have in mind a mechanism similar to the third or fourth theory above. "The less direct the incidence of the force which is acting upon the price level, and the greater the relative importance of the host of specific price-making factors which affect individual commodities, the more widely dispersed will the price relatives be."[12]

Mills' work was updated and refined by Vining and Elwertowski (1976) who used the wholesale price index at the 8 digit level (about 100 items) over the period 1947 to 1974. They confirm Mills' finding that relative price variability was positively correlated with inflation. Using the standard deviation of changes in the various components of the wholesale price index to measure variability, their results show a positive coefficient of 0.43 in a regression of relative price variability on inflation. They also found that the distribution of price changes exhibited a positive skew which was increasing in the level of inflation. That is, most price changes were below the average rate of inflation but a few prices changed by an amount significantly above average. Vining and Elwertowski also found similar results using the consumer price index.

---

[10] Mills 1927 p284. Mills discussion is generally framed in terms of the price level rather than inflation.

[11] See references in the footnote on p280 in Mills

[12] Mills 1927 p254

We reproduced the analysis of Vining and Elwertowski, using a longer series for the aggregate CPI. We used data for US inflation for the period 1934-1992 across 34 categories. A regression of the standard deviation of the inflation rates of the components against the total CPI inflation rate yields a significant positive coefficient of 0.47. There is also a significant positive relation between the skewness of the distribution of the inflation rates of the components in each year and the overall inflation rate. Wald tests for the normality of the price distribution in each year rejected the assumption of normality in 23 of the 57 years. When the sample was shortened to enable the inclusion of more categories, similar results were obtained and the assumption of normality was rejected in almost every year.

Similar findings of a positive correlation between inflation and relative price variability have been found by Parks (1978) for the Netherlands (1921-1963) and the US (1930-1975), by Graham (1930) for the German hyperinflation, by Glejser (1965) for a cross-section of European countries, and by Fischer (1981) and (1982) for the US (1931-1980) and Germany (1967-1980). However, Vining and Elwertowski note that they could not find such a relationship using Jevons' data for the 1800s in Britain.[13] Thus the correlation between relative price variability and inflation has been found across different countries, in times of hyperinflation, stable low inflation, uncertain inflation and deflation.

Some of the existing work has attempted to determine whether the relationship is stronger with the level of inflation or unanticipated changes in inflation. Parks (1978) found that for the US, it was driven by the relationship between *unanticipated* inflation rather than the level of inflation. Fischer (1981) regressed relative price variability on inflation, changes in inflation, and expected and unexpected inflation. He found that the relationship between relative price variability and the actual level of inflation was generally significant, if not always stable. Both expected and unexpected inflation were found to be significant. He also finds that relative price variability appeared to respond asymmetrically to changes in inflation, suggesting some degree of price

[13] Vining and Elwertowski (1976) p707. They point out that this may be due to the commodity-based monetary system of the time.

rigidity.[14]

A number of authors have also found a positive relationship between intra-market price variability and inflation. Domberger (1987) examined the movements of prices of goods within 4-digit SICs in the UK. Van Hoomissen (1988), Tommasi (1992) and Lach and Tsiddon (1992) used data on the same product across different stores in countries which were experiencing high rates of inflation.[15] All reported a positive relationship between inflation and price variability, while Tommasi also found a positive relationship between relative price variability and deflation.

Reinsdorf (1992) examined the somewhat distinct concept of the relationship between inflation and price dispersion, where price dispersion is defined as the standard deviation of various prices for the same good at a particular point in time, but across different locations. Using data from 1980-82 for the US, he finds a negative relationship between price dispersion and unexpected inflation but a positive relationship with expected inflation.[16]

In summary, the positive relationship between RPV and inflation appears to be robust across countries and time (except possibly in times of hyperinflation). Our approach differs from this existing literature by controlling for nationwide and monetary disturbances, by utilising the cross-sectional information from the US cities.

3.4 Data and Results

Our data consists of two balanced panels of annual Consumer Price Index inflation rates for US cities. The first panel runs from 1954-1986 for 19 US cities: Atlanta, Baltimore, Boston, Buffalo, Chicago, Cincinatti, Cleveland, Detroit, Houston, Kansas City, Los Angeles, Milwaukee, Minneapolis-St Paul, New York, Pittsburgh, St Louis,

[14]Hartman (1991) casts doubt on some of these findings. He argues that due to the statistical relationships between the various measures of inflation, some of the results are spurious. He supports an analysis along the lines of Parks who uses monetary variables as instruments. However, Hartman concludes that using the level of inflation as a single regressor is econometrically valid.

[15]Israel 1971-1984, Argentina 1990 and Israel late 1970s and early 1980s respectively.

[16]Note that Reinsdorf only uses data from the Volcker disinflation.

San Francisco, Seattle, and Washington DC.[17] For each city, we used price indices calculated by the US Bureau of Labor Statistics (BLS) for the total annual average consumer price level and for 14 categories of goods and services: cereal and bakery products; meats, poultry and fish; dairy products; fruit and vegetables; food away from home; shelter; household fuels and utilities; men's apparel; women's apparel; footwear; private transportation; public transportation; medical care; and personal care. The second panel runs from 1977 to 1986 and includes five additional cities (Anchorage, Dallas, Denver, Honolulu and San Diego), four additional categories (alcoholic beverages, other food at home, entertainment, and household furnishings), replaces personal care with the more inclusive "other goods and services", and provides a set of price indices which exclude particular classes of commodities from the total consumer price index.

We chose these two panels to provide long and wide cross-sections of cities with the greatest possible level of disaggregation. The disaggregated components provide almost complete coverage of the total components of the CPI: in June 1983, the components of the 1954-86 sample represent about 78 per cent of weight of CPI and the components of the 1977-86 sample represent 92 per cent of the CPI. In terms of cities, the coverage is less complete: the 26 cities in the 1977-86 sample represent about half the weight of the CPI. We truncate the sample in 1986 because the BLS changed its methodology, substantially decreasing the sample size and frequency of observation that underly the city price indices. After 1986, the city-level components of the CPI became much more volatile.

Using our indexes, we followed standard practice in defining inflation for city j as

$$INF_{jt} = lnP_{jt} - lnP_{jt-1} \tag{3.1}$$

where P_{jt} is the price index for city j at time t. Relative price variability for city j at time t was defined as

[17]More precisely, the geographical unit is the (consolidated) metropolitan statistical area, or (C)MSA.

$$STD_{jt} = \sqrt{\sum_{i=1}^{n} \frac{1}{n-1}(INF_{ijt} - INF_{jt})^2} \tag{3.2}$$

where i indexes commodities.[18]

From these city-level variables, we subtracted the US national inflation rate and RPV, creating:

$$DEVINF_{jt} = INF_{jt} - INF_{USt} \tag{3.3}$$

$$DEVSTD_{jt} = STD_{jt} - STD_{USt} \tag{3.4}$$

so that the variables are expressed as deviations from national averages.

Graph 2 plots (for the 1954-86 sample) on the horizontal axis $DEVINF$ (the difference between the city inflation rate and the national rate), and on the vertical axis $DEVSTD$ (the difference between the standard deviation (across sub-groups of commodities) in the city and the standard deviation in the nation), after controlling for city and year effects.[19] Graph 3 shows the same information for the 1977-86 sample. Another way of describing the horizontal axes is that they show the change in the relative price of a basket of goods in a given city compared to the national average. In testing for a positive correlation between inflation and RPV, our basic strategy is to test for a positive slope in graphs 2 and 3. Before reporting the results of these test, there are three reasons why we might expect the data in these graphs to exhibit a U- or V-shaped pattern; that is, one where RPV is higher for cities whose inflation rates are far above or below the national average.

The first reason reflects the existing literature which suggests RPV should be

[18] INF_{ijt} and the underlying P_{ijt} indices are also used to calculate INF_{jt} and P_{jt}, so that P_{jt} is a weighted average of the P_{ijt}. In practice we observe most but not all of the individual price indices and inflation rates P_{ijt} and INF_{ijt} that the BLS uses to calculate the total CPI price index P_{jt} and INF_{jt}. INF_{jt} is thus an almost exact linear combination of the INF_{ijt}'s.

[19] That is, we plot the residuals from a regression of $DEVINF$ and $DEVSTD$ on a set of dummy variables (one for each city and each year.) The fact that we use year dummies on the right hand side means that it is irrelevant whether we subtract the national average from the left-hand side (as in equations (3.3) and (3.4)). Calculating the deviation from the national average is only relevant when computing the variable $ABSINF$ described below.

related to (unanticipated) *changes* in inflation in either direction (associated with theories 1 and 5 in table 3.1 and documented by Mills, Fischer and Tommasi). We take the city-specific equivalent of this relationship to be that *differences* from the US average should be associated with higher RPV. The other two reasons are unrelated to the traditional explanations of the inflation/RPV relationship.

The second reason to expect a V-shaped pattern is based on economic theory and depends on the relative shocks and related adjustment processes of cities in the US. Consider the following basic story, in which the classical dichotomy holds. Different cities face different relative shocks in different years. This shock could be a change in the demand for that cities' production, a change in the relative (national) price of goods that city disproportionately consumes, or some other economic shift. Some goods are highly tradeable and intercity arbitrage forces their prices to be (roughly) equal across cities. Other goods (e.g. houses) are highly non-tradeable and their prices are different across cities. When a city receives, say, a negative demand shock compared to the national average, two things happen: (a) the relative price of all goods in that city falls, so that the city's inflation rate is less than the national average and (b) the relative prices of different goods within that city change as well. The first effect, (a), is essentially identical to the familiar real depreciation with fixed exchange rates. The second effect, (b), may occur for several reasons. One is that relative prices within the city change because national prices change as well (gasoline become more expensive than hamburgers). Secondly, since the prices of traded goods are constrained to be equal across cities, but non-traded goods prices must adjust fully to the shock, the price changes of traded and non-traded goods becomes more dispersed following a shock. Thus we expect to see higher price dispersion in cities that have total inflation that is either higher or lower than the national average.

The third reason that the data might conform to a V-shaped pattern is purely statistical, and depends on the fact that both INF_{jt} and STD_{jt} are functions of the realisations of INF_{ijt}. Suppose that we examined a set of means and standard deviations from a series of sets of random numbers with the same mean. Then, depending on the data generating process, conditional on having a above- or below-average realized mean in a given set, we might also find a high realized standard deviation in the same set.[20] To control for this, we include the variable $ABSINF$, the absolute value of $DEVINF$ in the regressions.

Since it is difficult to know which of these factors might be causing a V-shaped curve to appear in the data, in our empirical tests, therefore, we focus on *asymmetries* in the relationship between city inflation and city RPV. That is, we examine whether, holding constant the absolute value of a city's inflation rate relative to the national average, higher inflation is associated with higher RPV.

3.4.1 Regression Results

We stacked our 627 city-year observations and ran fixed-effects regressions, including a dummy variable for each city and year. The first column in Table 3.2 reports our baseline results in the 1954-86 sample. The coefficient of interest, on $DEVINF$, is positive (0.21) and highly significant (with a t-statistic of about 5). The coefficient of $ABSINF$ is also positive and significant.

In words, column (1) says that holding constant the absolute value of city inflation relative to the national average, higher inflation is associated with higher RPV. By estimating separate coefficients on $DEVINF$ and $ABSINF$, we are essentially estimating the slope of two different lines on either side of the vertical axis in Graph 2, with the left hand side having a slope equal to the difference of the $DEVINF$ and $ABSINF$ coefficients, and the right hand side having slope equal to the sum.

In the next few pages, we describe a battery of cross-sectional regressions testing whether this regression result is robust. We found that the relationship is strikingly robust to a variety of different assumptions, and is not caused by a particular observation, city, year, time-horizon, or category of goods and services.

Column (1) uses Newey-West standard errors to allow for complex year- and city-specific heteroskedasticity. This correction made little difference to the calculated

[20]For example, it is easy to generate a V-shaped pattern using iid mean-zero normal distributions. With 14 categories, for example, one would observe a clear V-shaped pattern by having $INF_{ij} \sim N(0,1)$, for $j \leq 13$ and $INF_{ij} \sim N(0,10)$ for $j = 14$.

Table 3.2: Baseline Regression Results: 1954-1986

	(1)	(2)	(3)	(4)	(5)	(6)
DEVINF	0.208	0.208	0.198	0.198	0.198	0.214
	(0.040)	(0.052)	(0.045)	(0.046)	(0.043)	(0.042)
ABSINF	0.109	0.109		-0.0384	0.132	
	(0.046)	(0.088)		(0.071)	(0.054)	
ABS2			4.736	5.993		
			(1.99)	(3.14)		
DEVSTD(-1)					0.0322	
					(0.041)	
$\bar{R}^2$	0.069	0.069	0.080	0.079	0.069	0.079
N	627	627	627	627	608	627

Notes: The dependent variable is $DEVSTD_{jt} = \sigma_{jt} - \sigma_{USt}$ for city j at time t, where σ is the standard deviation of inflation rates across categories.

$DEVINF = INF_{jt} - INF_{USt}$ where INF_j is the inflation rate in logs in city j.

$ABSINF = |DEVINF|$, $ABS2 = ABSINF^2$

Standard errors in brackets, Newey-West corrected except (2).

All regressions include city and year dummies (coefficients not shown).

standard errors; column (2) shows the uncorrected OLS standard errors.[21]

We also checked to see whether using different control variables affected the coefficient on $DEVINF$. Using the squared value of $ABSINF$, $ABS2$ instead of $ABSINF$, (so that the equation fitted a quadratic instead of an asymmetric V) hardly changed the coefficient on $DEVINF$ in column (3); including both terms (column (4)) also had minimal effect. Column (6) shows the result when neither of $ABSINF$ and $ABS2$ are included. The results were also robust to the inclusion of a lagged dependent variable (shown in column (5)).

Although an F-test rejected the hypothesis that the city and year dummies were

[21] Although we found no evidence of heteroskedasticity or autocorrelation in the residuals of our baseline regression, we used Newey-West standard errors on all our equations to make sure our results were robust. We implemented Newey-West by stacking the data by city and then by years, then estimating Newey-West by allowing for the errors to be correlated for 34 periods, so that the disturbance in city i in year t can be correlated with both with its own lags and with the disturbance in city $i-1$ in year t.

not jointly significant,[22] we also tried excluding these dummies from the right-hand side. These restrictions had almost no effect on the coefficient of $DEVINF$, as shown in column (7) Table 3.3.

Table 3.3: Sensitivity Analysis: 1954-1986

	No Dums (7)	No Outliers (8)	Pre-71 (9)	Post-71 (10)	% chg (11)	Var (12)	Var (13)
DEVINF	0.203	0.251	0.289	0.163	0.242	0.00150	0.00146
	(0.046)	(0.040)	(0.087)	(0.040)	(0.043)	(0.00040)	(0.00041)
ABSINF	0.186	-0.0198	-0.0544	0.183	0.106	0.00109	
	(0.060)	(0.047)	(0.17)	(0.080)	(0.049)	(0.00063)	
ABS2							0.419
							(0.21)
$\bar{R}^2$	0.037	0.170	0.043	0.065	0.089	0.044	0.044
N	627	599	323	304	627	627	627

Notes: See Table 3.2

Graph 2 suggests that outliers may be influencing the regression results.[23] We therefore discarded the top and bottom 1 percent of the sample ranked on the values of $DEVINF$ and $DEVSTD$ shown in Graph 2, and reran the regression.[24] Column (8) shows the result: discarding outliers raises the coefficient on $DEVINF$, although the coefficient is not significantly different from the full sample estimate (the coefficient on $ABSINF$ falls, however, as might be expected if it were a statistical artifact generated by measurement error).[25] We also checked to see if the results depended on our use of natural logarithms instead of percent changes; column (11) shows this was not an important factor. Our qualitative conclusions about $DEVINF$ were also

[22] F(50,574)=1.419, p=.04

[23] The prominent outlier in the graph with a standard deviation of above .10 is the observation for Atlanta in 1972; in that year, the price index for public transportation fell by more that 50 percent.

[24] That is, we discarded observations based on extreme values of $DEVINF$ and $DEVSTD$ after controlling for time and city as explained in footnote 19.

[25] We also tested whether a specific city was driving the results. We re-estimated the baseline regression 19 times, each time omitting a specific city. This procedure had little impact on the coefficient on $DEVINF$, which ranged between 0.19 and 0.24 and was always highly significant.

unaffected by using the variance (instead of the standard deviation) of relative price changes as the dependent variable, as shown in columns (12) and (13). .[26]

We investigated the subsample stability of the estimates by splitting the sample roughly in half. Since the Nixon price controls were initiated in 1971, we used the two samples 1954-1970 and 1971-1986. Table 3.3 columns (9) and (10) shows that the coefficients on $DEVINF$ were positive and significant, and were statistically indistinguishable from each other (the latter period includes the 1972 outlier mentioned in the previous paragraph). We were surprised by the stability of the coefficient on $DEVINF$, given the radically different environment of monetary growth and oil shocks in the two periods.

We also tried estimating separate year-by-year equations, so that for each of the 34 years 1954-86 we ran a simple regression on 19 city observations, including $DEVINF$, $ABSINF$, and a constant on the right hand side. Of these 34 regressions (which are not reported here), 24 had a positive estimated coefficient on $DEVINF$.[27] Seven of the 24 positive coefficients were statistically significant, while none of the 10 negative coefficients were. The years in which the coefficient was significant - 1955, 1969, 1970, 1977, 1978, 1980 and 1985 - do not include the peaks in 1973-74 and 1986 that can be seen in Graph 1.

We investigated whether the results are driven primarily by the non-traded goods in the sample. We might expect traded goods inflation to be more similar across the cities while non-traded goods inflation may have a significant local component. Hence we divided the 14 commodities into the two types[28] and recalculated STD_{jt} and $DEVSTD_{jt}$ using only the traded or non-traded goods. The results are shown in Table 3.4. The coefficient on $DEVINF$ in the traded goods regression (column (14)) is lower than that for the non-traded goods (column (15)), but it is still significant. Correspondingly, we also dropped each of the 14 commodities in turn from the

[26]Note that there is not a simple linear transformation between variance and standard deviation due to our use of deviations from the national average.

[27]If the coefficients of DEVINF were drawn from an iid distribution with 0.5 probability of being positive, the probability of this event occurring would be 1.22 per cent.

[28]We classified food away from home, shelter, public transportation, medical care and personal care as non-traded goods.

Table 3.4: Regression Results: Traded/Non-Traded and 1977-1986

	1954-86 sample		1977-86 sample	
	Traded	Non-Traded	Base	Ex Shelter
	(14)	(15)	(16)	(17)
DEVINF	0.115	0.210	0.141	0.230
	(0.034)	(0.062)	(0.027)	(0.072)
ABSINF	0.0192	0.286	0.0901	0.239
	(0.049)	(0.026)	(0.066)	(0.088)
$\bar{R}^2$	0.208	0.117	0.127	0.092
N	627	627	260	260

Notes: See Table 3.2

calculation of $DEVSTD_{jt}$. There was no discernible difference in the results.

The baseline results of the 1977-86 panel in column (16) of Table 3.4 show similar results to the 1954-86 baseline, with the coefficient on $DEVINF$ a bit lower (the underlying data is shown in Graph 3). In addition to providing a larger number of cities, the 1977-86 sample also provides a set of indices calculated by the BLS which show the effect of specific components of the CPI on the total index.[29] Graph 4 and column (17) show the effect of excluding the quintessential non-traded good, housing, from the calculation of both INF_{jt} and STD_{jt}.[30] The coefficient of $DEVINF$ is higher than in the baseline 1977-86 case, showing that the results are not driven by the fluctuations of the regional real estate markets.

3.4.2 Longer Time Horizons

To investigate whether the correlation between inflation and RPV was a short or long term relationship, we used our data to examine inflation rates and relative price changes over longer horizon. Our priors (based on the theories in Table 3.1) were that

[29]These indices could in principle be calculated for the entire 1954-86 sample. However, because the BLS uses different (unpublished) weights for each city and year when calculating the overall CPI, we were not able to accurately reproduce these series with available information.

[30]We used the index of total inflation less shelter where shelter includes rent, homeowners equivalent rent, house maintenance and repair and lodging while out of town.

the relationship would be short-lived. We were surprised to find that the correlation persisted for intervals of five or more years, thus casting some doubt on misperceptions (theory 1) as an explanation for the results.

We recomputed *DEVINF* and *DEVSTD* using price changes over 5 year intervals, and re-estimated the baseline regression in two ways: using overlapping and non-overlapping observations. So, for the non-overlapping observations, the five year inflation rates were calculated for the periods 1956-1961, 1961-1966, 1966-1971, 1971-1976, 1976-1981 and 1981-1986 for each city and category; the variability of these rates was calculated as in equations 1-4, and the baseline regression was estimated a dummy variable for each city and time period. Graph 5 shows the data produced by this procedure, and Table 3.5 shows the regression results.

At a five year horizon, the regressions using both the overlapping and non-overlapping data show a positive and significant coefficient on *DEVINF* (columns (18) and (22)).[31] At a ten year horizon, the results are more ambiguous; the non-overlapping sample gives a positive and significant coefficient (column (19), while the overlapping data gives a positive but insignificant coefficient (column (22)). Not surprisingly, using the largest possible interval of 34 years shows no relationship whatsoever (column (20)). Looking in more detail at the range of time horizons, we found that for the non-overlapping sample, the statistical relationship ceases to be significant at a twelve year horizon. For the overlapping sample, the significance declined gradually as the interval was increased until it was no longer significant at the 10 year interval.

3.5 Conclusion

The main innovation of this paper is the use of cross-sectional data on inflation and relative price variability. In using differences across city, we automatically exclude as explanations those theories of the inflation/RPV nexus that rely on endogenous monetary policy. Although on the national level and in the long run, inflation may

[31] Using the approach described previously, we found that the results in column 18 do not depend on outliers.

Table 3.5: Regression Results: Longer Intervals

	Non-Overlapping			Overlapping	
Interval	5 yr (18)	10 yr (19)	34yr (20)	5 yr (21)	10yr (22)
DEVINF	0.220	0.393	-0.0586	0.274	0.121
	(0.10)	(0.083)	(0.51)	(0.060)	(0.091)
ABSINF	0.269	0.200	-0.316	0.0418	0.115
	(0.17)	(0.24)	(0.68)	(0.097)	(0.21)
$\bar{R}^2$	0.184	0.360	-0.101	0.234	0.308
N	114	57	19	551	456

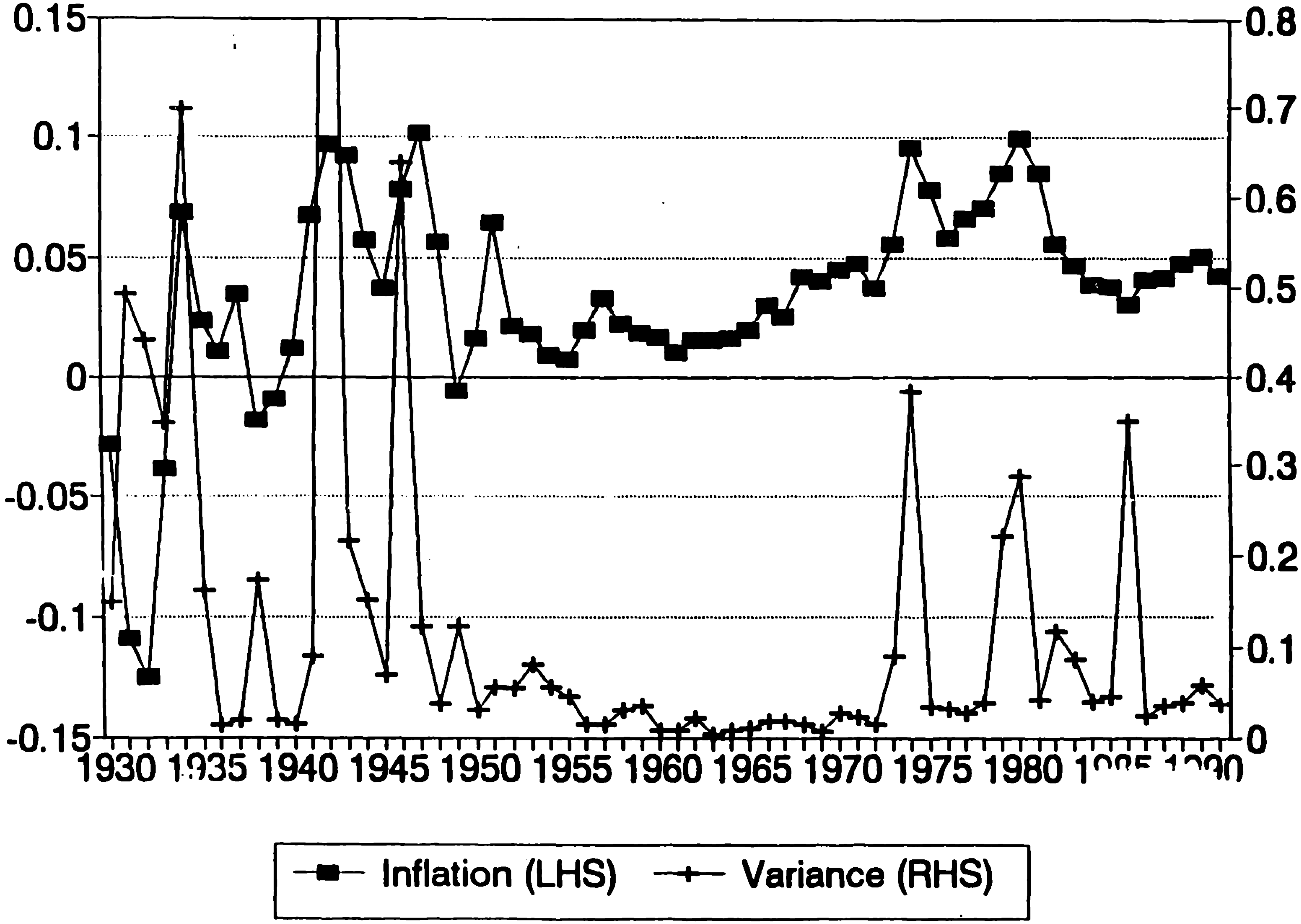
Notes: See Table 3.2

be always and everywhere a monetary phenomenon, by construction our approach only captures price changes which are caused by relative shocks to cities, not Federal Reserve policy.

Although cross-sectional data has advantages over time-series data in this respect, it also has disadvantages in that the evidence presented here does not necessarily directly relate to national inflation and RPV. That is, national inflation and city-specific inflation are by construction orthogonal variables, so we cannot aggregate city-specific inflation and RPV shocks to reach conclusions about the national variables. Another limitation is that, as with many studies in this field, we are simply observing the correlation of two endogenous variables and so cannot come to strong conclusions about causality. Our approach is valuable, however, in that it illuminates basic facts about the price system that are applicable to the national level.

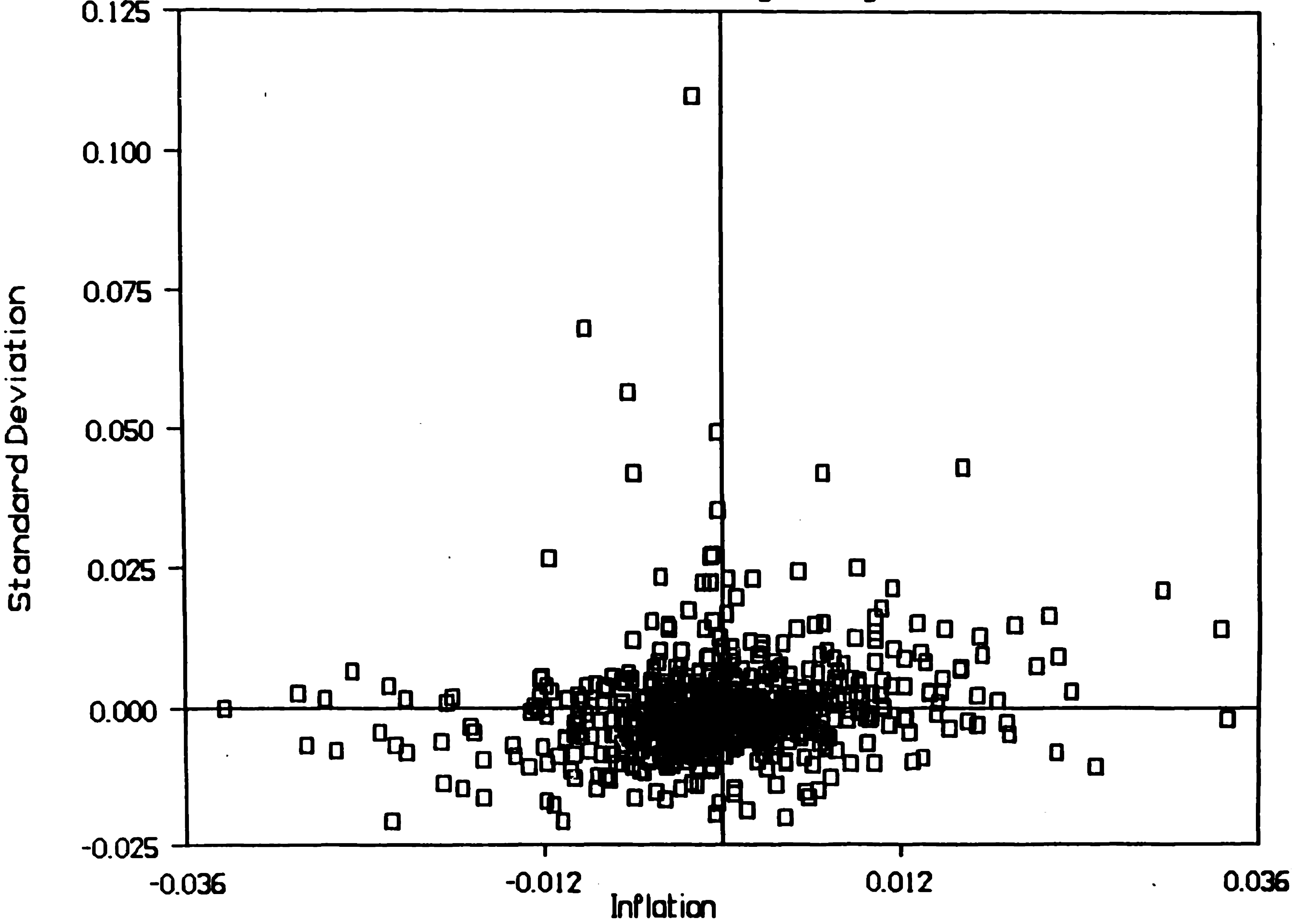
We have found a robust empirical regularity: across cities, RPV and inflation (relative to the national average) are strongly correlated. This correlation cannot be explained by theories 1, 5 and 6 presented in Table 3.1, insofar as those theories depend on monetary or federal government action. In addition, we found that the correlation between inflation and relative price variability was surprisingly persistent over time. Our findings are consistent with the view that real prices are downwardly sticky in the face of relative shocks.

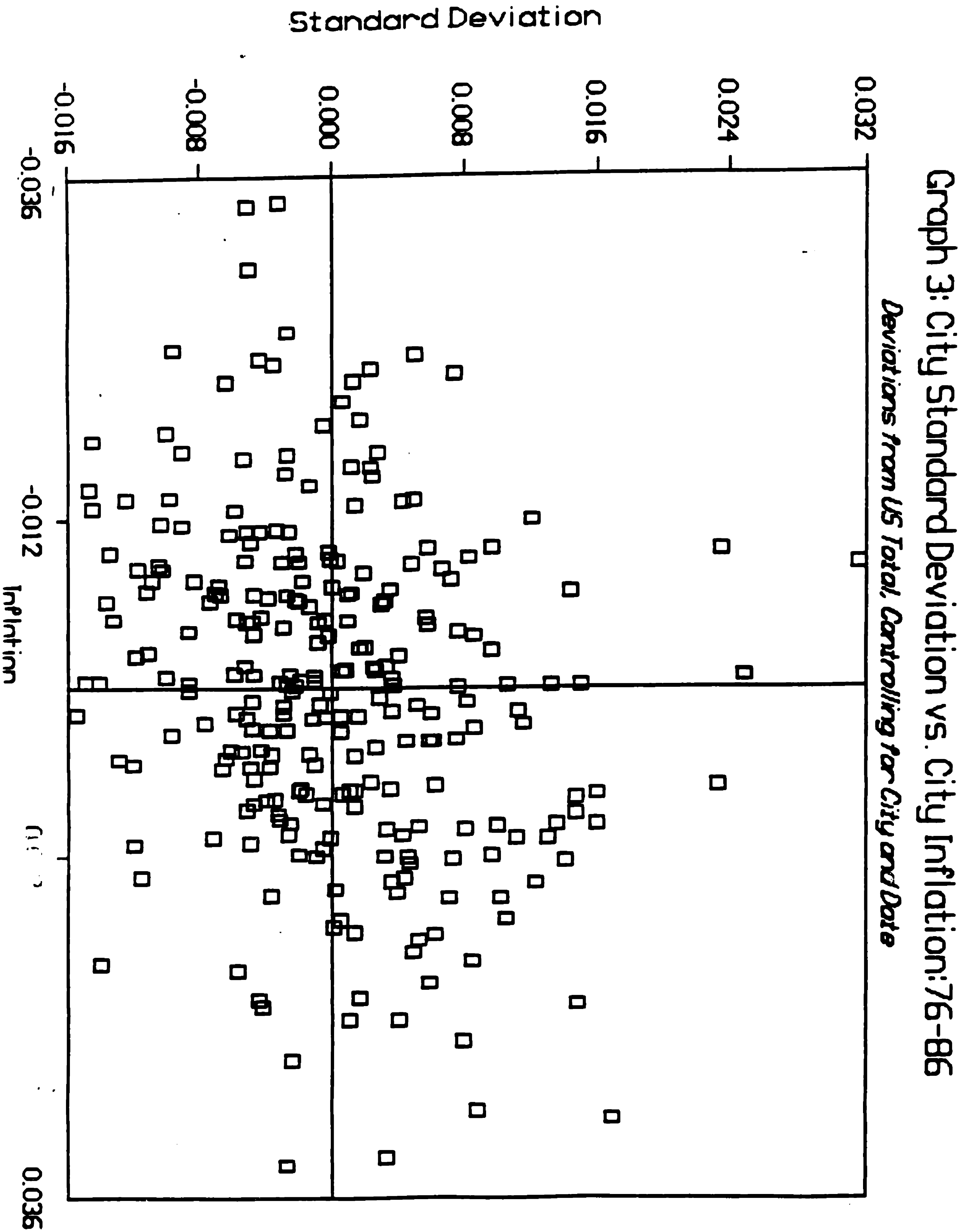
Graph 1: Inflation and RPV



Graph 2: City Standard Deviation vs. City Inflation: 1954-86

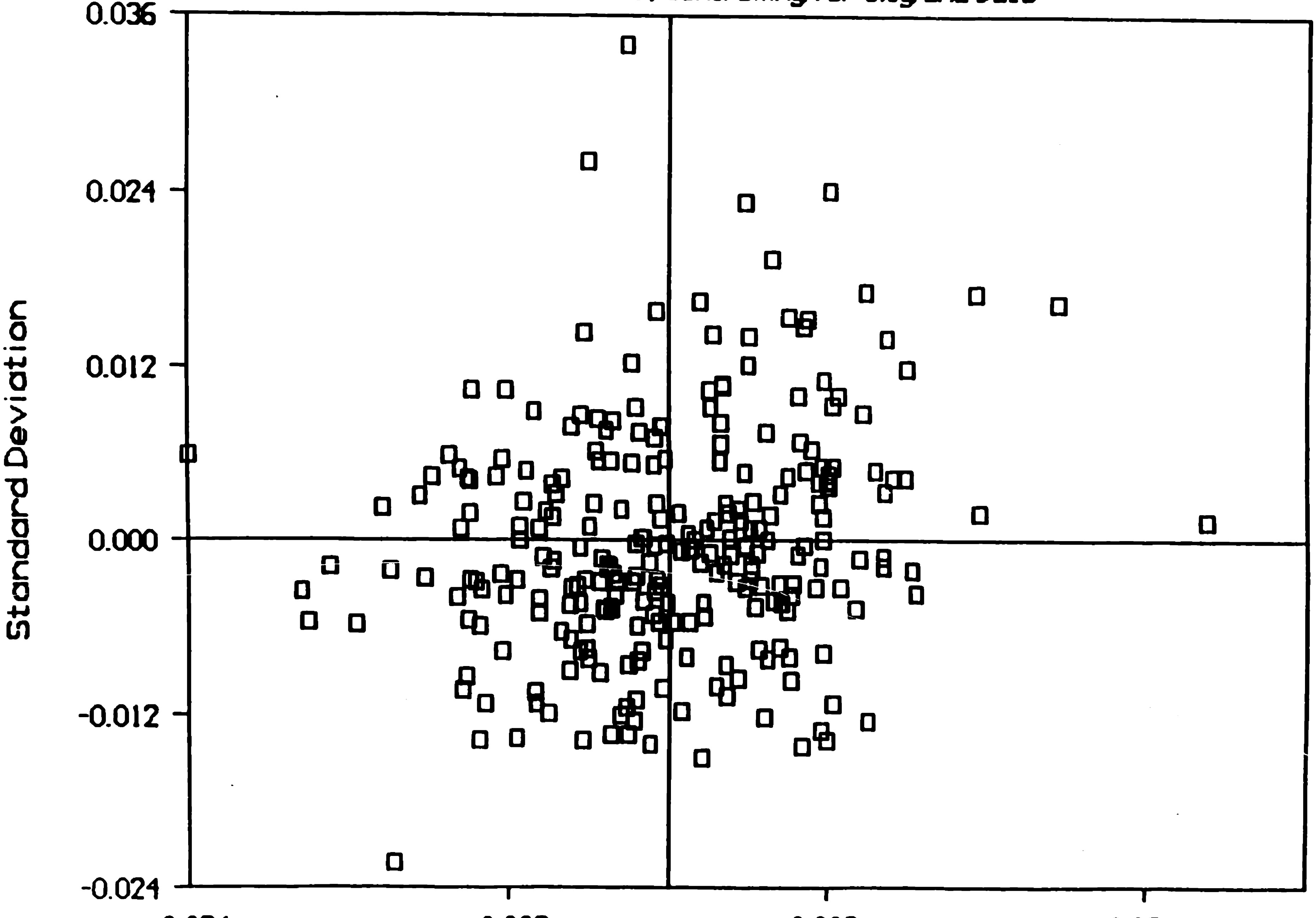
Deviations from US Total, Controlling for City and Date




Graph 3: City Standard Deviation vs. City Inflation:76-86
Deviations from US Total, Controlling for City and Date
Standard Deviation
0.032
0.024
0.016
0.008
0.000
-0.008
-0.016
-0.036
-0.012
0.036
Inflation

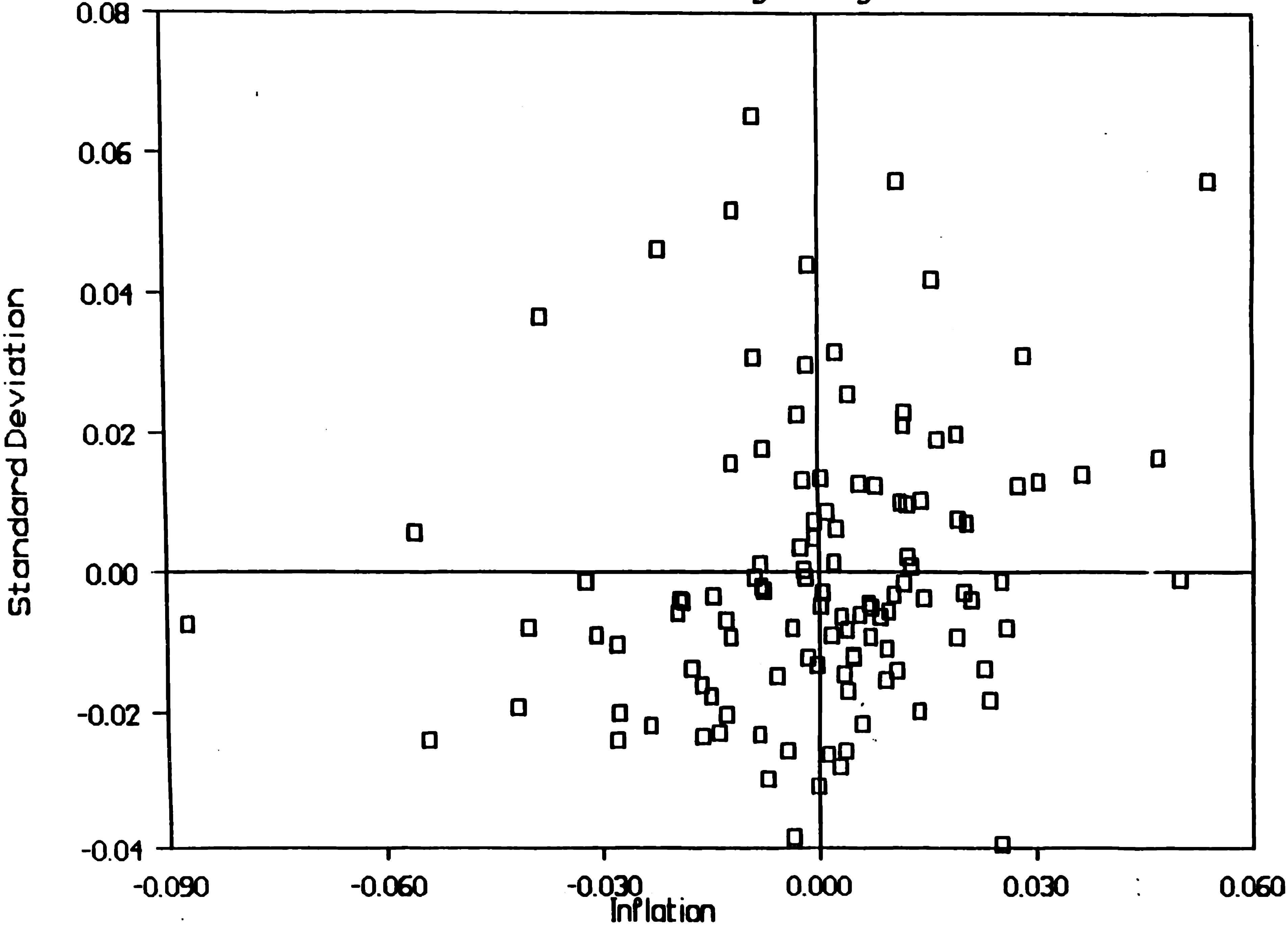
Graph 4: City Standard Devn vs Inflation:76-86 Excluding Shelter

Deviations from US Total, Controlling for City and Date



Graph 5: City Standard Devn vs Inflation: 57-86, 5-Yr Intervals

Deviations from US Total, Controlling for City and Date



Appendix A

References

Alchian, Armen, "Corporate Management and Property Rights," in Henry Mainne (ed.), *Economic Policy and the Regulation of Corporate Securities* 1969, 337-360.

Baily, Walter Toshi, "Relationship Banking:Evidence from the Southwest Bank Failures", mimeo. 1993

Ball, Laurence, 1992, "Why does high inflation raise inflation uncertainty". *Journal of Money, Credit and Banking,* Vol 29 pp 371-388.

Ball, Laurence and Steven Cecchetti, 1990, "Inflation and Uncertainty at Short and Long Horizons", *Brookings Papers on Economic Activity,* vol 1 pp 215-245.

Barro, Robert, 1976, "Rational Expectations and the Role of Monetary Policy", *Journal of Monetary Economics,* vol pp 1-32.

Benabou, Roland, 1988, "Search, Price Setting and Inflation", *Review of Economic Studies,* vol 55 pp 353-373.

Benabou, Roland, 1991, "Inflation and Markups: Theories and Evidence from the Retail Trade Sector", mimeo, MIT.

Blanchard, Olivier, "Consumption and the Recession of 1990-1" *American Economic Review Papers and Proceedings* 1993, 270-274.

Blanchard, Olivier Jean and Nobuhiro Kiyotaki, "Monopolistic Competition and the Effects of Aggregate Demand," *The American Economic Review* 1987, 647-666.

Blanchard, Olivier, Florencio Lopez-de-Silanes, and Andrei Shleifer, "What Do Firms Do With Cash Windfalls?" NBER Working Paper 4258, 1993.

Caplin, Andrew and David Spulber, 1987, "Menu Costs and the Neutrality of Money", *Quarterly Journal of Economics,* Vol 102 pp 703-725.

Caplin, Andrew and John Leahy, 1991, "State-Dependent Pricing and the Dynamics of Money and Output," *Quarterly Journal of Economics,* Vol 106 pp 683-708.

Carlson, Keith M., "On the Macroeconomics of Private Debt," *Federal Reserve Bank of St. Louis Review* 1993, 53-66.

Cooper, Russell and Andrew John, "Coordinating Coordination Failures in Keynesian Models," *Quarterly Journal of Economics* 1988, 441-463.

De Gregorio, Jose, A. Giovanni, Holger Wolf, 1993, "Sectoral Inflation: Empirical

Regularities from Regions and Countries", mimeo.

Domberger, Stephen, 1987, "Relative Price Variability and Inflation: A Disaggregated Analysis", *Journal of Political Economy*, vol 95 pp 547-566.

Eckstein, Otto, and Allen Sinai, "Mechanisms of the Business Cycle in the Postwar Era," in Robert J Gordon, ed., *The American Business Cycle* 1986.

Fazzari, Steven, R. Glenn Hubbard, and Bruce Petersen. "Financing Constraints and Corporate Investment", *Brookings Papers on Economic Activity*, 1988, 141-195.

Fisher, Irving, "The Debt-Deflation Theory of Great Depressions," *Econometrica* 1933, 337-357.

Fischer, Stanley, 1981, "Relative Shocks, Relative Price Variability, and Inflation", *Brookings Papers on Economic Activity*, vol 2 pp 381-431.

Fischer, Stanley, 1982, "Relative Price Variability and Inflation in the United States and Germany", *European Economic Review*, Vol 18 pp 171-196.

Frenkel, Jacob, 1982, Comment on "Relative Price Variability and Inflation in the United States and Germany", *European Economic Review*, Vol 18 pp 197-205.

Friedman, Benjamin, "Increasing Indebtedness and Financial Stability in the United States," in *Debt, Financial Stability, and Public Policy* 1986.

Gertler, Mark, "Financial Capacity and Output Fluctuations in an Economy with Multiperiod Financial Relationships," *Review of Economic Studies* 1992, 455-472.

Gertler, Mark, "Financial Structure and Aggregate Economic Activity: An Overview" *Journal of Money, Credit, and Banking* 1988, 559-588.

Gertler, Mark, and R. Glenn Hubbard. "Financial Factors in Business Fluctuations," in *Financial Market Volatility.* 1988, 33-71.

Gertner, Robert, David Scharfstein, and Jeremy Stein, "Internal versus External Capital Markets", mimeo 1993.

Gertner, R. and D. Scharfstein, "A Theory of Workouts and the Effects of Reorganization Law," *Journal of Finance* 1990, 1189-1222.

Gilchrist, Simon, and Charles Himmelberg, "Evidence on the Role of Cash Flow for Investment", mimeo. 1992

Glejser, H., 1965, "Inflation, Productivity, and Relative Prices - A Statistical Study", *Review of Economics and Statistics* Vol 47 pp 76-80.

Graham, F.D., 1930, *Exchange, Prices and Production in Hyper-Inflation: Germany, 1920-23*, Princeton University Press.

Grossman, Sanford, and Oliver Hart, "The Costs and Benefits of Ownership: A Theory of Vertical and Lateral Integration," *Journal of Political Economy* 1986, 691-719.

Hall, Robert E. "Commentary on Financial Factors in Business Fluctuations," in *Financial Market Volatility.* 1988, 73-78.

Hart, Oliver, "Theories of Optimal Capital Structure: A Principal-Agent Perspective," MIT Working Paper, 1991.

Hart, Oliver, and John Moore, "Default and Renegotiation: A Dynamic Model of Debt," working paper, 1989.

Hart, Oliver, and John Moore, "A Theory of Corporate Financial Structure Based on the Seniority of Claims," MIT Working Paper, July 1990.

Hartman, R., 1991, "Relative Price Variability and Inflation", *Journal of Money*

Credit and Banking, Vol 23 pp 185-205.

Hercowitz Z., 1981, "Money and the Dispersion of Relative Prices", *Journal of Political Economy*, Vol 89 pp 328-356.

Holmstrom, Bengt, and Jean Tirole, "Market Liquidity and Performance Monitoring," *Journal of Political Economy*, 1993.

Hoshi, Takeo, Anil Kashyap, and David Scharfstein, "Corporate Structure, Liquidity and Investment: Evidence from Japanese Industrial Groups," *Quarterly Journal of Economics*, 1991, 33-60.

Jaffee, D. and E. Kleiman, 1977, "The Welfare Costs of Uneven Inflation" in E. Lundberg (ed) *Inflation Theory and Anti-Inflation Policy*, Macmillan.

Jensen, Michael, "Agency Costs of Free Cash Flow, Corporate Finance, and Takeovers," *American Economic Review* 1986, 323-329.

Kaplan, Steven, "The Effects of Management Buyouts on Operating Performance and Value," *Journal of Financial Economics*, 1989, 217-254.

Kashyap, Anil K., Owen A. Lamont, and Jeremy C. Stein, "Credit Conditions and the Cyclical Behavior of Inventories: A Case Study of the 1981-2 Recession," mimeo, MIT Sloan School of Management, 1992.

Kashyap, Anil, and Jeremy Stein, "Bank Lending and Monetary Policy," working paper 1992.

Kiyotaki, Nobuhiro, "Multiple Expectational Equilibria Under Monopolistic Competition," *Quarterly Journal of Economics,* 1988, 695-713.

Lach, S. and D. Tsiddon, 1992, "The Behavior of Prices and Inflation: An Empirical Analysis of Disaggregated Price Data", *Journal of Political Economy,* Vol 100 pp349-389.

Lucas, Robert, 1973, "Some international evidence on Output-Inflation Tradeoffs", *American Economic Review,* vol 66 pp 326-334.

Mills, F.C., 1927, *The Behaviour of Prices*, National Bureau of Economic Research.

Myers, Stewart C., "Determinants of Corporate Borrowing," *Journal of Financial Economics* 1977, 147-175.

Okun, Arthur, 1971, "The Mirage of Steady Inflation", *Brookings Papers on Economic Activity* Vol 2 pp483-498.

Parks, R., 1978, "Inflation and Relative Price Variability", *Journal of Political Economy,* Vol 86 pp 79-95.

Poterba, James M. "Comment on Financing Constraints and Corporate Investment," *Brookings Papers on Economic Activity,* 196-206.

Reinsdorf, M., 1992, "New Evidence on the Relation between Inflation and Price Dispersion", mimeo, Bureau of Labor Statistics.

Sheshinki, E. and Y. Weiss, 1977, "Inflation and the Costs of Price Adjustment", *Review of Economic Studies,* Vol 64 pp 287-303.

Shleifer, Andrei and Robert W. Vishny, "Asset Sales and Debt Capacity," working paper 1991.

Taylor, John, 1981, "On the Relation Between the Variability of Inflation and the Average Inflation Rate", *Carnegie-Rochester Conference on Public Policy,* Vol 15, pp 57-85.

Tommasi, Mario, 1992, "Inflation and Relative Prices Evidence from Argentina", mimeo, UCLA.

Van Hoosmissen, T., 1988, "Price Dispersion and Inflation: Evidence from Israel", *Journal of Political Economy*, Vol 96 pp 1303-1314.

Vining, D. and T. Elwertowski, 1976, "The Relationship between Relative Prices and the General Price Level", *American Economic Review*, Vol 66: pp. 699-708.

Weitzman, Martin L., "Increasing Returns and the Foundations of Unemployment Theory," *The Economic Journal* 1982, 787-804.

Appendix B

Data Appendix

This appendix describes detailed information about the procedures used to select and check the baseline sample of 79 segments for Chapter 2.

For calculating which firms were oil-dependent, I wanted to use segment data to determine how much of the firms' cash flow came from the oil and gas extraction industry (code 13). Unfortunately, companies sometimes lumped different industries together in the same segment. I used Compustat's system of assigning two SIC codes to each segment in order to get around this problem. If a segment's primary SIC code was in code 13, I counted all of that segment as code 13; if only the secondary SIC code was code 13, I counted only half the segment, since that is the highest possible proportion of the segment that could be in code 13.[1]

I also read the line of business description for each segment from the companies' 10K and annual reports. I excluded the following segments because I judged the segment to be adversely affected by the oil price shock: Freeport McMoran - segments including uranium and sulphur; Mitchell Energy - real estate segment in Houston, Texas; Nicor - marine service segment serving oil industry; Petrolite - chemicals used in oil production; Rowan Companies - operates airline in Alaska and Gulf of Mexico; Tidewater - marine service segment serving oil industry.

[1]Some companies in the sample, for example Chevron, did not disaggregate their petroleum business into refining and extraction but instead reported it as a single unit, which was assigned primary SIC code 2911 (refining) and secondary SIC code 1311 (extraction) by Compustat. I treated these units as if they had a primary SIC code of 1311.XXX

Table I: Oil-dependent industries

SIC Code	Compustat Name	Comments
1094	Uranium	
12	Coal Mining	
13	Oil and Gas Extraction	
16	Heavy Construction - Not Bldg Construction	pipelines construction
29	Petroleum Refining	
3317	Steel pipe and tubes	
349	Misc. Fabricated Metal Prods	valves and pipes
353	Construction, Mining, Materials Handling Equipment	
46	Pipelines, Ex. Natural Gas	
49	Electric, Gas, Sanitary Services	nat. gas transmission
517	Petroleum and Pet. Prds - Whsl	
554	Gasoline Service Stations	
598	Fuel Dealers	
679	Misc. Investing	includes oil royalty trading
7389	Business services NEC	
871	Engineering, Arch., Survey Svcs	

I also checked Compustat figures for accuracy. I found (apparently) typographical errors in the segment data for four companies: Amoco, ARCO, Occidental, and Schlumberger. Compustat's general policy was to report pre-tax operating income before special charges; however, for six companies (Burlington Northern, Canadian Pacific, Fluor, Goodyear, Union Pacific, and USX Corp) I found that Compustat had included special charges even though the company documents clearly stated and quantified the impact of the accounting charges. I therefore corrected the data so that cash flow was reported consistently for all companies.

For two companies I had to exclude subsidiaries companies; that is, to accept only one set of segment data from each corporate entity. These were: Occidental Petroleum (I excluded segment data from Canadian Occidental); and Royal Dutch/Shell (I included Compustat's computed "Royal Dutch/Shell Group" and excluded Royal Dutch, Shell Transport and Trade, and Shell Canada.)

All variables in Compustat are stated in US dollars, so that when the original data is in Canadian dollars or pounds sterling, Compustat converts using end-of-year exchange rates. Exchange rates changes did not appear to have a large affect on $\frac{\Delta I}{S_0}$.

I note that the inclusion of Placer Dome is slightly misleading, since Placer and

Dome merged in 1987, so that the restated data reflects a corporate entity that did not exist in 1985-6. However, the 1985-6 $\frac{\Delta I}{S_0}$, the oil share, and other variables from the original company, Placer, are virtually identical to the variables of the successor company. Therefore, in order to get a continuous set of variables from 1985-7, I retained Placer Dome data as it existed in the Compustat database.

Industry-adjusting Method 1: First, I screened on the size, data availability, and other criteria described previously. Then I tried to find segments with matching four digit primary and secondary SIC codes. If I could find at least five such segments, I used them as the control group; otherwise, I loosened the required match on the secondary SIC code to the three digit level and then to the two digit level. If this did not supply at least five segments, I reduced the level of precision to a three digit match on both the primary and secondary SIC code, and so on down to the two digit level. Using this procedure, I was able to calculate industry-adjusted figures for 39 of the 40 observation (I found no match for Dekalb Energy's agricultural seed division).

The "firm size" variable, FS_0, is simply the sum of the sales of all firm segments. This does not necessarily equal total firm-level sales reported by the company due to miscellaneous sales, discontinued operations, or unclassified sales.

Table II: Segment Data, All Firms

	Company	Segment	$\frac{\Delta I}{S_0}$	Size (Mil $)	SIC Codes	
1	AMOCO CORP	CHEMICALS	0.04	2905	2860	2820
2	ASHLAND OIL INC	CHEMICAL	-0.00	1499	2800	5169
3	ATLANTIC RICHFIELD	SPEC & INT. CHEMICALS	0.01	2155	2869	2865
4	BURLINGTON NORTHERN	FOREST PRODUCTS	-0.01	258	2411	2421
5	BURLINGTON NORTHERN	RAILROAD	-0.07	4098	4011	6519
6	CANADIAN NATIONAL	RAIL OPERATIONS	-0.06	2684	4011	4111
7	CANADIAN NATIONAL	RAILWAYS	0.00	395	4011	
8	CANADIAN NATIONAL	TELECOMMUNICATIONS	-0.02	217	4813	4822
9	CANADIAN PACIFIC	FOREST PRODUCTS	0.02	1546	2621	2421
10	CANADIAN PACIFIC	RAILROAD	-0.03	2408	4011	
11	CHEVRON CORP	CHEMICALS	-0.02	2246	2869	2865
12	DEKALB ENERGY CO	AGRICULTURAL SEED	-0.03	201	115	119
13	DOMTAR INC	CHEMICALS	-0.02	205	1479	2865
14	DOMTAR INC	CONSTRUCTION MATLS	0.02	410	3275	3083
15	DOMTAR INC	PACKAGING	-0.05	268	2631	5093
16	DOMTAR INC	PULP AND PAPER	0.22	636	2621	2611
17	DU PONT	AG-INDUST. CHEM	-0.01	3388	2879	2819
18	DU PONT	BIOMEDICAL PRODUCTS	0.01	1016	3844	3841
19	DU PONT	FIBERS	0.02	4483	2824	2297
20	DU PONT	INDUST-CONS. PRODUCTS	0.00	2780	3861	3679
21	DU PONT	POLYMER PRODUCTS	0.00	3379	2821	3081
22	DWG CORP	FAST FOOD REST.	-0.01	124	5812	6794
23	ETHYL CORP	ALUMINUM	-0.00	253	3354	3442
24	ETHYL CORP	CHEMICALS	0.03	995	2869	2865
25	ETHYL CORP	PLASTICS	0.00	247	3089	3081
26	FINA INC	CHEMICALS	-0.01	405	2821	2821
27	FLUOR CORP	METALS	-0.00	393	3339	1000
28	GOODYEAR	RUBBER-CHEM-PLASTIC	0.00	1102	3052	2822
29	GOODYEAR	TIRES-TRANSPORT	-0.01	7676	3011	3714
30	GRACE (W.R.) & CO	SPECIALTY BUSINESS	-0.01	787	2066	5192
31	GRACE (W.R.) & CO	SPECIALTY CHEMICALS	-0.01	2254	2800	3086
32	HOMESTAKE MINING	GOLD	-0.12	169	1041	
33	IMCERA GROUP INC	ANIMAL PRODUCTS	0.01	157	2048	2834
34	IMCERA GROUP INC	FERTILIZERS	-0.01	1000	2874	1470
35	IMPERIAL CHEM INDS	AGRICULTURE	-0.02	2722	2873	2879
36	IMPERIAL CHEM INDS	CONS. & SPEC. PRODS	0.03	4679	2834	2851
37	IMPERIAL CHEM INDS	INDUSTRIAL PRODUCTS	-0.01	6545	2869	2812
38	IMPERIAL OIL LTD	CHEMICALS	0.01	542	2860	2870
39	K.C. SOUTHERN	TRANSPORTATION	0.04	337	4011	4213

Table II: Segment Data, All Firms, Continued

	Company	Segment	$\frac{\Delta I}{S_0}$	Size (Mil $)	SIC Codes	
40	KATY INDUSTRIES	CONSUMER PRODUCTS	0.02	194	913	2022
41	KERR-MCGEE CORP	CHEMICALS	-0.03	483	2812	2816
42	LITTON INDUSTRIES	ADVANCED ELECTRONICS	0.03	1863	3812	3679
43	LITTON INDUSTRIES	MARINE ENGIN.	0.00	975	3731	3663
44	MOBIL CORP	CHEMICAL	-0.00	2266	3081	2821
45	MOBIL CORP	RETAIL MERCH.	-0.01	6073	5311	5961
46	MONSANTO CO	ANIMAL SCIENCES	0.03	79	2048	
47	MONSANTO CO	CHEMICALS	-0.01	4051	2824	3080
48	MONSANTO CO	CROP CHEMICALS	-0.03	1073	2879	181
49	MONSANTO CO	ELECTRONIC MATLS	-0.03	137	3674	
50	MONSANTO CO	LOW-CAL SWEETENER	0.11	317	2869	
51	MONSANTO CO	PHARMACEUTICALS	0.08	262	2834	
52	NOVA CORP	PETROCHEMICALS	0.07	541	2869	2821
53	OCCIDENTAL PETROL.	AGRIBUSINESS	0.00	6510	2011	6512
54	OCCIDENTAL PETROL.	CHEMICALS	0.01	1621	2812	2874
55	PHILLIPS PETROLEUM	CHEMICALS	0.00	2266	2869	2821
56	PLACER DOME INC	MINING	0.02	221	1041	1021
57	PS GROUP INC	AIRLINE OPERATIONS	0.07	577	4512	
58	QUANTUM CHEMICAL	OLEOCHEMICALS	0.02	308	2899	2841
59	QUANTUM CHEMICAL	PETROCHEMICALS	0.02	730	2821	2869
60	RAYTHEON CO	AIRCRAFT PRODUCTS	-0.08	743	3721	3728
61	RAYTHEON CO	ELECTRONICS	0.02	3794	3812	3761
62	RAYTHEON CO	MAJOR APPLIANCES	0.00	785	3632	3585
63	ROYAL DUTCH/SHELL	CHEMICALS	-0.01	8583	2800	2820
64	SANTA FE PACIFIC	REAL ESTATE	0.17	436	1531	6512
65	SCHLUMBERGER LTD	MEASUREMENT	0.02	1619	3820	7373
66	SOUTHDOWN INC	CEMENT	-0.04	265	3241	6519
67	TENNECO INC	AUTOMOTIVE PARTS	0.02	1074	3714	5531
68	TENNECO INC	CHEMICAL	-0.01	841	2819	2800
69	TENNECO INC	PACKAGING	0.00	851	2631	3089
70	TENNECO INC	SHIPBUILDING	-0.02	1801	3731	3610
71	TEXAS INSTRUMENTS	COMPONENTS	-0.03	1941	3674	3625
72	TEXAS INSTRUMENTS	DEFENSE ELECTRONICS	0.04	1458	3812	
73	TEXAS INSTRUMENTS	DIGITAL PRODUCTS	-0.00	958	3571	3575
74	TEXAS INSTRUMENTS	METALLURGICAL MATLS	-0.06	145	3471	3678
75	UNION PACIFIC CORP	TRANSPORTATION	-0.04	3786	4011	4213
76	UNOCAL CORP	CHEMICALS	-0.03	1217	2873	2999
77	UNOCAL CORP	METALS	-0.12	129	1099	1061
78	USX CORP	STEEL	-0.02	6263	3312	1011
79	ZAPATA CORP	MARINE PROTEIN	-0.11	93	2048	2077