Price Mark-ups and Market-Share Uncertainty: Theory and Evidence*

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Abstract

The Phelps and Winter (1970) customer-market model predicts that firms will charge lower than the static monopoly mark-up because monopolistic pricing policy is moderated by the potential effect of high prices on the market-share. This paper extends Phelps and Winter (1970) to incorporate stochastic market- share evolution and shows that mark-ups could potentially exceed static monopoly mark-ups therefore reversing the original Phelps and Winter (1970) result. We also present valuable empirical evidence on British industries and show that market-share uncertainty and mark-ups are positively correlated. This can potentially explain the pension puzzle of 1988 where one observed both high mark-ups and high profitability. The paper also empirically shows that financial market indcies proxing for customer-value are linked with price mark-ups.

Keywords: Mark-ups, Market-Share, Uncertainty, Customer-Value
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1. Introduction[1]

A key implication of the customer-market model is that the level of the mark-up over the marginal cost is lower than the textbook's static monopoly mark-up. The reason for this is that by raising prices to exploit current profits, the firm puts future profits at risk as customers will move to firms which charge lower prices. I call this the Phelps–Winter effect. The quicker the customers learn about price differences, the lower are mark-ups when firms attempt to protect the market share.

However, one often observes both high mark-ups and high demand. For example, one often observes high mark-ups for financial services products such as individual pensions in the early stages of the product cycle. These high mark-ups do not decline

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until the growth potential of the market has fallen. A prototypical example here is the UK's experiment starting in 1988 with personal pensions. Initial profitability and sales were both high followed by a more mature phase where costs declined slightly (Murthi, Orszag and Orszag, 1999).

One potential reason why products at early stages of development may have high mark-ups is that uncertainty about the future market share may reduce the optimal level of investment in customers hence raise mark-ups.

Indeed, the industrial economics life-cycle literature (Klepper, 1996) suggests that the early stages of an industry are characterized by market share volatility; the Schumpeterian literature on technological progress holds creative-destruction responsible for such volatile market shares (Malerba and Orsenigo, 1996). Moreover, the literature on product-search shows that when search becomes a random activity, because it may not be adapting to the fast changing nature of information, product type and market structure, there is randomness in the market share (see Stigler (1961), Kohn and Shavell (1974) and Nelson (1970) and Stiglitz (1979)). Hence, a producer may have to charge consumers more in order to correct for risk-bearing costs.

The aim of this paper is to theoretically analyze and test empirically the effect of market-share uncertainty on the firm's pricing decision using a stochastic variant of Phelps and Winter (1970) model. The closed-form solution shows that uncertainty raises mark-ups. Indeed, I find that the implied level of mark-ups can exceed the static monopoly mark-ups - hence reversing the results obtained by Phelps and Winter (1970). The empirical results confirm our hypothesis. This paper also tests for the "Phelps-Winter effect" which is basically a bridge between the product markets and the financial markets. In particular, we find that there exists a negative relationship between price mark-ups and various stock market indices proxing for the customer-value as predicted by Phelps-Winter (1970). To the authors' knowledge, this is the first time such results are obtained on the UK data.

This paper is organized as follows: In section 2, the model is presented and the general intuition discussed. In section 3, I solve the model and discuss implications for the firm's value. Section 4 is devoted to examining customer-market pricing. Section 5 presents the empirical methodology, the data and estimation results for the mark-ups. A final section concludes.

2. Basic setup

Consider an industry with an arbitrary number of identical monopolistically-competitive firms. Each firm maintains a stock of customers and chooses its price at any point in time to maximize expected discounted utility from profits from selling to its existing customers.

$$\begin{aligned} & \underset{p^i}{Max}\; E\int_{t_0}^{\infty} u(\pi^i)e^{-\rho(t-t_0)}dt \\ \text{where } \pi^i &= \left(p^i - \bar{c}\right) y^i x^i \qquad (2.1) \end{aligned}$$

$u(\pi^i)$ is the concave utility functions in profits, π^i (a specification used in Coes (1977) and Nishimura (1989)). The concavity implies that the firms are risk-averse. The terms p^i, p , $\bar{c}$, y^i, x^i denote the price charged by the ith firm, the average industry price, the marginal cost of production, the ith firm's demand per customer and the proportion of total number customers buying from firm i or its market share. The firm therefore sells quantity $y^i x^i$.

Increasing its price, p^i, relative to the industry average, p, lowers the quantity demanded by the current customers, y^i. This type of demand per customer explicitly results from a model where customers conduct sequential search for the cheapest product with uniform distribution of search costs across buyers [See Carlson and McAfee(1983) for a proof]. Such demand specification has appeared in numerous papers e.g., Phelps and Winter (1970), Telser (1962), Maccini (1978), Rodriguez (1985).

Overtime, customers gradually learn about lower prices elsewhere, they slowly drift towards the cheapest seller. For example, customers may exchange information on prices during random encounters. For this reason the dynamics of the market share, x^i, depend on relative prices[2] and the function, g_0, in the customer-flow equation captures the rate at which customers drift from one firm to another when relative prices differ across firms.

$$\dot{x}^i = g_0\left(\frac{p^i}{p}\right)x^i$$

Without loss of generality, we normalise the market share, x^i, so that $0 \leq x^i \leq 1$. [Note that as in the original Phelps and Winter (1970) model, the changes in the market-share dynamics are proportional to the flows of customers between sellers]

However, if we stay very faithful to the way information spreads in the market, which is that the rate of diffusion of information is stochastic rather than deterministic, then unlike Phelps and Winter (1970) the customer-flow equation is stochastic. This happens because of the "random" nature of encounters amongst customers as means of price information exchange. As a result the complete dynamics of the market-share are governed by the following geometric Brownian motion;

$$dx^i = x^i g_0\left(\frac{p^i}{p}\right)dt + x^i\sqrt{g_1\left(\frac{p^i}{p}\right)}\sigma dz, \tag{2.2}$$

where z is a Wiener process; $dz = \varepsilon\sqrt{dt}$ since ε is a normally-distributed random variable with mean zero and a standard deviation of unity. The function, g_1, is the same as, g_0, but with a constant term added to it. This is to ensure that firms face uncertainty at all times, even at the equilibrium. The term σ measures the relative importance of uncertainty in the evolution of customer flows. This makes percentage changes in market share normally distributed and the absolute changes in market share log-normally distributed.

In the spirit of Phelps-Winter (1970), a firm operating in the regime described above must weigh the short and long-run impact of its mark-up decision. By reducing current prices, the firm reduces its current profits but also is more likely to retain existing customers and attract new ones.

[2] A complete derivation of this can be found in Phelps and Winter (1970).

The representative firm indexed by i with x^i market share solves the following optimization program:

$$
\begin{aligned}
V(x^i) &= \sup_{p^i} E[\int_{t_0}^{\infty} u(\pi^i)e^{-\rho(t-t_0)}dt] \\
& \quad where \\
\pi^i &= \left(p^i - \bar{c}\right) y^i x^i \\
& \quad subject\ to \\
dx^i &= x^i g_0 \left(\frac{p^i}{p}\right) dt + x^i \sqrt{g_1 \left(\frac{p^i}{p}\right)} \sigma dz
\end{aligned}
$$

$V(x^i)$ is the firm value. The firm faces an exogenously determined rate of pure time preference, ρ. This discount factor determines the rate at which output at time t can be traded for output at time zero. The firm's aim is to maximize the expected present discounted value of the utility derived from the stream of profits over time by choosing a price subject to the stochastic customer-flow.

3. The Closed-Form Solution

In order to obtain a closed-form solution to this stochastic customer-market model, I use the following functional forms (also used in Choudhary and Orszag (1999)) all of which were chosen for their simplicity and tractability:

- **Customer Evolution**. The equations capturing the evolution in the market shares are given by,

$$g_0 \left(\frac{p^i}{p}\right) = \gamma - \gamma \left(\frac{p^i}{p}\right)^{\mu} \qquad g(1) = 0 \tag{3.1}$$

and

$$g_1 = g_0 + \tau \qquad g\left(1\right) = \tau \tag{3.2}$$

The first equation shows how the market shares change when prices across firms are not equal. When the firms charges a price that is greater than the industry average, the marginal loss in the market share is equal to $-\frac{\mu\gamma}{p^i}(\frac{p^i}{p})$. The term $\mu\gamma$ denotes the level of information friction in the economy. The higher this term, the quicker the customers receive information about changes in prices.

The second equation is the same as the former, except that it has a constant, τ, added to it. As explained earlier, this is needed to ensure that the firm faces uncertainty at all times in the customer-flow equation (2.2). The condition attached to this equation shows that with $\tau > 0$ there is positive uncertainty, even at the equilibrium where $p^i = p$.

- **Consumer Demand**. The equation for demand per customer, assuming constant elasticity of demand η for goods, is

$$y^i = f\left(\frac{p^i}{p}\right) = A\left(\frac{p^i}{p}\right)^{-\eta} \tag{3.3}$$

where A is consumer demand in symmetric equilibrium.

- **Utility Function**. We assume that utility is concave in profits.

$$u(\pi) = \ln \pi,\ u'(\pi) > 0 \text{ and } u''(\pi) < 0 \tag{3.4}$$

Using Itô's Lemma, I get the following Bellman equation which describes the representative firm's optimisation problem with respect to the firm's posted price,

$$\begin{aligned} \rho V &= \underset{p^i}{Sup}\,[u(\pi) + E(dV)] \\ &= \underset{p^i}{Sup}\,[u(\pi) + (x^i V_{x^i} g_0 + \frac{g_1}{2}\left(x^i\right)^2 \sigma^2 V_{x^i x^i})] \end{aligned} \tag{3.5}$$

V denotes the value of the firm, π is profits, ρ is the discount rate and V_{x^i} is the shadow price of a customer. The first term is the intantaneous utility from current profits. The second term shows the value of an increase in market share.

Maximisation gives an immediate necessary condition

$$u^{'}(\pi)\pi^{'}(p^i) + [(x^i V_{x^i} + \frac{1}{2}\left(x^i\right)^2 \sigma^2 V_{x^i x^i})]\frac{\partial g_0}{\partial p^i} = 0 \tag{3.6}$$

This equation plays a key role in this model. Using Equations (3.1), (3.2), (3.3) and (3.4) and assuming that at the equilibrium average prices elsewhere equal the firm's own price, $\frac{p^i}{p} = 1$, the necessary condition can be conveniently expressed as

$$\frac{\partial \pi}{\partial p^i}\frac{p^i}{\pi} = \mu\gamma(x^i V_{x^i} + \frac{1}{2}\left(x^i\right)^2 \sigma^2 V_{x^i x^i}) \tag{3.7}$$

This expression is the elasticity of profits in prices, η_{π,p^i}, describing how profits respond to changes in prices. In particular, when there are no customer flows, $\mu\gamma = 0$, the elasticity of profits is zero and the necessary condition boils down to the usual first-order condition for profit optimization of imperfectly competitive firms, where the marginal revenue equates to marginal cost;

$$\underbrace{p^i(\frac{1-\eta}{\eta})}_{MR} + \underbrace{\bar{c}}_{MC} = 0 \tag{3.8}$$

On the other hand, when there is no market share uncertainty, $\sigma^2 = 0$, but customer flows exists the elasticity of profits in prices, η_{π,p^i}, are strictly positive. The necessary condition is transformed such that,

$$p^i(\frac{1-\eta}{\eta}) - \bar{c} = -\mu\gamma V_{x^i} \tag{3.9}$$

Equation (3.9) shows that, the marginal revenue charged by the monopolist is lower than the marginal cost, $MR - MC < 0$, since he sacrifices some of his current revenue in the interest of keeping future custom. This holds so long as the customer-value, V_{x^i}, is positive. This is precisely what distinguishes a customer-market from other types of markets. However, what I am about to show is that this effect can be reversed with sufficiently high market-share uncertainty making the elasticity of profits with respect to prices negative, $\eta_{\pi,p^i} < 0$.

In the appendix I show that the second-order ordinary differential equation, the Bellman equation (3.5), has the following solution,

$$\begin{aligned} V(x^i) &= k_0 + k_1 \log(x^i), \\ k_0 &= \frac{\log((p^i - \bar{c})A)}{\rho} - \frac{\tau\sigma^2}{2\rho^2} \\ k_1 &= \frac{1}{\rho} \end{aligned} \tag{3.10}$$

Differentiating (3.10) with respect to x^i gives the shadow price of a customer V_{x^i} :

$$V_{x^i} = \frac{k_1}{x^i} = \frac{1}{\rho x^i} > 0 \tag{3.11}$$

Equation (3.11) shows that customer value is positive and is lowered by an increase in the discount rate.

4. Market Pricing with Uncertainty.

In this section I address the prime objective of this paper; the implication of market-share uncertainty for pricing in a partial steady-state equilibrium. This is a partial equilibrium because the term structure and the level of real interest rates are exogenously given – the capital market is not explicitly modelled. Assuming symmetric equilibrium, that average price elsewhere is equal to the firm's own price, $\frac{p^i}{p} = 1$, the necessary condition of the Bellman equation becomes

$$\frac{\partial \pi}{\partial p^i}\frac{p^i}{\pi} = \mu\gamma(x^i V_{x^i} + \frac{1}{2}\left(x^i\right)^2 \sigma^2 V_{x^i x^i}) \tag{4.1}$$

Using the solution for the Bellman equation (3.10) in the necessary condition (3.7), the following price mark-up equation results,

$$\frac{p^i}{\bar{c}} = \frac{\left[\eta + \frac{\mu\gamma}{\rho}(1 - \frac{1}{2}\sigma^2)\right]}{(\eta - 1) + \frac{\mu\gamma}{\rho}(1 - \frac{1}{2}\sigma^2)} \tag{4.2}$$

Equation (4.2) is the optimal customer-market pricing equation and assuming that the elasticity of demand is greater than unity in absolute terms. This is always so, since monopolies only operate on the elastic part of their demand curve. Next, I examine it under various circumstances.

First, when there are no customer flows, i.e., $\mu\gamma = 0$, the pricing equation boils down to the static monopoly mark-up where the elasticity of profits $\eta_{\pi,p^i} = 0$.

$$\frac{p^i}{\bar{c}} = \frac{\eta}{\eta - 1} \tag{4.3}$$

In this case the trivial pricing rule $MR = MC$ applies.

Second, when there is no market-share uncertainty, σ^2, but there are customer-flows between sellers and customer-value, V_{x^i}, is positive, we obtain Equation (4.4).

$$\frac{p^i}{\bar{c}} = \underbrace{\frac{\eta}{\eta - 1}}_{\text{Monopoly mark-up}} - \underbrace{\frac{\mu\gamma}{(\rho(\eta-1) + \mu\gamma)(\eta - 1)}}_{\text{Phelps and Winter effect}} \tag{4.4}$$

The first term on the right hand of this equation is the static monopoly mark-up . The second term is the standard Phelps and Winter Effect (1970) which captures the effect of price changes on expected mean future business and has the effect of reducing the mark-up levels.

Third, with market-share uncertainty price mark-ups may be higher than the static monopoly mark-up, thus reversing completely the Phelps-Winter effect. This is clear in the second term of Equation (4.5) where uncertainty, σ^2, appears.

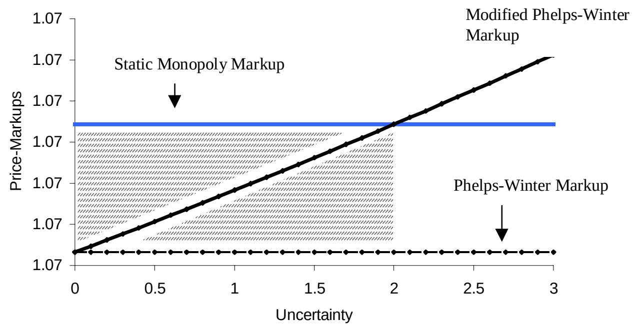
$$\frac{p^i}{\bar{c}} = \underbrace{\frac{\eta}{(\eta - 1)}}_{\text{Monopoly mark-up}} - \underbrace{\frac{\mu\gamma(1 - \frac{1}{2}\sigma^2)}{(\rho(\eta-1) + (1 - \frac{1}{2}\sigma^2)\mu\gamma)(\eta - 1)}}_{\text{Modified Phelps and Winter effect}} \tag{4.5}$$

The second term of Equation (4.5) shows that market-share uncertainty affects the usual trade-off in the customer markets, that the marginal benefit from raising prices - in the form of higher current profits - is equal to the marginal cost - in the form of a smaller market share and lower profits in the future. Indeed, market-share risk reduces the value of future business compared to its current level, resulting in a reduction of customer-value. As a result, firms raise mark-ups. In order to fully offset this Phelps-Winter effect, the level of market share uncertainty, σ^2, has to exceed 2 in my model.

Figure[3] 1 helps to demonstrate this point by simulating equation (4.5). The bottom horizontal line represents the pure Phelps and Winter mark-up with no uncertainty. The top horizontal curve represents the textbook monopoly mark-ups with no uncertainty as well. The diagonal line is pricing with uncertainty. The first point to note is that, ceteris paribus, uncertainty and pricing are linearly and positively related. Second, when uncertainty lies in the limit of $0 < \sigma^2 < 2$ (the shaded area), the firm still charges a mark-up that is below the textbook monopoly mark-up. This is because the Phelps-Winter effect is still effective within this region. However, beyond the limit of $\sigma^2 = 2$ this effect vanishes.

[3]To carry out the simulation I assume the following arbitary values for paramaters: $\eta = 15, \bar{c} = 1, \mu\gamma = 1, \rho = 1.2$.

Figure 1. The Relationship of Markups and Uncertainty



This result has two main implications. First, the Phelps-Winter effect can be reversed with uncertainty. Second, our results refine the conclusions drawn in the 1970's about the relationship between mark-up and uncertainty. While, all those studies concluded that monopolies charge an outright risk-premium on top of the textbook's monopoly mark-up in the presence of uncertainty, our model suggests that uncertainty diminishes the Phelps-Winter effect and the question of a risk-premium arises only when the level of uncertainty exceeds a certain threshold.

5. Empirical Testing

We now turn to testing the implications of the stochastic customer-market model presented in the pervious section. The main testable implications are:

- A higher customer-value leads to lower price-mark-ups.
- Uncertainty about customer flows tends to raise mark-ups.

I use the following pooled regression model to estimate the relationship between markups and uncertainty and customer-value

$$m_{it} = \alpha_i + \beta z_{it}^n + \xi_{it} \tag{5.1}$$

where, m_{it}, are mark-ups and, z_{it}^n, are the explanatory variables; i, t, and n, denote industry, time and the variable respectively.

The pooled estimation will simply take the sample time average of each variable for each industry. This method is consistent with this work as we are interested in identifying relations of a model in the steady-state(5.1). Indeed, Hsiao (1996) and

Pesaran and Smith (1995) show that pooled estimators are only inconsistent for the estimation of dynamic relationships.

The estimation proceeds in two stages. In the first stage, price-mark-ups, m_{it}, are estimated. In the second stage, these estimated mark-ups are used as regressands in equation (5.1) to be explained by variables such as uncertainty and customer value.

5.1. Stage 1: A Statistical Model for Estimating Mark-ups

The method I have chosen to estimate mark-ups falls in between the most straightforward and the most intricate[4]. I estimate mark-ups by the procedure popularized by Hall (1986, 1988). This method is an extension of Solow's (1957) effort to estimate total-factor-productivity (TFP) growth. Hall (1986) assumes that labour, N, is the only input in the production process. The marginal cost of production is then

$$MC = c = \frac{w \bigtriangleup N}{\bigtriangleup Y} \tag{5.2}$$

where, Y and, w, denote output and current wages respectively. Since, marginal cost is not observed, I multiply the left-hand side of the equation above by $\frac{p}{p}$, where p is the price of output and divide both sides by Y. Rearranging gives the following equation,

$$\frac{\bigtriangleup Y}{Y} = \frac{p}{c}\frac{wN}{pY}\frac{\bigtriangleup N}{N} \text{ or } \frac{p}{c} = \frac{p\Delta Y}{w\Delta N} \tag{5.3}$$

This equation states that the growth in output is equal to the mark-up, $\frac{p}{c}$, times the share of labour in output, $\frac{wN}{pY}$, valued at current prices, times growth in labour input. Equivalently, the price mark-up is simply equal to the value of the marginal good sold over the cost of producing the marginal good.

Introducing capital, K, as a second factor of production brings the following key changes in equation(5.2),

$$c = \frac{w \bigtriangleup N + r\Delta K}{\bigtriangleup Y - \theta Y} \tag{5.4}$$

This equation allows for marginal cost of capital input, r, in the numerator and also adjusts for changes in output generated exogenously by, θ, commonly known as the Solow residual or total-factor-productivity (TFP). Rearranging equation (5.4) I obtain,

$$\frac{\Delta Y}{Y} = \theta + \frac{wN}{cY}\frac{\Delta N}{N} + \frac{rK}{cY}\frac{\Delta K}{K} \tag{5.5}$$

Assuming constant returns to scale[5] - which has the useful property that the sum of the share of labour and capital in production is unity - and manipulating the

[4] A longer working paper discusses in detail the new methods of measuring the mark-up such as Roeger (1992), Bresnahan (1982) and Appelbaum (1992). The author will provide a copy of the longer working paper on demand.

[5] The assumption of constant returns implies that $(wN + rK)/cY = 1$, that is that the ratio of total factor payments to output valued at marginal costs is unity. I use this result below.

right-hand side of equation (5.5) and multiplying the last two terms by $\frac{p}{p}$ I obtain,

$$\left(\frac{\Delta Y}{Y}-\frac{\Delta K}{K}\right)_i=\theta+\frac{p}{c}\times sh_{it}^L\times\left(\frac{\Delta N}{N}-\frac{\Delta K}{K}\right)_i \tag{5.6}$$

where, sh_{it}^L,denotes share of labour of the i^{th} industry at time t.

This equation states that the growth in per-capita output is equal to the sum of TFP and the product of the share of labor in the growth of labour per capita and the mark-up.

Assuming that the mark-up, $\frac{p}{c}$, and TFP are constant overtime and using data on output, capital and labour, we can use the equation (5.6) to estimate price-mark-ups, p/c, as the unknown coefficient on the right- hand side. When, the mark-up is significantly greater than unity, the assumption of constant returns along with imperfect competition is validated. The main criticism about Hall's method is that equation (5.6) suffers from endogeneity in that $\Delta K/K$ is on both sides of the estimation equation. As a remedy, Hall (1988) suggests using instruments for the right-hand side.

5.1.1. The Data and the Estimation of Mark-ups

Hall's method calculates average mark-ups over the chosen sample period for each industry. I have 24 years of data, 1968-1991, for thirteen industries. This implies that the fixed-effect estimation method will give only 13 observations on mark-ups (one mark-up observation per industry). This small sample size may impair the quality of the second-stage empirical tests. Consequently, I have chosen to enlarge the sample by spliting the 24 year data into two periods: 1968-1980 and 1981-1991. The choice of periods is motivated by changes in oil prices. Indeed, the 1968-1980 period coincides with the period of rising oil prices, whereas the period 1981-1991 is one of falling prices. This split gives 26 point estimates of price mark-ups–two for each industry–for the subsequent analysis instead of the previous 13.

The data was collected for thirteen industries over the period of 1968-1991[6]. The industries are: metal manufacturing, other mineral products, chemicals, other metal product, mechanical engineering, electrical engineering, motor vehicles, textiles, clothing and footwear, paper printing and publishing, distribution and repair, and hotels and catering (please refer to the appendix for sources). The data is composed of value-added, total employment, capital stock, nominal value-added and actual labor hours.

I use the following modified version of Hall's equation (5.6) and estimate mark-ups in a fixed-effects model,

$$\Delta\left(y-k\right)_{it}=\theta_i+adum_{it}+m_i\times sh_{it}^L\Delta\left(l+h-k\right)_{it}\ \ ,\ i=1,2..13\ \ t=1,2,..24 \tag{5.7}$$

where $\Delta(y-k)$ is growth output per capital, $\Delta(l+h-k)$, is growth in labour per capital, μ, is the mark-up, h, is actual labour hours and l is labour. Lower case letters represent logs.

[6] I cannot use data after 1991 because of industrial classification changes after 1991.

Equation (5.7) is an enhanced version of Hall's equation in that $N = LH$, where L is employment and H is hours as in Haskel, Martin and Small (1995) and Small (1997). Secondly, TFP growth, θ, is allowed to vary by industry in view of Layard and Nickell (1989) who provide evidence that UK's TFP growth varies substantially across industries. To accomplish this I follow Haskel et al. (1995) and Small (1997), Bean and Symons (1989) by including various time shift dummies, dum_{it}, in equation (5.7) in order to control for shifts in TFP. In particular, I use three sets of dummy variables to estimate three sets of mark-ups for the sample periods of 1968-1980 and 1981-1991. In this way I try to circumvent the problem of an absence of an agreement amongst authors on the choice of time dummy variables. Indeed, tests not reported here suggest that for certain industries some time dummies and instruments perform better than others[7]. Haskel at al. (1995) and Small(1997), for example, obtain different levels of mark-ups using different shift dummies.

The first set of estimated mark-ups, m_1, is calculated using no dummy variable. The second set, m_2, has a single dummy variable for the period of 1974-1980. The last set of mark-ups, m_3, has also dummy variable for 1974-1980, but uses a different set of instruments, a topic to which I turn shortly. The choice for the time dummy is purely based on the timing of specific oil price shocks. One may be inclined to dispense with time dummies due to lack of observations. However, I show later that this may not be sensible.

Hall (1988) pointed out that an estimation of equation(5.6) suffers from endogeneity in that the growth in output per unit capital, $\Delta(y-k)$, and the weighted growth in labor per unit capital, $\Delta(l-k)$, are jointly determined. Indeed, I successfully carry out the "Wu-Hausman Test"[8] rejecting the hypothesis of exogeneity for $sh_{it}^L \Delta\left(l+h-k\right)_{it}$. As a result, I use instrumental variables (IV). I use instruments common and specific to industries. The set of instruments common to all industries include: Current and lagged growth in OECD total output, rate of growth in real GDP in the UK, growth in national output per worker, growth in national defence expenditures. The set of industry-specific instruments include: the labor-capital ratio, labor's share in production, the log of employment time hours and the lagged and current growth in capital stock. For each industry regression, I use the best instruments available for that period. The choice of instruments was based on their explanatory power, r^2, for, $sh_{it}^L \Delta\left(l+h-k\right)_{it}$, and low standard error. Table 1 below summarises.

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[7]The problem with the choice of intruments is that some of them work better for certain industries whilst some do not. Therefore, what I have done is to use the best instruments available for *markup1&2* and common instuments accross industries in *markup3*. For similar reasons the choice of time dummy for each markup is different. The number of instruments for each markup is the same. The choice of instuments is based on low standard error and high R^2.

[8]The Wu-Hausman Test is as follows: let $y_{it} = \alpha_i + \beta_i x_{it} + u_{it}$ be the equation suspected for endogeneity where x_{it} is the explanatory variable for y_{it}. Assume, z_{it} is a chosen set of instrument for x_{it}. By running $x_{it} = \gamma_i + \delta z_{it} + v_{it}$, I recover the estimated $\hat{v}_{it}$. Finally, run $y_{it} = \alpha_i + \beta_i x_{it} + \lambda \hat{v}_{it} + u_{it}$. The test for $\lambda = 0$, is the Wu-Hausman test for exogeneity of x_{it}.

Table 1. Various Definitions of mark-ups, m.

Periods	m_1	m_2	m_3
1968-1980	No Dummy	Dummy 1974-1980	Dummy 1974-1980
1981-1991	No Dummy	No Dummy	No Dummy
IV Choice	Best from the IV set	Best from the IV set	Same IV across time and industry

The Degree of Imperfect Competition in UK Industries

Table 2 in the appendix shows the estimated average mark-ups for each industry during the period of 1968-1991. The columns differ from one another due to the differential treatment of time dummies and instruments in the estimation of mark-ups. The fixed-effects model is estimated using a within-group estimator where mark-ups are allowed to vary by industry but are assumed to be constant over time.

A first glance at Table 2 suggests that during the 1968-1991 period all UK industries were operating in an imperfectly competitive markets. The estimated mark-ups for individual industries are statistically above zero and greater than unity for all industries with the sole exception of the clothing and footwear industry. The Chi-Squared test, χ^2, in Table 2 rejects the hypothesis that mark-up 1,2 and 3 are the same across industries and equal to unity. However, this test is weak for mark-up 1.

Recall that our estimated equation (5.7) was derived using two assumptions: constant returns to scale and imperfect competition. Given these assumptions, the hypothesis of a mark-up greater than unity follows. The question remains whether constant returns to scale is a reasonable assumption. Following Haskel et al. (1995) this can be tested by noting that the sum of the shares of factor inputs can deviate from unity,

$$\frac{wN}{cY} + \frac{rK}{cY} = 1 + s \tag{5.8}$$

where, $s > 0$, denotes increasing returns to scale, $s < 0$, denotes decreasing returns to scale and, $s = 0$, denotes constant returns to scale. Substituting this equation into equation (5.6) and after some algebraic manipulation, I derive the following fixed-effects model for estimation,

$$\Delta (y-k)_{it} = \theta_i + adum_{it} + m_i \times sh^L_{it} \Delta (l+h-k)_{it} + s\Delta k_i \ , \ i = 1, 2..13 \quad t = 1, 2, ..24$$

where again the mark-up is allowed to vary by industry but is assumed to be constant over time. The fixed-effect model is estimated using a within-group estimator and the results are reported in Table 2. The point estimates of, s, are not significant at both the 5% and the 10% levels[9]. This provides some support for the assumption of constant returns to scale.

The results obtained are broadly similar to those of Haskel, Martin and Small (1995), Martin, Scarpetta and Pilat (1996) and Small (1997) who also find significant elements of imperfect competition in UK industries. The main difference here lies in the level of the mark-ups. Broadly, the estimates reported in Table 2 are lower than

[9] However, the sign of, s, in markup1&2 is pointing towards an industry with decreasing returns to scale (Haskel et al.(1995) get similar results).

Haskel et al. (1995)[10] and Small (1997) and higher than those reported in Martins, Scarpetta and Pilat (1996)[11].

5.2. Stage 2: Cross Industry Evidence for Various Relationships

This section explores the linear relationships between mark-ups and a list of regressors. Using the method described in the previous section I first estimate the average mark-ups for the periods 1969-1980 and 1981-1991. Then I construct average real share prices, price-earnings ratios and output growth per capital to proxy for customer value, and the standard deviation of sales to measure for market-share uncertainty for each industry over 1969-1980 and 1981-1991. Overall, this exercise allows us to construct a new panel data set with two observations for mark-ups and the other variables of interest for each industry[12].

5.3. Mark-ups and Uncertainty.

The theory concluded that firms manage the risk of market-share uncertainty by charging an extra premium on top of their price mark-ups. A positive relationship between mark-ups and uncertainty result was predicted by equation (4.5). The estimation of equation (4.5) can be formulated in the following linear form

$$(m)_{it} = \alpha + \beta\,(\sigma)_{it} + \xi_{it} \text{ where } i = 1,..,13 \; t = 1,2 \tag{5.9}$$

where, m_{it}, are the mark-ups estimated with Halls' method and , σ, is uncertainty proxied by the standard deviation of real value added for the same period for which the mark-ups is estimated. As previously explained, due to the problems of the choice of instrumental variables in Hall's method, various estimates of mark-ups with different instruments and time dummies are used.

The results of the estimation for equation (5.9) using the OLS estimator are reported in Table 3 (column 1) and Figure 2 presents a scatter diagram in the appendix.

The coefficient of uncertainty is always positive and significant in every case but one. The error term of equation, (5.9) are White-Heteroscedasticity consistent. The goodness of fit, R^2, and the DW tests for error-term correlation are satisfactory. The results suggests a positive relationship between uncertainty and mark-ups. Thus, uncertainty is one possible determinant of mark-ups.

5.4. Mark-ups and Customer Value

Another key implication was that higher customer-value leads firms to trim their mark-ups. The reason for this is that when firms value growth in their customer base

[10] Note that Hasket et al. (1995) only have manufacturing industries in their study.

[11] Martins et al. (1996) also have metal manufacturing, chemical, other metal product, textiles and footwear.

[12] All the financial data was obtained from Datastream except for metal manufacturing, mechanical engineering, clothing and footwear. Communication industry data was also not available for the period 1968-1980.

they reduce mark-ups - hence sacrifice current profits-in order to expand their market share. This effect was given by equation (4.5). Equation (4.5) can be rewritten as

$$(m)_{it} = \alpha + \gamma \log \left(\frac{PI}{Y/L} \right)_{it} + \xi_{it} \text{ } where \text{ } i = 1, .., 13 \text{ } t = 1, 2 \tag{5.10}$$

where $\frac{PI}{Y/L}$ is the shadow value of customers- proxied by a share-price index, PI, and normalised by output per worker, Y/L. Following Phelps (1999) firm's share prices proxies for the customer-value. The share prices are normalised by output per worker in the industry. This can be thought of as the ratio of the benefit and to the cost of trimming mark-ups. The denominator captures the cost of changing mark-ups. The higher is output, the greater is the sacrifice in terms of current profits when mark-ups are reduced. The numerator is a proxy for the benefit of changing mark-ups. The results of the pooled regression are shown in Table 4 below and Figure 3.

Table 4. Results for customer-value and mark-ups

Coefficients	Mark-up 1	Mark-up 2	Mark-up 3
α	1.08 (0.34)	1.82 (0.58)	2.06 (0.69)
γ	0.055 (0.07)	-0.07 (0.10)	-0.134 (0.12)
R^2	0.04	0.03	0.07
DW	2.5	1.98	2.13

Standard errors in brackets

Estimates of the coefficient of real share price, γ, have a negative coefficient which is significant at 25% for all estimates of equation (5.10) but one[13]. It is therefore safe to stipulate a negative relationship between mark-ups and customer value as predicted by Phelps and Winter (1970). In order to show that this finding is robust, I also use the price-earnings ratio, p/e, as another possible proxy for customer value. As expected, Table 3 (column 2) reports a negative coefficient of the price-earnings ratio for all cases. However, it has low significance (see Figure 4 in the appendix). The low significance may be due to fewer observations; there are 17 observations are available instead of the original 26.

5.5. Mark-ups and Other Explanatory Variables

I re-estimate equation (5.9) now in a multivariable setup. The explanatory variables are per worker output growth, customer-value and uncertainty.

The results of the pooled estimates are shown in Table 3 of the appendix. The coefficient of uncertainty remains positive (see uncertainty rows Table 2) as I add other explanatory variables. Compared with the other variables, it is also the most robust variable in explaining the mark-up levels and remains so as we add more explanatory variables. There is one exception, the sign on the coefficient of uncertainty in *mark-up 2* changes as more variables are added but it is also insignificant.

[13] The estimate giving the wrong sign is insignificant.

Another important variable in the regression is the price-earnings ratio, p/e, which proxies for customer-value. In all the pooled regressions, the coefficient of the price earnings ratio is negatively correlated with mark-ups, but it is sometimes significant and sometimes not. Restricting ourselves to the sign of the coefficient, it can be unequivocally concluded that high customer-value results in lower mark-ups. This is the crux of the basic customer-market model.

The next most significant variable is the growth rate of output per worker, g. The results suggest that with growth in output per worker and uncertainty as the only regressors, industries experiencing higher growth in output per capita are also the ones with lower mark-ups. However, the coefficient of g declines in significance. The motivation for including this variable in the regressions is that of Phelps and Winter (1970) who predicted that a higher valuation of customers, here proxied for growth in output per capita, should be reflected in lower mark-ups. For the first time, our results confirm this prediction on UK data.

5.6. Testing for Robustness

In order to show that the results derived so far are robust, I re-estimate equations (5.9) and (5.10) by first-differencing them on both sides. In doing so I loose half of the observations. Intuitively, we are estimating to what extent changes in mark-ups can be explained by changes in uncertainty and the customer- value. Equations (5.9) and (5.10) can generally be formulated by Equation (6.3) where $\triangle m_{it}$ is the change in mark-ups and $\triangle x_{it}$ represent the explanatory variables of the ith industry.

There are three explanatory variable: $\triangle uncertainty$, $\triangle \log(\frac{PI}{Y/L})$ and $\triangle p/e$, which denote changes in uncertainty, growth in normalized share-price index and changes in the price-earnings ratio respectively.

$$\Delta m_{it} = c + \lambda \Delta x_{it}^{n} + \epsilon \tag{5.11}$$

Table 5 below presents the estimates of the coefficient λ in equation (5.11). Using OLS, each equation is separetely estimated for each mark-up.

When uncertainty is used as the only explanatory variable we have 13 observations available and the estimates of λ are always positive and significant in every case except one. This implies that a positive change in uncertainty brings a positive change in the mark-up, supporting further our theoretical arguments that higher uncertainty involves higher mark-ups.

When either growth in the normalised price index or changes in the p/e ratio are used as explanatory variables, only 9 observations are available. Note that both variables proxy for customer value. The estimates of λ for both cases are always negative and significant in every case (except for the growth in the normalised price index) implying that a positive change in the customer value lowers the mark-up. Undoubtedly, the p/e ratio gives better results.

Table 5. Estimates of first-differenced equation (5.11)

$\triangle m^1$ (Markup 1)	a	b	c	d
c	-0.12 (0.26)	0.37 (0.31)	0.41 (0.22)	0.02 (0.25)
$\triangle$uncertainty	0.067 (0.044)	-	-	0.05 (0.03)
$\triangle\log(\frac{PI}{Y/L})$	-	-0.09 (0.13)	-	-
$\triangle$p/e	-	-	-0.06 (0.036)	-0.06 (0.03)
DW	1.70	1	0.50	1.5
R^2	0.17	0.05	0.24	0.44
$\triangle m^2$ (Markup 2)				
c	-0.41 (0.33)	-0.09 (0.43)	-0.07 (0.32)	0.08 (0.43)
$\triangle$uncertainty	0.022 (0.055)	-	-	0.002 (0.05)
$\triangle\log(\frac{PI}{Y/L})$	-	-0.13 (0.19)	-	$-$
$\triangle$p/e	-	-	-0.07 (0.05)	-0.07 (0.05)
DW	1.65	2.2	1.60	1.7
R^2	0.02	0.06	0.21	0.21
$\triangle m^3$ (Markup 3)				
c	0.26 (0.30)	0.20 (0.50)	0.24 (0.37)	0.05 (0.47)
$\triangle$uncertainty	0.052 (0.051)	-	-	0.04 (0.060
$\triangle\log(\frac{PI}{Y/L})$	-	-0.13 (0.22)	-	$-$
$\triangle$p/e	-	-	-0.08 (0.06)	-0.08 (0.06)
DW	1.70	1.31	0.80	1.7
R^2	0.09	0.05	0.19	0.25

Standard error in brackets

Finally, Table 5 (column d) reports an OLS regression of equation (5.11) using changes in uncertainty and p/e ratio together as the explanatory variables. I use p/e ratio as it preforms better as a proxy for customer value. The coefficient of uncertainty is always positive and significant at 20%. The coefficient of the p/e ratio is always negative and significant.

Overall our results support the hypothesis that mark-ups are positively correlated with uncertainty and negatively correlated with price-earnings ratio.

6. Conclusion

The chief aim of this paper has been to examine the determination of mark-ups with a stochastic market-share in a customer-market model. I have found that with stochastic customer dynamics and risk-averse firms, prices are affected by market-share risk in a way that causes mark-ups to be higher than the standard customer-market model and the static monopoly model. Indeed, high uncertainty about the future market-share reduces the value of market share causing firms to invest smaller amounts in their market shares in form of higher mark-ups. This effect has the potential to explain UK's 1988 pension-fund puzzle, where individual pension plans were initially sold at high mark-ups. Moreover, this paper also showed that mark-ups are affected by how much firms value their customers- a key relationship uncovered in the original Phelps-Winter (1970) customer-market model. A higher share price index – proxing for the customer-value – is expected to reduce price mark-ups. These various relationships between mark-ups, customer uncertainty, customer- value were supported by our empirical results.

Appendix A1

-The Data covers the period of 1968-1991 and is taken from the following sources,

-Real value added output: GDP at constant factor cost: Table B4, Census of Production (The Blue Book)

-Nominal value-added: Table B3 Census of Production.

-Nominal total wages: Table 3.3, Census of Production.

-Real Gross capital stock: Table A3.8 Census of Production.

-Total employment: Table A2 Employment Gazette.

-Actual hours data: Table 5.4, Employment Gazette.

-Share price index, price-earnings ratio are taken from Datastream.

-OECD, industrial output and GDP at factor cost, oil prices indices and government defense expenditure are from Datastream.

-Definitions:

y-log of real GDP at factor cost that is taken from the "Blue Book" Table B4.

k- log of real capital stock taken from "Blue Book" Table A3.8.

n- log of total hours taken from "Employment Gazette" Table 5.4.

l- log of total employment taken from Employment Gazette Table A2

PI- share price index from Datastream. The index is not available for metal manufacturing, mechanical engineering and clothing and footwear. Communication industry data was also not available for the period 1968-1980. It was therefore excluded from regressions.

$p/e-$price earnings ratio from Datastream.

$uncertainty-$the standard deviation of the log of real value added at factor cost for the periods of 1968-1980 and 1981-1991.

Appendix A2: In this appendix, it is shown that the solution to the Bellman equation (3.5) is,

$$V(x^i) = k_0 + k_1 \log(x_i) \tag{6.1}$$

Equation (6.1) uses the following relationship,

$$V_{x^i} = \frac{k_1}{x^i} \tag{6.2}$$

Substituting equations (2.61) into (3.5) and assuming symmetric equilibria, $p^i = p$, gives

$$\rho(k_0 + k_1 \log(x_i)) = \log((p^i - \bar{c})A) + \log(x^i) - \frac{\tau}{2}\sigma^2 k_1 \tag{6.3}$$

Multiplying by the real rate of interest on both sides of (A.2) gives

$$k_0 + \log x^i = \frac{1}{\rho}\log((p^i - \bar{c})A) - \frac{\tau}{2\rho}\sigma^2 k_1 + \frac{1}{\rho}\log(x^i) \tag{6.4}$$

Now, comparing the elements of the left-hand side with the right-hand side gives

$$k_0 = \frac{1}{\rho}\log((p^i - \bar{c})A) - \frac{\tau}{2\rho}\sigma^2 k_1 \tag{6.5}$$

$$k_1 = \frac{1}{\rho} > 0 \tag{6.6}$$

Since $k_1 > 0$, the value function is concave. This completes the proof.

Figures 2, 3 and 4

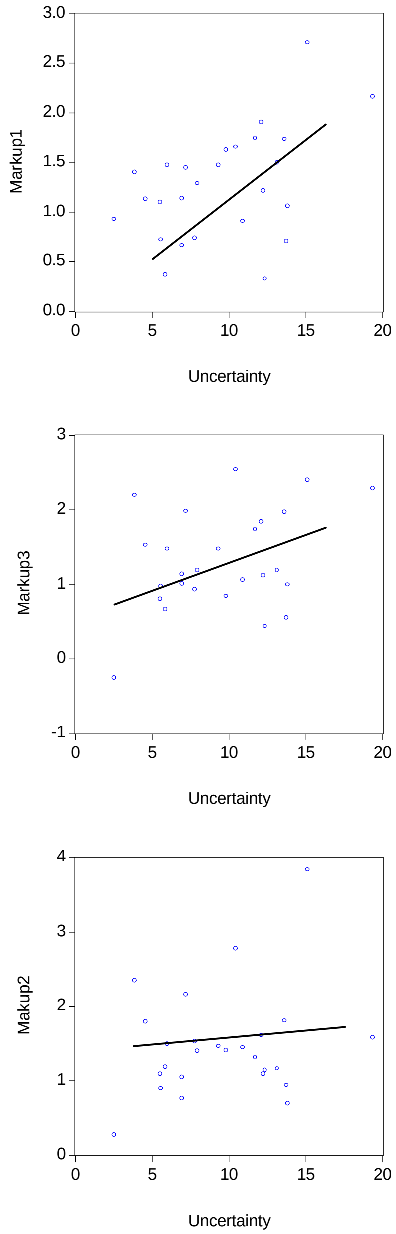

Figure 2: Markups and Uncertainty

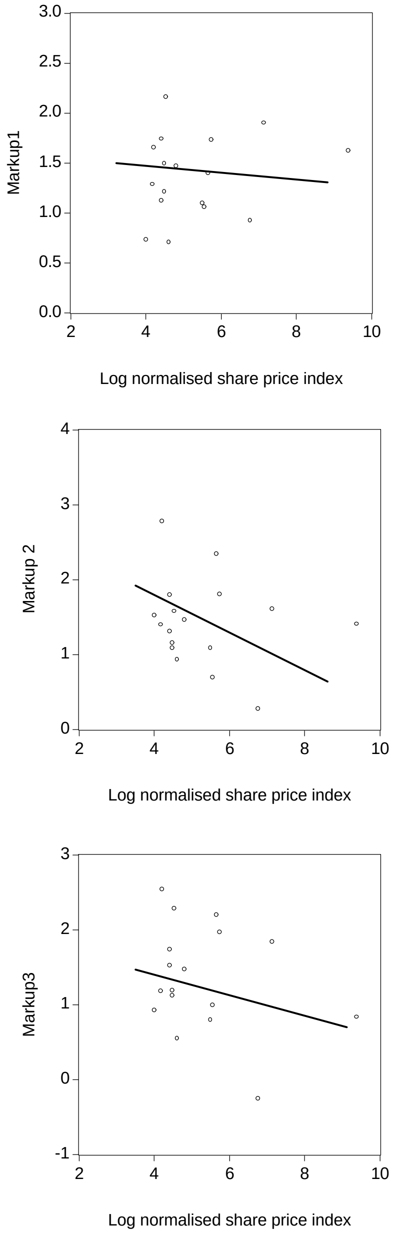

Figure 3: Markups and Normalised Share Price

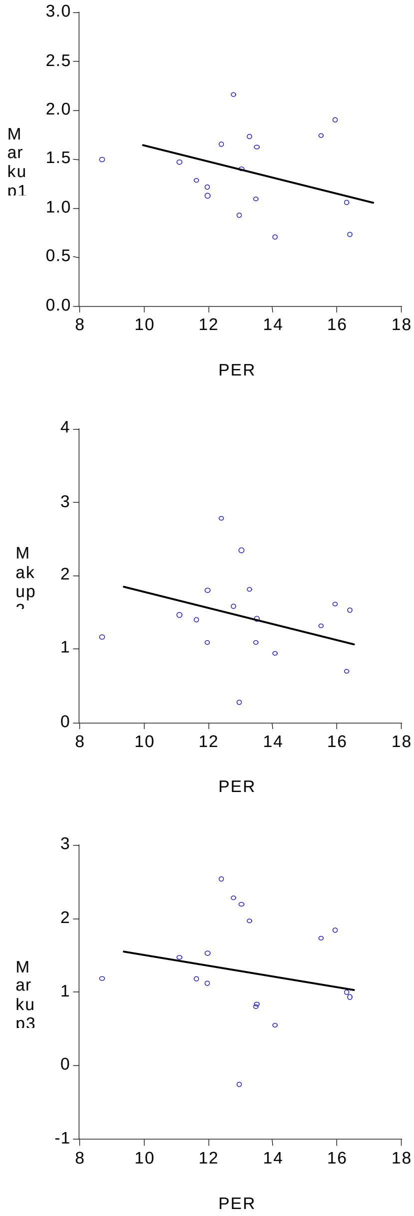

Figure4: Markups and P/E ratio

Table 2. Estimates of Markups

Industries	Markup 1 (A)	Markup 2 (B)	Markup 3 (C)	Average (D)
Other mineral products	1.08	1.49	1.19	1.371
	(0.28)	(0.30)	(0.26)	
Metal manufacturing	1.13	2.20	1.27	1.453
	(0.29)	(0.36)	(0.27)	
Chemicals	1.39	1.77	1.81	1.588
	(0.50)	(0.56)	(0.50)	
Other metal product	1.04	1.21	1.10	1.139
	(0.25)	(0.23)	(0.23)	
Mechanical engineering	1.08	1.27	1.28	1.210
	(0.32)	(0.38)	(0.32)	
Electrical engineering	1.56	1.49	1.51	1.368
	(0.45)	(0.51)	(0.39)	
Motor vehicles	1.48	1.23	1.45	1.315
	(0.22)	(0.21)	(0.22)	
Textiles	1.32	1.14	0.99	1.215
	(0.29)	(0.24)	(0.24)	
Clothing and footwear	0.42	0.99	0.69	0.811
	(0.25)	(0.31)	(0.28)	
Construction	1.16	1.80	1.71	1.484
	(0.45)	(0.49)	(0.48)	
Distribution	1.45	1.97	2.02	1.968
	(0.62)	(0.61)	(0.64)	
Hotels and catering	1.32	0.95	0.28	0.951
	(0.69)	(0.51)	(0.47)	
Communications	1.32	1.49	1.53	1.532
	(0.58)	(0.89)	(0.62)	
R^2	0.51	0.6	0.59	-
Durbin-Watson Test	1.91	2.2	2.05	-
Chi- Squared Test	χ^2 =15; p=0.3	χ^2=24.9; p=0.02	χ^2 =20; p=0.09	-
s**	0.38(0.26)	-0.39(0.274)	-0.16(0.28)	

Notes: Standard errors are in the parentheses below the estimates. The sample period is 1968-1991. The method of estimation is fixed effects with variable coefficients. Column A contains the estimates of average markups of model from equation (3.77) with a time dummy for 1981-1991. Column B contains the estimates of average markups with time dummies for 1974-1980 and 1981-1991 and a common set of instrumental variables across industry and time. Column C contains the estimates of average markup with time dumies for 1974-1980 and 1981-1991 and instruments other than column B . Column D is the simply the mean of Cloumns A, B, and C.
**The coefficient for testing returns to scale.

Table 3. Cross-section results of the split period regressions

Markup 1	1	2 (Obs 17)	3 (17 Obs)	4 (17 Obs)
C	0.66	1.75	1.37	1.19
	(0.21)	(0.69)	(0.59)	(0.71)
Uncertainty	0.063	-	0.05	0.06
	(0.02)		(0.02)	(0.02)
P/E	-	-0.03	-0.04	-0.03
		(0.05)	(0.04)	(0.05)
Growth	-	-	-	-2.40
				(5.00)
R^2	0.223	0.02	0.27	0.28
s.e	0.492	0.38	0.37	0.38
Markup 2				
C	1.10	1.86	1.85	1.98
	(0.36)	(0.99)	(1.07)	(1.27)
Uncertainty	0.04	-	-8.97E-05	-0.01
	(0.035)		(0.04)	(0.04)
P/e	-	-0.03	-0.03	-0.04
		(0.07)	(0.07)	(0.08)
Growth	-	-		1.69
				(8.42)
R^2	0.05	0.01	0.1	0.015
s.e	0.71	0.40	0.62	0.65
Markup 3				
C	0.76	1.65	0.56	1.17
	(0.38)		(1.52)	(0.99)
Uncertainty	0.06	-	0.058	0.06
	(0.03)		(0.048)	(0.04)
P/e	-	-0.02	-0.03	-0.03
		(0.09)	(0.08)	(0.09)
Growth	-	-	-	-0.15
				(9.6)
R^2	0.123	0.01	0.13	0.13
s.e	0.63	0.40	0.70	0.73

a) The split period is 1968-1980 and 1981-1991. The Number of observations is 26 i.e., 13 for each period. With the financial variables used 17 observations are available. The method of estimation is OLS.

b) The Markup 1 is estimated with a dummy variable for 1981-1991in the original IV panel set. This period separates the turbulent oil shock period of seventies with the one 1980's. At the split stage no dummies are used.

c) Markup 2 is estimated with instruments different to Markup1 and two dummies are used 1974-1980 and 1981-1991 in the original IV. At the split stage only one dummy is used 1974-1980.

d) Markup 3 is calculated with two dummies 1974-1980 and 1981-1991 at the IV stage. At the split stage only one dummy for 1974-1980 is used.

e)Growth and p/E denote per capita output growth and price-earnings ratio.

f) Standard-errors are in parentheses.

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