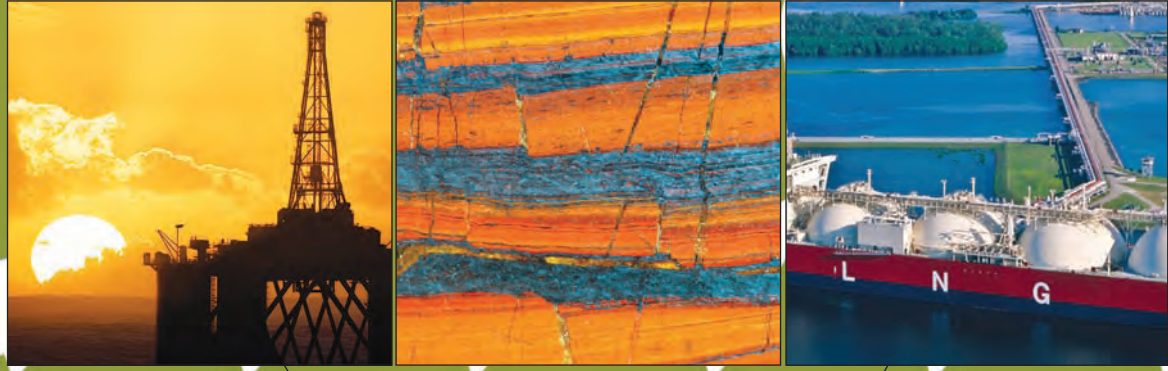


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Rockets and Feathers



Asymmetric Petroleum
Product Pricing in
Developing Countries

Robert Bacon
Masami Kojima

**World Bank Group's Oil, Gas, and Mining Policy Division
Oil, Gas, Mining, and Chemicals Department**

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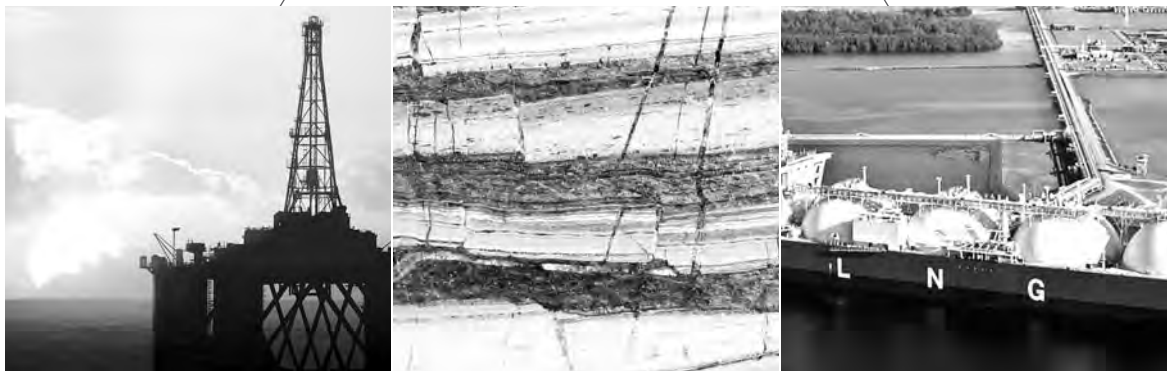
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Cover photos: Oil rig, hematite-banded ironstone, LNG tanker

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Abbreviations

FIFO	first in, first out
HHI	Herfindahl-Hirschman index
LIFO	last in, first out
OECD	Organisation for Economic Co-operation and Development

Executive Summary

At times of high and volatile petroleum product prices, commentators in many countries have suggested that part of the very high retail price of these products is due to lack of competition that allows sellers to increase their profit margins. Supporting this contention, industry observers have noted that the relationship between crude oil prices and retail petroleum product prices appears to exhibit an asymmetric, “rockets and feathers”¹ pattern—when crude prices rise, retail prices follow quickly (like a rocket); in contrast, when crude oil prices fall, retail prices go down more slowly (like a feather). A large literature analyzes this phenomenon in developed countries, mainly the United States, but very little concerns the experience in developing countries. However, recent experiences following high oil price volatility caused commentators in developing countries to suggest that they too were subject to rockets and feathers pricing, and that the government should act to prevent this pricing distortion.

The persistence and pervasiveness of this topic raises a number of important questions for policy makers in developing countries:

1. Are petroleum product margins excessively high at certain times?
2. Does asymmetry of price responses to cost changes exist, and, if so, what are the possible reasons that could account for it?
3. If there is asymmetry of petroleum product price responsiveness, how large is the cost to consumers compared with symmetric pricing?
4. What policies can combat excessive petroleum product margins?

The debate on asymmetric pricing revolves around the idea that if the price is above a level that would emerge in a competitive market (the marginal cost), then there is a welfare loss to consumers. The degree of excessive pricing is measured by the ratio of the margin (difference) between price and cost to the level of price. However, it is often difficult to obtain information on the true costs of supply, and so policy makers

¹This term is used mainly in the literature on petroleum product pricing, although it is occasionally referred to in the literature on other products. The term was first coined in Bacon (1991).

may focus on the number of sellers in the market and their shares in the market. Too few sellers or the presence of one or more firms with large market shares can be seen as pre-conditions for the exercise of market power. There is a link between market concentration (as measured by the Herfindahl-Hirschman index) and the magnitude of any excess price, but this link depends on the exact nature of the pricing strategy followed by the sellers. These links are explained in this study.

A number of theories have been suggested to explain the presence of excess prices, and possibly asymmetric pricing. Factors that allow firms with market power to exploit their position include

- the use of *inventories* to handle demand declines and *prices* to handle large demand increases;
- tacit collusion;
- asymmetric search behavior by consumers, who search for the lowest price more actively following a price rise than a price fall;
- price wars; and
- the presence of menu costs of adjustment that make firms reluctant to change prices when costs change by small amounts.

A considerable number of studies have tested these theories during the last 20 years using a variety of data, covering different time periods, and in different countries. A recent review of some of the leading studies from the United States and the European Union by Grasso and Manera (2007) noted that 16 out of 23 of such studies found evidence of asymmetric pricing. The present paper reviewed another eight studies carried out in developing countries and found statistical evidence of rockets and feathers in all eight countries.

The presence of rockets and feathers pricing imposes an extra cost to consumers compared to the situation of symmetry of price responses to cost increases and decreases. Borenstein, Cameron, and Gilbert (1997) showed for United States data that following either an increase or a decrease of one U.S. cent (US\$0.01), the extra total costs due to the asymmetric pricing to consumers purchasing one unit per period until prices reached a new equilibrium would equal 2.6 cents (US\$0.026). That is, if prices had fallen as fast as they had risen following cost changes of the same magnitude, the consumers would have paid 2.6 cents less under symmetric pricing than they would have paid under asymmetric pricing.

An example of statistical testing for the presence of asymmetric pricing is constructed using data taken from the government of Guatemala's Web site. A preliminary analysis showed that there were several months

during which the international price of refined products (measured in local currency) was falling while the domestic retail price was increasing. Although the variance may be due to the normal working of companies with inventories selling at the prices of the oldest units in stock (first-in-first-out pricing), such behavior could appear to the casual viewer as an example of companies exercising market power at times of cost declines. Statistical testing found no evidence of asymmetric pricing for gasoline, but retail diesel prices adjusted slowly to costs and showed evidence of rockets and feathers. Compared to symmetric pricing, the net incremental cost to the consumer of asymmetric pricing following a cost increase versus decrease of 1 quetzal per liter of diesel would be 2.4 quetzals.

Governments have a number of policy responses to combat asymmetric retail petroleum product pricing and to reduce excessive margins. One option is to ensure that more information be made available to the public on the range of prices paid. This can include better price displays at retail stations and the official collection and publication of data from stations in major population centers, as is now done in a number of countries. Another approach is to remove barriers to entry, especially for firms that would be large enough to have an effect on industrial concentration. An important example of this approach is legislation to ensure that all retail companies and wholesale companies have equal access to sources of supply (storage, pipelines, and refineries) that may be controlled by just one or a few companies that themselves are active in the downstream markets. Although rarely exercised in practice in downstream petroleum markets, a number of governments also have antitrust legislation, intended to constrain the behavior of existing companies where there is strong evidence of excessive prices and implicit collusion. The possibility of the imposition of fines and orders to divest some market share provides strong disincentives for companies to collude and provoke the use of such legislation.

Chapter 1

Background

Periods of high and fluctuating petroleum product prices regularly raise questions of attribution. Many commentators, both lay and professional, have suggested that part of the very high retail price of these products at such a time is due to lack of competition that allows sellers to increase their profit margins.

Supporting this contention, commentators have noted that the relationship between crude oil prices and retail petroleum product prices appears to exhibit an asymmetric, “rockets and feathers” pattern. That is, in countries where retail prices are not controlled by the government, when crude prices rise, retail prices follow quickly (like a rocket); in contrast, when crude oil prices fall, retail prices go down more slowly (like a feather). This tendency has been taken to imply that there has been implicit collusion between companies to increase profits, at least temporarily, by delaying the full price cut warranted by the fall in costs.

Concern with asymmetric pricing has been voiced in many countries and during several high price episodes. Karrenbrock (1991) provided several quotations in the United States made at the time of the gasoline price spike caused by Iraq’s invasion of Kuwait in 1990. Sen (2003) included references to official investigations into anticompetitive practices in Canada and the United States. The analysis of Bacon (1991) noted that the Monopolies and Mergers Commission in the United Kingdom had investigated gasoline pricing for anticompetitive behavior three times and once looked for evidence of asymmetric pricing.

The high oil prices that led to the peak reached in 2008 produced similar reactions. Typical responses were the Attorney General’s Report into gasoline pricing in Alaska (2009) and an investigation into asymmetric pricing in Portugal (International Law Office 2009). Similar reactions have taken place in developing countries, as noted by Kojima (2009a). In 2008, the Cambodian government formed a special committee to assess whether there might be price gouging (Kojima 2009b). Indeed in some countries with liberalized petroleum product markets, there were calls for the government to control oil prices and to repeal

downstream deregulation rules. Many empirical studies in the academic literature test for the presence of asymmetric patterns of retail pricing or petroleum products, mainly gasoline. The majority of these studies relate to the United States or to EU members, but a number of studies focus on developing countries.

The persistence and pervasiveness of this topic raise important questions for policy makers in developing countries:

1. Are petroleum product margins excessively high at certain times?
2. Does asymmetry of price responses to cost changes exist and, if so, what are the possible reasons that could account for it?
3. If there is asymmetry of petroleum product price responsiveness, how large is the cost to consumers compared with symmetric pricing?
4. What policies can combat excessive petroleum product margins?

This paper aims to provide those working in developing countries with a review of the issues that can help address the four questions above. The discussion focuses mainly on liberalized markets, because, in markets subject to price control, the pattern of responses of prices to cost changes will be determined partially or largely by the government. This chapter describes asymmetric pricing and the structure of the oil market, focusing in particular on the links between the retail sector (filling stations) and the rest of the chain of supply. The chapter next briefly reviews types of legislation that exist in liberalized markets to protect consumers from monopolistic or collusive behavior in petroleum products pricing. Chapter 2 describes different types of firms' pricing behavior, including both collusive and non-collusive behavior, and provides an overview of how lags in pricing behavior arise and the reasons they can lead to asymmetry. Following this section on theories, econometric studies testing for the presence of asymmetric pricing are reviewed, with special reference to those studies carried out in developing countries. Based on these models, a sample calculation of the extra costs to the consumer of asymmetric pricing relative to those under symmetric pricing is given, including an illustration based on a specially constructed estimate for Guatemala. Chapter 3 provides an overview of policy responses to asymmetric pricing.

Excessive Prices and Rockets and Feathers

Standard economic analysis suggests that in a market with strong competition among sellers, prices will tend to the level of the marginal cost

of supply. Where there are no market failures due to externalities, this also corresponds to a condition for the optimum allocation of resources. If prices are above this level because of lack of competition and the presence of market power over prices, there is a welfare loss to consumers. One measure of the degree of excessive pricing is the Lerner index, defined as the ratio of the margin (difference) between the price and the cost to the level of price, or $(\text{price} - \text{cost})/\text{price}$. The Lerner index takes its lowest value of zero when the price is equal to marginal cost. As the price increases above the marginal cost, the Lerner index tends toward its maximum value of 1.

Two widely discussed approaches can test for the possible presence of the welfare loss due to prices being far above marginal costs. The first, and more difficult in practice, is to calculate the marginal cost of supply and compare it with the price charged. This requires knowledge of the structure of costs for firms in the industry, and such information is rarely publicly available. The second approach focuses on the number of sellers in the market and their shares in the market. Too few sellers, or the presence of one or more firms with large market shares, can be seen as pre-conditions for the exercise of market power. As discussed below, these market shares and the magnitude of any excess prices may be linked, but the relation depends on the exact nature of the pricing strategy followed by the sellers.

One possible manifestation of excess margins is the existence of rockets and feathers pricing. Some of the literature follows the idea that tacit (or even explicit) collusion among sellers can enable them to make excess profits and hold retail prices up even in times of falling costs. However, more recent studies have suggested that, even with evidence of rockets and feathers pricing, keeping prices high may not be due to collusion but rather to the natural operation of the market where firms have market power.

Two different forms of asymmetry have been discussed in the literature. *Temporal (or pattern) asymmetry* focuses on the time taken to reach a new equilibrium price once costs have changed, and suggests that this time span is greater following a cost fall of a given amount than for an equal cost increase. *Amount asymmetry* refers to the change in the equilibrium price itself being different following equal cost increases or decreases. Geweke (2004) pointed out that even if prices were stationary—that is, fluctuating about a constant mean value—amount asymmetry would imply that upstream and downstream prices would tend to drift farther and farther apart without limit. This argument indicates that analysis

should concentrate on temporal asymmetry since amount asymmetry could not be sustainable.

Structure of the Oil Market and Prices

Understanding the structure of the petroleum product market is a crucial step in analysis of the links between costs and retail prices, because the production chain has several stages. Market power may be exercised at any of these links, and policies would need to focus on which links, if any, are responsible for excessively high prices and rockets and feathers behavior.

The structure of the market has been described by a number of authors (U.S. EIA 1999; Borenstein, Cameron, and Gilbert 1997; Attorney General of Alaska 2009). All consider international crude oil prices as given. Crude oil prices are not set strictly by competitive market forces in that the Organization of Petroleum Exporting Countries meets regularly to set production quotas in the hope of influencing prices. The price of crude oil is quoted in U.S. dollars, and daily quotations are publically available and widely referred to in the media. Other stages in the supply chain are subject to varying levels of competition:

1. Crude oil is transported to a refinery, typically by ship or pipeline, and converted into petroleum products. Petroleum products are internationally traded, with prices for benchmark products quoted in U.S. dollars in major markets for free on board as well as including cost, insurance, and freight. The link between international crude prices and international petroleum product prices depends on the relative demands and supplies of the various products, the prices of which move broadly but not exactly together over time. For example, relative diesel shortages in 2007 and 2008 led to world diesel prices being markedly higher than gasoline prices. A lag between the time of establishing of the crude price and the actual production of products from crude purchased at that price creates the possibility of a lag between the two prices. Refineries have to cover other operating costs (transport, capital, chemicals, labor, and energy) as well as crude costs. Movements in these costs are likely to be gradual and small relative to movements in crude oil prices. In addition, because international prices of both crude oil and refined products are expressed in U.S. dollars, the exchange rate against the dollar is an important additional factor for nondollarized economies: movements in crude or product prices purchased in dollars will imply

- different costs in local currency, depending on movements in the exchange rate.
2. Once refined, petroleum products of the required amount and quality are transported to storage facilities close to the final markets. Transport modes from refineries to secondary storage include marine tankers, pipelines, road tankers, rail, and barges. For countries that have no domestic refining capacity, imported products are purchased in U.S. dollars.
 3. Oil marketing companies usually act as the wholesale distributors. Refined products are delivered by road tanker to the oil marketing companies' affiliated (branded) retail service stations, as well as to bulk consumers—power generation plants, industry, large commercial customers, government agencies, and transport fleet operators such as trucking companies and bus operators. In some markets, oil marketing companies may also deliver petroleum products to independent retailers under supply contract sales arrangements. Oil marketing companies may own the assets used in their operations or outsource most of the road transport activities to independent owner-operators and use storage depots owned by others under throughput fee arrangements.
 4. Retail marketing involves selling gasoline, diesel, and lubricants at service station outlets and selling kerosene and liquefied petroleum gas through other shops. Depending on the arrangements with dealers, oil marketing companies have varying degrees of ownership of the assets of their own network. Nonvertically integrated retailers receive products from wholesalers, while vertically integrated retailers receive products from their upstream operations. The retail price charged includes taxes and costs of retail station operation. In the absence of commercial malpractice—such as short-selling, fuel adulteration, and mislabeling—quality differences are most important for gasoline and diesel. Two retail stations across the street from each other can sell the same grade of gasoline, both fully meeting the fuel specifications but at different prices because of different additives used and the perception by consumers that a particular brand is better than another for keeping the engine cleaner, boosting fuel economy, and so on. Where commercial malpractice is more prevalent, those with a reputation for not engaging in market abuses can charge more for the same product. These factors, which contribute to varying price levels for the nominally same products at the same point in time, make it difficult to identify causes of higher prices.

At all stages in the chain, sellers not only try to recover their costs, but also have the opportunity to increase profits if the market will permit it. Competition among sellers at each stage of the chain is the key factor that limits excess profits. Given that international petroleum product prices are determined in a competitive market, opportunities for excess profits and for rockets and feathers pricing will arise downstream of the international transactions. However, because there may be factors not related to anticompetitive pricing that produce lags of adjustment between the prices at various points in the supply chain, some studies have examined each link for evidence of rockets and feathers. The most common comparison is the international price of crude with the retail price.

Protecting Consumers from Anticompetitive Pricing in a Liberalized Market

Governments that have liberalized the downstream oil sector and that permit companies to charge prices that they see fit nevertheless typically have certain powers that relate to oil price setting (Wisconsin Policy Research Institute 1999; Attorney General of Alaska 2009). Legislation might cover some areas of concern. Antitrust legislation could cover rockets and feathers pricing if it could be shown that the action resulted as a deliberate attempt to raise margins through collusive action. If the pricing resulted from other reasons, antitrust-type legislation would not ban it, but it could still impose a welfare loss on consumers.

Antitrust Laws and Market Concentration

Antitrust laws make it illegal for competitors to engage in any conduct that unreasonably restrains competition, such as colluding to fix prices, or for the competitors to allocate part of the market to a specific group of sellers. Such legislation could also forbid companies from taking actions that are intended to monopolize the industry. The test of these laws is not normally judged primarily by the prices charged but by the associated activities of the companies. In general, governments are rarely able to demonstrate explicit collusion, because firms would be careful to avoid creating evidence that would indicate that they had agreed to collude. Tacit collusion, where actions are taken to achieve the end without explicit consultation among the firms involved, is by its nature difficult to prove. For this reason analysis usually focuses on the structure or conduct of the industry. Cases where the industry is too concentrated or where a potential merger would increase its concentration to some unreasonable level can act as a signal for a more in-depth analysis of pricing

behavior. *Parallel pricing*, whereby all firms increase prices in unison, or *price leadership*, in which one particular firm always leads in new rounds of price changes (thus defining a target level for the industry), may give rise to antitrust investigations.

The concentration of an industry is often measured by the Herfindahl-Hirschman index (HHI)—defined as the sum of the squared shares of market sales over all the firms in the market. The index can range from zero (very many small firms each with a small share of the market) to unity (a single firm).² The United States adopts a range of cut-off points of the HHI for viewing whether a potential merger might lead to excessive market power (see appendix A). An alternative measure of industry concentration is given by the market share of the k largest firms, the k firm concentration ratio (C_k), where k is commonly taken as 4.

Price Gouging Laws

Price gouging laws, as exist in many U.S. states, prohibit sellers from increasing prices above levels ordinarily charged for comparable goods in the same area at times of abnormal market disruption or market emergencies, unless the increase is due to increased costs for reasonable expenses and attendant business risks. This type of legislation would not cover the situation of a sharp increase in international oil prices, so that companies raising petroleum product prices sharply following such an increase would not be price gouging unless the increase was disproportionate to the increase in costs.

Unfair Sales Laws and Predatory Pricing

Some U.S. states have unfair sales acts that prevent the sale of any item below cost for the purposes of attracting business. Some even mandate that retail prices have a minimum markup over wholesale prices. The purpose of such a law is to protect small suppliers from being driven out of business by larger firms using predatory pricing.

Law of Supply

Argentina has a law of supply that provides for fines and imprisonment of executives of firms that fail to supply goods with the intent to create a shortage. This law has been repeatedly invoked against two foreign oil

²The index can also be measured as the sum of the squared percentage shares of the market. In this case it varies between 0 and 10,000. Formulae linking excess pricing to the degree of concentration use the HHI based on shares.

companies and such cases are still with the courts (Kojima 2009; *Economist* 2010).

Divorcement Laws

The European Commission and Argentina have restrictions on the permitted degree of vertical integration, in which one company controls two or more stages in the supply chain (Serebrisky 2003). However, non-vertically integrated industries, where there is market power at different stages, can multiply the welfare loss created (the double marginalization problem where each stage applies its own separate markup). Certain U.S. states limit the deployment of company-oriented stations (affiliates and franchisees) through divorcement laws, and prices have been shown to be higher in states with such laws (Borenstein and Bushnell 2005). This suggests that forbidding vertical integration may lead to higher end-consumer prices.

Chapter 2

Pricing Behavior

In most countries and at each stage of the petroleum product supply chain, the markets do not conform to the textbook model of perfect competition. That is, usually only a few firms compete with each other; if a single firm slightly lowered (raised) its price below (above) all other firms, it would not immediately attract (lose) the whole of its market share. Even in retail markets for gasoline and diesel, where a very large number of individual supply points may operate nationally, the spatial separation of the stations means that each one is likely to have a certain market power. Its customers will not all switch to rival stations if it raises prices slightly, because for some customers the extra cost of travelling to another station, even with a cheaper price available, will be greater than the savings in price. Quality differences, real or perceived, and brand loyalty also enable price differences for the nominally same products—such as 95 research-octane gasoline—to be maintained and some stations to offer consistently higher prices than its competitors.

The ability of firms in a liberalized market to charge prices different from rivals without necessarily either losing all their sales or causing others to lose all their sales leads to a need for strategic pricing decisions. Firms, in deciding their strategies, need to take into account the reactions of their competitors. Several different approaches have been analyzed in the literature. These include cases that ignore rivals' behavior and focus solely on costs; cases where, through explicit or implicit collusion, the firms in a sector act as if they were a monopoly; and cases where the set of reactions of rivals to each firm's price or output decision determines an equilibrium outcome. A group of theories have been developed specifically to take into account the possibility that firms will price asymmetrically.

In a nonliberalized market, it is also possible that government price control is exercised in such a way as to produce a rockets and feathers pattern. If the government hurried to raise prices when costs rose but were slow to reduce them after costs fell, the pattern would look similar to the situation described under private sector pricing approaches.

However, in many countries governments are reluctant to raise prices quickly, for fear of popular resistance, and anxious to reduce them as soon as economically viable. Where governments are able to finance a temporary subsidy or force companies to subsidize consumers, controlled prices could even exhibit an inverse rockets and feathers pattern.

The next three sections discuss monopoly pricing, which is a theoretical limiting case; oligopoly pricing, which can follow a Cournot or Bertrand model as described below; and markup-based pricing, which can exist in both competitive and collusive markets.

Monopoly Pricing

Absent government intervention, a single firm supplying the whole market can choose the price it charges. It will trade off price against sales so as to maximize profit, and it is a standard result of microeconomic theory that this results in a price above marginal cost, implying a welfare loss for society. The margin between monopoly prices and marginal costs is inversely related to the magnitude of the price elasticity of demand—the greater the price elasticity, the smaller the margin. Similarly, the Lerner index is equal to the inverse of the magnitude of the price elasticity of demand (see appendix B). The same results would apply to an industry made up of a few firms that are tacitly or explicitly colluding to maximize joint profits.

Table 2.1 shows the price-to-cost ratio for a firm (or firms) acting as a profit-maximizing monopolist at different values of the elasticity of demand. At low levels of price elasticity, a monopoly is able to price far above costs. A profit-maximizing monopolist will always produce in that section of the industry demand curve where marginal revenue is positive. It can be readily shown that a profit-maximizing monopoly will constrict supply until price elasticity of demand is less than -1 (greater than 1 in absolute value); at a price elasticity of -1 , the ratio of price to cost is infinity.

Table 2.1 Price-Cost Ratio of a Monopoly at Different Elasticities of Demand

Price elasticity	Ratio of price to cost	Lerner index
-3	1.5	0.33
-2	2.0	0.50
-1.5	3.0	0.67
-1.25	5.0	0.80

Source: Authors' calculations based on formulae in appendix B.

If there were a single seller, such a firm would not need to indulge in asymmetric pricing for reasons of profit maximization, because the firm would be able to maximize profits with respect to cost changes at every moment in time. However, there could still be a lag between input and output prices caused by the time dimension of production and procurement.

Cournot and Bertrand Type Pricing

Where there are only a few firms in an industry, each is affected by the reactions of its rivals to its behavior. The simplest models of oligopolistic pricing are based on the original Cournot and Bertrand duopoly cases in a static (one-shot) context. In the Cournot case, each firm chooses its target sales level and accepts whatever price clears the market. Every firm expects no reaction from its rivals to its chosen target sales level. This scenario corresponds to the conjectural variation—a conjecture by one firm about how other firms will adjust their actions in response to an action taken by it—being equal to zero. In this case, there is an equilibrium price set above cost. The Lerner index and the price-cost margin are positively related to the Herfindahl-Hirschman index (HHI) based on industry shares of the firms and inversely related to the magnitude of the industry elasticity of demand (see appendix B).

A Cournot oligopoly will produce in a section of the demand curve where the price elasticity in absolute value is larger than the industry's HHI. For example, an oligopoly in a market with a HHI of 0.3 would supply the market until the price elasticity rises to -0.3 . At that limiting price elasticity, the ratio of price to cost reaches infinity. Table 2.2 illustrates the price-cost margin and the Lerner index for a Cournot oligopoly with different values of HHI and price elasticities. The table shows, for example, that were the industry elasticity of demand to be -1 , while the concentration index were 0.2, the equilibrium price would be 25 percent above costs.

Table 2.2 Price-Cost Ratio and Lerner Index of a Cournot-Type Oligopoly at Different Elasticities of Demand and Industry Concentration

HHI	Price elasticity of demand			
	-2	-1.5	-1	-0.4
0.1	1.05 (0.05)	1.07 (0.07)	1.11 (0.10)	1.33 (0.25)
0.2	1.11 (0.10)	1.15 (0.13)	1.25 (0.20)	2.00 (0.50)
0.3	1.18 (0.15)	1.25 (0.20)	1.43 (0.30)	4.00 (0.75)

Source: Authors' calculations based on formula in appendix B.

Note: Lerner index shown in parentheses.

If, instead, the firms, having identical costs and selling identical products, price according to the behavior of the static Bertrand model, in which each plans a profit-maximizing price based on an assumption about its rivals' prices (the conjectural variations for sales are all negative), then the equilibrium price can be shown to be equal to the cost, and the Lerner index is zero.³ In a more realistic case, firms know that they will be in business not just for one day, but over an indefinite horizon. Decisions taken on one day will affect the decisions their rivals will take not only in the current period but also in future periods. This consideration leads to a wider range of cases in which tacit collusion may arise, as described by Kováč, Putzová, and Zemplerová (2005). Some studies have explicitly tried to establish what sort of pricing regime is being followed in an oligopolistic retail market. For example, Coloma (2002) concluded that, prior to a large merger in the Argentinean retail gasoline market, pricing followed Cournot behavior, but afterwards followed a price leadership approach.

Markup-Based Pricing

Many countries that control retail prices of petroleum products use a formula for price that is built on the basis of a markup over costs. Prices are set equal to the sum of costs plus a margin for profit. All costs, except the cost of the petroleum product itself, are typically assumed to be constant. The formulae may be revised from time to time to reflect changes in other costs—such as the cost of transporting fuels, which would move with world oil prices—but these are seen to be much less important than changes in the price of oil or petroleum product used as inputs. Costs should include capital as well as operating costs so that a firm covering such costs would make sufficient profit to stay in business.⁴

This suggests that pricing in liberalized markets might also be reasonably well described by a markup approach. In this case changes in retail prices (net of taxes) would move in parallel with changes in the prices of petroleum products ex-refinery (whether domestically produced or imported). When firms merely pass on costs in this way and

³Each firm would plan to undercut its rivals so as to obtain the whole of the market, providing that the price it sets will cover costs. If all firms price in the same way, then the equilibrium industry price will be where price is set equal to costs. The conjectural variations with respect to price are zero, so that one firm thinking to lower its price will expect its quantity sold to increase and its rival's quantity sold to decrease.

⁴The markup approach implicitly assumes that the various stages of the industry enjoy constant returns to scale so that long-run marginal and average costs are constant.

do not attempt to set prices with a view to increasing market share or expect others to do so, then the margin for each firm will remain constant. However, all firms may be making excess profits if the margin were greater than that required to cover all costs and a normal profit margin. The markup model can be consistent with a competitive market or with a noncompetitive market with tacit collusion.

There are some qualifications:

1. Crude and imported petroleum products are priced in dollars so that changes in the exchange rate will also be reflected in changes in domestic prices under a markup scheme. This does not of itself introduce a lag if exchange rates are taken into account, but failure to do so may introduce the appearance of a lag at times when exchange rate movements are lagged behind international oil price movements.
2. Taxes on petroleum products usually include excise duties, which are typically a fixed amount and altered infrequently, and sales taxes, which change in proportion to the input costs. Depending on the tax regime, there may not be a simple markup relation between costs and retail prices.
3. When inputs are purchased some time before they are sold (or, in the case of refiners, converted into output and sold), a lag between the input cost and the output price may occur. This depends on the pricing strategy and inventory management as explained below.

At all stages of the supply chain, firms have inventories of goods to sell in order to meet unexpected surges in demand or to continue to sell to customers when supply to the firm itself is disrupted. Refiners hold inventories of inputs (crude oil) as well as outputs (refined products). Because input prices can change almost continuously and by large amounts, the average price at which inventory has been purchased does not correspond to the current price of input supply. Depending on the firm's pricing policy, this fluctuation can introduce a regular lag between input costs and output prices. The pricing approach may also be linked to the accounting valuation that is used for inventory in making tax returns and statements to shareholders. First-in-first-out (FIFO) sets the output price according to the cost of the oldest unit in the inventory and introduces a lag proportional to the ratio between the size of the inventory and the level of sales. The average-cost approach prices output according to the average purchase cost of the inventory held

and introduces a lag about half as long as that of FIFO pricing.⁵ The lag introduced by FIFO pricing would not produce asymmetric responses to cost increases or decreases unless the ratio of inventory to sales changed over the price cycle. Companies making normal profits or making excessive profits could price according to FIFO principles. In cases where the level of inventory is large in relation to sales, FIFO pricing can result in a substantial lag. For example, in southeast and western Alaska, where fuel is supplied by barge with just a few large deliveries of fuel per year, price lags of several weeks or even months have been reported (Attorney General of Alaska 2009).

In summary, markup pricing can be used by companies in both competitive and collusive markets, and either case could experience lags in the pricing process. However, a pure markup approach is not likely to introduce asymmetric pricing.

Lags in Price Setting in a Noncompetitive Market Structure

Several possible explanations for lags between prices at different stages of the oil supply chain have been suggested. These models all imply that firms have market power.

- 1. Asymmetry introduced by the limited size of inventory.** Firms with market power holding an inventory of products to sell may have asymmetric responses to unanticipated decreases and increases in demand. Borenstein, Cameron, and Gilbert (1997) suggested that an unexpected fall in demand causes firms to cut production and sell from inventory, resulting in the need for only a small decrease in price initially. In contrast, an unexpected increase in demand cannot be met quickly from production or safely from inventory (because of its limited size) so that an increase in prices is used to dampen down the demand increase. This results in asymmetric pricing. This behavior is possible only with a noncompetitive structure and market power; in a competitive market, firms would not be able to hold prices up if demand, input costs, or both are falling.
- 2. Focal price and oligopolistic coordination.** Borenstein, Cameron, and Gilbert (1997) introduced an alternative explanation for asymmetric pricing that drew on a feature of noncompetitive markets.

⁵Last-in-first-out (LIFO) prices output, and values inventory, at current input prices so that there is no lag between input and output prices.

Firms have imperfect knowledge of rivals' prices and costs and are cautious about giving misleading signals about their own intentions. When input prices fall, the former output prices, established before the drop in input costs, become a focal point for any price changes. Firms are reluctant to cut their own prices in case other firms interpret this action as a price war to gain market share. A firm will reduce its price only if there is a significant drop in sales, indicating that other firms are cutting prices. Hence, prices will tend to stay near to the original price for some time even though costs are falling. Conversely, an increase in input costs will trigger an immediate price response since this will not be interpreted as breaking ranks to hold prices above costs, and margins would decrease otherwise. This behavior generates asymmetric pricing, but this explanation is silent on how the original output price is set.

3. **Asymmetric search behavior.** A third hypothesis put forward by Borenstein, Cameron, and Gilbert (1997) is that, because of the volatility of oil prices and retail prices, consumers find it difficult to assess the full market picture. When prices rise, consumers tend to search for sellers with lower prices, thus putting pressure on rivals to stay in line. However, when prices fall, consumers tend not to devote as much effort searching for even lower prices, which allows firms to temporarily increase their margin by not reducing prices as fast as costs.
4. **Edgeworth price cycles.** Noel (2007) explained cyclical price behavior observed in certain Canadian cities on the basis of price wars between retail stations. On the downward part of a price cycle, firms repeatedly undercut each other by small amounts in order to increase market share. When the price reached marginal cost, each firm considered raising its price substantially—there was then a war of attrition as each waited for the other to react first. Once one did, the others followed to the top of the cycle, following which the undercutting began again. This asymmetric cyclical pattern was not driven by cyclical changes in costs but rather by the attempt to increase profits.
5. **Menu costs.** The process of adjusting prices carries some costs and, where these costs are significant, firms will not wish to change prices too often. As firms wait to adjust their prices, a lag between an initial cost change and the resulting price change can result. Menu costs as a reason for introducing lags require that the industry be monopolistic or that there be firms with market power.

A model of pricing based on menu costs was described by Apslund, Eriksson, and Friberg (2000) in the case of a fixed cost to changing prices. This threshold (S, s) model assumed that, for cost changes greater than some threshold S , firms would increase prices, and that for cost decreases larger than s , the firm would cut prices. For cost changes within the range s to S , the firm would leave prices unchanged. This model gave rise to sticky prices. If S and s were not symmetric about zero, it could give rise to the appearance of asymmetric pricing. Some have argued that menu costs for retail petroleum products are very small—mainly altering price lists at stations—and unlikely to introduce a lag of any significance.

Governments also may have a direct effect on the shape of retail price responses to cost changes. Governments would prefer petroleum product prices not to rise very rapidly, and they may put pressure on private sector companies not to increase prices to the full extent justified by cost changes following sharp increases in world oil prices. Recognizing a government's aversion to large rapid price increases, companies may be reluctant to cut prices when world oil prices fall, because they fear they will face (or they have in the past faced) tacit pressure from the government not to increase prices when costs rise. Depending on the strength of these two factors, the shape of price responses to cost increases or decreases could produce a rockets and feathers pattern (thus transferring money from consumers to themselves) or an inverse pattern that transfers money from themselves to the consumers. In this case caution must be exercised in attributing observed price patterns to particular models of oligopolistic firm behavior.

Evidence on Rockets and Feathers Pricing

A very large number of studies address rockets and feathers pricing for petroleum products, with a quick Internet search suggesting 200 or more papers on the topic. The great majority of these papers concern gasoline in the North American market. A minority of these studies are based on European countries, and just a few have extended the analysis to other petroleum products. Many researchers review selections of earlier studies relevant to their own approach. A brief overview of this literature is presented before turning to the small group of studies focusing on developing countries that have not been highlighted hitherto.

Shin (1994), Geweke (2004), Radchenko (2005), Grasso and Manera (2007), and Deltas (2008) reviewed earlier studies and found that they

were divided in their findings. Some claimed to have found evidence of asymmetric pricing, while others found no statistically significant evidence. One feature of these studies was that the statistical basis of testing differed substantially among them. The time periods examined also differed considerably, covering episodes of very different behavior of crude oil prices, and hence of expected prices downstream. Sources of differences arose from a number of aspects:

1. **Aggregation over time.** Studies ranged from using monthly average prices to daily prices. Investigations of lags of different lengths may benefit from using the most disaggregated time unit available. Lengthy time intervals may even conceal important movements within the period.
2. **Aggregation over space.** Earlier studies tended to use aggregate national, state, or city-level time series data. Differences between cities or even between stations in pricing behavior (lag lengths and degree of asymmetry) may be blurred at higher levels of aggregation. More recent studies have introduced the use of station-level data.
3. **Model specification.** Two aspects of model specification have produced considerable variation between studies. The actual dynamic form of the model and lags to be used are critical, as explained by Geweke (2004). Different studies have added explanatory variables related to the causal hypothesis under investigation other than the input prices, and their omission or inclusion may change the findings. The majority of such studies are constructed around an error correction mechanism as explained below.
4. **Econometric estimation.** The technique of econometric estimation utilized has also varied among studies. In particular, the treatment of dynamic responses requires investigation of the properties of the input and output price series before a model using them can be appropriately estimated. An outline of the general approach to econometric estimation is given in appendix C.

Shin (1994) reviewed earlier studies and illustrated some aspects of issues in testing for asymmetric pricing by standardizing different approaches taken by different authors for a common set of data. He concluded that the studies reviewed, once re-estimated on a common data set, common period, and by a common model, did not show evidence of asymmetry between crude oil and wholesale gasoline prices, or between wholesale and retail gasoline prices.

Nevertheless, many later studies of the U.S. gasoline market have found evidence of asymmetric pricing. Borenstein, Cameron, and Gilbert (1997) came to the conclusion that there was an asymmetric lag between crude oil and retail gasoline prices, with small contributions at various stages of the supply chain. The studies reviewed by Radchenko (2005) included several that claimed to have identified asymmetric pricing in the U.S. gasoline market. Grasso and Manera (2007) reviewed 23 studies from countries belonging to the Organisation for Economic Co-operation and Development (OECD), and found that 16 had identified significant evidence of asymmetric pricing.

Johnson (2002) tested separately for asymmetric pricing at retail for gasoline and for diesel in the United States. He found that diesel prices responded more rapidly to changes in input costs and with less asymmetry than was the case for gasoline. This finding, based on a search model of consumer behavior, attributed the difference for diesel to the fact that the typical purchaser of diesel is a commercial operator that made larger purchases and was therefore more willing to search for lower prices. This reduced the ability of stations to price asymmetrically in response to input cost increases and decreases. Liu, Margaritis, and Tourani-Rad (2010) came to the opposite conclusion for the New Zealand market: diesel prices showed evidence of asymmetry while gasoline prices did not. The authors explained these results with evidence that the gasoline market was more competitive, with smaller margins, than the diesel market.

Kaufman and Laskowski (2005) applied an inventory/production adjustment model to the U.S. gasoline and home heating oil markets. They found no evidence of asymmetric pricing for the gasoline market in reaction to cost changes, but found statistical evidence of asymmetric pricing for the home heating oil market. The authors noted the existence of long-term contracts between heating oil consumers and retailers that greatly increased the transaction costs of searching and switching to suppliers with lower prices, thus leading to stronger possibilities for asymmetric pricing.

A number of recent studies have used station-level data in order to give the most direct insight into the factors determining pricing at retail. Due to locational and other advantages, market power differences may be largest at the station level, potentially leading to the clearest evidence of asymmetric pricing. Verlinda (2008) used weekly station prices for a geographically contiguous group of nearly one hundred stations in California between July 2002 and May 2003 (a period with two large price cycles) and showed that stations with greater market power

exhibited greater price response asymmetry. Hosken, McMillan, and Taylor (2008) analyzed weekly panel data for 272 stations over a three-year period in the Northern Virginia suburbs of Washington, DC. They found that, while the data were consistent with asymmetric pricing, the stations did not consistently pursue rockets and feathers pricing. One important finding was that retail margins changed substantially over time, suggesting that the distribution of prices across stations shifted. Further, some stations switched from being “high price” to being “low price,” or vice versa, suggesting that stations changed their pricing strategy over time. The authors compared their findings to a variety of models of pricing behavior and concluded that, while each theory was consistent with certain of the empirical findings, none provided a complete explanation for the observed price dynamics.

A smaller number of studies have been carried out for European countries. Grasso and Manera (2007) used monthly data for the period 1983 to 2003 for France, Germany, Italy, Spain, and the United Kingdom to analyze the links between crude oil prices, ex-refinery gasoline prices, and the net-of-tax retail price. Three different econometric models were estimated, all based on an error correction mechanism. Although some evidence of asymmetric pricing behavior was found, asymmetry was not consistently demonstrated across countries or across models. Bettendorf, van der Geest, and Varkevisser (2003) investigated the Dutch retail gasoline market using daily data and were not able to identify a consistent pattern of asymmetry. Apslund, Eriksson, and Friberg (2000) looked at the Swedish retail market using daily prices. The period studied (3 months in 1995) was characterized by infrequent but sizeable retail price changes, while costs changed much more frequently. Using the (S, s) threshold model they found that price adjustments were stickier in the downward direction, taking longer to react.

For developing countries, only a few studies of product pricing behavior have been published, but they are of considerable interest because these markets may be very different from those in the United States and Europe. Antitrust legislation and enforcement may well be weaker, while the smaller local markets may give greater opportunities for the exercise of market power by a limited number of suppliers at each stage of the petroleum product chain. The main features of these studies are summarized in Table 2.3 using the same format as Grasso and Manera (2007); the table includes all studies identified. Some of the studies analyzed the reasons why asymmetry of pricing appeared to exist, while some stopped at providing econometric evidence of asymmetry.

Table 2.3 Studies from Non-OECD Countries on Asymmetric Pricing

Study	Country	Time period	Data period and type	Linked series	Petroleum product	Asymmetry
Mercuri (2001)	Argentina	1993–2001	Weekly, aggregate	Crude oil to retail	Gasoline	Yes
Salas (2002)	Philippines	1999–2002	Weekly, aggregate	Crude oil to retail	Gasoline	Yes
Vasquez (2005)	Peru	1996–2003	Monthly, aggregate	(i) Crude oil to wholesale (ii) wholesale to retail	Diesel	Yes
Bakytzhanova (2005)	Russia	2002–2004	Weekly, panel	Wholesale to retail	Gasoline	Yes
Bakytzhanova (2005)	Kazakhstan	2003–2004	Weekly, panel	Wholesale to retail	Gasoline	Uncertain
Rao and Rao (2006)	Fiji	1997–2004	Quarterly, aggregate	Crude oil to retail	Gasoline	Yes
Hofstetter and Tovar (2008)	Colombia	2003–2006	Monthly, panel	Wholesale to retail	Gasoline	Yes
Balmaceda and Soruco (2008)	Chile	2001–2004	Weekly, panel	Refinery to retail	Gasoline	Yes
Alper and Torul (2009)	Turkey	1991–2007	Monthly, aggregate	Crude oil to retail	Gasoline	Yes

Source: Authors.

Using monthly data between 1996 and 2003, Vasquez (2005) studied diesel in the wholesale and retail markets in Peru and found price asymmetry in both markets. Rao and Rao (2006) found evidence for asymmetric pricing for gasoline based on quarterly data in Fiji. Salas (2002) analyzed weekly data for the retail gasoline market in the Philippines between 1999 and 2002, and found evidence of asymmetric pricing with respect to movements in the price of crude oil. A feature of the data was that retail prices were also sticky—during the 3-year period studied, major firms changed prices only 45 times and other firms changed prices only 35 times. This suggested that costs need to change by some threshold amount before retail prices change.

Bakytzhanova (2005) investigated weekly company-level data for the period 2002 to 2004 and found evidence of pricing asymmetry in Moscow and some limited evidence for asymmetry in Astana. Changes in market concentration were not significant in explaining pricing behavior, but the number of firms in the market and the degree of oil price volatility were both associated with the degree of asymmetry found. Mercuri (2001) found evidence of asymmetric pricing of retail gasoline with respect to crude oil prices in Argentina using monthly data between 1993 and 2001. Hofstetter and Tovar (2008) examined monthly data between 2003 and 2006 on a panel of retail stations in 10 cities in Colombia and found evidence of pricing asymmetry of retail gasoline with respect to changes in wholesale prices. They attributed the appearance of asymmetry to the nature of search behavior of consumers based on the way in which they formed expectations about retail prices. Balmaceda and Soruco (2008) analyzed weekly data between 2001 and 2004 for Chile and found evidence of asymmetric pricing of retail gasoline with respect to changes in the ex-refinery price. They argued that evidence of collusive behavior partly explained this finding. Using monthly data for Turkey from the period 1991 to 2007, Alper and Torul (2009) found evidence that the retail prices of gasoline and diesel showed asymmetric pricing behavior with respect to changes in the price of crude oil. Because they analyzed prices inclusive of tax, they were able to show that in Turkey—which has extremely high retail prices—much of the asymmetry was due to the way in which the government changed tax rates in response to increases or decreases in the cost of oil.

Estimating the Costs to the Consumer of Asymmetric Pricing

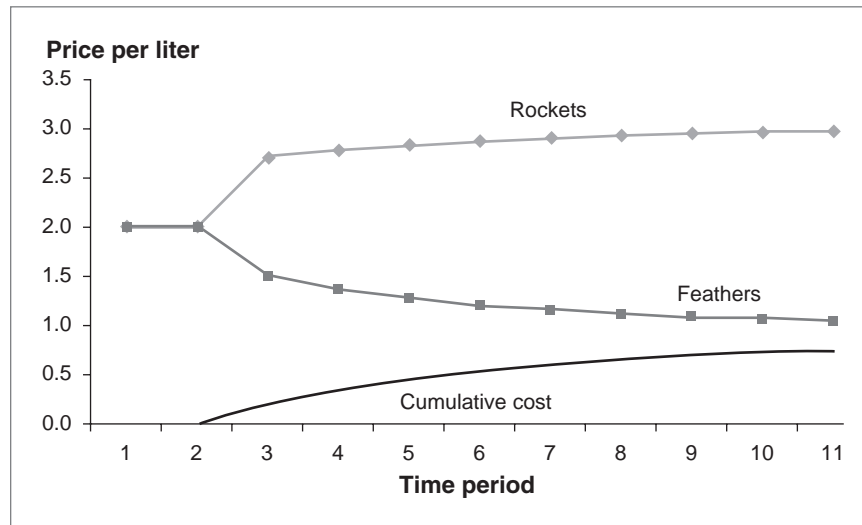
Most studies have demonstrated only the evidence for asymmetric pricing and have not used the findings to estimate the associated consumer costs.

Because the motivation for studying the potential existence of asymmetric pricing is the extra consumer cost imposed, a few studies have estimated this effect. Researchers have developed two different approaches to assess these costs. Borenstein, Cameron, and Gilbert (1997), Geweke (2004), and Balmaceda and Soruco (2008) discuss, for various dynamic models, how to calculate the cumulative response function for each period following the initial cost change, where the cumulative response function is the accumulated predicted price change up to a given point in time.

For example, Borenstein, Cameron, and Gilbert (1997) simulated the effects of a 1-unit increase in costs and a 1-unit decrease in costs, starting from the same initial situation. They used one-time increases or decreases—that is, the cost changes by 1 unit and stays at this new level so that subsequent cost changes are zero. Using their dynamic model, it was possible to determine the change in the output price relative to the previous period for all future periods until such a change was zero and the final price had converged to a new equilibrium. Adding the sum of such changes yielded the cumulative change in output price at each time period. The cumulative price change for the cost increase was compared with the cumulative price change for the cost decrease, period by period. This sum gave the extra amount the consumer would have paid in that period due to pricing asymmetry. Adding together these differences for all periods until the final prices converged gave the total cost to the consumer caused by the asymmetry. Another way to view this calculation is to see it as the total extra cost paid by the consumer following a 1 unit permanent cost fall if prices followed a feathers path down compared to a path down that changed as fast as the rockets path. For data the authors analyzed, the incremental cost per liter purchased per period caused by rockets and feathers pricing amounted to 2.6 U.S. cents (US\$0.026) following a cost increase or decrease of 1 cent (US\$0.01).

Figure 2.1 illustrates the concepts used in this type of calculation. Prices are assumed to adjust according to an error correction model. The increment in prices in a period is a fraction of the change in costs in that period, plus a fraction of the extent to which prices were out of equilibrium with costs in the previous period. In the figure, prices are initially in equilibrium with respect to costs at a level of 2 per unit. A positive cost shock of 1 unit produces the series of price adjustments increasing toward a final equilibrium of 3 per unit, while a negative cost shock of 1 unit produces a series of price adjustments falling toward a new equilibrium of 1 per unit. The adjustment speed is greater for the positive

Figure 2.1 Paths of Rockets and Feathers Pricing Following Equal Positive or Negative Cost Changes



Source: Authors' calculations.

shock, producing prices that rapidly approach the final equilibrium (the rockets path), while the slower adjustment speed for an equivalent fall in cost produces a slower move toward the new lower equilibrium (the feathers path). In each period, these changes add to the sum of costs to consumers facing price increases or reductions. The cumulative effect of these sums until the new equilibrium is reached is the extra cost to the consumer of the asymmetric pricing. In effect, this calculation derives the overpayment by consumers if the price fall followed the feathers path rather than a downward path mirroring the rockets path. Had there been symmetric adjustment, the cumulative sum of cost changes would have been equal to zero.

Table 2.4 illustrates the period-by-period adjustment of prices following initial cost changes of +1 and -1 for the model described in Figure 2.1. For example, in period 2, prices would increase by 0.7 to a level of 2.7, or decrease by 0.5 to a level of 1.5. The sum of the two changes is +0.2 and this is the extra the consumer pays in period 2. In the next period, prices either increase by a further 0.075 units to 2.775 units, or decrease by 0.125 units to 1.375 units. The sum of the incremental price changes following the cost increase is 0.775, while that following the cost fall is -0.625. The sum of these two effects is 0.150, this being the extra amount the consumer pays in period 3. The cumulative

Table 2.4 Rockets and Feathers Changes in Prices Following Cost Changes

Period	Rockets price path	Incremental rockets price	Feathers price path	Incremental feathers price	Sum of incremental price changes	Cumulative incremental price changes
1	2.000	0.000	2.000	0.000	0.000	0.000
2	2.700	0.700	1.500	-0.500	0.200	0.200
3	2.775	0.075	1.375	-0.125	0.150	0.350
4	2.831	0.056	1.281	-0.094	0.113	0.463
5	2.873	0.042	1.211	-0.070	0.084	0.547
6	2.905	0.032	1.158	-0.053	0.063	0.610
7	2.929	0.024	1.119	-0.040	0.047	0.658
8	2.947	0.018	1.089	-0.030	0.036	0.693
20	2.998	0.001	1.003	-0.001	0.001	0.797
∞	3.000	0.000	1.000	0.000	0.000	0.800

Source: Authors' calculations.

Notes: Initial shocks are equal to +1 or -1. The adjustment coefficients are $\beta^+ = 0.7$ and $\beta^- = 0.5$, $\gamma = 0.25$. See appendix C for definitions of the adjustment coefficients.

Table 2.5 Cumulative Costs of Rockets and Feathers Pricing Following One Unit Changes in Costs

β^-	$\gamma = 0.75$	$\gamma = 0.50$	$\gamma = 0.25$
0.7	0.00	0.00	0.00
0.5	0.27	0.40	0.80
0.3	0.53	0.80	1.60

Source: Authors' calculations.

Note: $\beta^+ = 0.7$. See appendix C for definitions of coefficients.

sum paid by the consumer over periods 2 and 3 is 0.350. Following through until there is complete adjustment to new equilibrium prices yields a cumulative adjustment cost of 0.8 units.

The magnitude of the extra costs of rockets and feathers pricing depends on the magnitudes of the difference between the speeds of adjustment to positive and negative shocks in equation 3 in appendix C and also on the extent to which disequilibrium in the previous period is compensated for in the current period (γ). Table 2.5 provides a range of values of the cumulative costs of rockets and feathers pricing following increases or decreases in costs by 1 unit. As the difference between the speeds of adjustment to the original cost change increases, the total cost to consumers per unit purchased increases. Costs to the consumer also increase at lower speeds of adjustment of the magnitude to which prices are out of line with costs.⁶

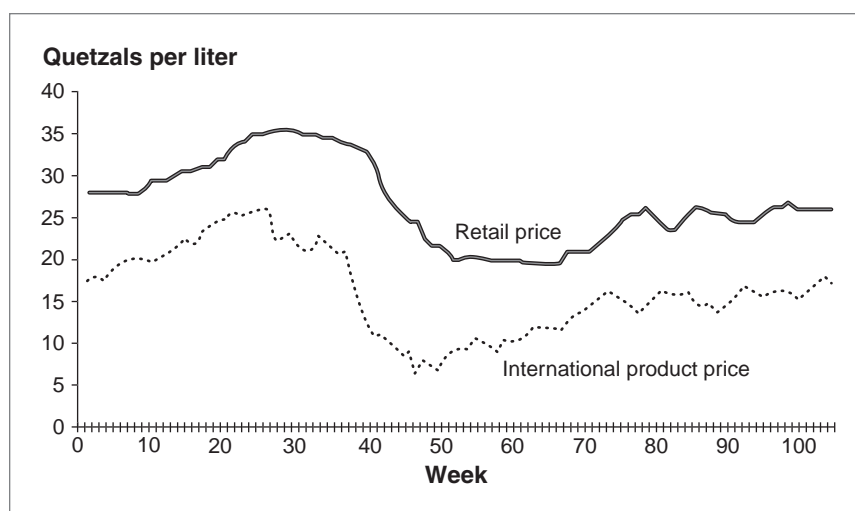
Kaufmann and Laskowski (2005) followed a different route to estimation of the costs of asymmetry to consumers. The authors compared the best model of price behavior that allowed the responses to be asymmetric with an otherwise equivalent model that imposed symmetry. Using the two models, the authors simulated the price outcomes for the monthly heating oil markets in five U.S. states from April 1986 to April 2001, based on actual values of all the explanatory variables. The differences between the two sets of simulations yielded the extra costs to consumers over the period. These ranged from an average extra cost of 1.5 percent in Maryland (at a cost of US\$20 million) to an extra 2.3 percent (\$2 million) in New Hampshire. The simulation in this approach is conditional on the actual sequence of cost changes that took place, and as such the results are dependent on the pattern of these changes. For example, an overall decrease or increase in costs over the period would have meant differences between the symmetric model and the asymmetric model.

⁶In the case considered, with unit shocks, the cumulative cost difference at equilibrium is given by the value of $(\beta^+ - \beta^-)/\gamma$.

Illustrative Calculation for Guatemala

The estimation of possible rockets and feathers pricing is illustrated with data for Guatemala. The government Web site provides daily retail prices in local currency for super gasoline, regular gasoline, and diesel from the beginning of 2008. It also provides U.S. Gulf Coast product prices converted into local currency as an indication of the costs of importing petroleum products. The international product market is highly competitive, with many suppliers and buyers, and such prices would not be expected to be manipulated to increase or decrease margins with respect to crude oil prices themselves. Accordingly the analysis focuses on the link between U.S. Gulf Coast prices and retail prices, both denominated in local currency.

Figure 2.2 Weekly Prices of Retail and International Regular Gasoline in Local Currency in Guatemala (January 18, 2008–January 15, 2010)

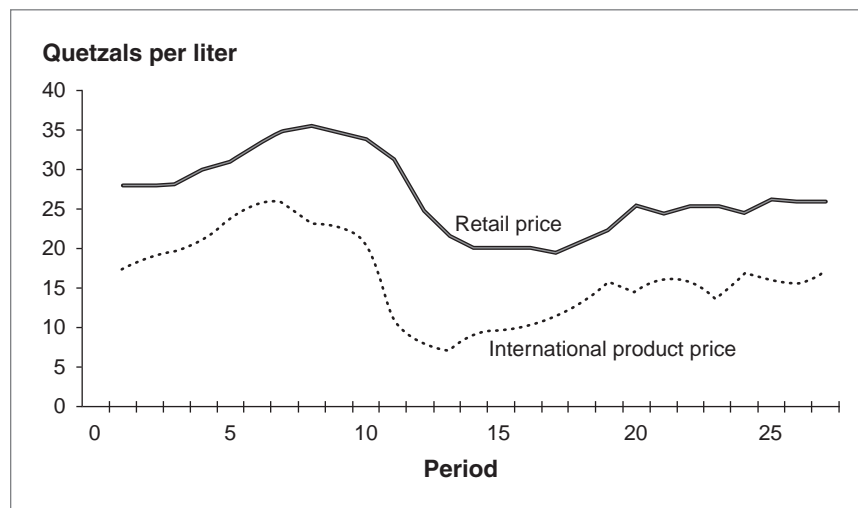


Source: Ministry of Energy and Mines 2010.

A preliminary analysis of the data through investigation of daily, weekly, and four-weekly prices revealed certain key features⁷ (the weekly and four-weekly prices for regular gasoline are shown in Figure 2.2 and

⁷Weekly prices are the price on the last day of the week, and 4-weekly prices are the prices on the last day of every 4-week period. Data for international product prices for period 35 (September 2008) are omitted because of the sharp temporary spike caused by Hurricane Ike.

Figure 2.3 Four-weekly Prices of Retail and International Regular Gasoline in Local Currency in Guatemala (January 2008–January 2010)



Source: Ministry of Energy and Mines 2010.
 Note: Each period consists of four weeks.

Figure 2.3, respectively). They show that domestic retail prices generally follow the pattern of international product prices but with a lag of about four weeks. Examination of the graphs reveals periods when international prices were falling at the same time as domestic prices were rising (for example, between periods 19 and 20, and again between periods 24 and 25, in Figure 2.3). Even though such episodes do not indicate that the price increases prior to these episodes had followed cost increases more rapidly than during the cost decrease periods, the movements in opposite directions over sustained periods of at least one month could have led to suspicions that companies were deliberately holding prices up when they should have been lowering them.

More formal evidence can be sought through the estimation of a rockets and feathers model applied to the data. For simplicity, and reflecting the apparent lags of about four weeks, an error correction model using four-weekly data, allowing for asymmetry in the adjustment to cost shocks but symmetry in the error correction term, was formulated. Pre-testing of the series indicates that both the U.S. Gulf Coast price and the Guatemalan retail price exhibited unit roots during this period, but were cointegrated so that the two-step procedure described in appendix C was utilized. Lags on both the change in cost term and the

Table 2.6 Parameter Estimates for Error Correction Model of Pricing in Guatemala (4-weekly data)

Product	β^+	β^-	γ	δ_0	δ_1	Asymmetry
Regular gasoline	0.37 (1)	0.37 (1)	0.28 (1)	14.3	0.76	No
Super gasoline	0.32 (1)	0.32 (1)	0.32 (1)	15.1	0.75	No
Diesel	0.97 (1)	0.32 (1)	0.27 (2)	9.1	0.90	Yes

Source: Authors' calculations. See appendix C for definitions of coefficients.

Notes: All coefficients different from zero using a one-sided 5 percent significant test; numbers in brackets indicate lag length of associated variable; for gasolines the results of equations imposing symmetry are reported.

error correction term were varied and the best-performing equations were chosen. Results of these estimations are shown in Table 2.6.

All three markets produce estimated equations in which all terms are significant when symmetry was imposed. When the model allowed for asymmetry, the coefficients on cost declines were smaller than those on cost increases, but the differences between them were not significant for super and regular gasoline. The difference was significant for diesel, indicating the existence of asymmetric price adjustments. These results support the view that casual observation on the gasoline markets might appear to suggest asymmetry, but in fact this is due to variations in the data that are statistically consistent with symmetric pricing behavior. However, for the diesel market, adjustment appears slower and strongly asymmetric. The impact is that for an increase of one quetzal per liter on the international market, versus a decrease of one quetzal, the consumer would pay an extra 2.4 quetzals for every liter purchased each month following the cost change due to the asymmetric pricing.

Chapter 3

Policy Responses to Asymmetric Pricing

Where governments have established that asymmetric pricing exists to the extent that consumers are suffering significant losses, a number of policies can mitigate the adverse effects. Where there is a high degree of market concentration and the price elasticity of demand is low, it will be easier to practice asymmetric pricing and prices are likely to be higher relative to costs. Policies to address asymmetric pricing will certainly need to take the degree of concentration into account. Three separate approaches can be used singly or in combination. The first approach tackles the problem at the level of the existing firms and imposes some form of sanction or order that eliminates asymmetric pricing. This approach is aimed at constraining or discouraging the use of market power to increase prices. The second approach aims to make consumers better informed so that opportunities for holding prices up will be reduced as consumers more aggressively search for low prices. In effect this approach is aimed at increasing the price elasticity of demand with respect to individual stations so that consumers will react more readily to price changes, thereby reducing the market power of the suppliers. The third approach aims to weaken the position of existing firms in the market by encouraging the entry of new firms that will lead to more competition between firms, thus tackling the problem through a reduction in market concentration. Each method has its advantages and disadvantages, and governments will tailor their response to the situation in their particular case. More interventionist policy is to set price ceilings for retail products, thus interfering with the possibility of competitive efficiency and running the risk of burdening the government or firms with the costs of financing the subsidy when capped prices are below costs.

Antitrust Legislation

Many countries have some form of antitrust law that permits the government to investigate whether a company or companies are acting in an

anticompetitive fashion (including within industry mergers). The sanctions for violations of this legislation can be severe. For example, in the United States, individuals can be fined up to \$350,000 and sentenced to up to three years in prison, while companies can be fined up to \$10 million. Damages can also be awarded as a result of violations of the antitrust law. In addition, companies have to cease their anticompetitive practice, while proposed mergers can be banned. The European Union does not have criminal penalties for individuals who violate antitrust law, but can levy heavy fines, up to 10 percent of a company's worldwide annual revenue for intentional or negligent violations. In some countries, governments can order the demerger or divestiture of some part of a company violating antitrust, in order to increase competition in the market. However, Weymouth (2009) examined 113 developing countries and reported that 53 did not have any independent regulatory oversight with respect to competition.

The disadvantage of relying on antitrust legislation is the difficulty and cost of the process itself. Because a full legal process must be carried out, the government has to obtain evidence against the alleged offenders, who will be defended by lawyers in whatever form of court is used to hear such cases. Because many of the potential companies are large national or international firms that would suffer loss of reputation as well as undergo various form of punishment if found in violation of the act, defense is likely to be vigorous. The process is also likely to be slow. Often governments have several cases from different sectors to examine and the time to go to a hearing may be lengthy. Once the case is heard, it can then be difficult to establish whether asymmetric pricing did in fact take place, or what was thought to be observed was purely an artifact of natural movements in prices. Given the sophistication and variety of statistical approaches used to test for the presence of asymmetric pricing, such tools are not well suited to a court of law where findings have to be established with some reasonable measure of certainty. Jiménez and Perdiguero (2010) report on applying statistical testing to the detection of collusion in the case of the Canary Islands gasoline market. Overall the use of antitrust legislation is likely to be worthwhile and effective only in cases of evidence of egregious violation of the law.

The Philippines established a task force in 2008 with the objective of determining whether a case of unfair market practice and overpricing could be filed against the top three oil companies, which together held an 83 percent share of the market. The task force reported in 2009, clearing the oil companies of monopolistic practices and cartelization (Kojima 2009a).

Public Information Improvement

As the review of various studies points out, the possibility of asymmetric pricing is made easier when consumers are not fully informed and are unwilling to shop around for better deals. This allows firms to exert some market power, especially following a fall in costs. A natural antidote to this situation is to improve consumer and government information about prices. Where information is more easily available, consumers can make better comparisons at lower cost, and the government is in a stronger position to identify unusual and unacceptable pricing patterns.

The simplest way to improve lacking or deficient information is to require stations to post current prices in some easily readable and accessible fashion. The display of pump prices for the different gasoline grades ensures that passing motorists are well informed. However, it does not address the problem of getting information to motorists who are not passing by a particular station.

To provide a benchmark against which prices at any station can be compared, governments can require all stations to report their current posted prices weekly (or at some other short regular interval). The average of these prices (preferably by city) can be easily posted on a government Web site and made publicly available. The local press is then able to report on current prices and recent trends, thus adding to the flow of information to the general public. This corresponds to practice in the European Union where governments have to provide a weekly report of petroleum product prices to the European Commission that are then published (European Commission 2010). The United States also publishes weekly information on average prices at the pump for selected states and cities (U.S. EIA 2010). Web sites also provide information on international crude and petroleum product prices that can be compared with retail prices.

Other countries follow a similar practice allowing an almost current flow of information to consumers. For example, the Ministry of Mines and Energy of Guatemala publishes daily prices of gasoline (super and regular) and diesel on its Web site (<http://www.mem.gob.gt/Portal/home.aspx>). The data are published with a lag of only two days, while prices of internationally traded products (quoted in dollars and in local currency) are provided with a longer delay. The Energy Policy and Planning Office of the Government of Thailand publishes the daily build-up of retail gasoline, diesel, fuel oil, liquefied petroleum gas, gasohol, and biodiesel in Bangkok (<http://www.eppo.go.th/petro/price/index.html>). All taxes and the marketing margin are shown separately, as well as the refinery-gate

and final retail prices. The information for a day is published at the end of that day. Argentina publishes monthly data by company and by city for all petroleum products on its Web site (http://energia.mecon.gov.ar/downstream/DS_PJur.asp) while the government of the Philippines publishes average weekly prices in Manila for the principal petroleum products on its Web site (<http://www.doe.gov.ph/OPM/Archives.htm>). Other countries that publish historical prices on the Internet include Brazil, Chile, Colombia, Ghana, Honduras, Kazakhstan (for paid subscribers), Madagascar, Mexico, Nicaragua, Nigeria, Pakistan, Peru, South Africa, and Tanzania (Kojima 2009a).

Encouraging Entry and Competition

As the preceding discussion has indicated, highly concentrated markets have the potential to raise prices well above long-run marginal costs and also to engage in asymmetric pricing. Accordingly governments can examine the market situation to see whether there is excessive concentration, whether there are barriers to entry, and how to reduce or remove such barriers.

The degree of concentration in a market can be measured by the Herfindahl-Hirschman index (HHI) or the C_k value. Although there is little evidence on downstream petroleum market concentration in developing countries, Table 3.1 gives information from a recent study of selected Sub-Saharan countries (ESMAP 2009) on the distribution of retail sales by company in December 2008. This table illustrates some important issues in interpreting measures of industry concentration. The C_4 and HHI indices do not necessarily give the same warning signals. For example, for Kenya the C_4 index is 80 percent and the HHI is 0.194—the latter not indicating a particularly high degree of concentration. By contrast, for Niger the C_4 is almost identical at 83 percent, but the HHI is very high at 0.296. High values of the HHI are usually associated with the presence of only a few firms (as in Madagascar and Malawi with a total of four), but in some cases a high value of the HHI is associated with a substantially larger number of firms (as in Niger with 18). In Niger, the result is explained by the very large shares of the two or three leading firms, coupled with very small shares of the remaining firms. The mere presence of extra firms is not necessarily sufficient to make a large reduction on the market power of the leaders. The value of the Lerner index for a core of large firms and fringe of small firms, under alternative assumptions about conjectural variations, was derived by Dickson (1979). The actual relationship between the

Table 3.1 Market Shares and Industry Concentration in Selected Sub-Saharan Countries

Country	Number of oil marketing companies	Market share of leader (%) C_1	Market share of top four (%) C_4	HHI
Botswana	5	31	93	0.24
Burkina Faso	19	38	71	0.21
Cote d'Ivoire	23	25	75	0.15
Kenya	25	32	80	0.19
Madagascar	4	34	100	0.27
Malawi	4	n.a.	100	0.28
Mali	53	15	46	0.09
Niger	18	48	83	0.30
Senegal	13	40	84	0.24
South Africa	9	25	71	0.17
Tanzania	25	16	50	0.11
Uganda	40	33	69	0.18

Source: ESMAP 2009.

Note: n.a. indicates information not available.

value of the HHI (or C_4) and the Lerner index depends on the behavior of the firms, but the results quoted in appendix B indicate that, with a low price elasticity and high values of the HHI, as exhibited in some of these countries, the excess of the price over marginal cost could be substantial.

Not only is the entry of very small firms unlikely to significantly reduce the market power of the existing larger firms, but also their entry introduces a further consideration for policy. Small firms tend to have fewer financial resources and suffer from lack of any available economies of scale. To compensate for these competitive disadvantages, they may be tempted to reduce the quality of service (Kojima and Bacon 2001). Inadequate safety procedures, short selling, or product adulteration, if not reflected in lower prices, would result in a loss in consumer welfare. Consumers are often not aware of these shortcomings, and governments need to intervene through regulation and monitoring to avoid the consequences. In the absence of strong enforcement of standards, minimum financial and size standards (for example, as measured by storage capacity) could be applied to potential entrants who would need to obtain a license to be allowed to participate in the industry.

There may also be situations where willing entrants have suitable qualifications but face serious barriers to entry. The barriers to entry concern mainly third-party access. For example, company A may own a refinery (or import facilities) and supply its own retail affiliates. If company B wishes to enter the retail market, it will have to acquire its supply from company A, or from some other party that may also have retail interests. Company A could either refuse to supply B at all (on grounds of insufficient capacity) or could supply at a price that would make it impossible for B to compete at retail with A's affiliates. The latter case may be ruled out explicitly by antitrust legislation but may be difficult to demonstrate. Governments can legislate to ensure that all retail companies have equivalent access to the upstream facilities that supply them (storage, pipelines, or refineries).

Barriers to entry can arise from a number of factors (Nexant 2006; ACIL 1997), including small market size, government regulations, entry-level costs, or supply conditions:

- Small market size limits the number of efficient-size participants that can operate in the market. New entrants would be forced to operate at a scale that is uneconomic.
- Government regulations, although often designed to improve the operation of the market, can discourage entry by imposing stringent conditions on new entrants.
- Entry-level costs are linked to the costs of land and equipment. In some economies the price of land has increased in real terms over time so that new entrants find it hard to pay the cost of a lease. This was the case in Macau (Nexant 2006).
- Asymmetry of supply conditions between existing firms and new entrants can provide a major barrier to entry. Legislation on third-party access is often required to provide equal access to all players, but it may need to be supplemented with increased investment in key bottlenecks in the supply chain.

Ellig (2003) described how three factors were leading to lack of competition and excessive retail prices in Hawaii, and made recommendations for amending legislation to increase competition in the industry. The first factor was the particular form of land ownership that made it difficult to obtain fee-simple (freehold) ownership of land and hence reduced the incentive to invest in stations. The second was the existence of rent-cap legislation that limited the rent wholesalers could charge retail dealers who leased their stations. Rent control can reduce

the supply of stations and increase the market power at retail and prices charged. The third factor was the law prohibiting “encroachment” that constrained the ability of new entrants to establish new stations near existing stations (one-eighth of a mile in urban areas and one-quarter of a mile elsewhere). Repealing the second and third pieces of legislation was recommended in order to increase competition in the sector.

In Portugal, the Competition Authority noted some, but not conclusive, evidence of asymmetric pricing, and that stations associated with supermarkets appeared to charge lower retail prices. It also noted a number of barriers to entry and made the following recommendations (International Law Office 2009):

1. Access to existing infrastructure should be guaranteed, in particular to a pipeline, storage depots adjacent to refineries, and a hub depot.
2. Import capacity should be increased with expansion of a marine terminal and adjoining import depots.
3. Incentives to establish service stations next to supermarkets should be granted.
4. Licensing of new service stations should be expedited.
5. The government should ensure that there be more than one operator on each motorway.
6. Rules on price displays in service stations should be enforced.

Serebrisky (2003) described how the antitrust regulator in Argentina made recommendations to the government for changes in the law to weaken the effects of vertical integration in the industry. The new law limited the contract duration between oil supply companies and dealer-owned, dealer-operated filling stations to a maximum of 5 years, against the average duration of the existing contracts of about 10 years. This reduction in duration, to a period similar to that mandated by the European Commission in 1999, was designed to permit the market to be more contestable by enabling dealers to switch supplier more often. In addition, the law limited to 40 percent the number of stations an oil marketing company supplied that it also owned. This divorce ruling was intended to prevent oil suppliers from counteracting the effects of reduced duration by acquiring the stations themselves.

Conclusions

There is substantial, but not universal, evidence that retail petroleum products in many countries exhibit rockets and feathers pricing. That this has been identified in economies with large markets, well-informed

consumers, appropriate legislation, and active regulators strengthens the case for being vigilant in economies where the situation is more favorable to the exercise of market power. The handful of studies about developing countries all indicate the presence of asymmetric pricing, although evidence is mixed on whether such pricing is due to collusive practices or to other features of the market. Some studies have indicated that the way in which the testing is carried out can have an important impact on whether asymmetry is identified. Several studies have identified non-collusive behavior that exploits market power and has led to asymmetry. As a result new studies need to investigate why the asymmetry exists before concluding that there is collusion in the market.

Where pricing asymmetry and excessive margins are evidenced, governments have a number of policy instruments at their disposal: anti-trust legislation to counter collusive behavior, policies to improve public information, and policies that encourage entry and increase competition among suppliers.

Formal statistical testing for the presence of asymmetric pricing may not be possible in many economies that lack suitable data. However, investigations into the size of margins and costs at various stages of the supply chain, as well as comparisons with other similar markets, can help determine whether a given market is out of line with what would be normal pricing.

Whether or not there is already evidence of asymmetric pricing or excessive margins, because of public concern with this highly visible market, particularly at times of large fluctuations in international prices, governments should start to collect and monitor retail and wholesale prices and to publish them in an easily accessible form. This effort should be done before the next oil price crisis leads to calls for governments to cap prices and repeal liberalization laws because of perceptions of inappropriate company pricing behavior.

Appendix A

HHI Index and Merger Approval in the United States

If a potential merger is being investigated, the United States considers a resulting value of the Herfindahl-Hirschman index (HHI) less than 0.1 as grounds for considering approval of the merger. If the value lies between 0.1 and 0.18, the merger could be approved if the increase in the HHI resulting from the merger is less than 0.01, but could need to be further investigated if the increase is greater than 0.01. If the HHI is greater than 0.18 but the increment is less than 0.005, then the merger could be approved, but if the HHI is greater than 0.18 and the increment is greater than 0.005, the proposed merger should be investigated to see whether it might be against the public interest. Merger synergies that would result in lowered costs could be used as an argument in favor of a merger, even when its effect on concentration is large. In the same way, high values of the HHI for an existing market structure could add to pressure for a more detailed investigation.

Appendix B

Price-Cost Margins and Industry Concentration

Analysis of market power links measures of industry concentration to the price-cost margin under assumptions about pricing strategies (Landes and Posner 1981; Ordovery, Sykes, and Willig 1982). The margin for firm i is conventionally defined by the Lerner index L_i

$$L_i = \frac{(P_i - C_i)}{P_i} \quad (1)$$

where P_i is the price charged and C_i is the marginal cost incurred by the i^{th} firm. The index varies between zero and one.

For a profit-maximizing monopoly, the Lerner index L_M can be shown to be inversely related to the price elasticity of demand ε^8 facing the firm (and the industry) by the equation

$$L_M = \frac{-1}{\varepsilon}. \quad (2)$$

$\frac{(P - C)}{C}$, the percentage markup over costs, and $\frac{P}{C}$, the price-cost ratio, can be similarly linked to the elasticity of demand:

$$\frac{(P - C)}{C} = \frac{-1}{(\varepsilon + 1)}; \quad \frac{P}{C} = \frac{\varepsilon}{(\varepsilon + 1)} \quad (3)$$

In an industry with several firms, the industry Lerner index is defined as

$$L = \sum s_i L_i \quad (4)$$

where s_i is the market share of the i^{th} firm.

Dickson (1979) shows that the industry Lerner index can be related to the industry price elasticity of demand, a measure of industry concentration, and the set of conjectural variations of all the firms. The conjectural

⁸The price elasticity of demand is typically negative.

variation λ_i for firm i is defined as the sum of the output (x) responses of all other firms relative to a change in its own quantity supplied:

$$\lambda_i = \sum_{j \neq i} \frac{dx_j}{dx_i}. \quad (5)$$

Hence

$$L = \sum s_i L_i = \frac{-H}{\varepsilon} - \frac{\sum s_i^2 \lambda_i}{\varepsilon} \quad (6)$$

where H is the Herfindahl-Hirschman index (HHI),

$$H = \sum s_i^2. \quad (7)$$

For a monopoly or for perfect collusion equation (6) simplifies to equation (2). For a Cournot oligopoly, where each firm assumes in choosing its planned sales level that its rivals will not respond to its choice (all λ_i are zero), the Lerner index L_c is equal to the HHI divided by the price elasticity of demand:

$$L_c = \frac{-H}{\varepsilon}; \quad \frac{(P - C)}{C} = \frac{-H}{(\varepsilon + H)}; \quad \frac{P}{C} = \frac{\varepsilon}{(\varepsilon + H)}. \quad (8)$$

The lower the concentration of the industry, the lower the Lerner index and the price-cost margin.

By contrast, in a Bertrand oligopoly, where each firm chooses its target price, in a one-shot game where firms do not consider more than the current situation, equilibrium price is equal to marginal cost and the value of L is zero.

This approach can also be generalized to the case of a dominant firms model, where the largest k firms collude perfectly and the fringe of the smallest $n-k$ firms act as price takers (Dickson 1979). The Lerner index is then related to C_k , the k firm concentration ratio, to the industry elasticity of demand, and the supply elasticity of the competitive fringe.

Appendix C

Estimating and Testing for Asymmetric Pricing

To estimate the response of output prices to changes in input costs in such a way that can test for asymmetric pricing, three components of an econometric model need to be specified:

1. A long-run or equilibrium relationship between the output price and various drivers, including input costs
2. A dynamic structure that allows output prices to lag behind changes of the driving variables
3. A separate dynamic structure following price increases or decreases so that tests for equality of magnitude can be carried out

These components can be illustrated with a simple model that has become standard for basic estimation of asymmetric pricing.

1. Long-run relationship

This relates the output price at time t (y_t) to the input cost variable (x_t) through a constant markup equation,

$$y_t = \delta_0 + \delta_1 x_t. \quad (1)$$

The intercept (δ_0) represents the markup of prices over costs. If the intercept is expected to change during the estimation period, or to vary between cross-section observations (for example, differentiating between stations of different characteristics), extra variables can be added to the relation to take account of these variations. The value of the coefficient linking costs to prices (δ_1) is expected to be close to 1, representing a situation whereby all costs are fully passed on into prices in the long run.

2. Dynamic structure

To allow for the fact that output prices are not fully and instantaneously adjusted to changes in input costs, lags are introduced into the long run equilibrium model with an error correction model. Current changes in output prices are determined by two factors: the extent to

which output prices were out of equilibrium as measured by equation 1 in the previous period, and the extent to which input costs have been changing in the recent past. The simplest model of this form can be written as

$$\Delta y_t = \beta \Delta x_t - \gamma (y_{t-1} - \delta_0 - \delta_1 x_{t-1}) + \varepsilon_t. \quad (2)$$

More complex dynamic adjustment paths can be introduced by including longer lags on the changes in input costs.

3. Asymmetry

Asymmetry of pricing is usually introduced by allowing for a different magnitude of price changes with respect to cost increases or decreases. This form of asymmetry can be introduced into equation 2:

$$\begin{aligned} \Delta y_t = & \beta^+ (\Delta x_t)^+ + \gamma^+ (y_{t-1} - \delta_0 - \delta_1 x_{t-1})^+ \\ & + \beta^- (\Delta x_t)^- + \gamma^- (y_{t-1} - \delta_0 - \delta_1 x_{t-1})^-. \end{aligned} \quad (3)$$

A positive superscript (+) indicates that the associated variable takes the actual value if positive and is zero otherwise; a negative superscript (-) similarly indicates that the variable takes the actual value if negative and is zero otherwise. Asymmetry may exist not only with respect to changes in input costs but also to the disequilibrium term, $(y_{t-1} - \delta_0 - \delta_1 x_{t-1})$. That is, if the output price were greater than the equilibrium value it might be expected that adjustment would be slower than if it were less than the equilibrium value. The hypothesis of symmetric pricing would impose the following parameter restrictions:

$$\beta^+ = \beta^- \text{ and } \gamma^+ = \gamma^-. \quad (4)$$

The estimation of equation 3 depends on whether the underlying cost and price variables are stationary. When they are not stationary, then the technique described below is commonly utilized. If the data are stationary, equation 3 can be estimated in a single step by an ordinary least squares approach.

Oil prices have tended not to be stationary over the period covered in most studies—that is, they did not return to the same average value throughout the period—and this raises complications for statistical analysis. However, if the output price and input cost both have a unit root but are cointegrated (output prices and input costs are themselves not stationary but a linear combination of them is), then a two-step estimating procedure can be used that avoids the dangers of spurious correlations that could arise ignoring the presence of nonstationary data

(for a simple account see, for example, Thomas 1997). The approach followed in a number of studies has the following steps:

1. Regress y on x (in the equilibrium relationship) and form the residuals (\hat{u}) from this estimation. This yields estimates of δ_0 and δ_1 in equation 1.
2. Regress the change in the residual ($\Delta\hat{u}_t$) (on the lagged value of the residual and lagged differences of the residuals. Test whether the coefficient on the lagged value of the residual is zero and, if the coefficient is significantly less than zero, accept that the residuals are stationary. This in turn implies that y and x are cointegrated. This form of the adjusted Dickey-Fuller test uses critical values taken from work by MacKinnon (1996). If the series are cointegrated, replace the term based on $(y_{t-1} - \delta_0 - \delta_1 x_{t-1})$ by its estimated value (\hat{u}_{t-1}), distinguishing if necessary between positive and negative residuals to make the substitution.
3. Carry out the estimation of the adjusted equation to yield the four unknown parameters: β^+ , β^- , γ^+ , and γ^- .
4. Test for symmetry of response using a Wald test.

Details of more advanced estimation methods and alternative dynamic models are given by Manera and Frey (2007) and Grasso and Manera (2007).

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