NBER WORKING PAPER SERIES

THE RIGIDITY OF PRICES

Dennis W. Carlton

Working Paper No. 1813

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
January 1986

I thank NSF and the Law and Economics Program at The University of Chicago for support. I thank Frederic Miller, Virginia France, Larry Harris, Deborah Lucas, and Steven Oi for research assistance. I also thank Claire Friedland and George Stigler for making this data available to me and for assisting me in its use. I thank Edward Lazear, Sam Peltzman, Goerge Stigler and participants at seminars at Stanford, University of Cincinnati, University of Montreal, University of Pennsylvania and University of Virginia for helpful comments. The research reported here is part of the NBER's research program in Economic Fluctuations. Any opinions expressed are those of the author and not those of the National Bureau of Economic Research.

NBER Working Paper #1813
January 1986

The Rigidity of Prices

ABSTRACT

This paper presents evidence on the amount of price rigidity that exists in individual transaction prices. Using the Stigler-Kindahl data, I examine the behavior of individual buyers' prices for certain products used in manufacturing. My most important findings are:

1. The degree of price rigidity in many industries is significant. It is not unusual in some industries for prices to individual buyers to remain unchanged for several years.

2. Even for what appear to be homogeneous commodities, the correlation of price changes across buyers is very low.

3. There is no evidence that there is an asymmetry in price rigidity. In particular, prices are not rigid downward.

4. The fixed costs of changing price at least to some buyers seem trivial. There are plenty of instances where small price changes occur.

5. The level of industry concentration is strongly correlated with rigid prices. The more concentrated the industry, the longer is the average spell of price rigidity.

6. There appears to be a relationship between price rigidity, size of price change, and the length of time a buyer and seller deal with each other.

I interpret the findings as evidence that it is erroneous to focus attention on price as the exclusive mechanism to allocate resources. Nonprice rationing is not a fiction, it is a reality of business and may be the efficient response to economic uncertainty.

Dennis W. Carlton
Graduate School of Business
University of Chicago
1101 East 58th Street
Chicago. IL 60637

I. Introduction

Economists focus on price as a mechanism to allocate resources efficiently. It is well recognized that inefficient resource allocation could occur if prices are not free to adjust. Much of macroeconomics relies on some, usually unexplained, source of price rigidity to generate inefficient unemployment. And in industrial organization there is a large literature on "administered" prices which fail to respond to the forces of supply and demand. Recently, there have been several attempts to develop a theory to explain why efficient resource allocation requires price to be unchanging or "rigid" (Carlton, Hall, Williamson). Whether or not price rigidity is efficient, one common conclusion emerging from models with price rigidity is that markets with rigid prices behave very differently than markets with flexible prices. Therefore, an important unanswered question is just how rigid are prices. Despite the great interest in this question, there have been virtually no attempts to answer it with data on individual transaction prices.

The purpose of this paper is to present evidence on the amount of price rigidity that exists in individual transaction prices. Previous studies of price rigidity have relied almost exclusively on an examination of aggregate price indices collected by the Bureau of Labor Statistics (BLS).[1] The use of BLS data has been strongly criticized

---

1. Research on prices includes the early and important work of Mills (1926), Means (1935), and more recently Stigler and Kindahl (1973) and Qualls (1978).

on the grounds that the BLS data are inaccurate measures of transaction prices. Stigler and Kindahl sought to remedy this deficiency by collecting price data on actual transactions. Stigler and Kindahl then showed that price indices of average transaction prices were more flexible than the BLS price indices.

The difficulty with using indices is that they can mask the behavior of individual transaction prices. For example, suppose that two persons buy varying amounts of commodity A monthly for many years. Suppose that each buyer pays a constant price on each transaction for a period of several years, that when the price to one buyer changes the price to the other buyer is unaffected and that the price rigidity that exists is more pronounced for a downward price movement. All of these facts could be perfectly consistent with a flexible aggregate price index as long as the amount purchased by each buyer varies from month to month. Yet the implication that many draw from a flexible price index, namely that price is allocating resources efficiently, could be completely inappropriate. Moreover, there are several interesting questions that cannot be answered by examining aggregate price indices. For example, how long do prices to a buyer remain unchanged, what is the relationship between contract length and price rigidity, and how closely together do the prices to different buyers move?

Using the Stigler-Kindahl data, I have examined the behavior of individual buyers' prices for certain products used in manufacturing. My main conclusions are:

1. The degree of price rigidity in many industries is significant. It is not unusual in some industries for prices to individual buyers to remain unchanged for several years.

2. Even for what appear to be homogeneous commodities, the correlation of price changes across buyers is very low.

3. There is a (weak) negative correlation between price rigidity and length of buyer-seller association. The more rigid are prices, the shorter the length of association.

4. There is a positive correlation between price rigidity and average absolute price change. The more rigid are prices, the greater is the price change when prices do change.

5. There is a negative correlation between length of buyer-seller association and average absolute price change. The longer a buyer and seller deal with each other, the smaller are the average price change when prices do change.

6. There is no evidence that there is an asymmetry in price rigidity. In particular, prices are not rigid downward.

7. The fixed costs of changing price at least to some buyers seem trivial. There are plenty of instances where small price changes occur.

8. There is at best very weak evidence that buyers have systematic preferences across products for unchanging prices.

9. The level of industry concentration is strongly correlated with rigid prices. The more concentrated the industry, the longer is the average spell of price rigidity.

The most startling finding to me is the very low correlation of price changes for homogenous products across buyers. Some of the theories referred to earlier explain why this is likely to occur, especially for specialized goods. The fact that it occurs for what most economists (though not necessarily businessmen) would regard as a homogeneous product emphasizes how erroneous it is to focus attention on price as the exclusive mechanism to allocate resources. Nonprice rationing is not a fiction, it is a reality of business and may be the efficient response to economic uncertainty. See Carlton (Forthcoming).

Two general caveats deserve mention. First, a fixed price contract for a fixed quantity creates no economic inefficiency in the standard competitive model. If prices change subsequent to the signing of the contract, the buyer incurs a capital gain or loss but his marginal price remains the same as every other buyer as long as the product can be readily bought and sold. However, if either the buyer cannot readily resell his product or if the buyer does not have a fixed quantity contract, then a fixed price may well lead to buyers facing different marginal prices. My understanding of the data I use is that the contracts typically leave the quantity unspecified, so that different buyers paying different prices do indeed face different marginal prices. Although this is inefficient in the standard competitive

model, it need not be under more realistic assumptions that recognize the cost of making a market. But the finding of different prices and price movements to different buyers does emphasize the inadequacy of the simple market clearing model.

Second, the time period I examine is one with relatively low levels of inflation and therefore I have made no adjustment for it. However, even if inflation were rampant and all prices indexed so that no (nominal) price rigidity existed, the main conclusion of the paper would stand. The conclusion is that price alone is not allocating goods and that theories are required to justify what looks like non-market clearing behavior.

This paper is organized as follows. Section II describes the Stigler-Kindahl data and discusses measures of price rigidity. Section III analyzes the characteristics of price rigidity found in several general product groupings. Section IV investigates the relationship between price rigidity, price change and length of buyer-seller associations. Section V examines whether buyers have systematic preferences for price stability across different products. One criticism of using broadly defined product groups as the unit of analysis is that there is so much heterogeneity of products within a single product grouping that results can be biased. Therefore, in Section VI, I redo the analysis for a select group of narrowly defined products. Section VII shows how to measure whether the prices to different buyers move in concert and classifies the various products

according to how similar are price changes to different buyers. Section VIII examines some specific implications the results have for the prediction of price behavior. Section IX examines whether there is any relationship of the various characteristics of price movements to the industry's structural characteristics. Section X presents the conclusion.

II. The Stigler-Kindahl Data

George Stigler and James Kindahl collected data mainly from buyers on actual transaction prices paid for a variety of products. They tried to correct for any explicit or implicit discounting and for any changes in the specifications of the product. Although there is undoubtedly some misreporting of prices, it is the most accurate and comprehensive data I know of on individual transaction prices.

The buyers who report prices are typically firms in the Fortune 500. The identity of the seller is not known. Typically, there is only scant information on quantity purchased, though it is believed that during the course of the reporting buyers were using the product regularly. Ideally, actual transaction prices are reported monthly. However, in several instances, prices are reported less frequently. A decision on how (or whether) to interpolate prices had to be made.

If the price was unchanged between reportings, I assumed that the intervening price was also unchanged. If the price was not the same, then I created two different

series. One method assumed a change in each unobserved month. The other assumed only one change over the entire period. For example, suppose that for January, the price is $10, and for April, it is $20 with missing reports for February and March. The first interpolation approach assumes that the price was $13.30 in February and $16.60 in March (i.e., linear interpolation), while the second interpolation approach assumes that the price changed to $20 in either February, March or April. (It turns out that our results on length of rigidity are unaffected by which particular month we assume for the price change in this second approach.)

The period of observation is January 1, 1957 through December 31, 1966. Few associations between buyers and seller last for the entire 10 year period, a point which we analyze later on. Transactions often take place under "contract" and the length of the contract (e.g., semi-annual, annual) is indicated. Appendix I provides information on the frequency of use of each type of transaction. Many contracts specify neither a price nor quantity. They seem not to be binding legal documents but rather more like agreements to agree.

The commodities chosen for study were preselected by Stigler and Kindahl to contain many that others had claimed were characterized by inflexible prices. The commodities are intermediate products used in manufacturing. Within broad commodity classes, finer product distinctions are made. So, for example, one can examine the general category of steel or a specific product category like carbon steel

pipe less than 3 inches in diameter. Even within fine product specifications, the individual transactions will probably not involve perfectly homogeneous goods. Therefore, I never compare absolute price levels across products but instead look only at percentage changes in price and compare movements in percentage changes in price across buyers.

There are a few instances where price series are believed to be list prices, and those prices have been excluded from the analysis. Also excluded are price series that contain inconsistent information. For example, a series is excluded if the reporter claims to produce prices through 1965 but instead prices only through 1960 appear. For several transactions, the product undergoes a specification change. When this occurs, I treat the prices under the new specification change as a new transaction.

III. Analysis of Product Groups

Table 1 describes the price rigidity present in the individual transaction prices by product group. The first column in Table 1 lists the type of product purchased. The second column lists the number of buyer-seller pairings that are observed for goods of unchanged specification. (One pairing could last anywhere from 1 month to 10 years.) The third column lists the average duration of price rigidity. This last figure is computed as the average length of spell for which price remains unchanged. For example, if the

TABLE 1

PRICE RIGIDITY BY INDUSTRY

Product Group	Number of Buyer Seller Pairings*	Average Duration of Price Rigidity (Months) (Spells)	Standard Deviation of Duration (Months) (Spells)	Average Duration of of Price Monthly Contracts(Months) (Spells)	Average Duration of Price Rigidity (Transactions)
Steel	348	13.0	18.3	9.4	17.9
Non-Ferrous Metals	209	4.3	6.1	2.8	7.5
Petroleum	245	5.9	5.3	2.5	8.3
Rubber Tires	123	8.1	12.0	7.8	11.5
Paper	128	8.7	14.0	8.8	11.8
Chemicals	658	12.8	10.7	9.6	19.2
Cement	40	13.2	14.7	5.6	17.2
Glass	22	10.2	12.1	8.5	13.3
Truck Motors	59	5.4	6.3	3.7	8.3
Plywood	46	4.7	7.7	1.2	7.5
Household Appliances	14	3.6	3.6	2.5	5.9

* A "pairing" means a transaction over time for a good of constant specification.

observations on monthly price were $5, $5, $5, $6, $6, $7, $7, $7, $7, there would be an average rigidity of 3 months. The procedure for calculating an average rigidity actually involves an underestimate since the price before our period of observation may have been $5 and the price after our period of observation may have been $7. Calculations including and excluding the beginning and ending spells were done with no material change in the substantive interpretation of the results. We have reported in Table 1 calculations based on the second method of interpolation of prices (only one price change between missing observations - see previous section) and have included the beginning and the end of each price series. The fourth column reports the standard deviation in the rigidity of prices. The fifth column reports the same estimate of price rigidity as in column (3) except that only "monthly" contract series are used. These series have fewer missing observations than the other types of transactions, hence much less interpolation is needed. If the implication of the numbers in column (3) across commodities differ greatly from those in column (5), one might be suspicious of the interpolation used in column (3). We expect price flexibility of monthly contracts to exceed that of all other contract types, so column (5) really puts a lower bound on column (3).

To avoid misinterpretation of the results, it may be helpful to review a standard issue in duration analysis. Imagine that there are two observed transactions, each lasting for a one year period and each involving the same size

of monthly purchase. The first transaction involves a different price each month, while the second involves the same price each month. There are 13 spells of rigidity, 12 of which last one month and one of which lasts 12 months. Based on spells, the average rigidity is 24 ÷ 13 or 1.8 months with 92% of the spells lasting one month and 8% lasting twelve months. Conditional on a price change just having occurred, the average time to the next price change is 1.8 months. Yet, one half of all goods sold involve a rigid price over the entire period. In other words, holding monthly purchases constant, the analysis based on spells underestimates the fraction of goods sold with rigid prices. The results in columns (3) and (5) utilize spells data. Even though I have no quantity information, I expect based on the foregoing reasoning that this analysis underestimates the fraction of goods sold at rigid prices.

In column (6), I calculate price rigidity using a transaction as the unit of analysis, not a "spell." For each transaction, I calculate the average price rigidity, and then take an average (with each transaction weighted according to its length) over all transactions. Return to the earlier example of two transactions, each lasting one year, but one involving 12 price changes and the other no price changes. An analysis based on transactions (not spells) would calculate average rigidity to be $\frac{1 + 12}{2}$ or 6.5 months. It is that type of calculation that is reported in column (6).

Several interesting facts emerge from Table 1. In several industries, prices are on average unchanged over periods exceeding one year. The degree of price inflexibility varies enormously across products groups. Steel, chemicals and cement have average rigidities exceeding one year while plywood and non-ferrous metals have average price rigidities of less than five months. For any one product group the standard deviation of rigidity is quite high. In fact the standard deviation tends to rise as the average duration of rigidity rises. The simple correlation and the Spearman Rank Correlation between the standard deviation and the average duration (columns (3) and (4)) are both above .80. This suggests (though does not prove) either that each product group presented in Table 1 contains heterogeneous products which differ widely in their price flexibility or that for even a homogeneous product a great heterogeneity in price flexibility is present.[2]

Column (5) shows that using monthly contracts rather than all contracts does not change the basic implications of column (3) regarding relative price rigidity across groups. Column (6) shows that, as expected, the average of price rigidity rises when the unit of analysis is a transaction. Indeed, the results of column (6) are striking in that they show that every product group has an average rigidity in

---

2. An alternative explanation is that price movements for the same product are similar across different transactions at any one instant but not across time. As we will see in Section VII, this explanation will turn out to be incorrect.

excess of roughly 6 months, and that 6 of the 11 product groups have average rigidities of roughly one year or more.

In Table 2, more detailed evidence is provided on the time pattern of price rigidity by product group for three types of transactions. The three transaction types are monthly, in which case the transaction occurred monthly (with no necessary future commitment), quarterly monthly in which case the transaction was monthly but was reported quarterly, and annual in which case the transaction was pursuant to an annual contract. For most product groups, these three types of transactions account for well over 60 percent of all transactions. (See Appendix 1 for a breakdown by product of the various types of transactions that comprise the sample.) One important point to note about these transactions is that an annual "contract" rarely means a price change every 12 months, nor does a monthly "contract" mean a price change every month. Although annual contracts do involve more rigidity than monthly ones, it is incorrect to think of "contracts" as inflexible price rules set at specified intervals. A more appropriate view is that they are flexible agreements that can be renegotiated when and if the need arises.

The results in Table 2 show that, as one would expect from Table 1, the pattern of rigidity across product groups is highly varied. As a general rule, all product groups for each of the three transaction types in Table 2 are characterized by spells of price rigidity that in the majority of cases last less than one year. Some commodities like

TABLE 2
FREQUENCY OF DURATION OF PRICE RIGIDITY FOR VARIOUS TYPES OF TRANSACTION BASED ON SPELLS OF PRICE RIGIDITY.

Product	Type of Transaction	Percent of all Trans-Actions	Number of Pair-ings	0 - 3 Months	4 months-1 Year	1 year-2 Years	2 - 4 Years	Over 4 Years
Steel	Quarterly	53%	185	.34	.26	.18	.12	.09
	Annual	3	11	.11	.41	.24	.22	.03
	Monthly	32	111	.48	.27	.15	.07	.04
Nonferrous Metals	Quarterly	19	40	.61	.29	.08	.02	.02
	Annual	4	8	.16	.69	.12	.03	0
	Monthly	42	87	.78	.20	.02	.01	0
Petroleum	Quarterly	15	37	.74	.23	.02	.00	--
	Annual	27	66	.20	.69	.07	.04	0
	Monthly	7	16	.83	.15	.02	0	--
Rubber Tires	Quarterly	37	45	.34	.48	.11	.04	.04
	Annual	26	32	.19	.72	.07	.01	.01
	Monthly	20	24	.44	.44	.07	.01	.06
Paper	Quarterly	2	3	.17	.42	.29	.08	.04
	Annual	17	22	.04	.69	.18	.08	.01
	Monthly	28	36	.46	.36	.12	.04	.02
Chemicals	Quarterly	11	72	.37	.30	.12	.16	.04
	Annual	43	286	.11	.58	.17	.09	.06
	Monthly	20	134	.53	.27	.09	.06	.04
Cement	Quarterly	50	20	.19	.27	.23	.14	.05
	Annual	20	8	.04	.78	.13	.04	0
	Monthly	10	4	.64	.29	.02	.04	.02
Glass	Quarterly	9	2	.25	.50	.19	0	.06
	Annual	36	8	0	.87	.10	.03	0
	Monthly	41	9	.51	.22	.18	.09	0
Truck Motors	Quarterly	2	1	.21	.57	.21	0	0
	Annual	14	8	.05	.86	.09	0	0
	Monthly	58	34	.69	.26	.04	.01	0
Plywood	Quarterly	96	44	.64	.29	.04	.02	.01
	Annual	0	0	0	0	0	0	0
	Monthly	4	2	.99	.02	0	0	0
Household Appliances	Quarterly	0	0	0	0	0	0	0
	Annual	21	3	0	.82	.18	0	0
	Monthly	57	8	.78	.22	0	0	0

The numbers in rows of the Table may not add to one because of rounding.

Note the "Number of Pairings" is not the number of spells of price rigidity in all contracts. See the discussion preceding Table 1, and the footnote to Table 1.

non-ferrous metals and plywood are characterized by very flexible prices with over 60% of all spells in the monthly and quarterly-monthly category lasting less than three months. On the other hand, there are definitely a substantial number of transactions involving very inflexible prices. For example, in steel, over 39% of the spells of rigid prices in the annual and quarterly monthly category (which comprises over half of all the transactions in steel) last more than one year. Other commodities with important transaction types showing fairly inflexible prices include paper, chemicals, cement and glass. In fact, a histogram analysis based on transactions (not spells) shows that 50% or more of all transactions involving steel, paper, chemicals, or glass, have average rigidities of one year or more.

As one would expect, the annual category involves less price flexibility than the quarterly category which itself exhibits less flexibility than the monthly category. It is also interesting to note that even within a particular product group and transaction type, there is a high degree of heterogeneity in price flexibility. For example, for chemicals monthly, over 50% of spells of rigidity are less than three months, but still a significant fraction (10%) involve spells of rigidity in excess of two years. This suggests that either the products sold are different or, the buyer-seller pairings have different properties, or the method

chosen to allocate (i.e., price versus non-price) is simply different.[3]

One issue frequently raised in discussions of price flexibility is the cost of making a price change (see, e.g., Barro (1972)). There are many types of costs associated with a price change. New price sheets have to be constructed, price information must be conveyed to buyers, buyers may find planning more difficult, buyers may distrust sellers if prices change often, and so on. The real question is how important are these costs. One way to address this question is to see how important small price changes are. Table 3 reports the percent of all price changes that are less than 1/4%, 1/2%, 1% and 2% in absolute value for the same product groups and transaction types reported in Table 2.

Table 3 makes two points. First, very small price changes occur more often in monthly than in quarterly monthly or in annual transaction types. Second, and most important, there are a significant number of price changes that one would consider small (i.e., less than 1%) for most commodities and transaction types. This finding presents a bit of a puzzle if buyers are homogeneous. Either the cost of changing price is small or the costs of being at the "wrong"

---

3. Alternatively, the heterogeneity in spells could arise because supply and demand are changing over time. This last explanation turns out not to provide the full answer, as we shall see in Section VII. Moreover, a table analogous to Table 2, based on transactions, not spells, confirms the heterogeneity across transactions.

TABLE 3
FREQUENCY OF SMALL PRICE CHANGES BY PRODUCT GROUP BY CONTRACT TYPE

Product	Percent of Price Changes less than 1/4%	1/2%	1%	2%	Average Price Change (absolute value)
steel:					
annual	.04	.08	.11	.27	.033
quarterly	.05	.11	.17	.24	.042
monthly	.09	.20	.36	.52	.025
non-ferrous metals:					
annual	.02	.05	.09	.27	.070
quarterly	.02	.05	.12	.25	.050
monthly	.08	.15	.28	.49	.029
petroleum:					
annual	0	0	.08	.24	.053
quarterly	0	0	.02	.17	.054
monthly	.01	.05	.19	.47	.029
rubber tires:					
annual	.12	.21	.30	.44	.030
quarterly	.07	.11	.18	.34	.045
monthly	.13	.23	.38	.63	.023
paper:					
annual	.04	.09	.08	.27	.063
quarterly	0	.19	.24	.33	.036
monthly	.13	.23	.43	.62	.020
chemicals:					
annual	.04	.08	.13	.24	.077
quarterly	0	.05	.11	.24	.073
monthly	.05	.14	.30	.42	.050
cement:					
annual	.14	.22	.32	.46	.033
quarterly	0	0	.01	.19	.041
monthly	.71	.75	.85	.94	.005
glass:					
annual	0	0	.07	.19	.065
quarterly	0	0	.20	.40	.062
monthly	.03	.20	.45	.67	.021
trucks, motors:					
annual	.03	.03	.12	.20	.039
quarterly	0	0	0	.08	.072
monthly	.12	.27	.50	.75	.017

plywood:					
annual	--	--	--	--	--
quarterly	.01	.02	.06	.19	.061
monthly	.19	.38	.54	.72	.019
household appliances:					
annual	0	0	0	.25	.043
quarterly	--	--	--	--	--
monthly	.22	.44	.70	.95	.008

price -- even one off by 1% -- are very high. Yet this explanation would run into difficulties in explaining how it can be that some transactions seem to involve prices that do not change over long periods. Another explanation is that perhaps price does not need to change in those transactions for which prices are unchanging (i.e., neither supply nor demand curves are shifting). This explanation runs into the problem that, as is suggested from Table 2 (and as will be confirmed later on), within the same product grouping there are likely to be changing prices for one transaction at the same time that there are constant prices for another. The only possible explanations consistent with efficiency seem to be either that firms differ in their allocation ability with some firms relying on price more than others or alternatively that every firm must rely more on price when dealing with certain buyers than with others.

The foregoing analysis can also shed light on the question of whether there is an asymmetry in price movements. For example, are prices rigid downward? If prices are rigid downward, then one can think of the fixed cost of changing price as being higher for price declines than price increases. If so, the minimum positive price change should be less than the minimum negative price change. In fact, an analysis of minimum positive and negative price changes reveals no such pattern.

IV. Relationship Between Price Rigidity, Price Change, and Length of Buyer-Seller Association

If within a particular product group, there is a wide degree of heterogeneity in price rigidity across buyers, are there any predictable correlations that emerge between price rigidity, price change, and length of buyer-seller association?[4] There are several different theories of price rigidity and the theories often have different implications for these correlations. We now investigate three questions. First, is there a positive correlation between length of association and price rigidity across transactions for the same product?[5] That is, if buyer A has been dealing with his seller for 10 years, while buyer B is beginning a new relationship, are buyer A's prices more rigid? One rationale for this relationship would be that if buyers and sellers deal with each other over long time periods, they set one average price and thereby save on the transaction cost of changing price constantly. However, it is quite possible to justify the reverse relationship. The

---

4. Length of association is measured as the total time the buyer and seller have engaged in a transaction for a product whose specifications may change over the time of the association.

5. See Table 3A for data by product group on average length of association, average duration of price rigidity and average price change. Correlation of these three variables across product groups is not as good a way of uncovering systematic relationships among these three variables as is correlation of the three variables across transactions for the same product because many factors differ between product groups.

impediment to changing price may be that the buyer or seller may feel the other side is taking advantage of him (see e.g., Williamson). If buyers and sellers have been dealing with each other for a long period of time, it will be in their interest not to take advantage of the other in the short run for fear of damaging the ongoing relationship (See e.g., Telser (1980)). If buyers and sellers know each other well because of their long-standing relationship, this fear of being taken advantage of in the short run will be reduced. In such a case, flexible prices may emerge.

Second, is there an inverse correlation between the size of price change and duration of price rigidity across transactions within the same product group? That is, if buyer A purchases steel on a contract in which price changes frequently, while buyer B has a contract in which price changes infrequently, are the price changes (when they occur) of buyer A larger than those of buyer B? This relationship would make sense if prices are rigid on some transactions because there is a cost to changing price. If so, one would expect that those transactions with the most rigid prices (those to buyer B) have the highest costs of changing price and therefore only large price changes will be observed on those contracts. An alternative prediction would be that some prices are rigid because buyers (or sellers) want price stability for insurance-type reasons. In such a case, price changes on the more rigid contract could well be smaller than on the flexible price contract

since the function of insurance is to smooth out price fluctuations.

The third question we examine is whether there is a negative association between length of association and the size of price change. If buyers' and sellers' distrust of or lack of knowledge about each other explains rigid prices, then the longer the association the lower the cost of changing price and hence the more flexible should be price and the smaller the observed price changes. The opposite prediction could emerge from a theory in which buyers and sellers who deal with each other over long periods care about getting only the average price right. In such a case, we would expect to see rigid prices that infrequently change. When they do change, they will change by larger amounts than prices in less rigid contracts.[6]

Table 4 presents information to address these three questions. Based on Table 4, the relationship between length of association and rigidity is a bit ambiguous. Annual contracts, which have the greatest rigidity, have the shortest length of association. On the other hand, the quarterly monthly contracts, which are more rigid than the monthly contracts, tend to have slightly longer lengths of association than the monthly contracts. Overall, the evidence suggest that, to the extent a relationship exists, it

---

6. This assumes that price changes are motivated by changes in the permanent price component whose changes are assumed larger than the transitory component. The reverse relation between permanent and transitory would flip the prediction.

TABLE 4
CHARACTERISTICS OF CONTRACTS BY TYPE

Product	Type of Transaction*	Average Duration of Price Rigidity (months)	Average Absolute Price Change (%)	Length of Association (months)
steel	A	18.1	3.3	61
	QM	17.4	4.2	119
	M	9.4	2.5	105
non-ferrous metal	A	9.9	7.0	83
	QM	7.1	5.0	96
	M	2.8	2.9	105
petroleum	A	10.3	5.3	73
	QM	4.1	5.4	88
	M	2.5	2.9	94
rubber tires	A	10.1	3.0	84
	QM	10.6	4.5	116
	M	7.8	2.3	119
paper	A	13.7	6.3	76
	QM	14.5	3.6	116
	M	8.8	2.0	112
chemicals	A	16.5	7.7	72
	QM	14.0	7.3	119
	M	9.6	5.0	91
cement	A	13.7	3.5	88
	QM	17.7	4.1	119
	M	5.6	0.5	96
glass	A	13.8	6.5	77
	QM	13.9	6.2	118
	M	8.5	2.1	96
trucks motors	A	11.8	3.9	63
	QM	8.4	7.2	118
	M	3.7	1.7	113

plywood	A	--	--	--
	QM	5.9	5.9	114
	M	1.2	1.2	120**
household appliances	A	14.2	4.3	52
	QM	--	--	--
	M	2.5	0.8	108

*A = annual, QM = quarterly monthly, M = monthly. See Appendix 1 for a description of the various types of transactions.

**There are only two contracts for monthly plywood series.

is likely to be a negative one. Longer associations lead to more flexible prices.

The evidence between rigidity and size of price change is clear in suggesting a positive link. Annual and quarterly monthly contracts, both of which have more rigid prices than monthly contracts, have much larger price changes than monthly contracts.

The evidence between length of association and size of price change is a bit ambiguous. Annual contracts, which have larger price changes than monthly, have shorter lengths of association than monthly. But, quarterly monthly contracts, which have larger price changes than monthly, seem to have about the same or longer lengths of association than monthly. To the extent a relationship exists, the evidence suggests a slight negative association between price change and length of association.

The evidence in Table 4 is based on using contracts grouped into one of three categories (annual, quarterly monthly, monthly) and then seeing whether the annual contracts which have the lowest frequency of change have, for example, the longest buyer-seller association. An alternative to examining correlations across three subgroups is to examine each contract individually and see whether length of association, price change, and rigidity are correlated across individual contracts.

Table 5 reports for each product group the correlations, and indicates when they are statistically significant at the 10% level (*), 5% level (**) and 1% level

TABLE 5
CORRELATIONS OF CONTRACT CHARACTERISTICS

Product	Correlation between: Length of Association & Rigidity	Rigidity & Average Absolute Price Change	Length of Association & Average Absolute Price Change
Cement	.28	.17	.24
Chemicals	.16***	.10*	-.12**
Glass	-.11	.69***	-.24
Household Appliances	-.87***	.71**	-.66**
Non-Ferrous Metals	.12	.12	-.15**
Paper	.03	.20	-.25*
Petroleum	-.25***	-.06	-.09
Plywood	.10	.54***	-.11
Rubber Tires	-.08	.43***	-.27**
Steel	.03	.14**	.01
Trucks, Motors	-.56***	.60***	-.23

*Statistical significance at the 10% level indicated by *, 5% level level by **, and 1% level by ***.

(***). There is clearly not a uniformly positive correlation between length of association and rigidity within all product groups. In fact, a strong positive association exists only for chemicals, while a strong negative association exists for petroleum, household appliances, and truck motors. To the extent any relationship exists, it is a negative one. The second column of Table 5 indicates that there is a positive association between price change and rigidity. All but one correlation is positive, and all seven statistically significant correlations are positive. The third column suggests that there is a negative correlation between length of association and price change. All but two correlations are negative, and all five statistically significant correlations are negative.

In short, the evidence in Tables 4 and 5 is consistent with the following explanation. Buyers and sellers who do not have long associations are more likely to use fixed price contracts because they don't trust each other. The "cost" of changing price on such a contract is to risk creation of mutual distrust. Prices change on these contracts only for substantial price movements. Buyers and sellers who have long associations aren't as worried about mutual distrust. Hence, price changes are more frequent (i.e., less rigid prices) and on average smaller.[7] There can, of

---

7. A model that would generate such results would be one where costs are undergoing a random walk, production is constant returns to scale, and the "cost" of changing price is negatively related to length of association.

course, be other explanations for the results, but the one just given seems to be most consistent with recent theoretical work surveyed earlier.

One common explanation for price (or wage) rigidity has to do with insurance. I have not incorporated that explanation into the one just given for several reasons. First, recent work (e.g., Rosen) casts doubt on the theoretical undergoings of an insurance explanation. Second, large firms should be able to diversify such risks, and hence not need insurance.[8] Third, as we will see in the next section, the insurance explanation does not seem supported by the data.

V. Relationship Among Types of Transactions

Do some buyers seek out stable pricing arrangements in which the price changes infrequently? If so, one would expect to see a correlation in the rigidity of pricing across transactions of different commodities. For example, if the transactions of a particular buyer who purchased steel involved price changing much less frequently than the industry average, will it also be the case that the buyer's transactions involving paper have prices that change less frequently than the industry average?

For the product categories of Table 1, I have calculated for each buyer a vector of the average price rigidity

---

8. This must be qualified by agency theories of monitoring.

for each of the commodities he purchases. I then examine pairs of products to see if there is a correlation across firms in these rigidities, (i.e., does a firm buying steel with overly rigid prices buy paper with overly rigid prices?). There are 227 buyer firms in my sample. There are many fewer (almost 62) who purchase any two commodities. The pairwise correlations were primarily positive, but in most cases the correlations were not statistically significant and were often sensitive to the interpolation method used to calculate price rigidity. The most stable and statistically significant results were the (positive) correlations between price rigidity for contracts in steel and rubber, metals and plywood and rubber, and cement.[9] Because of the instability of the results, these results should be regarded as at best weak support that buyers may have certain preferences across transaction types for different products.

VI. Analysis of Specific Products

One drawback to the analysis of the previous sections is that the product groups may be so broad that a heterogeneity appears in the results which is caused only by the heterogeneous nature of the products in any one commodity group. To remedy this problem, an analysis of 32

---

9. One curious finding is that price rigidity is negatively correlated at a statistically significant level for truck and steel contracts.

specific products was performed. These 32 products were chosen primarily because there were numerous data on them. The products analyzed are listed in Table 6 along with information similar to that presented in Table 1.

The results are similar to those of Table 1 in several respects. As in Table 1, there is wide variation across products in the rigidity of price. Even within a single detailed product specification, there still exists a great deal of heterogeneity in durations of spells of rigidity. The standard deviation of duration rises with the average duration.[10] One is struck by the rigidity of some prices.Even for monthly contracts, there are many products (e.g., chlorine liquid, steel plate) where the average length of a spell of price rigidity is well over one year. And, column (6) indicates that, using transactions as the unit of analysis, most commodities have average durations of price in excess of 8 months.

In Table 7 we present the histograms of price rigidity by commodity for a frequently used contract specification. The pattern that emerges is similar to that in Table 2. Even within detailed product specification for a particular contract type, there is considerable heterogeneity in length of spells of price rigidity. This suggests that the price of a good is changing for some transactions but not for

---

10. The simple and rank correlations of average duration and the standard deviation of duration exceed .9.

TABLE 6
PRICE RIGIDITY FOR
DETAILED PRODUCT SPECIFICATIONS

Product	Number of Buyer-Seller Pairings	Aver.Duration Price Rigidity (months) (spells)	Stand.Deviation of Rigidity (months) (spells)	Aver.Duration of Price Rigidity (months) monthly contracts (spells)	Aver.Duration of Price Rigidity (Transactions)
steel plates	28	18.5	19.4	21.6	20.3
hot rolled bars and rods	33	15.1	17.6	10.6	17.5
steel pipe and tubing (3" or less in diameter)	33	12.1	16.4	12.7	15.9
aluminum wire & cable (bare)	26	3.8	5.4	2.6	4.1
gasoline (regular)	66	6.2	5.7	2.7	8.9
diesel oil #2	75	4.7	4.3	1.4	6.9
fuel oil #2	41	7.3	4.9	4.6	8.3
residual fuel oil #6	59	6.5	6.4	2.9	9.2
container board-fiber board	28	11.6	8.0	11.5	12.6
caustic soda (liquid)	33	16.2	22.9	27.6	21.3
chlorine liquid	28	19.9	18.7	60.0	27.1
oxygen, cylinders	30	16.8	14.6	36.3	21.5
acetylene	22	16.0	16.2	26.4	21.9
portland cement (sack)	28	16.4	16.8	NA	19.0
steel sheet and strip, hot rolled	25	18.6	18.5	NA	19.1
new rail (R.R.)	20	22.1	31.4	17.1	23.2
tie plates (R.R.)	18	21.9	33.0	20.0	23.0
steel wheels "one	25	21.4	22.6	24.0	24.9
track bolts (RR) wear" (RR)	18	14.5	17.4	4.4	17.2
zinc slab ingots	25	21.4	22.6	24.0	5.6
coal (R.R.)	20	6.8	12.2	1.4	15.9
kraft wrapping paper	12	7.5	6.0	5.7	9.2
paper bags	16	9.4	5.3	20.0	10.3
sulfuric acid, bulk	15	14.1	18.7	22.3	20.9
sulfuric acid	19	11.0	17.1	5.1	19.5
methyl alcohol	18	12.3	12.9	17.4	17.8
phthalic anhydride	10	7.2	6.1	6.8	8.3
succinate antibiotic	16	34.4	52.1	57.0	25.4
kapseals antibiotic	16	56.1	66.7	40.0	44.0
meprobanate tablets	16	13.8	12.0	18.7	15.5
librium	13	19.1	23.1	56.0	20.9
plywood	25	3.7	4.8	1.1	6.2

NA means no data available.

TABLE 7
HISTOGRAMS OF DURATIONS OF RIGIDITY BY DETAILED PRODUCT
BASED ON SPELLS OF RIGIDITY

Product/ Transaction type*	0 - 3 Mo.	3 Mo.- 1 Yr.	1 - 2 Yrs.	2 - 4 Yrs.	Over 4 Yrs.
steel plate	.24	.24	.23	.18	.11
hot rolled bars and rods	.36	.21	.21	.16	.07
steel pipe and tubing (less than 3" diameter)	.39	.31	.16	.10	.05
aluminum wire and cable (bare)	.67	.30	.02	0	.01
gasoline (regular)(A)	.33	.59	.05	.03	0
diesel oil #2	.79	.22	0	0	0
fuel oil #2 (A)	.03	.88	.08	.02	0
residual fuel oil #6 (A)	.22	.64	.07	.06	0
container board- fiberboard (A)	0	.73	.19	.06	0
caustic soda (liquid) (A)	.10	.64	.14	.06	.06
chlorine liquid (A)	0	.69	.14	.10	.06
oxygen	.32	.27	.14	.26	.01
acetylene	.37	.24	.15	.21	.01
portland cement (bag or sack)	.19	.32	.24	.14	.05
steel sheet & hot rolled strip	.25	.27	.19	.21	.08
new rail	.53	.07	.16	.06	.18
tie plates	.53	.08	.17	.06	.16
steel wheels "one wear"	.13	.35	.22	.22	.09
track bolts	.27	.34	.23	.06	.11
zinc slat inst	.44	.44	.09	.03	0
coal, for RR	.60	.23	.11	.03	.03
kraft wrapping paper	0	.40	.40	.20	0
paper bags (no A either- so used Mly)	.17	0	.67	.17	0
sulfuric acid, bulk	.68	.18	.08	0	.05
some type of sulfuric acid (A)	.13	.56	.20	.05	.05
methyl alcohol (A)	.38	.38	.15	.07	.01
phthalic anhydride (Mly)	.47	.41	.09	.03	0
succinate antibiotic	0	.30	0	.50	.20
kapseals antibiotic	0	.08	.08	.31	.54
meprobanate tablets (A)	.14	.67	.11	.06	.03
librium (A)	.13	.39	.22	.17	.09
plywood	.73	.23	.03	.01	.01
missing	.16	.33	.28	.20	.06

*A = annual, otherwise quarterly monthly.

others.[11] Table 7 reveals that although most prices do not remain in effect for over one year, for many products (e.g., steel plate, hot rolled bars and rods, oxygen) a significant number (over 15%) of spells of rigid prices remain in effect for over two years.

In Table 8, we present the fraction of price changes that are less than 1/4%, 1/2%, 1% and 2% in absolute value in order to assess the importance of the fixed costs of changing price. Table 8 corroborates the message of Table 3. For most products, there are numerous (over 10%) instances of small price changes (below 1%). This fact reinforces my earlier conclusion that theories that postulate rigid prices solely because of high fixed costs of changing price to any buyer are not supported by the evidence. The most reasonable explanation is that firms and buyers must differ in their need to rely on the price system to achieve allocative efficiency.

An analysis of the minimum positive and negative price changes reveals no tendency for one to exceed the other. Just as in the earlier analysis, there appears to be no evidence to support asymmetric price changes.

In Tables 9 and 10, we present information, comparable to Tables 4 and 5, to investigate the relationship between price rigidity, length of association, and average price change for transactions in the same product. (Table 4A in

---

11. Histograms like Table 7 based on a transaction as the unit of analysis confirms this.

TABLE 8
FREQUENCY OF SMALL PRICE CHANGES

Product	Percent of Price Changes less than 1/4%	1/2%	1%	2%
steel plate	0	1	11	16
hot rolled bars and rods	1	8	13	28
steel pipe and tubing (less than 3" diameter)	4	6	14	27
aluminium wire and cable (bare)	3	5	8	19
gasoline (regular) (A)	0	1	13	27
diesel oil #2	0	0	2	19
fuel oil #2 (A)	0	0	7	22
residual fuel oil #6 (A)	0	0	2	25
container board-fiberboard (A)	4	4	4	12
caustic soda (liquid) (A)	2	5	11	15
chlorine liquid (A)	6	13	17	31
oxygen	0	0	3	14
acetylene	0	10	18	23
portland cement (bag or sack)	0	0	1	19
steel sheet and string, hot rolled	0	2	7	13
new rail	1	3	6	10
the plates	3	5	5	9
steel wheels "one wear"	4	4	10	16
track bolts	1	3	14	16
zinc slab ingots (M)	6	6	11	20
coal (RR)	3	8	18	37
kraft wrapping paper (M)	3	8	20	53
paper bags (M)	0	20	20	60
sulfuric acid, bulk	3	12	34	54
sulfuric acid (M)	1	1	57	76
methyl alcohol (A)	0	15	24	32
phthalic anhydride	0	0	0	0
succinate antibiotic	0	0	0	0
kapseals antibiotic (A)	0	0	0	50
meprobonate tablets (A)	0	0	0	27
librium (A)	0	0	0	14
plywood	1	3	7	18
missing	0	0	3	5

All contracts are monthly, unless followed by an "A" which indicates annual.

TABLE 9
CHARACTERISTICS OF CONTRACTS BY TYPE

Product		Average Duration of a Spell of Price Rigidity (months)	Average Price Change (percent)	Length of Association (months)
1. Steel Plate (011400)				
	A	17.5	2.4	70
	QM	19.7	4.4	119.8
	M	21.6	2.1	108
2. Hot Rolled Bars and Rods (01160)				
	A	18.0	2.7	72
	QM	16.7	4.4	119.8
	M	10.6	1.8	111
3. Carbonsteel Pipe (011710)				
	A	--	--	--
	QM	13.4	5.0	118.5
	M	12.7	2.7	95
4. Copper Wire and Cable, bare (022310)				
	A	--	--	--
	QM	4.7	5.2	58
	M	2.6	2.2	82.5
5. Gasoline (031000)				
	A	8.9	4.6	81.3
	QM	--	--	--
	M	2.7	2.9	98.6
6. Diesel #2 (03200)				
	A	11.2	6.1	60.9
	QM	3.7	4.6	118.6
	M	1.4	2.8	104
7. Fuel Oil #2 (03300)				
	A	11.8	5.1	69.7
	QM	--	--	--
	M	4.6	4.1	104
8. Fuel Oil #6 (034000)				
	A	10.3	5.9	72.2
	QM	4.9	7.7	59
	M	2.9	2.4	77
9. Corrugated Cartons (055010)				
	A	14.4	8.0	77
	QM	18.7	5.7	112
	M	11.5	4.5	78.4

10. Caustic Soda, Liquid (061200)				
	A	16.9	7.7	85
	QM	--	--	--
	M	27.6	10.4	105
11. Chlorine, Liquid (061400)				
	A	17.5	4.6	86
	QM	--	--	--
	M	60.0	3.2	120
12. Oxygen Cylinders (061550)				
	A	16.0	12.1	96.1
	QM	16.6	10.1	118.9
	M	36.3	5.1	109
13. Acetylene (062115)				
	A	20.0	6.1	60
	QM	15.2	7.0	18.8
14. Portland Cement, in bag or sack (071000)				
	A	13.2	1.9	79.3
	QM	17.6	4.1	118.6
	M	60.0	0	60
15. Steel Sheet and Strip, Hot Rolled (011200)				
	A	--	--	--
	QM	18.6	5.9	119.9
	M	--	--	--
16. New Rail (014500)				
	A	--	--	--
	QM	22.5	3.9	115.5
	M	17.1	3.4	120
17. Tie Plates (015000)				
	A	--	--	--
	QM	22.1	4.5	119.4
	M	20.0	4.1	120
18. Steel Wheels "One Wear" (015500)				
	A	--	--	--
	QM	21.3	3.9	118.4
	M	24.0	2.2	120
19. Track bolts (016030)				
	A	--	--	--
	QM	16.8	4.4	118.7
	M	4.4	3.3	120
20. Zinc Slab Ingot (023200)				
	A	--	--	--
	QM	6.9	6.3	118
	M	4.4	4.5	120

21. Coal for RR (02600)				
	A	--	--	--
	QM	8.8	4.5	119.2
	M	1.4	1.4	120
22. Kraft Wrapping Paper (053020)				
	A	21.6	10.9	108
	QM	--	--	--
	M	5.7	2.1	120
23. Paper Bags (053040)				
	A	--	--	--
	QM	--	--	--
	M	20.0	2.4	120
24. Sulfuric Acid, bulk (061100)				
	A	16.8	6.6	100.5
	QM	9.1	2.5	115
	M	22.3	7.3	78
25. Some type of Sulfuric Acid (061110)				
	A	17.0	5.9	104
	QM	--	--	--
	M	5.1	2.0	111.5
26. Methyl Alcohol (062500)				
	A	10.4	6.5	93.9
	QM	--	--	--
	M	17.4	10.4	91.5
27. Phthalic Anhydride (064110)				
	A	--	--	--
	QM	--	--	--
	M	6.8	10.9	103.2
28. Succinate Antibotic (064110)				
	A	35.4	8.5	44.3
	QM	--	--	--
	M	57.0	29.3	85.5
29. Kapseals Antibiotic (064120)				
	A	58.5	7.6	69.1
	QM	--	--	--
	M	40.0	29.3	80
30. Meprobanate tablets (065100)				
	A	13.0	10.7	52.1
	QM	--	--	--
	M	40.0	29.3	80

31. Librium (065200)				
	A	19.7	10.7	50.2
	QM	--	--	--
	M	56.0	--	56
32. Plywood (120000)				
	A	--	--	--
	QM	4.7	6.0	109
	M	1.1	2.8	120
33. Missing (130000)				
	A	--	--	--
	QM	18.4	6.2	59.5
	M	10.0	1.8	80

TABLE 10
CORRELATIONS OF CONTRACT CHARACTERISTICS

Product	Correlation between: Length of Association and Rigidity	Rigidity and Average Price Change	Length of Association and Average Price Change
Steel Sheet & Strip, Hot Rolled (011200)	--	-.40*	--
Steel Plate (011400)	.07	-.11	.27
Hot Rolled Bars & Rods (011600)	-.00	.32*	.26
Carbonsteel Pipe (011710)	-.21	.19	-.32*
Plywood (120000)	.10	.04	-.34*
Missing (130000)	-.34	.14	-.26
New Rail (014500)	.14	.41*	-.64**
Tie Plates (015000)	--	.47**	--
Steel Wheels "One Wear" (015500)	.07	-.33	-.14
Track Bolts (016030)	--	.54**	--
Copper Wire & Cable, bare (022310)	-.06	.76***	-.20
Coal for RR (02600)	--	-.14	--
Gasoline (031000)	.02	.08	-.02
Diesel #2 (03200)	-.74***	-.22	.27
Fuel Oil #2 (03300)	-.20	-.31	.60*
Fuel Oil #6 (034000)	-.12	-.02	-.14
Sulfuric Acid, bulk (061100)	.51**	-.06	-.45**
Sulfuric Acid (061110)	-.52***	.15	.10
Caustic Soda, Liquid (061200)	.35	.58***	.22
Chlorine, Liquid (061400)	.40*	-.00	-.56**
Oxygen Cylinders (061550)	.10	-.17	.07
Acetylene (062115)	.04	.50**	.12
Methyl Alcohol (062500)	.21	.53***	.02
Portland Cement, in bag or sack (071000)	.34	.19	.33

Significance at 10% indicated by *, 5% by **, 1% by ***.

the Appendix presents information by product on average price change and average length of association.) Table 9 suggests a positive correlation between price change and rigidity. Monthly contracts, which often have the lowest rigidity, have the smallest price changes. The evidence on the correlation between rigidity and length of association and on price change and length of association is less clear. The ambiguity arises because monthly contracts typically have less rigid prices, longer lengths of association and smaller price changes than annual contracts, but shorter lengths of association, larger price changes and less rigid prices than quarterly monthly contracts.

A detailed correlation analysis for each product is presented in Table 10 for those commodities with at least 10 transactions.[12] The results mirror those of Table 5. There is, at best, a negative correlation between rigidity and length of association. Of the 20 correlations, only 4 were statistically significant. Two negative correlations were significant at the 1% level, while the positive correlations were significant at the 5 and 10% levels. (However, the number of positive correlations exceeded the number of negative ones.) The evidence on the correlation between price change and rigidity is clearer. Of the nine significant correlations, eight were positive. The number of positive correlations exceeded the number of negative ones. The evidence on the correlation between price change and

---

12. Most correlations involve between 20 to 30 observations.

length of association indicates a negative correlation. Of the six significant coefficients, five were negative. The number of negative correlations exceeded the number of positives.

VII. The Heterogeneity of Price Movements Across Buyers

The previous evidence reveals that price movements across different transaction types for the same commodity may be very different. In this section we investigate in more detail the heterogeneity of price movements for the same commodity. By limiting the analysis to transactions of the same type, we have automatically screened out considerable heterogeneity. Despite this, we will still find a startling amount of heterogeneity. We limit our analysis to annual contracts or quarterly monthly and monthly contracts, depending on the available data. We group price movements from quarterly monthly and monthly together on the grounds that they both represent price series whose prices are not necessarily expected to remain in force for more than one month.

We use two methods to describe how heterogeneous price movements are. The first method measures the difference in the stochastic structure of each price change series while the second attempts to measure correlation in price movements across different transactions.

The first method computes for each individual price series the variance in the percent changes in price (actually the first difference of the log of the price series). A variance σ^2 is computed for each transaction price series. If all the price series have the same stochastic structure this variance should be the same across different price series for the same commodity. For each of the 30 commodities, we present the mean variance (i.e., the mean of σ^2), the variance of σ^2 (i.e., a measure of how σ^2 varies across transactions), and the coefficient of variation (square root of variance of σ^2 divided by the mean).

Table 11 shows that in general the individual price series within any one commodity and transaction type seems to be quite different from one another. The commodities that seem to have the least homogeneous transactions are carbon steel pipe, oxygen, sheet steel, steel railway wheels, and coal.

Another method of characterizing the degree of heterogeneity among price series is to look at the correlation of contemporaneous price changes. A slight extension of this method is to examine the correlation of filtered price series. An example will illustrate.

Suppose two monthly price series are

10 10 10 10 5 5 5 5 7.5 7.5 7.5 7.5, and

10 10 10 5 5 5 5 7.5 7.5 7.5 7.5 7.5

One might be especially interested in seeing how closely the

TABLE 11
MEASURES OF HETEROGENEITY AMONG PRICE SERIES

Product	Mean Variance of Individual Price Change Series	Variances of Individual Price Change Series	Coefficient of Variation
steel plate	1.33 10-6	1.56 10-9	29.7
hot rolled bars and rods	1.73 10-6	3.64 10-9	34.9
carbonsteel pipe	3.31 10-6	2.27 10-8	45.5
wire and cable, bare	1.45 10-5	4.36 10-8	14.4
gasoline	6.22 10.5	1.03 10-6	16.3
diesel #2	1.59 10-5	6.50 10-8	16.0
fuel oil #2 (A)	2.93 10-5	1.02 10-7	10.9
fuel oil #8	2.57 10-5	4.54 10-7	26.2
corrugated cartons	2.94 10-5	5.62 10-9	2.5
caustic soda	5.26 10-5	4.89 10-8	4.2
liquid chlorine (A)	8.48 10-6	6.57 10-8	30.2
oxygen	3.07 10-5	2.49 10-6	51.4
acetylene	6.66 10-6	4.63 10-8	32.3
portland cement	1.97 10-6	4.79 10-9	35.1
sheet steel & strip (hot rolled)	4.64 10-6	1.63 10-7	87.0
new rails	9.95 10-7	1.44 10-10	12.1
tie plates	1.55 10-6	1.43 10-10	7.7
steel railway wheels	9.51 10-7	8.08 10-9	94.5
railroad track bolts	2.87 10-6	4.93 10-9	24.5
zinc slab, ingot	6.21 10-5	7.09 10-8	4.3
coal R.R.	9.15 10-6	1.60 10-7	43.7
sulfuric acid, bulk (A)	5.92 10-5	1.91 10-6	23.3
sulfuric acid (A)	5.54 10-5	9.05 10-7	17.2
methyl alcohol(A)	7.24 10-5	1.55 10-7	5.4
phthalic anhydride	2.78 10-4	1.52 10-6	4.4
succinate (A)	5.42 10-6	3.13 10-8	32.6
kapseals (A)	2.52 10-6	2.77 10-9	20.9
meprobanate tablets (A)	2.59 10-4	3.83 10-6	7.6
librium (A)	6.39 10-5	5.40 10-7	11.5
plywood	2.08 10-5	1.43 10-7	18.2
unknown	5.07 10-6	3.33 10-8	36.0

percent changes in the price series are correlated. The two derived series of percent price changes are

-	0	0	0	-50%	0	0	0	50%	0	0	0
-	0	0	-50%	0	0	0	50%	0	0	0	0

It appears that the two series have no correlation in percent changes. But that conclusion is misleading. Both series change within one month of each other. Suppose that we construct a new series that takes the arithmetic average of the last two monthly percent changes in price. Then we obtain two series that look like

-	-	0	0	-25%	-25%	0	0	25%	25%	0	0
-	-	0	-25%	-25%	0	0	25%	25%	0	0	0

The correlation now will be positive and will equal .5. If we use a three month filter (i.e., average over the last three monthly percent changes in price), the correlation rises to .67. In general, we initially expect correlation to rise as the period of averaging increases (provided price changes within one price series are serially uncorrelated).

Before presenting tabulations of correlations by product for different filter sizes, it will be helpful first to decide what is a "high" or "low" correlation. In other words, we must develop some underlying standard as to how closely two very related series should move. Suppose we adopt the position that two price series that change by

identical amounts within, say, 3 months of each other are "highly" correlated. Let $\rho(F)$ be the contemporaneous correlation of the two price series when averaging over F periods is performed. Suppose that the two series representing percent price changes are identical, are displaced from each other by three months, and that price changes are independent of the preceding price change. Then, it is easy to show that

$$\rho(1) = \rho(2) = 0$$

$$\rho(F) = 1-3/F \quad F > 3.$$

This means that for a filter of size 6, the correlation between our two series is .5, and rises to .75 for filters of one year. In general, we should expect that very high correlations (above .7) will probably be unusual for filters below 12 months, even for "well behaved" price series.

Each of 30 products was analyzed separately.[13] For each product, and for each contract type an average correlation for a particular filter size was computed. For example, suppose that there are 10 individual contract transactions for steel plates, each lasting 10 years. The monthly percent change in price (difference in log of price) was calculated for each series for each month. The simple correlation was computed for every combination of contracts (i.e., 45 pairs) and an average correlation over the 45 pairs was then computed. If the average correlation is

---

13. Some products from Table 9 were dropped because of data incompleteness.

high, it says that on average the price series move together. If the average correlation is low, it suggests that price movements for the same good are only very loosely related to each other. If the low correlation persists as the filter increases to say 2 years, it says that knowing how person A's price has changed over a two year period doesn't help much in predicting how person B's price will change (averaged over the two year period).

In Table 12, I present measures of average correlation for filters of 1 month and 12 months for each of the 30 commodities for selected contract types.[14] As expected, $\rho(12)$ usually exceeds $\rho(1)$. If we use the criterion that correlations on the order of .5 and above represent price series that move pretty closely together, we see that for several products there is a homogeneity of price movements. On the other hand, there are several products like fuel oil no. 2, corrugated cartons, plywood, and several chemical products that have very low (sometimes even negative) correlations even for 12 month averaging. In fact, it is startling to find so many products where it is clear that some mechanism other than price is allocating resources.[15] It is noteworthy that corrugated cartons exhibit low

---

14. Filters of 2 years produced results similar to those for filters of 1 year. Correlations were also calculated on the timing of price changes (i.e., 0 or 1 indicating whether or not a price change occurred) and the same low correlations persisted.

15. Carlton (1979) presents a theory on buyer heterogeneity, which shows how prices to different buyers can exhibit low (or negative) correlations.

TABLE 12
HETEROGENEITY MEASURES:
CORRELATIONS AMONG PRICE SERIES

Product	ρ(1)	ρ(12)
steel plate	.42	.61
hot rolled bars and rods	.42	.60
carbon steel pipe	.16	.25
wire and cable	.53	.78
gasoline (A)	.02	.07
(M)	.04	.30
diesel fuel #2 (A)	.001	.06
(M)	.53	.69
fuel oil #2 (A)	.006	-.03
fuel oil #6 (A)	.02	.11
(M)	.26	.49
corrugated cartons (A)	.14	-.03
(M)	.06	.16
caustic soda (A)	.07	.07
(M)	.04	.36
liquid chlorine (A)	.05	.08
oxygen (A)	.03	.17
(M)	.28	.40
acetylene (M)	.30	.54
portland cement (M)	.15	.21
sheet steel (M)	.40	.44
rails (M)	.81	.94
tie plates (M)	.78	.88
steel railway wheels	.37	.54
railroad track bolts	.47	.62
zinc slab (M)	.52	.90
coal (RR) (M)	.14	.17
phthalic anhydride (M)	.27	.68
sulfuric acid, bulk (A)	.13	.32
sulfuric acid (A)	.10	.07
methyl alcohol (A)	.22	.46
succinate (A)	*0.0	*0.0
kapseals (A)	*0.0	*0.0
meprobanate tablets (A)	.03	-.07
librium (A)	-.02	-.06
plywood (M)	.16	.21

Notes: A - annual contract
M - Prices for monthly and quarterly monthly transactions.
ρ(i) - Correlations of price changes averaged over i months.
* - No price movement in most contracts.

correlations of price, since it is known that quantity rationing is frequently used in the paper industry in place of price rationing.

It is interesting to see whether there is any agreement between the two methods of characterizing heterogeneity in Tables 11 and 12. In fact, there is a low degree of agreement. The simple correlation between the measures of heterogeneity in Tables 11 and 12 is below .1 and is not statistically significant. On the other hand, there is a high degree of statistically significant (negative) correlation between $\rho(1)$ (or $\rho(12)$) and other measures of heterogeneity such as the coefficients of variation for rigidity, price change and length of association. This may imply that the measure in Table 11 is capturing an aspect of price different from the other measures or alternatively that the measure in Table 11 is not a useful one.[16]

VIII. Implications for Price Behavior

Tables 1 through 12 contain a wealth of predictable implications. For example, one could predict the following:

1. The products with high correlations for $\rho(12)$ in Table 12 should tend to have more serial correlation in their annual WPI component than products with low correlations,

---

16. Table 5A reports these correlations.

2. Industry-wide price adjustment for products with high values for $\rho(1)$ in Table 12 should tend to be swift,

3. Price controls on products with long spells of rigid prices (Table 1) are less likely to have harmful efficiency effects than controls on products with short spells of rigidity because non-price methods are probably already used for products with very rigid prices to allocate resources.

I have not systematically investigated these three claims for each of the products listed in Table 12. However, I have done some work (based on available data) to corroborate at least some of the claims for some products. For example, from Table 12 diesel fuel has a $\rho(12)$ of .69 while gasoline has a $\rho(12)$ of only .30. The first- order serial correlation in the WPI for diesel fuel is .70 which, as expected, exceeds that same measure for gasoline (the first-order serial correlation of the WPI for gasoline is .26).

Bordo (1980) has estimated adjustment lags in prices for some of the commodity groups well represented in Table 12, such as metals and metal products, chemicals and fuel. Based on the size of $\rho(1)$ in Table 12, I would predict the speed of adjustment to be fastest in metals and metal products, and the speed of adjustment in fuels and chemicals to be much slower and roughly equal to each other. In fact, Bordo finds the mean lag of price adjustment for metals and metal products to 3.66 months, while the lag for fuels and chemicals are 6.64 and 6.20 months respectively.

Finally, the only evidence I could find on the difficulty of price controls is Galbraith's (1952) A Theory of Price Control which is an account of his experience in controlling prices during World War II when he headed The Office of Price Administration (OPA). Although he does not deal explicitly with all the products in Tables 1-12, he does talk about metal products, which from Table 1 has a high degree of rigidity. Galbraith states (p. 12) "It was commonplace in early OPA experience that the primary metal markets; where sellers are few, were relatively easy to control without formal allocation" and (p. 17) "The Office of Price Administration controlled the price of all steel mill products with far less manpower and trouble than was required for a far smaller volume of steel scrap...it is relatively easy to fix prices that are already fixed."

Although bits of evidence corroborate the predictions for some types of commodities, they obviously are far from conclusive. They do, however, show the value of evidence like that in Tables 1 through 12.

IX. Structural Determinants of Price Behavior

Is there any correlation between industry characteristics and any of the measures of heterogeneity such as those in Tables 11 and 12 (and 5A)? Using 30 of the products of Tables 11 and 12, I correlated the measures of heterogeneity in price movements of Tables 11 and 12 with the following variables:

1. mean absolute growth and variability of price (the higher is this number the higher the expected correlation of price movements)
2. measures of competitiveness
   a) four firm concentration ratio
   b) fraction of shipments beyond 500 miles.
3. growth and variability of total industry shipments.
4. length of buyer-seller association.

Simple correlations never emerged statistically significant (with the exception of the variance of the growth rate in price), though the correlations were generally in the positive direction. However, since only at most 21 observations were available (I separately analyzed monthly and quarterly monthly, and annual contracts), it would be premature to conclude that these structural characteristics don't influence price heterogeneity in the industry.

Is there any correlation between concentration and duration of price rigidity or length of association or average price change? Using 30 of the products in Table 12, I calculated each of those correlations. The only significant correlation was between concentration (four firms) and duration of price rigidity. That correlation was statistically significant at the 5% level and equalled .45. The correlation implies that for every 10 point increase in the four firm concentration ratio, prices remain rigid for an extra

1.5 months.[17] This finding is particularly interesting because it suggests that allocations are performed differently in concentrated and unconcentrated markets. I believe it is incorrect to draw the conclusions, implicit in the work of Means, Burns, Galbraith and others, that the markets have stopped working when they become concentrated. Instead, the proper interpretation is that as firms become large they supplant the market's exclusive reliance on price as an allocation device and resort to other methods. In a world filled with transaction costs, exclusive reliance on a market-generated price to allocate goods could well be inferior to other non-price allocation methods. It is the case, however, that markets that use non-price allocation will respond to market shocks much differently than markets that exclusively use price to allocate. See Carlton ( ) for a fuller development of this theory.

X. Conclusions

Since this paper began with a summary of the empirical results, I will not repeat them here. The main conclusion is that several of the empirical results are sufficiently

---

17. The OLS equation is

$$\text{Av. Duration} = \underset{(3.10)}{5.05} + \underset{(5.76)}{15.43}\ \text{CR 4} \qquad R^2 = .25, \quad SEE = 4.9$$

(standard errors in parenthesis)

where Av. Duration is the average length of a spell of price rigidity and CR 4 is the four-firm concentration ratio.

startling that we should reexamine the central often exclusive role assigned to the price mechanism in theories of efficient resource allocation. It is not that the price mechanism has failed, but rather that alternative allocation mechanisms are used in addition to the price mechanism to achieve efficiency.

B I B L I O G R A P H Y

Barro, R., A Theory of Monopolistic Price Adjustment, Review of Economic Studies, Jan. 1972, pp. 17-26.

Burns, A., The Decline of Competition, 1936.

Carlton, D., A Theory of Rigid Prices, forthcoming.

Carlton, D., Contracts, Price Rigidity, and Market Equilibrium, Journal of Political Economy, Vol. 87, number 5, part 1, Oct. 1979.

Galbraith, J., Theory of Price Control, Harvard University Press, Cambridge, MA, 1952.

Hall, R., The Inefficiency of Marginal Cost Pricing and the Apparent Rigidity of Prices, NBER Working Paper 1347.

Means, G., Industrial Prices and Their Relative Inflexibility, U.S. Senate Document 13, 74th Congress, 1st Session, Washington 1935.

Mills, F., The Behavior of Prices, NBER 1927.

Qualls, P.D., Market Structure and Price Behavior in U.S. Manufacturing, 1967-72, Quarterly Review of Economics and Business, Winter 1978 18 (4) pp. 35-57.

Rosen, S., Implicit Contracts: A Survey, unpublished paper.

Stigler, G. and Kindahl, J., The Behavior of Industrial Prices, NBER 1970.

Telser, L., A Theory of Self-Enforcing Agreements, Journal of Business, Jan. 1980, 53 (1).

Williamson, O.E., Markets & Hierarchies Analysis and Antitrust Implications: A Study in the Economies of Internal Organization, Free Press 1975 New York, NY.

Appendix I

All transactions were classified into one of 10 categories by Stigler and Kindahl. Those classifications were:

annual contract	-	contract in force for one year
annual average	-	average of transaction prices during the year - no contract
annual monthly	-	annual observations of a transaction that occurs monthly
semi-annual contract	-	contract in force for six months
semi-annual average	-	average of transaction prices during six months - no contract
quarterly contract	-	contract in force for three months
quarterly average	-	quarterly observation of a transaction that occurs monthly
irregular	-	irregular
monthly	-	monthly observations of a transaction that occurs monthly

Tables 1A and 2A report the importance of each classification by product group and for individual products.

TABLE 1A

TYPE OF TRANSACTION
(Frequency)

Product	Annual Contract	Annual Average	Annual Monthly	Semi-Annual Contract	Semi-Annual Average	Quarterly Contract	Quarterly Average	Quarterly Monthly	Irregular	Monthly
Steel	.03	.02	0	0	0	0	0	.53	.09	.32
Non-Ferrous Metals	.04	.07	.02	.01	0	0	.03	.19	.22	.42
Petroleum	.27	.03	.02	.38	0	.01	.01	.15	.07	.07
Rubber	.26	.02	0	.01	.01	.02	0	.37	.13	.20
Paper	.17	.09	.01	.21	0	.05	.03	.02	.14	.28
Chemicals	.43	.07	.02	.02	0	.01	.02	.11	.11	.20
Cement	.20	.03	0	.03	0	0	0	.50	.15	.10
Glass	0	0	0	.09	0	0	0	.09	.05	.41
Truck Motors	0	.08	0	0	0	0	0	.02	.19	.58
Plywood	0	0	0	0	0	0	0	.96	0	.04

TABLE 2A
TYPE OF TRANSACTION
(Frequency)

Product	Annual	Quarterly Monthly	Monthly
Steel Plate	.04	.82	.04
Hot Rolled Bars & Rods	.03	.73	.18
Carbonsteel Pipe	0	.82	.09
Copper Wire & Cable, Bars	0	.54	.27
Gasoline	.03	0	.08
Diesel #2	.19	.25	.04
Fuel Oil #2	.27	0	.07
Fuel Oil #6	.31	.31	.08
Corrugated Cartons	.21	.04	.18
Caustic Soda, Liquid	.48	0	.18
Chlorine, Liquid	.75	0	.04
Oxygen Cylinders	.23	.63	.03
Cetylene	.05	.77	.14
Portland Cement-bar or sac	.14	.71	.04
Steel Sheet & Strip, Hot Rolled	0	1.00	0
New Rail	0	.90	.10
Tie Plates	0	.94	.06
Steel Wheels "one wear"	0	.96	.04
Track Bolts	0	.94	.06
Zinc Slat Ingot	0	.22	.44
Coal, for RR	0	.95	.09
Kraft Wrapping Paper	.08	0	.17
Paper Bags	0	0	.06
Sulfuric Acid, Bulk	.53	.20	.13
Some Type of Sulfuric Acid	.47	0	.26
Methel Alcohol	.50	0	.28
Ithalic Anhydride	0	0	.60
Succinate Antibiotic	.50	0	.13
Kapseals Antibiotic	.69	0	.06
Meprobanate Tablets	.63	0	.06
Librium	.69	0	.08
Plywood	0	.96	.04
Missing	0	.94	.06

TABLE 3A
CHARACTERISTICS OF CONTRACTS BY PRODUCT

	Average Length of Association Between Buyer and Seller(Months)	Average Size of Absolute Value of Price Change (percent)	Average Actual Price Change
Steel	105	3.5	.02
Non-Ferrous Metals	86	4.0	.01
Petroleum	87	4.4	-.01
Rubber Tires	98	3.9	0.0
Paper	91	3.4	.004
Chemicals	81	7.0	-.01
Cement	103	3.0	.02
Glass	91	4.2	.00
Truck Motors	82	2.7	.00
Plywood	114	5.0	.01

TABLE 4A
CHARACTERISTICS OF CONTRACTS BY PRODUCTS

Product	Aver.Duration Association between Buyer/Seller (monthly)	Aver.Size Price Change %
steel plates	108	3.8
hot rolled bars and rods	109	3.7
steel pipe and tubing (3" or less in diameter)	114	4.6
aluminum wire & cable (bare)	68	4.4
gasoline (regular)	91	3.3
diesel oil #2	94	4.3
fuel oil #2	89	4.6
residual fuel oil #6	73	5.8
container board-fiber board	78	5.2
caustic soda (liquid)	84	7.8
chlorine liquid	89	5.0
oxygen, cylinders	109	11.5
acetylene	116	6.9
portland cement (by sack)	104	3.7
steel sheet and strip, hot rolled	120	5.9
new rail (R.R.)	116	3.9
tie plates (R.R.)	119	4.5
steel wheels "one wear" (R.R.)	119	3.8
track bolts (R.R.)	119	4.2
zinc slab ingots	104	4.8
coal (R.R.)	119	3.7
kraft wrapping paper	94	4.3
paper bags	88	4.8
sulfuric acid, bulk	96	4.8
sulfuric acid	103	3.5
methyl alcohol	91	7.1
phthalic anhydride	93	11.7
succinate antibiotic	58	8.3
kapseals antibiotic	70	14.9
meprobanate tablets	64	12.1
librium	48	8.6
plywood	110	5.2

TABLE 5A
CORRELATIONS AMONG MEASURES OF HETEREOGENEITY

	CV DUR	CV DP	CV ASSOC.	CV VAR	$\rho(1)$	$\rho(12)$
CV DUR	1	.88*	.41*	-.03	-.63*	-.60*
CV DP		1	.35*	.39*	-.57*	-.66*
CV ASSOC.			1	-.58*	-.47*	-.30
CV VAR				1	.08	-.01
$\rho(1)$					1	.91*
$\rho(12)$						1

Notes: CV DUR = coefficient of variation of duration

CV DP = coefficient of variation of the absolute value of price change (log difference)

CV ASSOC. = coefficient of variation of the length of association

CV VAR = coefficient of variation of the actual price changes counting no change as zero change

$\rho(1), \rho(12)$ = see text for explanation

* = significant at 5% level