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AN ECONOMIC AND LEGAL ANALYSIS OF UNDUE PRICE DISCRIMINATION

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EXECUTIVE SUMMARY

Price discrimination is a routine matter in public utility regulation with commissions approving incentive rates, industrial discount programs, and prices intended to promote economic development. The law or commission rules, however, require that regulators prevent utilities from charging their customers prices that are unduly discriminatory. Unfortunately, limited guidance is provided by the law in helping policymakers understand the meaning of the term "unduly." Two avenues can be used to expand that understanding--policy analyses of general issues and empirical examinations of market conditions. Both are useful. Policy analysis is invaluable in evaluating broad concepts of price discrimination and assessing their relevance. Empirical study can probe deeply into the details surrounding potential price discrimination situations and can be helpful in uncovering aspects of discriminatory practices not revealed by the policy analysis approach.

This report examines the concepts of due and undue price discrimination from the perspective of both the economist and the lawyer. The economic analysis, which makes up most of the report, examines the economic efficiency and social equity consequences of various regulated pricing rules. The legal analysis examines the concepts of undue price discrimination as found in common law, statutes, and court decisions.

Legal Limits on Undue Price Discrimination

Two major sources of law on price discrimination are public utility and antitrust laws. Public utility law contains explicit and implicit limits on price discrimination. The explicit limit is found in statutory provisions prohibiting undue or unreasonable price discrimination. The prohibition requires that like customers receiving like services are charged the same price, which is achieved by grouping customers into customer classes. The primary consideration in determining whether rate differentials among customer classes are unduly discriminatory was and remains the cost of service. However, value of service can be taken into consideration to determine whether rates are unduly discriminatory. Where cost-based rates will not allow a utility to recover its revenue requirement, some value-based pricing is permitted.

State commissions usually apply this standard by prohibiting price discrimination that varies significantly from the cost of service, unless it can be shown that the variation is in the public interest. State commissions apply this public interest standard in a variety of ways. Some states allow price discounts to retain a customer who would otherwise leave the system. Other states allow price discrimination to serve such socio-economic goals as promoting growth in the local economy. Most of these states still require the favored customer to pay a price above variable cost, so that some contribution to capital is made. State commissions split on whether the prohibition against unduly discriminatory rates permits rate preferences that favor one class of customers while burdening another. Many commissions require utility stockholders to bear all or part of any revenue requirement deficiencies that result from discount rates. Because the public interest standard is applied in a variety of ways, it is difficult to summarize a general rule about the explicit prohibition against undue discrimination. It can be safely said, however, that most states would consider pricing below variable costs to be unduly discriminatory.

Public utility law's implicit limit on price discrimination is the requirement that rates be just and reasonable. For this to happen, rates must be set within the zone of reasonableness. To be within this zone, rates may not be less than the variable costs, but must be set lower than what would be considered excessive. The latter is a vague standard.

Antitrust law's implicit limits on price discrimination are found in the Sherman Act's prohibition against predatory pricing. The Act would be violated only if a utility engaged in extreme price discrimination, where a customer was charged less than variable costs. Even so, a utility might have a state-action defense if there is an affirmatively stated, clearly articulated, and actively supervised state policy allowing such pricing. Antitrust law's explicit limits on price discrimination are contained in the Robinson-Patman Act. The Act contains many defenses, so that a violation of the act is likely to occur only when prices are set below variable costs. Otherwise, a utility probably can avoid the provisions of the act or successfully make an affirmative defense.

In short, the law provides regulators with a wide latitude in determining when price discrimination is undue.

Price Discrimination in Competitive Markets versus Regulated Markets

In economics also, there are numerous concepts of price discrimination. All require that customers have a limited ability to resell the commodity amongst themselves, since otherwise different prices could not be charged to different customers. In competitive markets, price discrimination not justified by cost conditions is not a desirable outcome and is prohibited by antitrust statutes. The possibility that customers might resell a good helps to enforce the statutes.

In public utility markets, reselling is difficult because the commodity in question cannot be stored easily. Also, there are several arguments made by prominent economists that under conditions of natural monopoly some price discrimination can be a beneficial outcome.

In switching between competitive and regulated markets, then, the argument changes dramatically. Under competitive conditions, price discrimination is considered to be a bad thing and, luckily, is difficult to maintain if there is an active secondary market. Under public utility regulation, price discrimination can persist in reality and, luckily, it can be a good thing for all of us. The juxtaposition of these arguments suggests that public utility markets be examined for their unique characteristics that separate them from their competitive counterparts.

The social overhead represented by the utility's fixed costs is the principal difference between competitive and regulated markets. The need to recover such costs means that prices must be raised above marginal costs. Doing so with the least damage to the nation's overall allocation of resources requires that attention be paid to the relative ease with which funds to pay for the fixed costs can be raised from each separate public utility market. Such attention is needed to promote economic efficiency. These efficiency arguments are well known to economists and regulators.

This same difference between competitive and regulated markets also creates a distinction in the appropriate way to consider price discrimination, an equity consideration, in the two types of markets. Traditional standards of price discrimination used in competitive markets, such as "the same price for everyone" or "equi-proportional markups over marginal costs," may not work as well in regulated public utility markets that must meet a revenue requirement.

No-Loser Price Discrimination

One concept of how price discrimination can be a good thing in public utility regulation is so-called "no-loser price discrimination" in which a regulator can improve the economic well-being of all parties through some rearrangement of prices. This usually is expressed in terms of the ability of the regulator to lower the price of one group and simultaneously lower (or at least not raise) the price of all remaining customers and keep the utility's profits constant, with the result that everyone wins. Several respected economists have provided examples of circumstances in which this can happen.

It is easy to show that no-loser price discrimination is possible only if the price in at least one market is higher than that which would be charged by an unregulated monopolist. The job of a regulator, it can be argued, is to protect customers from the market power of the utility, both in terms of the utility's overall level of profits and the prices charged to each customer group. Accordingly, monopolistic prices charged to any group in a no-loser price discrimination situation should be lowered on the grounds that market power must be mitigated. It happens that lowering such a price has the fortuitous effect of allowing prices charged to other groups to be lowered as well. The opportunities for a regulator to successfully do this are likely to be rare, because of the constant care and attention already given to public utility prices by regulatory commissions.

Why Traditional Standards Are Inadequate for Public Utility Regulation

A different type of use for the concept of no-loser price discrimination is as a screening test to separate naive from sensible definitions of price discrimination. Suppose that someone proposes that residential and industrial customers of a public utility be charged the same price, and that any difference is undue discrimination. Begin at the suggested pricing standard and see if a rearrangement can be found that improves the social well-being of all market participants. If one can be found, the proposed concept is judged to be naive and is rejected. The rationale for the rejection is that a pricing pattern cannot be considered unduly or wrongly discriminatory if it can improve the lot of everyone.

The concept of the "same price for everyone" is clearly naive in this sense. Several economists have shown that no-loser price discrimination is sometimes possible from such an initial position. In addition, the more sophisticated version of this--that prices should deviate proportionally from marginal costs--turns out to fail this screening test, and should be classified as naive. That is, it is possible to concoct examples in which prices are proportional to marginal costs for two or more groups and where everyone's welfare can be improved by some rearrangement of prices. The fact that even one such example can be constructed is sufficient evidence to conclude the concept is naive.

This means that the traditional price discrimination standards used in analysis of competitive markets ("same price" or "equi-proportional markups") can yield naive results when applied to public utility markets. The reason is simple--these concepts do not account for the need to recover fixed costs.

<u>An Alternative Standard of Price Discrimination</u>

An alternative concept of discrimination is to measure deviation of prices from a standard that incorporates the effect of the revenue requirement consistently. The concept of "Ramsey pricing" can be used for this purpose. Ramsey, or inverse-elasticity, pricing is ordinarily advocated because it promotes economic efficiency. These efficiency properties are important, but are a separate matter from the insights about price discrimination that can be learned from the concept.

Price discrimination can be measured as the degree of pricing preference in favor of one group or another as implied by the pricing pattern that results from any regulatory policy. Pricing preference, in turn, can be measured as the implicit "welfare weight" that would have to be assigned to a customer group in order for the pricing pattern to represent the optimum of a weighted social welfare criterion. The intent is not to suggest that such weights should be assigned to customer groups or that regulators do so now; instead, it is that a determination of the inherent degree of preference implied by a pricing policy can help a regulator assess the extent of the price discrimination and thereby reach a judgment as to whether it is undue. It is a useful diagnostic, in this sense. Combined with a knowledge of aggregate economic efficiency, a regulator can assess the efficiency-equity trade-offs associated with various pricing rules-of-thumb. This concept of price discrimination withstands the no-loser price discrimination test for naivete because it is measured relative to a pricing standard, the Ramsey solution, that accounts for fixed costs.

<u>Industrial Discounts</u>

The no-loser price discrimination argument is sometimes reversed. A large industrial customer may argue for a discount on the grounds that it will switch fuels or perhaps even utilities if a discount is not granted. This raises the possibility that the price of all captive customers, who would bear the burden of all of the utility's fixed costs, would rise if the large industrial user takes its business elsewhere. All customers can be made perceptibly worse off, reversing the usual argument. This is the familiar "stranded investment" phenomena. The utility and its regulators may have little choice but to grant the discount because the large customer may have supply alternatives beyond the jurisdiction of the commission. Whether the discount is economically efficient is a separate matter.

The difficulty encountered in evaluating the reverse no-loser price discrimination argument is the narrowness of the regulatory jurisdiction in comparison to the choices available to the large user. The fact that some customers have the freedom to choose supply alternatives beyond the jurisdiction of the regulator does not necessarily improve overall economic welfare. Fixed costs are spread efficiently over a set of markets by prices that are higher than marginal costs, roughly in inverse relation to the price sensitivity of each market--that is, according to Ramsey pricing. Jurisdiction switching tends to drive the price paid by large users (those with competitive alternatives) down towards marginal cost, which has the effect of misallocating real economic resources.

The reason for the misallocation has to do with the price sensitivity of these customers, which the utility may perceive to be extremely high, perhaps infinitely so. Such a perception does not justify the conclusion that charging these customers only marginal cost will improve economic efficiency, however. From a national perspective, the price elasticity that matters has to do with the customer's real decisions about production schedules and techniques in response to a <u>national</u> price for public utility services. There is no improvement to overall national economic efficiency from an industrial discount program if the welfare of neighboring jurisdictions or alternative suppliers is considered also. The resulting inefficiency may be small, which is an empirical question, and to reiterate, the utility may have little choice in the matter; nonetheless, the argument that everyone's well-being or that overall economic efficiency is improved simply is incorrect.

<u>Empirical Analysis of Hypothetical Public Utility Markets</u>

The above discussion is representative of the insights available from broad policy analysis. Such an approach is inherently limited in its ability to separate due from undue price discrimination. More is required. An empirical examination of detailed market conditions is needed to assess whether observed price differences reflect undue discrimination. Five pricing policies are studied under a variety of hypothetical market conditions, including short- and long-term cost conditions. The economic efficiency and social equity implications of each policy are compared. Economic efficiency is measured as the overall social welfare (producer plus consumers' surplus) in all of the markets served by three utilities, assumed to be located in different regulatory jurisdictions. Social equity is measured by the implicit welfare weight described previously, which takes Ramsey pricing as a benchmark. The intent is to study and learn about price discrimination in public utility markets from a perspective that is consistent with those markets--it is not to advocate the adoption of such a standard for undue price discrimination by any commission.

Each of the five pricing rules satisfies the revenue requirement. The economist's favorite, Ramsey pricing, is included as a benchmark because it minimizes welfare losses. The others are (a) prices that maximize sales or throughput, (b) fully allocated cost prices as implemented by three different cost-of-service formulas, (c) prices that result from interjurisdictional competition for large industrial customers, and (d) prices that result from a so-called national tax program (with the tax calculated according to a rule-of-thumb and not optimally), which is intended to address the problems associated with interutility competition. The efficiency and equity implications of all five policies are evaluated under a variety of market conditions, including short- and long-run cost conditions, various demand elasticities for residential and industrial customers, several amounts of fixed costs as well as differences in fixed costs among the three utilities, and differing sizes of the industrial sector as a fraction of the utility's total sales.

<u>All Market Conditions Matter</u>

All market conditions, including fixed costs, marginal costs, and demand elasticities, matter as to whether an observed degree of price discrimination is due or undue. A price that is less than marginal cost in one set of circumstances (fixed costs are small, for example) can be less discriminatory, in the sense of implying a smaller degree of pricing preference, than a price above marginal cost in other conditions (with larger fixed costs). If the first price is unduly discriminatory, as most regulators, economists, and legal observers would conclude, then the second price is also unduly discriminatory, since it is more preferential in terms of the specific conditions that pertain to it. This may be a disturbing conclusion to many, since it means, among other things, that marginal or variable cost--measures that are appropriate in antitrust analysis--is not a sufficient standard by which undue price discrimination can be judged in public utility markets. Other market conditions are important also. In particular, the need to recover fixed costs distinguishes the private markets in antitrust analysis from the public utility markets studied here.

There is no cost standard, by itself, capable of distinguishing due from undue discrimination. This includes a policy of embedded cost pricing, which sometimes has a large degree of pricing preference, and in other conditions the discrimination is only moderate. No general conclusion can be drawn, such as fully allocated cost pricing is always or is never unduly discriminatory.

The cost-of-service information familiar to regulatory commissions is inadequate to differentiate due from undue price discrimination. The market conditions, identified in this report, are why the distinction has eluded us heretofore.

<u>A Pricing Policy To Maximize Sales</u>

The efficiency and equity performance of most of the five policies was mixed, at times good and at times poor. The policy whose objective it is to maximize sales or throughput, however, deserves special mention here. It is difficult to know precisely the weight of evidence needed in order to conclude that a pricing policy is unduly discriminatory, in general. Its performance must be very poor, indeed, to warrant such a conclusion. In the authors' opinion, the maximize-sales strategy should be classified as unduly discriminatory in almost all circumstances.

The degree of pricing difference between customer groups under this policy is more or less the same when fixed costs are very high (and the unregulated monopolist's pricing choices are approached) as when fixed costs are very low (and there is no need to discriminate at all). Furthermore, the degree of preference that is implicitly given to the elastic customer group is greater when the industrial price is above marginal cost (because fixed costs are large) than it is when the price is below marginal cost (because fixed costs are low). The overall economic inefficiency induced by such a policy is more or less the same at low levels of fixed cost (when inefficiency is easily avoided by prices that are close to marginal costs) as when fixed cost are high (and some resource misallocation is inevitable). The distortion to economic efficiency is large by any standard, usually on the order of 5 to 15 percent loss of overall social welfare--numbers that are significantly larger than those found in other applied welfare analyses--of taxation for example. In addition, the social price paid for the pricing preference embodied in the maximum sales policy was typically higher (but not always) than that found for the other four pricing policies studied here.

These conclusions are essentially unchanged whether a short- or long-term cost perspective is adopted. As studied here, the maximize-sales policy results in industrial prices below marginal costs if fixed costs are relatively low. The above conclusions would be moderated at low levels of fixed cost if the policy were constrained so as not to allow such predatory-type pricing, but the fundamental character of the policy would remain the same--the degree of price discrimination is as large as possible, as large even as that which an unregulated monopolist would charge to markets that can be successfully segmented. This is strong, and in the authors' opinion conclusive, evidence. If such an outcome is not unduly discriminatory, certainly no other would be.

Partial Competition and Fully Allocated Cost Policies

None of the remaining pricing policies seems as discriminatory as the maximize sales strategy. The partial-competition framework in which utilities compete for large industrial load as well as the fully allocated cost pricing policy are both substantially less discriminatory and more efficient than the maximum sales policy. The cost allocation method consistently favors the inelastic customer groups, while the partial competition model has the opposite effect of favoring the elastic users. When the inherent discrimination of each is placed on equal terms (that is, measured relative to the Ramsey standard), the result is more or less the same order of magnitude of implicit pricing preference. Also, the economic efficiencies of the two policies are similar.

These conclusions are borne out in a large number hypothetical cases, but they are somewhat sensitive to the specific economic circumstances surrounding the comparisons. Utilities with smaller, more elastic industrial sectors, for example, are likely to have more efficient and less discriminatory prices under a partial-competition policy than a traditional cost allocation exercise. With the reversed circumstances, fully allocated cost pricing would be superior. In addition, the relative attractiveness of these two policies depends on the policymaker's perspective regarding cost conditions. In short-run cost circumstances, the traditional cost allocation method is usually better than the interutility-competition outcome. In the longer run, when more costs are variable, the partial competition solution tends to yield a more efficient and less discriminatory outcome. Consequently, a policymaker's assessment of the relative merits of these two important pricing policies is likely to depend on both the current and future conditions surrounding the regulation of jurisdictional utilities.

A drawback to the partial competition framework for public utility regulation is that captive customers tend to pay an inefficiently large fraction of society's aggregate fixed costs. If carried to the logical conclusion, captive customers would pay all such costs and industrial customers with the opportunity of switching jurisdictions would escape from this cost responsibility. Comparing the interutility competition model and the traditional cost allocation procedure suggests that the partial competition framework can be superior at times, particularly in the long run, even if the fixed cost burden is placed entirely on captive customers.

A National Energy Tax Policy

To the extent that society wishes to address the remaining inefficiency and price discrimination problems associated with the distinction between captive and non-captive customers in the partial competition paradigm, the scope of policymaking must be expanded in some way to a national level. This is the purpose of studying a national tax that cannot be avoided by the action of a customer switching suppliers or regulatory jurisdictions. The analysis shows that an imperfect, ad-hoc tax (not optimal) is capable of significantly reducing the aggregate economic inefficiency incurred because of the localized regulation. The intent of studying such a national tax is not to advocate its adoption. It is, rather, to make the reader aware that national resource allocation is important. Although industrial discount programs may be unavoidable since there is no way to prevent some kinds of supplier switching, the programs ought not to be justified by the argument that they are economically efficient.

An Example of a Price Discrimination Standard and Its Drawbacks

A no-loser price discrimination test was previously suggested as a way of winnowing naive from sensible definitions of undue price discrimination. A regulator could apply the reasoning presented in this report and conclude that a pricing structure is unduly discriminatory if it implies a welfare weight for industrial customers larger than some number, say 1.5, or smaller than its reciprocal, 0.66 in this instance. Price structures with preferential weights between 0.66 and 1.5 would be acceptable by such a standard.

Three features of this standard are worth mentioning. First, it passes the "no-loser price discrimination" test of naivete. The only way to fail the test is for at least one of the initial prices to exceed that of an unregulated monopolist, in which case the welfare weight would be negative. The regulator's standard to maintain prices so that any preference falls within some range around a weight of unity automatically means that he is interested only in sensible pricing points that are "near" the Ramsey standard. These are not dominated by any others and so no-loser price discrimination is not possible.

Second, such a standard would not automatically ensure that all prices are above their respective marginal costs. If this is judged to be a separate important criterion, it can be imposed independently. This would narrow the range of acceptable preferential treatments. The new range could be computed and treated as additional information by the regulator.

Third, to implement such a standard would require that the regulator assemble data on marginal costs and on the elasticity of demands of the various markets served by a public utility. This would complicate regulatory proceedings and the conflicting testimony from opposing expert witnesses might shed little light on important issues. This is indicative of the fact that there is a large gray area in assessing price discrimination and determining whether it is acceptable or not.

Future Directions

The law provides limited guidance to regulators in recognizing undue discrimination, and yet they are charged with preventing it. A reason we are unable to distinguish due from undue discrimination is that the concept is inherently linked to all of the circumstances surrounding a market, not merely marginal cost conditions. To make further progress appears to require an effort to understand and estimate the market's response to prices. The alternative is to remain ignorant of such matters and rely on the marginal and variable cost standards familiar to antitrust analysts. This may not be unattractive for many purposes. The question is whether the additional insights about discriminatory pricing revealed through a study of the price sensitivity of demand is worth the administrative cost of unraveling competing testimony from expert witnesses. The empirical portion of this study and the conclusions just described are examples of what can be learned from taking a step in that direction.

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FOREWORD

The recent plethora of economic development, industry incentive, and other discount rates raises concerns about undue price discrimination. This report provides the regulator with economic and legal perspectives useful in addressing the issue.

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CHAPTER 1

INTRODUCTION

Public utility regulators are required by law in most jurisdictions and, in addition, by commission rules to prevent utilities from charging their customers prices that are unduly discriminatory. Yet, price discrimination occurs all the time in all three major regulated industries. The meaning of undue is not well developed in the law or in the rules, leaving to the discretion of the regulator the job of separating due from undue pricing practices. Many standards for undue discrimination have been proposed (marginal cost, stand-alone cost, proportional deviation from marginal cost, fully allocated cost, and the inverse-elasticity rule, to mention a few), and it is fair to say that none has gained universal acceptance.

This report examines the economic efficiency and social equity consequences of various regulated pricing rules from the perspective of both the economist and the lawyer. The economic insights are developed by first examining certain broad policy questions, such as whether a regulator can improve the economic well-being of all ratepayers by lowering the price of one of the customer groups. The possibility of such no-loser price discrimination has attracted the attention of reputable economists and has long interested regulators. It is closely related to the concept of a so-called "death spiral" and other notions of monopoly price limits.

This type of broad policy analysis, however, stops short of being able to identify undue price discrimination. More is needed. In this report, a tentative next step is taken by conducting an extensive empirical analysis of hypothetical market circumstances and a variety of possible regulatory pricing rules. The purpose of this analysis is to see which of the pricing policies performs well and under which circumstances. Policy performance is measured in terms of the overall economic efficiency of each policy, as well as the ability of the policy to achieve certain social equity objectives. The report describes a way to measure the equity implications of any pricing rule using a so-called weighted social welfare criterion, and applies it in the context of the hypothetical market conditions. This approach allows the analyst to assess the trade-off between economic efficiency and social equity in quantitative terms. Knowing this trade-off may help to distinguish due from undue price discrimination. The methodology of the report allows the reader to judge whether this kind of information is likely to be helpful, and how much progress in separating due and undue discrimination might be made with such an approach.

The report contains two types of analytical approaches. Chapters 2 and 3 present a policy analysis of price discrimination, with chapter 2 concentrating on the economic arguments and chapter 3 presenting the legal issues.

Chapters 4, 5, and 6 present the results of the empirical investigation conducted for this study. Chapter 4 describes the numerical exercise that was conducted for each of five pricing policies:

1. Ramsey pricing or the inverse-elasticity rule,
2. prices that maximize total sales or throughput,
3. fully allocated cost prices,
4. prices that result from interutility competition for large industrial customers, and
5. prices that are based on a so-called national energy or public utility tax, described later.

Chapter 5 shows the behavior of each of these pricing rules under a wide variety of economic conditions. The chapter presents separately the efficiency and equity implications of the various policies. The policies are compared to one another in chapter 6 using various measures of the average performance of each, including the concept of an efficiency-equity frontier that shows the relative position of each policy. Some concluding remarks are offered in the final chapter.

In addition, there are three technical appendices. Appendix A contains the mathematical derivation of the optimal pricing rules studied for each of the pricing policies. It also presents a rigorous development of the idea of an implied welfare weight used in this report to assess social equity implications. It measures the degree of pricing preference inherent in each of the pricing rules. Appendix B lists the computer code used to calculate the optimal pricing solutions for each of the pricing policies, while appendix C gives a list of the efficiency-equity frontiers computed for each set of economic circumstances examined in this study.

Throughout this report, the utility is assumed to meet its overall revenue requirement. This is an important limitation in that some states allow discount pricing or incentive rates on the condition that shareholders, not captive ratepayers, are responsible for any revenue shortfall. It is further assumed that marginal cost pricing results in a revenue shortfall. Also, the report examines only single-part prices, meaning that declining block rate structures or lump-sum customer charges are not considered. Both of these restrictions reflect a fundamental difficulty encountered in assessing long-term implications.

State commissions initially may limit incentive rate programs so that shareholders bear any financial risk, but a serious question exists about whether a commission could continue such a policy indefinitely. A commission that attempts to assign this risk to shareholders is likely to find such a policy elusive and difficult to enforce after several years. For one thing, a regulated utility more or less must meet its revenue requirement in the long run, or else cease to be financially viable. For another, the identity of which common costs are to be allocated to captive customers and which are the shared responsibility of noncaptive customers and shareholders becomes blurred over time. Alternatively, the commission may have no intention of maintaining the discount over a long term. In either case, the policy does not lend itself to a study of its long-term implications, and so is beyond the scope of this examination.

Likewise, multi-part tariffs are interesting examples of discriminatory pricing structures, but are not studied here because their long-term effects are uncertain. Such tariffs create a difference between the price consumers pay on average and at the margin. Customers have many more opportunities to respond to average prices (including any upfront loading due to initial pricing blocks or customer charges) in the long run than they do to marginal prices in the short run because, ultimately, they can change the capital investments that use the public utility services. Consequently, multipart tariffs may not be an effective way to price discriminate in the long run apart from the differences created in average prices. Such differences can be analyzed within the single-price framework of this study.

Other analysts might adopt a short-term perspective that considers revenue sharing between customers and shareholders, as well as customer reaction to marginal prices. The truth almost certainly lies somewhere in between such short-run analyses and this study's longer-term analytical framework. In particular, short-term behavior that a regulator observes daily is constantly being drawn toward some longer-run equilibrium not fully understandable. In this report, the regulator is invited to consider such longer-term issues as a way of balancing the day-to-day matters that necessarily demand considerable attention.

No attempt is made in this report to define undue price discrimination rigorously, although that is the sole topic under study. The simpler concept of ordinary, garden-variety price discrimination is elusive, and can be the subject of some disagreement even among learned economists.[1] The viewpoint expressed in this report is that prices become unduly discriminatory when they deviate further from marginal costs than can be justified by market conditions, including the amount of the utility's fixed costs and the responsiveness of market demand to price. Ultimately, the concept is one that requires a policymaker's judgment about the degree of social damage inflicted by a pricing structure, and so is not resolved in this report--merely explained. This concept of undue price discrimination is sophisticated and complicated to put into practice. Despite this, the concept is useful as an aid to understanding discriminatory pricing practices, their limits, and their consequences.

The price discrimination concept analyzed in this report is based on the idea of a weighted social welfare criterion. For any pricing policy, it is possible to impute a social welfare weight that reflects the degree of preferential treatment implicit in the regulated prices of one group or another. This weight can be used to analyze the price discrimination consequences of any pricing policy. The reader should be aware at the outset that this criterion, among other things, implies that Ramsey pricing

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[1] A hint about some of the remaining disagreement can be found in Stephen Layson, "Third-Degree Price Discrimination, Welfare and Profits: A Geometrical Analysis," American Economic Review, 78 (December 1988): 1131-2.

(or the so-called "inverse elasticity" rule) is neutral or nondiscriminatory. The authors are aware that many readers may believe that Ramsey pricing itself is discriminatory, and so may think peculiar the use of this standard of discrimination here. There are, however, subtle and complex reasons why Ramsey pricing may be an interesting benchmark from which to assess price discrimination.

The Ramsey rule is, for example, a pricing concept particularly well suited for a regulatory environment in which it is necessary to meet a revenue requirement and recover a utility's fixed and common costs. Other concepts of price discrimination, particularly those associated with antitrust matters, are particularly appropriate for competitive markets. The notion that the prices of similar services at similar costs ought to be equal, for example, is one that works well in the study of competition. Whether it is useful in an examination of price discrimination among regulated markets is a separate matter.

In this regard, it is worthwhile to consider so-called "no-loser price discrimination" which makes it possible to lower the price of one group while simultaneously keeping all other prices constant (thereby hurting no other consuming group) and maintaining the utility's revenue requirement. This is a simpler standard of due price discrimination and one that, at times, can be helpful to regulators. As the reader will discover in chapter 2, the usefulness of the no-loser standard appears limited, because the opportunities for a regulator actually to improve the welfare of everyone through rearrangements of prices are likely to be rare.

Nonetheless, one use for the concept of no-loser price discrimination is to separate naive definitions of undue price discrimination in regulated markets from sensible ones. To expand, suppose someone suggests that prices paid by residential and industrial customers of a public utility should be the same and that if different the prices are unduly discriminatory. Such a proposed concept of undue discrimination should be passed through a "no-loser price discrimination" filter in the following way.

Beginning at the proposed pricing standard (all prices must be the same) see whether a rearrangement can be found that improves the social well-being of <u>all</u> market participants. If one can be found, the proposed concept is judged to be naive and is rejected. The reason for this rejection is that a pricing pattern cannot be considered unduly discriminatory if it can improve the lot of everyone. The concept of "the same prices for all customer groups" is clearly naive in this sense, because several economists have shown that no-loser price discrimination is sometimes possible from such an initial position.

In addition, a more sophisticated concept that prices should deviate proportionally from marginal cost fails this screening test, and so can be classified as naive. That is, it is possible to concoct examples in which prices deviate proportionally from marginal costs for two or more customer groups and where everyone's welfare can be improved by some rearrangement of prices. The fact that even one such example can be constructed is sufficient evidence to conclude that the concept is naive.

The "same price" and the "equi-proportional" standards have their roots in antitrust analysis of competitive markets. They do not pass the "no-loser" test of naivete and have questionable application in regulated markets. In contrast, the welfare weight analysis adopted in this report passes this test, as might many others, of course. This may not be the use intended by proponents of no-loser price discrimination, but it can be an important one.

Furthermore, the legal standards for undue price discrimination discussed in chapter 3 give much latitude to the regulator's judgment and allow a wide spectrum of pricing outcomes to be accepted as duly discriminatory. Consider an extreme example in which one group's price is quite high, perhaps close to that which an unregulated monopolist might charge, thereby enabling some other group to be charged a relatively favorable price. As economic circumstances change, the antitrust standards for judging price discrimination (the "same price" and "equi-proportional" standards) will sometimes be close to such a pricing point and at other times they may be far away. As such, the antitrust standards sometimes can lead to the conclusion that the example is discriminatory and sometimes that it is not. A neutral view might hold that the example is discriminatory in all circumstances. The antitrust standards do not assess regulated pricing outcomes consistently.

The Ramsey benchmark, in contrast, turns out to be almost in the center of the region of what a regulator might find to be acceptable pricing outcomes. If a group's price is closer to the monopoly level than the Ramsey solution, the group is consistently judged to be discriminated against by the welfare weight analysis studied here. The same is not true for the antitrust standards. These can be unreliable indicators of price discrimination in regulated markets because they tend to become unreliable as the amount of fixed cost grows in relation to marginal or variable costs, and also as the price responsiveness of the markets (residential, commercial, and industrial) become more and more different from one another.[2] The Ramsey standard, however, accounts for such matters and consequently is a robust indicator of price discrimination in a variety of economic circumstances. Since regulators may be interested in the implications that fixed cost, demand sensitivity, and marginal costs have on the question of due and undue price discrimination, it is worthwhile to consider the lessons that can be learned from the welfare weight perspective studied for this report.

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[2] In competitive markets, fixed cost is not an issue. Because of this, the relative degree of price elasticity among customer groups is also irrelevant--marginal-cost pricing of the least efficient firm allows sufficient profits for the industry to be viable. The "same price" standard is not equipped to analyze the appropriate degree of price discrimination needed to recover a non-zero level of fixed costs.

CHAPTER 2

ECONOMIC CONCEPTS OF PRICE DISCRIMINATION

The lack of a concrete definition of undue price discrimination in the law alluded to in the previous chapter gives regulators only modest guidance viewed one way or allows them substantial leeway when viewed another. The absence of precise legal guidance is complicated by a confusing economic literature that suggests in places that discrimination in public utility pricing can be a good thing, while extolling elsewhere the virtues of charging all customers the same price.

This chapter attempts to make some order out of the economic concepts of public utility price discrimination and to lay the foundation for the empirical work described in subsequent chapters. In it, several strands of the economic literature are discussed and the current context in which the price discrimination issue arises is described. Various notions of discriminatory practice are set out and discussed from a broad policy perspective. As should become apparent, this type of policy analysis does not answer all of the important questions concerning due and undue discrimination. Some empirical content must be given to the discussion. That is the purpose of subsequent chapters.

Review of the Economic Literature

There are a number of economic concepts of price discrimination that have been discussed in the literature. All require that customers have a limited ability to resell the commodity amongst themselves, since otherwise different prices could not be charged to different consumers. In competitive markets, the freedom of customers to choose their supplier and to resell any product they can buy at a relatively favorable price helps to enforce what economists call "the law of one price." This "law" is an outcome of the freedom of customers to resell products and states that a single price will prevail in markets where reselling is costless. In public utility markets, however, price discrimination can persist because the commodities are not easily stored or transferred to another user once purchased.

Apart from the fact that price discrimination is possible in public utility markets, several arguments have long been made by prominent economists that price discrimination in such markets can be a good thing. This idea can be traced to the need of a natural monopolist to recover fixed costs. To do so ordinarily requires that prices be distorted upward from marginal cost for at least some of the regulated markets. In such circumstances, the argument is made that society's overall burden can be minimized if prices are distorted to account for the value of service as well as the cost of service. Since consumers' willingness to pay is responsible in part for the resulting pricing pattern, such a policy, called Ramsey pricing by economists, is considered discriminatory by many. The discrimination is commonly considered a good thing, however, in the sense that it minimizes society's aggregate burden of paying for fixed costs.

Under competitive conditions, price discrimination is considered to be a bad thing. Luckily, it tends to be difficult to maintain if the law of one price is at work in an active secondary market. In switching from competitive to regulated markets, then, the argument changes substantially. Under the conditions found in markets served by a natural monopolist that is subject to profit regulation, price discrimination can persist in actuality, and luckily, it can be a good thing for all of us. Students of public utility economics are at least struck, if not confused, by the juxtaposition of these arguments for reasons that will become clearer as this chapter unfolds.

Throughout this report, attention is restricted in large part to the case in which the utility charges the same price per unit for all units sold to a particular consumer. Different customers may be charged different prices, but quantity discounts are not available to anyone. This neglects such pricing practices as declining block rate structures and the fixed monthly customer charges commonly used for local telephone service. As such, the analysis is confined to so-called "third-degree price discrimination".

First- and second-degree price discrimination deal with nonlinear price schedules or quantity discounts. These topics have been thoroughly explored in the economics literature and include such issues as incentives that customers have to disconnect their service if up-front charges become too large,[1] the optimal way of arranging a nonlinear price schedule to achieve social engineering goals such as income redistribution,[2] the efficiency-enhancing properties of so-called "Pareto-dominating tariffs" in which the customer is given a menu of alternative price schedules with differing degrees of fixed and variable charges among which to choose,[3] and incentive compatibility issues that arise if a utility is given the freedom to price certain products in an unrestricted way subject only to an overall revenue constraint.[4]

All of these issues are important and address substantive matters of price discrimination that confront regulators routinely. This report does not deal with them, however, because its topic is due and undue discrimination as it pertains to the prices paid by one customer group versus another. The various possibilities for favoring one group at the expense of another are adequately covered by examining ways of charging different prices that are themselves constant with usage.

At least three different ideas can be found of what it means for third-degree price discrimination to be a good thing in regulated markets. First, there is the (by now) traditional example of an inviable utility that is

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[1] Roger Sherman and Michael Visscher, "Rate-of-Return Regulation and Two-Part Tariffs," Quarterly Journal of Economics, 97 (February 1982): 27-42.

[2] A.B. Atkinson and J.E. Stiglitz, "The Design of Tax Structure: Direct versus Indirect Taxation," Journal of Public Economics (July-August 1976): 55-75.

[3] Stephen J. Brown and David S. Sibley, The Theory of Public Utility Pricing, (Cambridge, England: Cambridge University Press, 1986).

[4] Ingo Vogelsang and Jorg Finsinger, "A Regulatory Adjustment Process for Optimal Pricing by Multiproduct Monopoly Firms," Bell Journal of Economics 10 (Spring 1979): 157-71.

revitalized by a policy of price discrimination.[5] That is, without the discrimination in prices, the firm would not be viable. All parties benefit by the survival of the firm. In this version of the idea, at least, price discrimination can be good. This can be called the "no-loser" version of price discrimination.

Second, price discrimination can minimize the aggregate consumer burden of paying for fixed costs, which yields an overall benefit for society as a whole. This is the idea behind so-called Ramsey pricing.[6] In order to pay for fixed costs, prices should be raised above their respective marginal costs in inverse proportion to the price elasticity of demand. In this way, distortions to consumers' decisions are kept to a minimum. This notion is founded on the concept of economic efficiency and suggests that society's productive resources are best allocated by prices that follow the inverse-elasticity rule. Here again, the discrimination is considered to be good.

Third, there is a concept that might be termed "reverse no-loser price discrimination." This involves a claim by a large industrial customer (say) that all ratepayers would be better off if its price were discounted, because otherwise it will take its business elsewhere and leave the captive customers to pay all of the utility's fixed cost. The argument usually continues that having a small contribution to fixed costs from the industrial customer is, after all, better than having none at all. Regulators and the utility may have little choice in such matters since the industrial user may have competitive alternatives that force the traditional supplier to deeply discount the customer's service. The terminology "reverse no-loser price discrimination" is not accurate, strictly speaking, as there are several important distinctions between this case and the first example described above. Nonetheless, proponents of the idea sometimes

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[5] Charles F. Phillips, The Economics of Regulation (Homewood, IL: Richard D. Irwin, Inc., 1965) discusses an example using second-degree price discrimination. Third-degree discrimination examples can be found in Alfred E. Kahn, The Economics of Regulation: Principles and Institutions, Volume I (New York: John Wiley & Sons, Inc., 1970); Keith M. Howe and E.F. Rasmussen, Public Utility Economics and Finance (Englewood Cliffs, NJ: Prentice-Hall, Inc., 1982); and, James V. Kock, Industrial Organization and Prices (Englewood Cliffs, NJ: Prentice-Hall, Inc., 1974).

[6] Frank P. Ramsey, "A Contribution to the Theory of Taxation," Economic Journal (March 1927):47-61.

claim there can be no losers from granting the industrial discount. The name thus may be a convenient shorthand for the following discussion.

A Simple Diagrammatic Analysis

All of these ideas can be easily understood in the context of a simple diagrammatic analysis. The diagram has been presented in a previous NRRI report and also in the economics literature and so is only briefly reviewed here.[7]

Suppose there is a public utility with several customer groups and a need to recover some level of fixed costs. Hold constant the prices of all consumer groups except for two, which we can call the industrial and residential sectors. The demand for the utility's service for each of these groups depends on the respective prices.

The locus of all possible pricing combinations that yield zero profits is shown in figure 2-1. The axes of the diagram are price levels with the industrial price shown on the vertical axis and the residential consumers' price depicted on the horizontal. The industrial market has relatively elastic demand compared to the residential sector. The marginal cost of serving each group is shown separately. Profits increase as prices are jointly increased up to the point labeled M, which is the pricing combination that an unregulated monopolist would charge. Because of the fixed costs, the zero-profit locus lies to the northeast of the marginal cost point, labeled E. That is, the socially efficient point, E, results in negative profits. Prices should be raised above this point to one along the zero-profit ellipse.

In the diagram, point A corresponds to the price an unregulated monopolist would charge the industrial sector. At that level the maximum contribution to fixed costs is extracted from the industrial market. Likewise, the point Z is at the level where an unregulated monopolist would

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[7] See J. Stephen Henderson et al., Natural Gas Rate Design and Transportation Policy under Deregulation and Market Uncertainty (Columbus, OH: The National Regulatory Research Institute January 1986); and J. Stephen Henderson, "Price Discrimination Limits in Relation to the Death Spiral," The Energy Journal 6 (July 1986): 33-55.

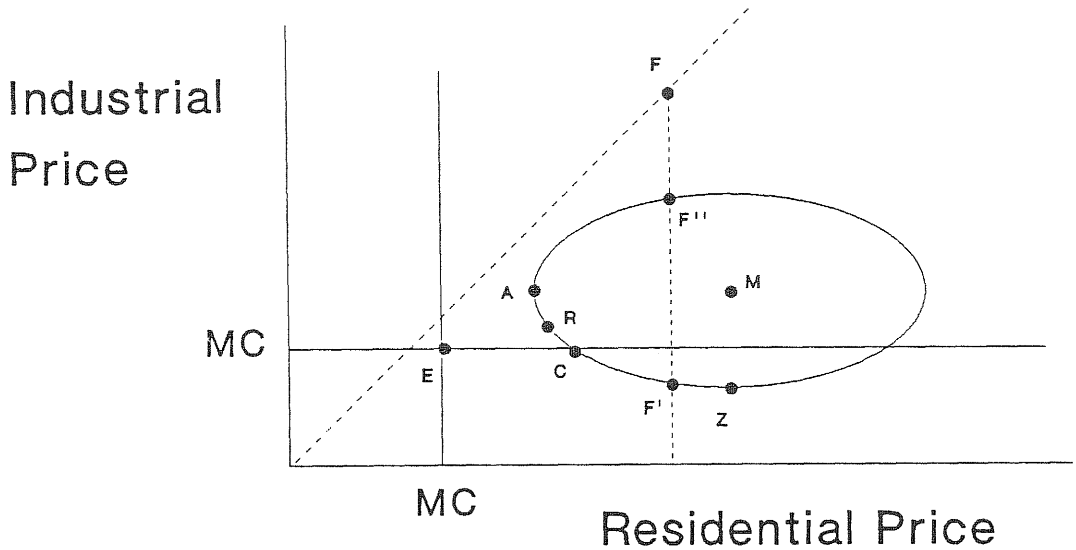

Fig. 2-1 Zero profit pricing locus

price residential services. This is the maximum contribution to fixed costs that can be extracted from the residential market.

The diagram is shown as an ellipse with its axes parallel to those of the diagram itself. This orientation holds as long as the market demands, whose prices are depicted on the graph, remain independent of one another. This will generally be true for separate customer classes, since industrial demand does not depend on the residential price, and vice versa. This implies, among other things, that the monopoly pricing level for one market does not change as the price for the other service changes. In the empirical work described later in this report, interdependent peak and off-peak markets are analyzed. The maximum fixed cost contribution from the peak market, for example, does depend on the price prevailing in the off-peak market for the same customer group. In this chapter, however, market demands are independent, and the diagram in figure 2-1 is appropriate.[8]

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[8] See John C. Panzar, "Sustainability, Efficiency, and Vertical Integration," in Regulated Industries and Public Enterprise, ed. Bridger M. Mitchell and Paul R. Kleindorfer (Lexington, MA: Lexington Books, 1979) for a discussion of the pricing ellipses when demands are interdependent.

In simple terms, the regulator's role in restricting the monopolist's profits (even down to zero) is to choose among the points along the zero-profit locus. Of these, the only sensible choices are those between points A and Z. Restricting the monopoly power of the utility ought to mean that no customers are charged more under regulation than they would be by an unregulated monopolist, in addition to the overall zero-profit restriction placed on the firm. Note that along this range of the zero-profit locus, the price of one customer group can be lowered only at the expense of increasing the price of the other group. In this sense, the regulator is forced to make substantive choices: when deciding to give one group a discount or some other favorable price treatment, another group of ratepayers is hurt.

The traditional type of no-loser price discrimination described in several textbooks is one in which this substantive trade-off does not exist, and where there is the possibility of improving matters for everyone simultaneously.[9] The analysis typically begins at a point where both customer groups are charged the same price (so that there is no price difference and hence no discrimination by such a standard). The circumstances and the initial price are chosen so that the firm cannot break even. F is such a point in figure 2-1. It lies on the 45-degree line, so that both prices are the same. The demand elasticities in the two markets, however, are such that the pricing ellipse does not cross the 45-degree line. At point F the firm earns negative profits and would go out of business unless it were allowed to discriminate between the two group.

No-loser price discrimination is possible from such an initial position. Drop a vertical line from point F to F′ on the zero-profit locus. The prices at F′ are lower for the industrial customers and the same for the residential customers, while the firm is able to break even. Everyone is better off. Indeed, all pricing combinations between points F" and F′ on the zero-profit locus are Pareto superior to point F. Of these, those between points A and F′ are sensible (because each group is charged less under regulation than under unrestricted monopoly) and Pareto superior, for

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[9] The regulatory equivalent of a free lunch. See footnote 5 for a list of textbook treatments of this argument.

reasons just described. There is no particular reason for choosing point F′, for example. At that point industrial users are charged a price that is less than marginal cost. Such pricing is generally considered to mean that residential consumers are subsidizing the industrial class. Many observers would consider that to be unduly discriminatory.

The second notion of "good" discrimination is Ramsey pricing, which is shown as point R in figure 2-1. It lies along the portion of the zero-profit locus where substantive choices must be made, that is, above the marginal cost lines for both groups. The pricing ellipse is elongated in the direction of the inelastic market, which is the residential group in this example. The Ramsey rule has a larger deviation between price and marginal cost for the inelastic market, and point R in the diagram reflects this. The virtue of the Ramsey point is that aggregate consumers' surplus in both the residential and industrial markets is greater than any other point along the zero-profit line, although this property cannot be demonstrated using this particular diagram. It is in this sense that economists call this Ramsey pricing solution economically efficient. The policy obviously involves some price discrimination since the point R is not on the 45-degree line. By allowing prices to be different, overall social well-being can be improved.

A third type of "good" price discrimination is the reverse no-loser variety, whereby large industrial customers argue that any price above marginal cost will improve matters for captive ratepayers because the industrial user will switch to an alternative fuel or to a different utility if the price is not discounted. This type of discounting results in a price close to marginal cost for the industrial class, which means prices in the vicinity of point C in the diagram. As mentioned, the utility and its regulators may have no choice but to offer the discount, because the competitive alternatives available to the large customer cannot be controlled or restricted.

The diagram should help to make clear that although the industrial discount cannot be avoided, the result should not be thought of as "good" discrimination. In the absence of an alternative supplier, the residential consumer is not made better off by the discount. That is, if the pricing point were initially R, the industrial discount would move the utility from the efficient Ramsey point in the direction of point C, which clearly increases the residential price. The marginal cost pricing point C is in the downward-sloping region of the zero-profit locus and as such a substantive trade-off must be made to discount the price of any group. Consequently, the claim cannot be made that everyone is made better off by extending the discount to the large users who have competitive alternatives. Such a discount may be justified by the argument that the utility has no choice in the matter, but it should not be supported by the erroneous idea that all ratepayers will benefit.

The industrial discount form of reverse no-loser price discrimination differs in several fundamental ways from the traditional no-loser discrimination described above, even though proponents of the idea tend to emphasize their similarities. First, the traditional no-loser discrimination situation ought to be regarded as an academic curiosity--a useful example that discrimination can be helpful and that efficient Ramsey pricing involves some discrimination, but little more. The example requires a utility's initial pricing point to be located in a perverse, backward-bending portion of the zero-profit locus, where point F" is located in figure 2-1, charging higher prices than an unregulated monopolist. Any regulator having the good fortune of being located in a such a position should act, of course, to reduce the offending price and thereby make all parties better off. Such opportunities are likely to be rare, however.

Second, the traditional no-loser situation involves only a single utility. There is no competing company available to enable a large customer to switch suppliers. The introduction of such competition changes the nature of the demand elasticity facing the utility. With protected markets, the industrial user's sensitivity to price is based on the rearrangements that can be made in its own productive processes or changes that can be made to its annual rate of production. The price elasticity of demand in such cases reflects the value of the public utility service in producing a good or service. Without market protection, direct competition for industrial customers creates the appearance to an individual utility that large users are extremely sensitive to price, even though the basic production processes employed by these utility customers does not change as the result of the direct competition. The utility is likely to react to the threat of competition as if the exaggerated demand elasticity that it perceives represents real rearrangements of economic resources. In actuality, the customer's real response to the price of public utility services, in terms of increased or reduced use of national resources, is the same with and without the interutility competition. Regulators are concerned about the real elasticity of demand, while the utility (and most likely the regulators) must contend with the perceived elasticity that arises from the competitive alternatives.

Third, the fact that some customers have the freedom to choose viable alternate suppliers does not necessarily lead to improvements in overall economic welfare, even though the introduction of competitive forces generally enhances economic efficiency. The need to recover fixed costs is spread efficiently over a set of markets by Ramsey pricing. Allowing some customers to escape the burden of these fixed costs by switching to another regulatory jurisdiction or utility tends to drive their price down to marginal cost, thereby relieving or at least reducing their share of the burden. Although a state utility commission may have no choice but to accept such an outcome, it should be clear, in principle at least, that a national regulatory program encompassing all of the relevant smaller state jurisdictions could overcome the problem.

There is no intent here to advocate any kind of national regulation of utilities. Instead, the concept is useful in creating the mental image that jurisdiction switching or utility switching is a problem because some customers' choices range farther than the jurisdiction of the local regulator. National regulation overcomes the difficulty directly. Hence, there is no improvement to overall, national economic efficiency as a result of an industrial discount program, if the welfare of the neighboring jurisdictions or alternative suppliers is also considered.

Fourth, the same conclusion is reached even if the industrial discount results from a threat to switch fuels as opposed to switching between utilities or jurisdictions. The reason is somewhat more subtle, but basically the same. In the economic literature discussing the optimal taxation of commodities, a well-known result is that a good and all of its close substitutes ought to be taxed together.[10] It is inefficient to tax a particular commodity and ignore its substitutes because the tax could then be easily escaped. This idea is developed more thoroughly in chapter 4.

The lesson here is quite modest: industrial discount pricing may be a fact of life, but it should not be justified on the grounds that everyone is made better off by it. Furthermore, industrial discounts that result in prices close to marginal costs are likely to be inefficient on global grounds. It is by no means obvious, however, whether the magnitude of the inefficiency is large or important. The question is addressed as part of the empirical analysis described in chapters 5 and 6. A "national tax policy" designed to overcome the limitations of local regulation is also addressed to judge the extent of the improvement, if any, from an approach with a national perspective.

The interjurisdictional competition for large industrial customers has been studied by several writers of economics articles. A particularly insightful study has been done by Braeutigam that addresses the issue of partial regulation in which some markets are competitive and others are regulated.[11] He concludes that a system of full regulation, corresponding to the national energy tax example mentioned above, is information intensive and would have substantial implementation costs and difficulties. Partial regulation in which intermodal or interutility competition is allowed would be less expensive to implement and might achieve nearly the same social welfare results. The issue is an empirical one, however, as Braeutigam acknowledges.

The empirical analysis conducted as part of this project addresses, in part, the issue raised by Braeutigam. The national tax model studied in this report has been designed purposely to yield a good tax, but not necessarily the optimal one. The objective is to see if social welfare can be improved by making an intelligent guess about an appropriate tax that can

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[10] See Peter A. Diamond and James A. Mirrlees, "Optimal Taxation and Public Production II: Tax Rules," American Economic Review 61 (June 1971): 261-285; also, Arnold Harberger, "The Measurement of Waste," American Economic Review 54 (May 1964).

[11] Ronald R. Braeutigam, "Optimal Pricing with Intermodal Competition," American Economic Review 69 (March 1979):38-49.

address interjurisdictional difficulties. The informational requirements of such an approach are much smaller than those suggested by Braeutigam.

Other Forms of Price Discrimination

The topic of discounting or incentive pricing has several different variations in current public utility forums. Incentive pricing, per se, usually means discounting in order to prevent a loss of load, much as it is presented above. In addition, economic development rates are used in many states to attract new large industrial customers or to encourage the expansion of existing plants. Although the circumstances surrounding the two policies are quite different and the situation is likely to be substantially more urgent if a load loss is threatened, the ultimate outcome is similar--price tends to be driven to marginal cost by the action of the interjurisdictional competition. Consequently, both motivations are studied using the same analytical framework in the subsequent empirical investigation.[12]

The quantitative analysis of incentive pricing in this report is based on the assumption that the utility continues to recover 100 percent of its fixed costs. That is, the company remains on the zero-profit locus in the empirical work discussed later. A regulatory program can be designed that places the financial risk of industrial discount programs on the utility's shareholders instead of on captive customers. To the extent that the regulator can succeed in this, the discount is clearly not discriminatory in the meaning studied in this report because the remaining customers would pay

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[12] For additional discussion of incentive pricing, see Alan R. Schriber, "Price Discrimination: Creatively Coping with Competition," Public Utilities Fortnightly, September 1, 1988, 11-15; K.W. Costello and R.C. Hemphill, "Competitive Pricing in the Electric Utility Industry," Argonne National Laboratory, paper presented to the Transportation and Public Utilities Group of the American Economics Association, Chicago, IL, December, 1987; Russell J. Profozich, "Major Industrial Consumer Electricity Issues," mimeo to Edison Electric Institute, April 1987; Incentive and Economic Development Rates: A Short-Term Strategy, (Springfield, IL: Illinois Commerce Commission Sunset Monograph No. 6, January 1985); and, Raymond W. Harr, "A Cost Effectiveness Measure Applied to Incentive Rates in Ohio," Proceedings of the 13th Annual Williamsburg Conference, (Williamsburg, VA, December 1981).

the same amount for fixed costs. Whether a regulator could ultimately succeed in shielding captive customers is a question that involves the fundamental nature of the facilities and costs shared by the captive customers and those with competitive alternatives. This is a thorny issue involving questions of whether or not to afford rate base treatment to certain facilities, the possible restructuring of the utility to isolate the competitive services in a subsidiary, and so on. These issues are not addressed in the subsequent empirical work, which assumes that the utility is subject to traditional profit regulation.

Federal Energy Regulatory Commissioner Stalon has addressed the price discrimination inherent in mixed systems of competition and regulation.[13] In part, he is concerned about a particular motivation that may be behind some recent rate proposals submitted by interstate natural gas pipelines. There is a view that relative prices among customer groups should be arranged to maximize sales. In the case of a pipeline, this takes the form of maximizing the amount of gas put through the pipe. It is common to hear practitioners discuss the need to increase the utilization rate of idle public utility facilities. The question is whether a policy that has the objective of arranging relative prices among customers to maximize throughput or utilization is discriminatory or not. In figure 2-1, such a policy might result in the pricing point F', which is depicted as being less than the industrial marginal cost. There is no way to know in general whether the point lies there or above marginal cost. The issue is an empirical one, and so is studied as part of the quantitative analysis presented in later chapters.

The concept of predatory pricing should be mentioned briefly in this review of price discrimination concepts. The idea normally means a price below marginal cost and has its roots in the antitrust tradition of the United States. In that context, the concern is with one company's predatory strategy against a competitor. The concept is also useful in the realm of public utility regulation because one customer group paying a price below marginal cost is evidence of cross subsidization. Utility regulators may or

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[13] Stalon, Charles G., "Economic Regulation and Discrimination When Regulation and Competition Are Mixed," paper presented at the Thirteenth Annual Rate Symposium, St. Louis, MO., February 1987.

may not favor preferential treatment for some customers, but most appear to draw the line at prices below marginal cost, considering these to be unduly discriminatory. Consequently, marginal cost is a useful benchmark for determining undue price discrimination.

Finally, it is sometimes asserted that fully allocated cost pricing as practiced under traditional public utility regulation can be discriminatory. It is not possible to say whether the prices that result from such a policy lie to the left or right of the Ramsey point in figure 2-1. For this reason, several such policies are investigated as part of the empirical study described later.

Some Current Institutional Settings

Price discrimination can result in regulatory policies that favor one group or another, but sometimes it happens as a result of economic events beyond the control of the utility or its regulator. Many of the major examples of possible price discrimination that currently concern state regulators appear to stem from the latter set of circumstances.

The natural gas industry is struggling to cope with competitive market conditions at the wellhead at a time when there is excess capacity to move gas in the nation's system of pipelines. Combined with a new federal program of gas transportation services, many large customers have competitive gas supply alternatives that are unavailable to smaller customers who remain captive to their local distributor, who is, in turn, obliged to honor supply contracts that probably would not be competitive in today's market. The result is a large differential in the price paid for natural gas by residential users and large customers with alternatives. The current situation appears to be part of the transition being experienced by this industry as it moves from complete regulation to one in which important components (the gas supply itself) are competitive. Since this industry is not vertically integrated, there may be little price discrimination in the long run even if some large customers are situated so as to interact directly with distant gas suppliers. The ability of the distributor to do the same thing on behalf of smaller customers may eliminate the discrimination being experienced under current market conditions.

The nation's electricity industry has not yet undertaken any major regulatory reform similar to that experienced by the gas and telephone industries, although the current federal initiative in electric transmission policy may have important ramifications along these lines. If independent, competitive power suppliers are to emerge they will need unbundled transmission service from utilities that are currently integrated generation and transmission companies. Eliminating discrimination in the pricing of such service may be difficult. One reason is that the transmission owner has the option of engaging in a simultaneous purchase-and-resale transaction that has an electrical effect similar to that of wheeling power for an independent supplier. The effective price of this implicit wheeling service is quite lucrative under current FERC rules with the proceeds of this service generally flowing through to local ratepayers under traditional state commission treatment of the utility's finances.

The issue, then, is not one of excessive profit but of the possibly discriminatory pricing of independent versus utility-generated power. The issue has its genesis in the advance of both generation and transmission technology. It is possible to build power plants in competitive sizes that can sell power to distant markets today in part because of technical advances in generation design and in part because economical transmission distances have grown with the advent of high-voltage transmission lines. Earlier, the engineering economics was not favorable to such an enterprise. The outcome of these competitive forces is by no means clear at this point.

The restructured telephone industry is revealing some possible instances of price discrimination practices. The current issue of open network architecture has to do with the pricing of certain network services that independent long-distance carriers would like to purchase. These are typically services made available by the advanced software that control electronic switching facilities. An example might be a service that would echo the dialer's number to the receiving station. This might be useful in certain security applications, such as confirming the identity of authorized users of a dial-up computer service. Whether such a network service will be available to independent carriers and at what price is a matter that has important price discrimination elements. The issue is raised by the advance of switching technology, which is challenging the limits of traditional telephone regulation.

Conclusion

Some questions do not lend themselves to answers in broad policy terms. Even though regulators may be comfortable with the concept that pricing below marginal cost is unduly discriminatory, is it possible that fully allocated cost pricing is equally or more discriminatory? If so, under what conditions? Is a policy to maximize the utilization of fixed facilities unduly discriminatory? Always? Sometimes? The diagrammatic analysis used in this chapter cannot answer these questions; however, it does provide the background that should help in understanding the nature of the quantitative results reported in chapters 5 and 6.

CHAPTER 3

LEGAL ANALYSIS OF UNDUE PRICE DISCRIMINATION

Two major sources of law limit price discrimination by public utilities: public utility law and antitrust law. Public utility law is concerned with balancing efficiency and equity. To do this, it contains both an explicit and an implicit limit on price discrimination.

The explicit limit is found in statutes prohibiting undue or unreasonable price discrimination. Interpretations of these statutes by commissions and the courts have developed a body of law defining what type of price discrimination is undue or unreasonable. Explicit prohibitions against undue price discrimination are dealt with in the first section of this chapter.

Public utility law implicitly limits price discrimination by requiring rates to be just and reasonable. This requirement originated in common law and has a body of case law interpreting it. The "just and reasonable" requirement is an implicit limit on price discrimination because rates that are not cost-based typically are found to be unjust or unreasonable and, therefore, unlawful. Furthermore, because rates that vary significantly from the cost of providing service typically are held to be unjust and unreasonable, the same requirement limits how much rate discrimination will be tolerated--an implicit curb on price discrimination. This is discussed further in the second section.

Antitrust laws comprise the second major source of limits on price discrimination. These primarily are concerned with promoting economic efficiency in markets, avoiding the allocative inefficiencies of monopoly power, and encouraging the efficient use of resources.[1]

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1 Some economists would add the goal of maintaining price close to cost to minimize unnecessary and undesirable accumulations of private wealth. See Pitofsky, "The Political Content of Antitrust," 127 U. Pa. L. Rev. 1051 (1979). Pitofsky argues that allowing excessive concentrations of economic power will result in antidemocratic political pressures, and that the antitrust laws were enacted to prevent this trend.

Two major federal antitrust acts apply. The Sherman Act contains implicit limits on price discrimination. In particular, its prohibition against predatory pricing by a firm with monopoly power limits how far a utility can discount its rates. Hence, the Sherman Act's prohibition against predatory pricing is an implicit limitation on price discrimination, discussed in the third section of this chapter. The Robinson-Patman Act sets forth explicit prohibitions against price discrimination, which are discussed in the fourth section of this chapter.

Prohibitions against Undue Discrimination

One of the most nearly universal obligations imposed by state and federal laws on public utilities is the obligation to serve at rates that are not unduly discriminatory.[2] The prohibition against undue price discrimination is rooted in English and American common law. English common law required many tradesmen and artisans, including common carriers, to serve anyone at reasonable rates. The requirement that rates be reasonable followed from the requirement that anyone requesting service must be served, since the ability to charge exorbitant rates is equivalent to the power to deny service. However, none of the early English cases required uniform rates. The reasonable rate requirement did not prohibit differences in rates based on either cost or value of service. Only extreme forms of price discrimination, when rates were unreasonable, were illegal. At common law, the prohibition against undue discrimination had the same meaning as the requirement that rates must be just and reasonable.[3]

There was no requirement that equality (that is, uniformity) of rates must exist until the advent of the railroad when the Parliament inserted what became known as Lord Shaftesbury Clauses into English railroad special

2 James C. Bonbright, Principles of Public Utility Rates (New York: Columbia University Press, 1961), 369.

3 Isaac Lake, Discrimination by Railroads and Other Public Utilities (Raleigh, North Carolina: Edwards & Broughton, 1947), 6-10.

incorporation acts.[4] Subsequently, the Parliament enacted the first general railroad act, the Railway Clauses Consolidation Act of 1845, which prohibited discriminatory rates for passengers, carriages, or goods of the same description traveling over the same portion of the railroad under similar circumstances.[5]

American common law did not explicitly prohibit undue price discrimination until 1864 when a Pennsylvania Supreme Court decision held in dicta that English, and hence American, common law required that rates not be unduly discriminatory.[6] In so ruling, Justice Strong misinterpreted English common law, asserting that the Lord Shaftesbury Clauses prohibiting discrimination in English railroad rates were merely a restatement and enactment of existing English common law. The Pennsylvania decision was quickly followed by others in Maine,[7] New Jersey,[8] Illinois,[9] New Hampshire,[10] Ohio,[11] and California.[12] All declared undue or unreasonable price discrimination in railroad rates illegal based on common law or some other source of authority. Perhaps the most insightful decision was California's, which declared that the prohibition against unduly discriminatory rates arose not out of English or American common law, but out of the monopoly power of the railroads and their ability to discriminate, particularly against smaller captive customers.

These cases were soon followed by the enactment of state Granger Laws, which explicitly prohibited undue or unreasonable discrimination by the railroads. Their language became the source for undue discrimination provisions in all state public utility statutes.

The United States Supreme Court held in Wabash, St. Louis & Pacific Railway Company v. Illinois that states cannot forbid rate discrimination

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4 Ibid., 14-16.

5 The Railroad Clauses Consolidation Act of 1845, 8 & 9 Vict. (1844) c. 20, which is discussed in Lake, Discrimination by Railroads, 16-22.

6 Shipper v. Pennsylvania R.R., 47 Pa. St. 338 (1864).

7 New England Express Co. v. Maine Central R.R., 57 Me. 188 (1869).

8 Messenger v. Pennsylvania R.R., 36 N.J. Law 407 (Sup. Ct. 1873).

9 Chicago & Alton R.R. Co. v. People, 67 Ill. 11 (1873); St. Louis, A. & T. H. R.R. v. Hill, 14 Ill. App. 579 (1884). But see, Toledo, Wabash & W. Ry. v. Elliott, 76 Ill. 67 (1875).

10 McDuffie v. Portland & R. R.R., 52 N.H. 430, 451 (1873).

11 Scofield v. Lake Shore & M.S. Ry., 43 Ohio St. 571 (1885).

12 Cowden v. Pacific Coast S.S. Co., 94 Cal. 470 (1892).

for railroad rates that are in interstate commerce.[13] This created a regulatory gap that was a major reason for the enactment of the Interstate Commerce Act in 1887. In particular, section three of this act forbids undue and unreasonable discrimination and preferences in general. Section two forbids charging any person a rate that is higher or lower than what is charged to any other person for like and contemporaneous transportation service under substantially similar circumstances and conditions. Section three forbids giving any person any undue preference or advantage, or subjecting any person to any undue or unreasonable prejudice or disadvantage.[14] Language prohibiting unreasonable or undue discrimination was also enacted in the Federal Power Act,[15] the Natural Gas Act,[16] and the Federal Communications Act.[17]

Not all discriminatory rates are unduly so, and only undue discrimination is explicitly forbidden by public utility law. The word discrimination itself is synonymous with any kind of rate difference not reflective of cost differences. While rate differences are easy enough to identify, how does one identify whether these differences are undue?

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13 118 U.S. 557 (1886).

14 49 U.S.C. sec. 2, 3(1) (1887), which is described below.

15 16 U.S.C. sec. 824d(b) (1935), which states "[n]o public utility shall, with respect to any transmission or sale subject to the jurisdiction of the Commission, (1) make or grant any undue preference or advantage to any person or subject any person to any undue prejudice or disadvantage, or (2) maintain any unreasonable difference in rates, charges, service, facilities, or in any other respect, either as between localities or as between classes of service."

16 15 U.S.C sec. 717c(b) (1938), which states "[n]o natural-gas company shall, with respect to any transportation or sale of natural gas subject to the jurisdiction of the Commission, (1) make or grant any undue preference or advantage to any person or subject any person to any undue prejudice or disadvantage, or (2) maintain any unreasonable difference in rates, charges, service, facilities, or in any other respect, either as between localities or as between classes of service."

17 47 U.S.C. sec. 202(a), which states that "[i]t shall be unlawful for any common carrier to make any unjust or unreasonable discrimination in charges, practices, classifications, regulations, facilities, or services for or in connection with like communication service, directly or indirectly, by any means or device, or to make or give any undue or unreasonable preference or advantage to any particular person, class of persons, or locality, or to subject any particular person, class of persons, or locality to any undue or unreasonable prejudice or disadvantage."

Early case law on price discrimination can be found in federal court decisions reviewing Interstate Commerce Commission decisions. Early on, the United States Supreme Court held that section two of the Interstate Commerce Act was substantially taken from the Equality Clause of the English Railway Clauses Consolidation Act of 1845, and that the clause had been construed as embracing only circumstances concerning the carriage of goods, not the identity of the sender. In other words, the Equality clause did not allow railroads to engage in rate discrimination because of differences in circumstances arising before or after the service. Equal rates were required when like and contemporaneous services were provided under similar circumstances and conditions. A rate differential was not permitted between persons engaged in different types of businesses, but transporting the same property.[18]

The Supreme Court has also held that rate differentials are not permitted under section two between shippers of the same kind of goods based solely on the difference in use to be made of the goods once shipped.[19] The practice of grouping customers that are provided like services under similar circumstances and conditions into customer classes probably can be traced back to section two.

Where conditions and circumstances of service do differ, section two is inapplicable. The legality of the rates then is determined under section three of the Interstate Commerce Act.[20] Section three, in essence, prohibits undue or unreasonable price discrimination between classes of customers, that is, between shipments of different commodities. The prohibition against undue discrimination does not require absolute equality of rates. The legality of a rate differential between classes of customers depends on its reasonableness.

One measure of determining reasonableness under section three that was recognized early on by the commissions and endorsed by the courts is the cost of service, although value of service was also considered to be a valid consideration. Justice Brandeis stated that "...difference in rates [between classes of customers] cannot be held illegal, unless it is shown

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18 I.C.C. v. D.,L., & W.R. Co., 220 U.S. 235 (1911).
19 I.C.C. v. Baltimore & Ohio R.R. Co., 225 U.S. 326 (1912).
20 Lake, 102-3.

that it is not justified by the cost of the respective services, by their values, or by other transportation conditions."[21] Thus, section two groups customers being provided like services under similar circumstances and conditions into customer classes. The end-use of a service is not a permissible factor for defining a customer class. Section three allows consideration of value of service, as well as cost of service, for setting rates for the customer classes. Regulatory practice in the electric, gas, and telephone industries uses end use in defining customer classes, however.

Early cases required that "outlays that exclusively pertain to a given class... must be assigned to that class, and the other expenses must be fairly apportioned."[22] In other words, a customer must be charged at least the separable variable costs. However, this rule did not address how other costs, particularly joint costs were to be apportioned. Also, if all customers were charged only their variable costs, the utility's average total costs (its revenue requirement) generally would not be covered. For those utilities that continue to have decreasing long-run marginal costs, charging customers more than their long-run marginal costs might be necessary to meet the revenue requirement.

Early cases allowed administrative agencies to consider the consumer's ability to pay and the value and quality of service as factors to be considered in allocating joint costs to customer classes.[23] One legal encyclopedia has restated the public utility's duty to serve without discrimination as follows:

> A public utility is obligated . . . to furnish its service to the general public . . . without arbitrary discrimination. It must, to the extent of its capacity, serve all who apply, on equal terms and without distinction as far as they are in the same class and similarly situated, since a reasonable classification is permissible, provided all those similarly circumstanced are treated alike . . . . Public utilities are prohibited . . . from maintaining unreasonable difference among various classes of service . . . . [A public utility] cannot arbitrarily . . . refuse to one a favor or privilege which it has extended to another . . . .[24]

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21 United States v. Illinois Central R.R., 263 U.S. 515, 524 (1924).
22 Northern Pac. Ry. Co. v. North Dakota, 236 U.S. 585 (1915).
23 Driscoll v. Edison Light & Power Co., 307 U.S. 104 (1938).
24 73B Corpus Juris Secundum Public Utilities sec. 8.

Administrative agencies and the courts struggled for years with these statements of law. While a wide variety of fully distributed cost-of-service formulations were attempted, they all had one problem in common: joint costs cannot be apportioned without some degree of arbitrariness, because in someone's eyes one customer class will be preferred over others. An unrestrained monopolist, given the opportunity, would likely engage in value-of-service pricing to maximize its monopoly profits. Such pricing disadvantages small, inelastic customers, the very customers that federal and state public utility commissions were established to protect.

Bonbright on Undue Discrimination

Another excellent source on the distinction between due and undue discrimination is the seminal work of the late Professor James C. Bonbright, who was recognized as perhaps the leading authority on public utility ratemaking.

As pointed out by Bonbright,

> the legal obligation of public utilities to avoid unduly discriminatory rate[s] . . . is distinguished from the equally general obligation to charge rates, each of which is 'just and reasonable' in itself. Needless to say, these two basic mandates are related; and a commission's finding of undue discrimination between rates is likely to go hand in hand with a finding that at least one of these rates is also 'unreasonable.' But not necessarily so; for undue discrimination may be held to exist between two rates, neither of which would be found 'unreasonable per se'--possibly because the one rate may lie near the bottom of a 'zone of reasonableness' whereas the other may lie nearer the top. In this event, the remedy may take the form of an increase in the former rate, of a decrease in the latter, or of a mutual adjustment.[25]

According to Bonbright, if rate differentials merely reflect differences in the costs of servicing different classes or groups of customers, then the discrimination cannot be classified as undue.[26] However, charging different prices to different groups of customers for like

25 Bonbright, <u>Principles</u>, 369-370.
26 Ibid., 371.

services rendered at the same marginal costs would constitute undue discrimination. Similarly, failure to charge higher prices for services that have higher marginal costs also is discriminatory.[27]

Bonbright observes that the ability of an unchecked monopolist to discriminate and maintain its discrimination is closely related to its ability to restrict or prevent the transfer of its services, and its ability to operate at declining costs as output increases. It is worth noting the similarity between the social-welfare-maximizing mechanism of Ramsey pricing and the type of pricing mechanism that would be utilized by an unchecked, profit-maximizing monopolist. Both mechanisms rely heavily on demand elasticities. It has been suggested that given the current paucity of information available on demand elasticities, regulators might justifiably feel uncomfortable trying to distinguish between the two.[28]

Given this dilemma, how is one to determine whether price discrimination is due or undue? Bonbright suggests that regulators apply four principles as a test. First, the legitimate role of the value-of-service pricing principle is limited to utility companies that must charge rates in excess of marginal cost to meet their revenue requirements. Second, value-of-service rate differentials should be permitted infrequently unless they can be expected to result in lower rates for all customers, even those discriminated against. In particular, Bonbright observes that the public interest might conceivably be served by decreasing rates for customers with a highly elastic demand, even if it increased rates for customers with an inelastic demand. This principle is consistent with allowing Ramsey pricing. Bonbright observes, however, that consideration of income-distributive fairness should be weighed against such price discrimination.

Third, price discrimination should be permitted only if there is good evidence that preferential rates will cover long-run incremental costs, not just the short-run incremental costs that might be relevant only during a period of temporary excess capacity. An alternative might be that

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27 Ibid., 374.

28 James C. Bonbright et al., Principles of Public Utility Rates 2d ed. (Arlington, Virginia: Public Utilities Reports, 1988), 543.

preferential rates be temporary only, phased out as overcapacity becomes used and useful for serving other customers. Fourth, even if a utility company could reduce its rates to all customers through skillful discrimination, such discrimination should be considered undue if it resulted in harm to competitors of the customers receiving the discounted rates.[29]

Under Bonbright's four principles, temporary price discrimination would be considered due only during periods of excess capacity. Other more permanent price discrimination would require that all customers receive lower rates as a result of the discrimination and that the competitors of those businesses receiving preferential rates not be harmed. Under those same four principles, few instances of permanent due price discrimination would exist.

State Implementation

At an earlier time, state commissions seldom adopted policies specifically aimed either at promoting economic growth or attracting and retaining industrial customers, whose demand is more elastic. Beginning in the 1980s, the use of economic development rates or industrial incentive (or discount) rates became relatively widespread.

In April 1987, the National Regulatory Research Institute published the results of a survey by Pollard and Davis on the spread of economic development and industrial incentive rate provisions. That survey found that twenty-five of the thirty-eight state regulatory commissions responding had such rate provisions.[30]

In their article, Pollard and Davis grouped states having these rates into three categories. The first contained states with economic development intended to encourage new industry to locate there or to promote increased production by existing industries. Nine states are in this category:

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29 Bonbright, Principles, 383-4.

30 William Pollard and Vivian Davis, "NRRI Report: New Rates Designed to Encourage Economic Development and Load Retention," NRRI Quarterly Bulletin 8:2, 227-240.

Alabama, Delaware, Indiana, Maryland, New Hampshire, New Jersey, New York, South Dakota, and West Virginia.

The second category contained states with industrial incentive rates that encourage highly elastic customers or those with alternative sources of supply (such as fuel switching or self generation) to remain on the system and to increase their usage. Six states were in this category: Montana, Nevada, Oregon, South Carolina, Tennessee, and Virginia.

The third category contained states whose rates were a blend of economic development and industrial incentive rate provisions. Ten states were in this category: Arkansas, Connecticut, Delaware, Florida, Illinois, Iowa, Michigan, New Mexico, Ohio, and Oregon.[31]

Besides the states identified in the 1987 NRRI survey, eleven additional states have adopted some form of economic development and/or industrial incentive rates. Those states adopting economic development rates include Missouri,[32] Pennsylvania,[33] and Wisconsin,[34] while states adopting industrial incentive rates are California,[35] Kentucky,[36] Louisiana,[37] and Texas.[38] States adopting rates incorporating both

31 Ibid., 235.

32 "Missouri PSC Approves AP&L Economic Development Tariff on Experimental Basis," NARUC Bulletin, October 12, 1987, 6-7.

33 "Pennsylvania Rate Incentive to Boost Industry, Add Jobs Proposed," Public Utilities Fortnightly, April 2, 1987, 51; "Pennsylvania PUC Permits Duquesne Light to Give Rate Breaks to New or Expanding Industrial Customers," NARUC Bulletin, December 16, 1985, 21.

34 "Electric Utilities May Be Able to Use Ratepayer Money for Economic Development Promotions in Wisconsin," NARUC Bulletin, March 25, 1985, 20; "Wisconsin PSC: Utilities Must Prove Load Promotion Benefits to Recover Costs," Electric Utility Week, June 3, 1985, 11.

35 James Norris, "Cogeneration and Small Power Production: Recent Regulatory Developments," Public Utilities Fortnightly, June 25, 1987, 46-49; "Calif. to Try Averting Bypass by Ending Rate Adjustments for Big Users," Electric Utility Week, June 22, 1987, 9-11; "Pacific Gas & Electric Gets Approval for 47-MW Cogeneration Deferral Pact," Electric Utility Week, August 17, 1987, 14; Re Electric Utility Ratemaking Mechanisms, 91 PUR4th 117 (Calif. PUC, 1988).

36 "Big Rivers Rate Hike Okayed by PSC, But Must Get REA and Banks' Approval," Electric Utility Week, August 17, 1987, 7-8.

37 "Louisiana P&L to Lower Firm's Rates for Delaying Cogeneration Project," Electric Utility Week, July 21, 1986, 10.

38 Re Gulf States Utilities Company, 92 PUR4th 250 (Tex.PUC 1987).

economic development and incentive rate provisions include Arizona,[39] Idaho,[40] Kansas,[41] and Oklahoma.[42]

Another recent study conducted by staff of the Illinois Commerce Commission reports that in the summer and fall of 1988 thirty-six state commissions had some form of economic development or incentive rate provisions.[43] The survey grouped those states having such rates according to the reasons for implementing the rates, which included discouraging customers from switching to alternative fuels, encouraging new industries to locate within the state, encouraging expansion of existing industries in the state, reducing excess capacity, and promoting job creation. Nearly all state commissions fell into more than one category.

Twenty-one state commissions offered discounted rates to discourage

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39 "Two Largest Industrial Customers of Arizona PS Granted Discount Rates," Electric Utility Week, November 10, 1986, 10; "Arizona Rates Tied to Copper Prices," Public Utilities Fortnightly, December 11, 1986, 46; and "Arizona PS Readies Incentive Rates; Lures One Big New Customer Already," Electric Utility Week, March 9, 1987, 17.

40 Re Atlanta Power Company, Inc., 93 PUR4th 161 (Id.PUC, 1988); "PUC Acts Quickly to Approve Idaho Power Plan for 50% Discount to Customers," Electric Utility Week, November 10, 1986, 12.

41 "Kansas CC Approves Special Contract Between KG&E and Farmland to Keep it On Line," NARUC Bulletin, November 23, 1987, 19-20; "Kansas CC Approves KG&E Request to Amend Vulcan Rates," NARUC Bulletin, January 18, 1988, 8-9; "Kansas CC Approves Economic Development Gas Rates for New Commercial and Industrial Customers," NARUC Bulletin, November 2, 1987, 21-22; "Kansas G&E Gets Approval to Cut Retail Rates to Potential Self-Generation," Electric Utility Week, October 6, 1986, 7.

42 "Oklahoma CC Approves Gas Purchase Programs to Boost Industrial Growth," NARUC Bulletin, May 25, 1987, 23-24; "Central P&L Cogeneration Deferral Rate Requires Customer-Supply Gas," Electric Utility Week, March 23, 1987, 17-18, which notes that Public Service of Oklahoma has cogeneration deferral rates; and "Oklahoma Nixes Economic Development Rates--With the Exception of Oil Fields," Electric Utility Week, June 9, 1986, 10-11.

43 Dennis L. Sweatman and Larry J. Mraz, "Economic Development-Incentive Rate Policies Implemented by State Utility Commissions," NRRI Quarterly Bulletin 10:3, 231-48. The thirty-six state public utility commissions include those in Alaska, Arizona, Arkansas, California, Connecticut, Florida, Idaho, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Montana, New Hampshire, New Jersey, New Mexico, New York, Ohio, Oregon, Pennsylvania, Rhode Island, South Dakota, Tennessee, Texas, Utah, Virginia, Washington, West Virginia, and Wyoming.

customers from switching to alternate fuels,[44] twenty-one had discounted rates to attract new customers to the state or to a particular service area,[45] fourteen had rate discounts to encourage expansion of existing industry,[46] fourteen had discount rates offered to reduce excess capacity,[47] and eight had discount rates to promote job creation.[48] Three commissions cited other reasons.[49]

Of the fourteen remaining states, the Illinois staff found six that had discounts offered for off-peak usage.[50] However, these rates were part of the normal rate design and were not designed specifically for economic development. Three state commissions allowed rate discounts on existing load for load retention purposes.[51] Only three state commissions offered no rate discounts: Nebraska, Oklahoma, and South Carolina.

Each of the economic development, incentive, or discount rates developed by the states listed above (other than those reflecting cost differences for off-peak usage) is discriminatory in the sense that they contain rate differentials that do not reflect the marginal cost of serving the preferred customers, and in the sense that they distinguish these customers from others receiving like service produced at the same marginal costs. By authorizing these rates, the state commissions have held

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44 The twenty-one state commissions include those in Arkansas, California, Florida, Idaho, Illinois, Iowa, Kansas, Louisiana, Minnesota, Mississippi, Montana, New Jersey, New Mexico, Oregon, Pennsylvania, Tennessee, Texas, Utah, Washington, West Virginia, and Wyoming.

45 The twenty-one state commissions include those in Arizona, Arkansas, Connecticut, Idaho, Illinois, Indiana, Kansas, Kentucky, Louisiana, Maryland, Michigan, Missouri, Montana, New Jersey, New Mexico, New York, Ohio, Pennsylvania, Texas, Virginia, and West Virginia.

46 The fourteen state commissions include those in Arizona, Arkansas, Connecticut, Illinois, Kansas, Kentucky, Louisiana, Michigan, New Jersey, New Mexico, New York, Ohio, Pennsylvania, and Texas.

47 The fourteen state commissions include those in Alaska, Arizona, Illinois, Indiana, Louisiana, Minnesota, Missouri, New Hampshire, New Jersey, New Mexico, Pennsylvania, Rhode Island, South Dakota, and Texas.

48 The eight state commissions include those in Illinois, Kentucky, Louisiana, Maryland, New Jersey, Ohio, Pennsylvania, and Texas.

49 These state commissions are Massachusetts, New Mexico, and Pennsylvania.

50 State commissions in Colorado, Hawaii, North Carolina, North Dakota, Vermont, and Wisconsin.

51 The state commissions in Delaware, Maine, and Nevada.

implicitly or explicitly that the rates are in the public interest and are not unduly discriminatory. A closer examination of how state commissions analyze whether these discriminatory rates are due or undue is warranted.

Typical State Analyses

Bonbright suggests a two-step analysis to judge whether rates are unduly discriminatory. The first step is to determine whether the rates are discriminatory at all. The second is to determine whether the discrimination is undue. To do this, commissions would apply a set of standards to determine whether rates are in the public interest and due, or whether they are not in the public interest and undue. Bonbright suggests using his four principles, described earlier, to make this public interest determination.

A typical state commission analysis does not use this two-step approach. Instead, commissions usually jump to the second step to analyze whether discriminatory rates are due or undue. While details of the analyses vary from state to state, most commissions apply a public interest standard to determine whether proposed discriminatory rates are due or undue.

State commissions look at and place emphasis on a variety of factors to determine whether proposed discriminatory rates are in the public interest. For example, for states that allowed economic development rates to go into effect, a primary concern is to attract new business or encourage the expansion of existing business in a service area. By encouraging new growth and expansion, the public utility commission hopes to bolster the state's economy, while making use of any existing excess capacity of the utility. By creating new load, the public utility commission could help the utility recover its investment in otherwise unused plant, and avoid spreading costs of unused capacity over the remaining customers. The rationale for this type of price discrimination applies only when excess capacity exists. Care must be taken that new load or expanded existing load does not require new investment in plant. Therefore, it is probably best if this type of rate is temporary, and phased out as excess capacity disappears.[52]

The New York Public Service Commission made its economic development rates effective in specific economic development zones to encourage financially distressed industries in impoverished areas to compete more effectively in the markets.[53] At least one state (Maryland) has tied its economic development rate directly to an increase in employment or capital investment by an existing customer.[54]

Some states have considered the effect of economic development rates on competitors of those customers receiving the preferential rate. For example, the Delaware Public Service Commission conditioned its acceptance of economic development rates on the utility's agreement that the proposed rate would be available to all similarly situated industrial customers. Such customers are also required to increase or add at least 10 MW of new load and take at least 95 percent of their total load on an interruptible basis.[55]

The Oklahoma Corporation Commission took the interesting approach of rejecting general economic development rates, designed to entice an industry into a state, while approving special economic incentive rates for the state's depressed oil industry. The Commission rejected economic development rates as being unfair to existing industrial customers because they would enhance the competitive position of new entrants over existing firms. However, special rates were to be provided to the oil industry because of the pervasive effect that the industry has on taxes, jobs, and other industries in the state. Lower electricity costs might allow oil well

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52 For example, the Arkansas Power & Light and Northern Indiana Public Service Companies economic development rates both have a five-year duration. See "Economic Development Rates," Public Utilities Fortnightly, January 7, 1987, 49; and Kenneth Breeden and Richard Metzler, "The Evolution of an Industrial Marketing Program: The AP&L Story," Public Utilities Fortnightly, December 10, 1987, 11-17; "Economic Development Rates Approved," Public Utilities Fortnightly, October 27, 1988, 45-6.

53 Re Brooklyn Union Gas Co., et al., Order G-2566, Docket EL-2134 (NYPSC 1987).

54 Re Conowingo Power Co., Order 67786, case 8011 (Md.PSC 1987).

55 Re Delmarva Power and Light Company, 84 PUR4th 684 (Del.PSC 1987).

operators to continue operating marginal wells that otherwise might shut down.[56]

One state commission, Wisconsin's, allows utilities engaged in the promotion of economic development through discounted rates only to recover their expenses from ratepayers, if the economic growth would not harm remaining ratepayers. In particular, the economic growth cannot come on-peak because that would require new capacity that would increase the present worth of the remaining ratepayers' long-term costs. Load promotion programs will increase costs to the remaining ratepayers unless they are targeted for off-peak periods.[57] Similarly, the Missouri Public Service Commission approved an experimental economic development tariff. It provided for a reduced electric rate when applied to new or increased existing electric load during non-summer months.[58]

State commissions implementing industrial incentive rates also have taken a variety of approaches in determining whether a discriminatory rate is in the public interest. A substantial number of state commissions have approved special incentive rates for large industrial customers that have the capacity for installing and operating cogeneration facilities. Even though such rates may have the otherwise anticompetitive effect of discouraging new entrants to the power generation market, some state commissions have found these rates in the public interest, and presumably not unduly discriminatory.

A typical commission rationale goes like this: the utility and ratepayers are benefited by maintaining the existing industrial load. If the load is in danger of shrinking or disappearing because rates are too high, approval of a lower rate that would increase or maintain the industrial load remaining on the system is in the public interest. Therefore, it is in the public interest (and, we infer, not "unduly" discriminatory) to provide special discounted incentive rates to certain

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56 "Oklahoma Nixes Economic Development Rates--With Exception of Oil Fields," Electric Utility Week, June 9, 1986, 10-11.

57 Order, Investigation on the Commission's Own Motion into the Environmental and Economic Impact of Electric Load Growth on the Eastern Wisconsin Utilities, Docket No. 05-EI-15 (Wis.PSC 1985).

58 "Missouri PSC Approves AP&L Economic Development Tariff on Experimental Basis," NARUC Bulletin, October 12, 1987, 6.

industrial customers based on their potential ability to cogenerate electricity, particularly where cogeneration would lessen utility load and burden the remaining ratepayers with the obligation of paying for stranded plant.[59]

Another argument in favor of industrial incentive rates to defer cogeneration is that the public interest is better served by an orderly, well-managed introduction of cogeneration into an existing utility system when needed, rather than having the disruption of cogenerators leaving the system to self-generate during periods of excess capacity. The latter would tend to result in revenue erosion for the utility, an increase in excess capacity, and, under traditional regulation, higher bills for remaining customers.

Similarly, some state commissions have granted industrial incentive rates to keep customers from leaving the system to buy cheaper energy from other sources. Typically, these commissions find the discriminatory rates in the public interest as long as the incremental cost of service is covered and some contribution is made to the utility's cost of capital.[60] Thus, the availability of alternative sources of energy from neighboring jurisdictions or through bypassing can result in a public interest argument in favor of industrial incentive rates.

In setting industrial incentive rates, some state commissions tie the rate to the price of the preferred customer's commodity on the market,[61] or even to the average industrial rates in the region.[62] This is held to be in the public interest since it results in local firms remaining competitive so that they can continue to purchase services from their host utility.

One final important factor should be noted. Many state commissions do not pass through the entire cost of an economic development rate or an

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59 Re Gulf States Utilities Company, 92 PUR4th 250 (Tex.PUC 1987).

60 For example, see In Re Application of Piedmont Natural Gas Company for Approval of Procedures to Enable the Petitioner to Participate in Industrial Sales Program, Order No. 83-226 (SCPSC 1983).

61 "Big Rivers Rate Hike Okayed by PSC, But Must Get REA and Banks' Approval," Electric Utility Week, August 17, 1987, 7-8; and "Arizona Electric Rates Tied to Copper Prices," Public Utilities Fortnightly, December 11, 1986, 46.

62 "20 of Illinois Power's Big Customers Tie Rates to a Midwest Index," Electric Utility Week, August 18, 1986, 1-2.

industrial incentive rate to other customers. Instead, they require a sharing by shareholders and ratepayers of any revenue deficiency that results from these rates.[63] According to the Illinois staff report, five states have a predetermined formula to split revenue requirement deficiencies between stockholders and ratepayers.[64] Thirteen states vary the allocation on a case-by-case basis depending on the circumstances of the case.[65] The California Public Utility Commission's approach is particularly interesting, because the revenue requirement deficiency risk is spread among the customer classes based on their price elasticity, thus, implementing something akin to Ramsey pricing. Still other states require the utility to bear the entire burden of any revenue deficiency caused by discounted rates.[66]

Summing Up

In early cases, the United States Supreme Court permitted value of service to be taken into consideration to determine whether rates were unduly discriminatory. However, the primary consideration in determining whether rate differentials are unduly discriminatory was and remains the cost of service. Yet, at least forty-one state public service commissions allow some form of rate discrimination, which usually favors the more elastic customers. Thus, a clear majority of the state commissions permit discriminatory rates that vary from the cost of service.

When do these rate differences become unduly discriminatory? In almost all instances, state commissions consider rates below the short-run

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63 Re Electricity Utility Ratemaking Mechanism, 91 PUR4th 117 (Calif.PUC 1988).

64 Sweatman and Mraz, "Economic and Development-Incentive Rate Policies," 240-4. These state commissions include those in Arizona, Arkansas, Minnesota for electric rates, Montana, and Ohio.

65 These state commissions include those in California, Florida, Iowa, Kentucky, Louisiana, Michigan, Rhode Island, South Dakota, Tennessee, Texas, Virginia, and Washington.

66 These state commission include those in Illinois, Indiana, Kansas, Massachusetts, Minnesota for discounted gas rates, and Utah.

marginal costs of service to be unduly discriminatory.[67] On the other hand, state commissions split on whether the legal prohibition against unduly discriminatory rates permits rate preferences that favor one class of customers while burdening another. Six state commissions pass on the revenue requirement deficiencies resulting from rate discounts to the nonpreferred customer class at the next rate case. Until then, the utility stockholders suffer revenue deficiencies. Six commissions require stockholders always to bear revenue requirement deficiencies. Most of the remaining state commissions fall somewhere in between.

State commissions typically consider a variety of public interest factors in determining what is permissible, as opposed to what is undue discrimination. Some factors include whether a utility's existing capacity is underutilized, the desirability of economic development, the short- and long-term effects of discriminatory rates on nonpreferred customers, the availability of alternative suppliers, the potential for bypass, and the socio-economic effects of losing major industries. The consideration of discriminatory rates is driven by immediate events, such as a utility having substantial excess capacity, rather than by a potentially desirable outcome, such as maximizing social welfare. Not surprisingly, any theory, such as Ramsey pricing, that requires accurate but generally unavailable data on customers' demand elasticities plays little role in commissions' current considerations about whether price discrimination is due or undue.

The courts have not provided clear guidance on when rates in favor of one class of customers and burdening another becomes unduly discriminatory. However, casual observation of current regulatory practice allows certain observations to be made. Under circumstances where cost-based rates will not allow a utility to recover its revenue requirement, Ramsey pricing may be legally permissible price discrimination. When one moves beyond its

67 Dennis L. Sweatman and Larry Mraz, p. 240. Only two state commissions report not requiring discount rates to cover short-run marginal costs in all instances. The Massachusetts Commission has not yet established a policy on the matter, but will place utility stockholders at risk for pricing below short-run marginal costs if it is determined to be predatory. The Montana Commission does not require discounts on an existing customers' entire load retention to cover short-run marginal costs, but requires discounts on incremental or new load to do so.

limits, however, the economic justification for price discrimination, that of obtaining social welfare-maximizing pricing, loses its force. Beyond Ramsey pricing, a utility uses its monopoly power to discriminate to convert consumer surplus into producer surplus. While cost-based pricing is the principal and preferred method of setting rates, value-based pricing is allowed as a valid secondary consideration to achieve a revenue requirement. However, value-of-service pricing that goes beyond what is necessary for a utility to meet its revenue requirement and allows a utility to exercise its monopoly power to charge a class of customers exorbitant rates would probably be found to be unduly discriminatory as well as unjust and unreasonable.

Just and Reasonable Rates

What are the limits placed on discriminatory rates by the just-and-reasonableness standard? The zone of reasonableness is the standard used by the United States Supreme Court to interpret the statutory definition of the just-and-reasonable standard contained in the Natural Gas and Federal Power Acts. To satisfy the standard, rates must be lower than what would be considered excessive to consumers and higher than what would be confiscatory to a utility's investors.[68]

Traditionally, the zone of reasonableness has been understood to require cost-based rates. For rates not to be confiscatory to the utility's investors, rates at least must not fall below the variable cost of service.[69] For rates not to be excessive to consumers, rates should never

68 See Permian Basin Area Rate Cases, 390 U.S. 747, 767 (1968), quoting FPC v. Natural Gas Pipeline Company, 315 U.S. 575, 587 (1941).

69 See for example the Lignite Coal Case, where a North Dakota statute was held to be confiscatory because it did not allow the railroad to recover its out-of-pocket costs from some customers. Northern Pacific Ry. Co. v. State of North Dakota, 236 U.S. 585, 599 (1915). Although the Hope Natural Gas case has made the end-result test the final measure of whether a commission has violated the confiscation clauses of the Fifth and Fourteenth Amendments, the out-of-pocket-costs test (variable costs) still remains as a valid test for the lower limit of the zone of reasonableness.

be set so high as to allow the utility to exploit its monopoly power.

A variety of tests can be used to determine when such rates would occur. Some courts consider the value of service to the individual customer when determining whether rates are excessive and outside the zone of reasonableness.[70] However, this test seems to beg the question of whether the utility is exploiting its monopoly power. Indeed, if a utility were to charge a customer whatever the market would bear, it would be acting as a monopolist. A utility would be engaged in discriminatory pricing if it were charging different prices to different groups of customers based on their price elasticities of demand. However, it could not necessarily be said that the resulting rates would be unjust or unreasonable, because it would not be clear that the utility was exploiting its monopoly power to gain monopoly rents.

Such Ramsey-style pricing has been widely accepted by regulatory agencies and the courts when discrimination has become necessary to recover the deficiency in total revenues that would result from the sale of services at the utility's marginal costs.[71] Indeed, the Interstate Commerce Commission for a time apparently attempted to use Ramsey-style pricing to discriminate in favor of some customers, but only to the extent that the benefit to the customers discriminated against was maximized. The rates of the customers being discriminated against were no more, and possibly were less, than they would have been without the discriminatory rates.[72]

Public utility law's just-and-reasonable-rates standard creates an implicit limit on price discrimination. Although it should occur rarely,

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70 Edison Light & Power Co. v. Driscoll, 25 F. Supp. 192 (1938), reversed on other grounds, Driscoll v. Edison Light & Power Co., 307 U.S. 104, rehearing denied, 307 U.S. 650 (1939).

71 Bonbright, Principles, 89.

72 See George W. Wilson, "The Effect of Rate Regulation on Resource Allocation in Transportation," American Economics Review, Papers and Proceedings (May 1964), LIV: 164-5, as cited in Alfred E. Kahn, The Economics of Regulation: Principles and Institutions, vol.1 (New York: John Wiley & Sons, 1970), 143-6. See Janis, "A Law and Economics Study of Rail Freight Rate Regulation: Tradition Standards, Ramsey Prices, and a Case of Neither," 15 Transportation L.J. 31, for a description of current rate discrimination practices at the I.C.C. since the passage of the Staggers Act. It should be noted that the I.C.C.'s reasoning is inconsistent with the economic analysis contained in chapter 2.

discrimination can be proposed where one or more of the rates fall outside of the zone of reasonableness. In such a scenario, the just-and-reasonable standard can set an implicit limit on how discriminatory the rates can be. Our analysis assumes that this scenario exists.

Traditionally, the just-and-reasonable standard has been interpreted by the Federal Energy Regulatory Commission (FERC) as requiring the use of embedded cost-based rates. However, the outer bounds of what courts are likely to consider permissible is the zone of reasonableness. But, to justify the use of marginal cost-based rates instead of embedded cost-based rates, the federal courts require the FERC to do more than rely on economic theory as a justification for abandoning established precedent. The FERC must demonstrate on the record with substantial evidence that a rational basis exists for the change in policy.[73]

In another sector, regulation of the telephone industry at both federal and state levels has traditionally relied on value-of-service pricing. Before the AT&T divestiture, policies of ratemaking by the FCC and state commissions were designed to yield adequate total revenues through higher charges on urban than rural subscribers, on business than residential subscribers, and on long distance than local service. These price differentials were defended primarily on the basis of value of service to the subscriber, not on the basis of cost. Such prices may bear little relationship to cost-based rates and are within the zone of reasonableness only by accident. They can be said to be just and reasonable, however, because of tradition and precedent. Since the AT&T divestiture, telephone rate regulation has been in a state of flux. The FCC has engaged in price cap regulation, under a social contract theory. State commissions are reexamining the application of cost-based rates to their basic operating companies.

Most state commissions also traditionally rely on some form of a fully distributed cost-of-service study to determine rates. Individual state courts may be more or less willing than the federal courts to allow state

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73 Electricity Consumers Resource Council v. F.E.R.C., 747 F.2d 1511 (1984).

commissions to consider and adopt marginal cost-based rates. Where just-and-reasonable rates are based on a fully allocated embedded cost-of-service study, state commissions may feel constrained to permit less leeway on deviations from the cost-of-service study results than would be permitted by the outermost bounds of the zone of reasonableness.

The just-and-reasonable standard requires rates to be set within a zone of reasonableness. Hence, the outermost limits must not be set below variable costs of service, nor set above a level that would result in exorbitant or excessive rates. A heavy reliance on value-of-service pricing, beyond that which is necessary to allow the utility an opportunity to earn its revenue requirement would probably result in excessive rates for some customers.

Predatory Pricing under the Sherman Act

Although section two of the Sherman Act prohibits monopolization and attempts to monopolize, the act does not prohibit the existence of monopolies. A monopoly that results from natural economic forces, such as a declining cost curve, or from business acumen or superior technological skill is not illegal. Public utilities are considered to be monopolies under section two of the Sherman Act and are subject to its provisions.[74]

Monopolization requires the possession of monopoly power in the relevant market and the willful acquisition or maintenance of monopoly power, as distinguished from growth or development stemming from a superior product, business acumen, or historical accident.[75] Thus, a legal monopoly, such as a public utility, cannot use its market power to maintain its monopoly. In particular, a monopolist cannot use its market power in

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74 Otter Tail Power Co. v. United States, 410 U.S. 359, reh. denied 411 U.S. 910 (1974); and MCI Communications Corp. v. AT&T Co., 708 F.2d 1081 (7th Cir.), cert. denied 464 U.S. 891 (1983).

75 United States v. Grinnell Corp., 384 U.S. 563, 570-71 (1966). For an excellent discussion of how antitrust law applies to regulated industries, see David Hjelmfelt, Antitrust and Regulated Industries (New York: John Wiley & Sons, 1985).

one market to harm or prevent competition from emerging in another market; one means that a monopolist might use to monopolize is to engage in extreme forms of price discrimination.

An attempt to monopolize requires a specific intent by a firm with market power in the relevant market to engage in predatory or exclusionary conduct that has a dangerous probability of successfully achieving monopolization. Under this offense, intentional predatory behavior (such as price discrimination) by a firm with market power can lead to an antitrust violation if the conduct could succeed in driving competitors from the market, or in preventing potential competitors from entering it.

Predatory Pricing

The Sherman Act contains no explicit prohibition against price discrimination. However, in 1975 two scholars, Areeda and Turner, proposed that a predatory pricing antitrust offense become one of the proscriptions contained in section two of the act.[76] The predatory pricing theory under this section of the act follows this logic: a monopoly firm or a firm having sufficient market power to engage in price discrimination between markets lowers its price in a market where it faces competition. The firm's intent is not to compete for customers (a desirable short-run effect), but to drive out competitors or prevent potential competitors from entering. In the long run, such a strategy may harm customers because the firm can later exercise its enhanced market power, for example, by raising prices.

However, it is virtually impossible in practice to decide whether the intent behind the firm's price cutting was predatory or simply hardball competition. Because of the difficulty in distinguishing predatory from vigorous competitive behavior, Areeda and Turner suggest that a workable test for deciding when a firm is engaging in predatory pricing is to note when a firm sets its price below short-run marginal costs. Under this test, a monopolist (a firm that has captured a sufficiently large portion of the market to determine the market price simply by varying its output) would not

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76 See Areeda and Turner, "Predatory Pricing and Related Practices under Section Two of the Sherman Act," 88 Harvard L. Rev. 697 (1975).

be allowed to set prices below marginal cost to meet the lawful price of a rival, particularly when the rival is a new market entrant.[77] Because of the difficulty in measuring short-run marginal costs, Areeda and Turner suggest that average variable costs be used as a surrogate.[78]

Before this classic article was published, only one significant predatory pricing case had been litigated, and it was a Robinson-Patman Act case, not a monopolization case under the Sherman Act.[79] Between the publication of the Areeda and Turner article in 1975 and 1986, approximately fifty-five predatory pricing cases were brought under the Sherman Act in federal courts.[80] The Areeda-Turner article created a new cause of action under section two of the Sherman Act--a predatory pricing action which prohibits a firm with market power from charging prices below its variable costs. This is an implicit limitation on price discrimination by monopoly firms.

In 1986, however, the United States Supreme Court in Matsushita Electric Industrial Co. v. Zenith Radio Corp. made predatory pricing more difficult to prove.[81] In that case, the plaintiff alleged a predatory pricing conspiracy by twenty-one Japanese-controlled corporations to sell television sets below the market price. The Supreme Court held that predatory pricing conspiracies are speculative by nature, because they require alleged conspirators to sustain substantial losses to recover uncertain gains. No plausible, rational motive was presented by the plaintiff to explain the defendant's engaging in predatory pricing. Furthermore, the Supreme Court found the plaintiff's evidence ambiguous and as consistent with permissible vigorous competition as with an illegal conspiracy. The Court reversed and remanded the decision of the Third Circuit Court of Appeals.

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77 Ibid., 715-6.

78 Ibid., 716. Average variable costs is simply an average of the variable costs over a set period of time, such as a year, month, or during a peak and off-peak period.

79 Utah Pie Co. v. Continental Baking Co., 386 U.S. 685 (1967).

80 Liebler, "Whither Predatory Pricing? From Areeda and Turner to *Matsushita*," 61 Notre Dame L. Rev. 1055.

81 Matsushita Electric Industrial Co. v. Zenith Radio Corp., 475 U.S. 574, 106 S. Ct. 1348 (1986).

In reaching its decision, the Court cited (then) Professor Robert Bork, noting that predatory pricing is likely only in rare circumstances when the predator can make a rational calculation that its losses from pricing below cost are an investment in future monopoly profits (where rivals are to be eliminated) or in future undistributed profits (where rivals are to be disciplined). The discounted flow of future profits must exceed the present losses.[82] This could only occur in those rare instances when some assurance exists that the predator can maintain its monopoly power for a significant period of time. Unless admissible direct evidence that this is possible is presented by the plaintiff, a predatory pricing case is subject to a motion for summary judgment. This effectively decides the case on the defendant's behalf because the admissible evidence does not raise a genuine issue of material fact as to the elements necessary to maintain a predatory pricing cause of action. Indeed, the Supreme Court held in Matsushita that the Court of Appeals had not applied the proper standard in evaluating the United States District Court's decision to grant the defendants' motion for summary judgment.

Application to Public Utilities

In the circumstances likely to arise when a utility engages in price discrimination, it might be possible to show that the utility is engaging in predatory pricing to maintain its monopoly status through exclusionary behavior. Such a strategy would work like this: an electric utility is faced with competition from cogenerators or independent power producers in a selected market, say the industrial market in this case. To maintain its monopoly status, the utility cuts its prices below its variable (or its average variable) costs. To successfully pursue a cause of action one would need to show that the utility has a monopoly in the industrial market. An argument can be made that since resale of electricity service is not possible, each customer classification represents a separate relevant

82 Ibid., 589.

market.[83]

Then, one would need to show that the utility intended to maintain its monopoly through predatory conduct. Clearly, pricing below variable costs is predatory conduct. For a court to believe that the conduct is plausible and rational behavior on the part of the monopolist, however, one would need to show that the utility could recoup its losses from a flow of future profits. Because the utility would raise its prices and recoup its profits from less elastic customer classes, one could easily argue that the utility was immediately recouping its losses by price discrimination.

However, Professors Bork and Richard Posner contend that, although high profits in one market can be used to finance predatory pricing in another, the profits themselves do not make predatory pricing more likely. Predatory pricing can be financed from any source and, if rational, ultimately must be profitable in and of itself.[84] Further, the Matsushita case implicitly rejected the possibility that high prices in one market are evidence of predatory pricing in another.[85] After all, conduct in one market may have little bearing on conduct in another since rational firms would set prices to maximize profits in each separate market.[86] Yet, direct proof of pricing below variable costs alone should be sufficient to show that a utility considers predatory pricing to be rational.

Because of this, the Sherman Act's prohibition against predatory pricing is an implicit limitation against price discrimination by utilities, but only to the extent that a price discrimination scheme results in prices below short-run marginal, or average variable costs in some market. A utility cannot engage in extreme price discrimination and set its prices below its variable costs without risking an antitrust violation. However, the Sherman Act only applies, if at all, if prices are set below variable

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83 If resale of services were possible, of course, this argument would not stand because a customer facing a higher price could always seek a lower price through the resale market.

84 Richard Posner, The Robinson-Patman Act: Federal Regulation of Price Differences (New York: Basic Books, 1976), 19; and Robert Bork, The Antitrust Paradox (Washington, D.C.: American Enterprise for Public Policy Research, 1978), 145.

85 475 U.S. at 595-6.

86 Rasmussen and Glazer, "Antitrust Implication of Cases Rejecting Cross-Subsidization Arguments," Antitrust Fall 1988, 28-32.

costs. Because most prices, even discriminatory ones, are set at or above variable costs, the Sherman Act would not apply in most price discrimination cases facing regulators.

Further protection from liability under the Sherman Act is available to utilities through a state action exemption, which has its genesis in Parker v. Brown, a 1943 United States Supreme Court case.[87] Under the exemption, an agency acting as an agent of the state, and with the full attributes of state sovereignty can permit actions that otherwise would be violations of the Sherman Act as long as the conduct is the result of a clearly articulated and affirmatively expressed state policy, actively supervised by the state agency.

Actions that otherwise would violate the antitrust laws can be exempt if (1) they are actively supervised by the state and (2) they are pursuant to a clearly articulated and affirmatively expressed state policy to substitute monopoly or regulation for competition.[88] For utility conduct to fall under the state-action exemption, it must be compelled by the state agency; mere state acquiescence is not enough.[89] State approval of a utility-proposed tariff alone would not provide antitrust immunity.[90] However, if a state commission had a clearly articulated and affirmatively expressed policy allowing price discrimination designed to result in prices below variable cost, and if the policy was actively supervised, a state-action antitrust exemption probably would be available.

Active supervision might take the form of a state commission determining whether tariffs conformed to its expressed policy and reforming those tariffs that did not. However, if a state commission merely received utility tariff filings after the fact without a clearly articulated and affirmatively expressed policy, a state-action exemption probably would not apply.

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87 Parker v. Brown, 317 U.S. 341 (1943).

88 California Retail Liquor Dealers Association v. Midcal Aluminum, Inc., 445 U.S. 97, 105 (1980).

89 For a more detailed discussion of the state-action exemption, see Robert E. Burns, "Legal Impediments to Power Transfers" in Non-Technical Impediments to Power Transfers ed. Kevin Kelly (Columbus, Ohio: The National Regulatory Research Institute, 1987) 88-9.

90 Cantor v. Detroit Edison, 428 U.S. 579 (1976).

Robinson-Patman Act Prohibitions against Price Discrimination

The Robinson-Patman Act was passed in 1936 as an amendment to the Clayton Act to prohibit explicitly certain discriminatory pricing practices by any business or industry. The Act is considered by some to be "singularly opaque,"[91] plagued by obscure statutory language and an unrevealing legislative history.[92] Nevertheless, the purpose of the Act can be described succinctly as prohibiting a seller from charging one buyer a price different from that charged to another, where the conditions surrounding the sale are the same.[93]

Elements

For the purpose of our analysis, the relevant portion of the Robinson-Patman Act is section 2(a). For there to be a violation of section 2(a) of the Robinson-Patman Act, there must be at least two sales in interstate commerce of commodities of like grade and quality by the same seller at different prices, the sale of which may cause the requisite injury to competition.[94] The Act does not require the discrimination to have actually harmed competition. Instead, it is sufficient to show that a reasonable possibility exists that the discrimination may have such an effect.[95]

A complaint against a discriminator can be brought not only by a direct competitor (a primary-line case), but also by a non-preferred customer (a secondary-line case). A primary-line case requires that a competitor show that the predatory nature of a seller's discriminatory actions caused an injury to competition. In a secondary-line case, the buyer must show only

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91 Justice Harlan in F.T.C. v. Sun Oil Co., 371 U.S. 505, 530 (1963).

92 Note, "The Requirement of Actual Competition Under Section 2(a) of the Robinson-Patman Act: You're Damned if You Do and You're Damned it You Don't," 36 U. Pitt. L. Rev. 186, 187 (1974).

93 Ibid., 186.

94 Eaton, "The Robinson-Patman Act: Reconciling the Meeting Competition Defense with the Sherman Act," 18 Antitrust Bull. 411, 412-13 (1972).

95 F.T.C. v. Morton Salt 334 U.S. 37, 46 (1948); and Utah Pie v. Continental Baking Co., 386 U.S. 685, 699-700 (1967).

that there is enough difference in wholesale price to influence resale prices and that such discrimination has occurred over time.[96]

Defenses

Even when the plaintiff makes a _prima facie_ case, the defendant can prevail by demonstrating any one of three statutory affirmative defenses: (1) a good-faith meeting of competition, (2) cost justification, and (3) changing market conditions.[97]

The two affirmative defenses most often used are the good-faith-meeting-competition defense and the cost justification defense. The former defense requires that the seller offer a lower price to meet, but not beat, a competitor's equally low price.

The latter defense allows a seller to pass cost economies on to its customers, even though this may benefit large-volume buyers.[98] In other words, price discrimination is not illegal if the price differential between the customers receiving a higher price and those receiving a lower price does not exceed the cost differential of doing business between the two groups of customers. Such cost differentials can result from differences in the cost of production, sale, or distribution. Thus, price discrimination based on differences in costs, such as that found in differing costs of service, are not violations of the Act.

In practice, however, this defense has been complex to prove, requiring meticulously exact historical cost data. Further, the use of such costs in a statutory cost-justification study is fundamentally flawed, since prices in competitive markets are often set at the incremental costs incurred by the seller for the particular sale. This problem is compounded by the inherent arbitrariness of joint cost allocations referred to elsewhere in

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96 Hansen, "Robinson-Patman Law: A Review and Analysis," 51 _Fordham L. Rev._ 1113, 1134-36 (1983).

97 Ibid. There is also one nonstatutory defense available: that the lower price is available to all customers. Note that a refusal to deal is not considered to be price discrimination under the act.

98 Ibid., 414-9.

this report.[99]

The changing-market-conditions defense can justify price differentials when there is an alteration in market conditions or in the product's marketability.[100]

Application to Public Utilities

The Robinson-Patman Act applies to price discrimination by public utilities by applying to any price discrimination that falls within its provisions. The mere fact that a public utility is a regulated monopoly does not exempt it from the Robinson-Patman Act. However, there may well be an issue of whether certain public utility services are commodities under the Act--electricity, in particular. Debates have arisen over price-squeeze complaints that have until recently been tried principally before the FERC.[101]

For example, the Eighth Circuit Court of Appeals held that electricity is a commodity for purposes of applying the Robinson-Patman Act. In the case of City of Kirkwood v. Union Electric Co., the Court held that electricity was a commodity because it could be felt, was produced, sold, stored in small quantities, transmitted, and distributed in discrete

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99 Rowe, "Cost Justification of Price Differentials under the Robinson-Patman Act," 59 Columbia L. Rev. 584 (1959); and Hansen at 1145-48.

100 Hansen, p. 1154.

101 A typical price-squeeze issue arises when electricity is sold by a utility at wholesale to a full- or partial-requirements municipal customer at a high wholesale price. Because the utility supplier is a competitor of the municipal utility, the high wholesale price may make the wholesale utility's own retail price more attractive than the retail price of the municipal utility. Such a price squeeze can have an anticompetitive effect, particularly if the wholesale price is not cost justified and the municipality has no alternative suppliers that can reach it. In Federal Power Commission v. Conway Corp., 426 U.S. 271 (1976), the United States Supreme Court held that this type of rate discrimination was between the wholesale rate set by the FERC and the retail rates set by state public utility commissions, and that the FERC had sufficient authority to determine allegations of wholesale-retail rate discrimination. For a general discussion of this issue, see Lori Burkhart, "'Price Squeeze' Lawsuits under the Clayton Act: Electricity as a Commodity," Public Utilities Fortnightly, December 22, 1988, 45-7.

quantities.[102] Other United States District Courts have followed this ruling.[103]

A Delaware District Court took the opposite position in City of Newark v. Delmarva Power & Light Co., ruling that electricity was not a commodity under the Robinson-Patman Act.[104] According to that court, electricity did not have the physical characteristics of a commodity, as described in the act. In particular, electricity was not synonymous with "goods, wares, or merchandise." Electricity also was not sold through a traditional commodities distribution system--from a supplier through a wholesaler to a retailer--but, through an integrated electric utility system with a simultaneous matching of supply and demand. The Second Circuit Court of Appeals followed the City of Newark decision in City of Groton v. Connecticut Light & Power Co.[105]

Thus, the applicability of the Robinson-Patman Act to electricity sales is at best uncertain. And although there has been only one case on the matter, it is clear that natural gas is considered a commodity under the Robinson-Patman Act.[106] On the other hand, the provision of telephone service has been held not to be a commodity.[107] If the cases were ever to arise, it also seems likely that forms of utility transportation service,[108] such as gas transportation service or the wheeling of electricity, would not be held to be commodities under the Act .

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102 City of Kirkwood v. Union Electric Co., 671 F.2d 1173, 46 PUR4th 182 (8th Cir. 1982), cert. denied, 459 U.S. 1170 (1983).

103 Borough of Ellwood City v. Pennsylvania Power Co., 570 F.Supp. 553 (W.D.Pa. 1983); Town of Concord v. Boston Edison Co., 676 F.Supp. 396 (D.Mass. 1988); and City of Gainesville v. Florida Power & Light Co., 488 F.Supp. 1258 (S.D.Fla. 1980).

104 City of Newark v. Delmarva Power & Light Co., 467 F.Supp. 763 (D.Del. 1979).

105 City of Groton v. Connecticut Light & Power Co., 497 F. Supp. 1040 (D.Conn. 1980), affirmed in part and reversed on other grounds, 662 F.2d 921 (2d.Cir. 1981).

106 B & W Gas Inc. v. General Gas Corp., 247 F.Supp. 339 (N.D.Ga. 1965).

107 See generally, TV Signal Co. of Aberdeen v. AT&T, 462 F.2d 1256 (C.A.S.D. 1972), which held that commodities are restricted to products, merchandise, or other tangible goods. Also, see H.R.M., Inc. v. Tele-Communications, Inc., 653 F. Supp. 645 (D.Colo. 1987).

108 Transportation services have been held not to be a commodity. See Shippers, Inc. v. Southern Pacific Transp. Co., 673 F. Supp. 1005 (C.D.Colo. 1986).

Assuming that this commodity standard is met for a Robinson-Patman Act application, still other hurdles must be cleared to prove a price discrimination violation under the Act. For example, courts have applied the traditional "in interstate commerce" standard in primary-line cases so that any price discrimination that tends to directly burden or affect interstate commerce falls within its reach. However, in secondary-line injuries, some courts have required that at least one of the allegedly discriminatory sales crosses a state line.[109] Thus, for a buyer to complain that another buyer has received a preferential price from the seller, at least one interstate sale must occur. It is not enough that the sale directly affects interstate commerce.

One hurdle that might be harder to clear is the requirement that the commodities be of like grade and quality. In the case of electricity, it is easy to argue that power delivered at different voltages is not of like grade or quality. The cost of these "grades" of electricity varies because of differing line losses, as well as the capital costs of low-voltage distribution systems. Thus, they cannot be compared for purposes of price discrimination under the Act. Similar arguments can be made for a variety of telephone, gas, and electric services based on the time of day or the conditions for delivery (such as whether the service is interruptible or not).

Another hurdle that may be difficult to overcome is the requirement that there be a requisite injury to competition. In the case of primary-line injuries, the competing supplier needs to show that the injury has a predatory effect. In its most recent case on price discrimination, Matsushita, the United States Supreme Court stated in dicta that "[a]s a practical matter, it may be that only direct evidence of below-cost pricing is sufficient" to prove predatory pricing.[110] Stated this way, the issue then becomes one of which cost is relevant. While there is no recent Supreme Court case that is dispositive, the general consensus in the federal

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109 Note, "Antitrust Law--Robinson-Patman Act--To Satisfy the 'In Commerce' Requirement of Section 2(a) at Least One of the Allegedly Discriminatory Sales in a Secondary-Line Case Must Cross A State Line," 27 Vanderbilt L. Rev. 539 (1974).

110 Matsushita Electric Industrial Co. v. Zenith Radio Corp., 475 U.S. 574, 585 (1986) at ftnt. 9.

courts is that pricing below short-run marginal or average variable cost is illegal per se and that pricing above these costs is one sign of legality.[111] Courts do consider other non-price factors as well.[112] In all but the most extreme instances of price discrimination, a utility will set prices above its variable costs. In the case of secondary-line injuries, there must be a difference in price sufficient to influence resale prices. This standard appears to require sustained price discrimination before a complaint can be brought.[113]

Even if a prima facie price discrimination case exists against a utility, the case still would be subject to the affirmative defenses described above. A utility might successfully claim that it was meeting competition if its discriminatory prices were the result of meeting the price of a potential bypasser or alternative supplier. A utility could almost certainly successfully use the cost-justification defense if its discriminatory prices were the result of a fully distributed cost-of-service study filed at a state public utility commission. Also, a utility might attempt to make use of a changing-market-condition defense when faced with competitors in its own markets. In sum, a utility engaging in discriminatory pricing could take advantage of one or more of the Robinson-Patman Act affirmative defenses.

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111 Southern Pacific Communications Co. v. AT&T, 740 F. 2d 980 (D.C. Cir. 1984); Barry Wright Corp. v. ITT Grinnell Corp., 723 F.2d 227 (1st Cir. 1983); Northeastern Tel. Co. v. AT&T Co., 651 F.2d 76, 88 (2d Cir. 1981); MCI Communications Corp. v. AT&T, 708 F.2d 1081 (7th Cir. 1983). The Areeda-Turner economic test has been used to assign the burden of proof in two circuits, William Inglis & Sons Baking Co. v. ITT Continental Baking Co., 668 F.2d 1014, 1035 (9th Cir. 1981); Arthur S. Langenderfer, Inc. v. S.E. Johnson Co., 729 F. 2d 1050 (6th Cir. 1984). Although the courts do not explicitly use the term short-run marginal costs, it is clear from the context that is what they are referring to. The marginal costs referred to are equivalent to average variable costs. But see, ILC Peripherals Leasing Corp. v. IBM Corp., 458 F. Supp. 423, 431-432 (N.D.Cal. 1978), which held that the tests for predatory pricing are (1) pricing below average variable costs and (2) pricing above such costs but below short-run profit-maximizing prices where barriers to entry are high; the second test should be applied only in limited circumstances and should probably be considered an exception to the first test. Also, the Eleventh Circuit in McGahee v. Northern Propane Gas Co., 858 F.2d 1487 (11th Cir. 1988) rejected average variable costs and used average total cost as a standard to determine whether predatory pricing exists.

112 Hansen, 1137-42.

113 Ibid., 1134-36.

Beyond the Robinson-Patman Act affirmative defenses, one additional antitrust defense is sometimes available to public utilities: the state-action exemption, previously mentioned. However, it also is uncertain whether the courts would apply a state-action exemption to a Robinson-Patman Act price discrimination case because the exemption normally applies only to Sherman Act violations. However, a strong argument could be made in favor of an exemption since identical public policy goals would be achieved through its application.

In conclusion, the antitrust standard of the Robinson-Patman Act is not very useful in preventing price discrimination, and the Sherman Act only prohibits extreme price discrimination in those rare instances where prices are set below variable costs. Although the Sherman Act provides the regulator with some minimal guidance on the lower boundary price of unduly discriminatory rates, a heavier reliance must be placed on public utility standards, on the explicit prohibition against undue price discrimination, and on the requirement that rates be just and reasonable to set the appropriate limits on price discrimination.

Summary

The limits on price discrimination as set out in the public utility laws and explained above can be summarized briefly. The explicit prohibition against unduly discriminatory prices means that prices cannot vary significantly from the cost of providing service, unless it can be shown that the variation is in the public interest. Value of service considerations are permissible, however, if necessary to meet the revenue requirement. Viewed from the standpoint of the public interest, Bonbright states that a _restrained_ use of Ramsey pricing is defensible because it is a _relatively_ harmless means of recovering the revenue deficiency that would result if services were priced at variable costs.[114]

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114 Bonbright, _Principles_, 89.

Commissions apply the public interest standard in a variety of ways. In some states, providing a rate discount to a customer who would otherwise leave the system meets the standard. These states still require the customer to pay a price that yields a contribution toward the utility's capital costs; a round-about way of stating that prices cannot be set below the variable costs of serving that customer. Some states permit the utility to recover its revenue requirement deficiencies from the remaining customer classes.

It is important to emphasize that many other states, while allowing a public utility to discount rates to variable costs for one class, do not allow a public utility to recover its revenue requirement deficiencies for that class from other customer classes. This stance is based on the theory that it would be contrary to the public interest to shift revenue requirement burdens to other customer classes merely because a utility competes for customers in some markets. Hence, the presumption made in the rest of this report, that the revenue requirement constraint must always be satisfied, does not always hold. Rate discounts to one customer class do not always result in immediate rate surcharges to another class, and price discrimination in favor of one class of customers does not always burden another, at least in the short run.

In these states, if other customer classes are not directly burdened, the price discrimination is considered not undue and hence legal. The utility's stockholders must bear the burden of discounted rates, an increased burden affecting the utility's cost of future capital. Some, if not all, of the costs of discounted rates may eventually be passed on, however, to the remaining customers indirectly through a higher cost of capital.

In some jurisdictions, the explicit prohibition against unduly discriminatory rates has been interpreted to mean that all like customers (that is, all customers within the same customer class) must be offered the same rate. A few states use the public interest standard to justify rates that are heavily discounted for socio-economic reasons. Sometimes these rates are set close to or at marginal cost to encourage economic development. In some states, other customer classes provide partial or total subsidies to customers who are given these rates.

The division of customers into customer classes allows commissions to assure that like customers receiving like services are charged the same price, thereby avoiding undue price discrimination. However, the existence of different classes of customers with similar characteristics also facilitates value-of-service pricing and creates an opportunity for an unchecked monopolist to engage in undue price discrimination. This is the case in particular when customers are divided into customer classes according to industry and other factors that reflect demand elasticity, instead of divided into customer classes according to factors reflecting cost causation, such as electric voltage levels and time of use.

The requirement that rates be just and reasonable provides an implicit limitation against extreme, and hence undue, price discrimination. First, it requires that all studies of price discrimination begin with a cost-of-service analysis, since the just-and-reasonable standard requires rates to be cost-based. The just-and-reasonable limit on discriminatory rates, at a minimum, requires that rates be set within a "zone of reasonableness." This requires rates to be set no lower than variable cost and less than a level at which rates would become excessive.

The courts give little guidance as to when rates become excessive, although the authors suggest that the use of value-of-service pricing that results in rates above those of an unrestrained monopolist would almost certainly be considered by the courts to be excessive. Rates that exceed those levels would represent a clear exercise of monopoly power by the utility. Some courts would likely consider value-of-service pricing short of this point also to be excessive, although where courts would draw the line is unclear.

Some jurisdictions require any significant variation from the commission-approved method of calculating rates (typically using fully allocated cost-of-service studies) to be justified as being in the public interest. Except in those jurisdictions allowing rate discrimination for economic development purposes, the just-and-reasonable requirement creates an implicit limit so that price discrimination cannot result in rates that are less than the variable costs.

The explicit limits on price discrimination contained within the Robinson-Patman Act are likely to come into effect only when prices are set below variable costs. In other circumstances, a utility probably will avoid the provisions of the Act or successfully make an affirmative defense. Similarly, a utility would violate the Sherman Act's implicit limits on price discrimination only if it engaged in extreme price discrimination, such as if a customer were charged less than the variable cost of providing service. An affirmatively stated and clearly articulated state policy in favor of economic development might allow a utility to charge less than variable costs if the program was actively supervised by the commission.

In sum, although some variation exists between jurisdictions, the variable costs of providing service to the customer represents one of the outermost legal limits against price discrimination. The other legal limit, that rates cannot be excessive, is ill-defined. However, the authors suggest that an extreme use of value-of-service pricing, as mentioned earlier, would probably be considered undue. To avoid excessive rates, many jurisdictions require a utility's shareholders to bare all or part of the revenue deficiency resulting from the implementation of economic development or incentive rates, thus assuring that discriminatory pricing will not be pushed past the point where small, inelastic customers are severely disadvantaged. In this manner, state commissions have reconciled their duty to protect the small inelastic customer with the market forces pushing utilities toward discriminatory pricing in order to achieve their revenue requirement.

CHAPTER 4

ECONOMIC EFFICIENCY AND EQUITY CONSIDERATIONS: THE ANALYTICAL MODEL AND THE PRICING POLICIES

The discussion so far has suggested that economists and regulators cannot expect to identify discriminatory pricing patterns in regulated markets from first principles alone, except in particularly obvious cases.[1] That is, the facts and circumstances of specific situations are likely to be important in assessing whether a set of prices is unduly discriminatory. In his treatment of intermodal competition, Braeutigam recognizes that a quantitative evaluation of specific industry characteristics is needed before one can know whether a scheme of partial price regulation is superior to one that attempts to regulate all relevant markets.[2] State commissions that have considered economic development rates or incentive rates intended to retain industrial load have proceeded in a measured and deliberate way in recognizing that the problem is complex and that its nature can change rapidly.[3] In addition, no way exists of determining whether a pricing policy intended to maximize the utilization of excess generation capacity is discriminatory merely by the policy merits of the idea in the absence of a factual background.

The regulatory pricing analyst, then, is faced with an inherent limitation to the insights about pricing discrimination that can be found in the principles of law and economics. Some empirical examination of specific

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[1] When firms are free to compete and customers are free to choose, broad principles, such as those embodied in our antitrust tradition, can be articulated because society can focus on the process of competition, as opposed to specific pricing results. Similar principles of regulatory process cannot be fashioned, because prices can be administered in a variety of ways, some good and some bad, and customer choice cannot be relied upon to drive out the discriminatory outcomes.

[2] Braeutigam, "Optimal Pricing with Intermodal Competition," American Economic Review.

[3] For more discussion, see Illinois Commerce Commission Incentive and Economic Development Rates: A Short-Term Strategy.

industrial circumstances is needed as well. There is no substitute, of course, for data about the actual participants, the regulated firm and its customers, in the case of regulation of real-world utilities. A difficulty, however, with real-world data is that important economic parameters such as the marginal cost of service or the price elasticity of demand can only be estimated and are always the topic of some dispute. This difficulty can be overcome by using hypothetical examples of markets, although the cost of this approach is the loss of some reality.

Such a loss was deemed acceptable for this project since one of its objectives is to compare a variety of possible regulatory policies using an identical set of economic circumstances--a condition not possible with real-world data. Accordingly, the analytical strategy adopted for this study is to construct hypothetical economic situations and then evaluate the pricing outcomes for several policies in terms of the resulting economic efficiency and social fairness.

Some Economic Background

For this project, optimal prices for six separate regulatory policies were calculated for several hypothetical economic settings. Finding the optimum and then describing it for even one policy in one setting is complicated. As the reader can appreciate, the technical discussion and numerical detail can easily become overwhelming. For this reason, most of the technical description of the optimal pricing policies is presented in appendix A for those interested in such matters. The calculations for this project were done on a microcomputer using a matrix algebra programming language called GAUSS. The optimal pricing programs written in this language are listed in appendix B. The numerical results are summarized at various points in the following chapters with somewhat more detailed presentations contained in appendix C.

Economic Setting

The economic setting consists of three customer groups, which can be thought of as the residential, commercial, and industrial sectors. To keep matters simple, each group is specified as having a linear demand curve in which the quantity demanded is a linear function of the price charged to that specific group. The price charged to industrial customers, for example, does not affect the demand of residential consumers, and so on. Residential demand is considered to be relatively inelastic, meaning that this sector's sales respond only modestly to changes in price. Industrial demand is the most elastic market, with the commercial sector lying between the two, although fairly inelastic itself.

The linear demand curve for each market is specified and fixed at the outset of the analysis of the various regulatory policies. All policies are examined using the same set of demand curves for the three customer groups. In finding optimal prices for different policies, residential demand may be high for one and low for another. Consequently, the resulting price elasticity of demand would be low for the policy with large sales and high for the policy for low sales, because the linear relation between demand and price is one in which the elasticity changes along the curve. It is not possible, then, to state the elasticities used in advance of the analysis.

In general, residential demand is specified as having a demand elasticity of about .25 at an arbitrary initial point. The industrial demand elasticity, by comparison, is about .7 and that of the commercial sector about .35. Setting the elasticity at an initial point fixes the demand curve for the remaining analysis. The industrial elasticity at the optimum, however, might be .5 for one policy and 2.0 for another. These elasticities correspond roughly to those that have been estimated and reported in the economics literature.[4]

All of the regulatory pricing policies are studied using a high and low value for the residential and industrial demand elasticities to determine the sensitivity of the results to these important economic parameters.

The hypothetical utility's cost structure is equally simple. Its variable or marginal cost of serving each group is constant, with the industrial sector having the lowest and the residential sector having the highest marginal cost. Together, the three groups have a responsibility to

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[4] See L.D. Taylor, "The Demand for Electricity: A Survey," The Bell Journal of Economics 6 (Spring 1975): 74-110.

pay for a certain amount of fixed cost. The regulated utility is subject to a revenue requirement that assures it of recovering all prudently incurred costs. Consequently, prices of at least some groups must exceed their respective variable costs in order to recover the utility's fixed costs. This corresponds to the traditional specification that production exhibits increasing returns to scale, or that unit costs decline with output.

The amount of fixed cost is an important factor in the performance of the pricing policies studied here. Consequently, it is analyzed at four levels, ranging from about 10 percent of total costs up to about 60 percent of total costs. This range is adequate to represent cost conditions in most public utilities today.

One of the pricing policies studied for this project involves interjurisdictional competition for industrial customers, which has the effect of driving the industrial price down to marginal cost. Because of this, the basic policy model has three utilities, each in a different regulatory jurisdiction. The utilities have different levels of fixed cost to add realism to the model. The difference in fixed cost among the three utilities is itself analyzed at two levels. In one case, the range between the utilities with the highest and lowest amounts of fixed costs is about 15 percentage points. In the other, it is analyzed at a difference of about 30 percentage points.

The final parameter that is varied in order to assess the sensitivity of the results is the size of the industrial market in relation to a utility's total sales. Utilities with about 50 percent and about 70 percent of industrial sales are examined in this report. These are relatively large industrial markets. Some companies have significantly larger residential markets. Nonetheless, the sensitivity of the results gives a good indication of this factor's importance.

In all, five parameters that describe the economic environment of the utility are varied in the following analysis. The residential elasticity of demand, the industrial elasticity of demand, the difference in fixed cost among the three utilities, and the size of the industrial market are each studied at two levels. The amount of fixed cost is examined at four levels.[5] There are, then, sixty-four combinations of values studied in a single sensitivity analysis of these five factors.

Several such sensitivity analyses were conducted for this study. In particular, circumstances intended to reflect long-run conditions were studied, as well as those appropriate for the short-run. The short-run is characterized as having relatively high fixed costs, with the marginal cost of serving each customer group about the same. By comparison, the long-term has different marginal costs of serving the three customer classes, with relatively small fixed costs. For completeness, all possible combinations of low and high fixed costs and the same and different marginal costs are studied.

In addition, the price discrimination problem is studied using three different "models." These are interesting in their own right; however, the primary intent is to study three different methods of fully allocated cost pricing. The basic model has a single market for each of the three customer groups and three utilities. For a single regulatory policy, then, optimal prices are found for each of these nine markets. A summary of the initial data for the basic model is given in table 4-1. This basic model is limited in that demand is represented for each customer group as a single commodity. In reality, the demand in each sector is multi-faceted.

To overcome this in part, two other models are examined. In the second model, each customer group participates in two markets, peak and off-peak. Although there are two separate markets, a single price is charged for both the peak and off-peak sales. This corresponds to the current practice of not differentiating price for most public utility markets and products. The initial data used for this single-price, peak and off-peak market model are given in table 4-2. The model is specified to be similar to the basic model. The additional richness of this model, however, allows the study of more complex and realistic pricing policies. For example, the peak-responsibility method of cost allocation is used to determine fully allocated-cost prices in this model.

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[5] Students of experimental design will recognize this as a full factorial 2 x 2 x 2 x 2 x 4 experiment.

TABLE 4-1

INITIAL PARAMETERS USED IN BASIC MODEL

UTILITY	GROUP	DEMAND ELASTCTY	MARG COST	QUANTITY
1	R	0.25	5.0	60
1	C	0.35	4.5	40
1	I	0.70	3.0	90
2	R	0.25	5.0	60
2	C	0.35	4.5	40
2	I	0.70	3.0	90
3	R	0.25	5.0	60
3	C	0.35	4.5	40
3	I	0.70	3.0	90

EXPERIMENTAL DESIGN

RESIDENTIAL DEMAND ELASTICITY:	.25, .375	
INDUSTRIAL DEMAND ELASTICITY:	.7, 1.4	
FIXED COST:	30, 40, 50, 60	(APPROX. PERCENT)
DIFFERENCE IN FIXED COST:	7.5, 15	(BETWEEN JURISDICTIONS)
SIZE OF INDUSTRIAL MARKET:	50, 75	(PERCENT OF TOTAL SALES)

Source: Authors' calculations.

The third and final model examines what happens when the peak and off-peak markets are charged different prices. The initial conditions for this peak and off-peak pricing model are listed in table 4-3 and are similar to those of the previous two models. The average-and-excess method is the example used for fully allocated cost pricing in this model. Appendix A provides a technical description of all three cost allocation methods used in this study.

Analytical Approach

The intent of this analysis is to find numerical measures of the economic efficiency and social fairness of several regulatory pricing

TABLE 4-2

INITIAL PARAMETERS USED IN SINGLE PRICE, PEAK AND OFF-PEAK MODEL

UTILITY	GROUP	PERIOD	PEAK ELAS*	OFF-PEAK ELAS	MARG COST	QUANTITY
1	R	P	0.25	-0.05	6.0	20
1	R	O	-0.05	0.15	3.0	40
1	C	P	0.35	-0.05	5.0	15
1	C	O	-0.05	0.25	2.5	25
1	I	P	0.60	-0.10	4.0	30
1	I	O	-0.10	0.50	2.0	60
2	R	P	0.25	-0.05	6.0	20
2	R	O	-0.05	0.15	3.0	40
2	C	P	0.35	-0.05	5.0	15
2	C	O	-0.05	0.25	2.5	25
2	I	P	0.60	-0.10	4.0	30
2	I	O	-0.10	0.50	2.0	60
3	R	P	0.25	-0.05	6.0	20
3	R	O	-0.05	0.15	3.0	40
3	C	P	0.35	-0.05	5.0	15
3	C	O	-0.05	0.25	2.5	25
3	I	P	0.60	-0.10	4.0	30
3	I	O	-0.10	0.50	2.0	60

EXPERIMENTAL DESIGN

RESIDENTIAL DEMAND ELASTICITY:	.25, .375	
INDUSTRIAL DEMAND ELASTICITY:	.7, 1.4	
FIXED COST:	20, 30, 40, 50	(APPROX. PERCENT)
DIFFERENCE IN FIXED COST:	7.5, 15	(BETWEEN JURISDICTIONS)
SIZE OF INDUSTRIAL MARKET:	50, 75	(PERCENT OF TOTAL SALES)

Source: Authors' calculations.
* The cross-price elasticity of demand is shown as the elasticity of the off-peak market (the row) with respect to peak price (peak-elasticity column).

policies for a variety of economic circumstances. The analysis is based on traditional social welfare theory as described in many texts and treatises.[6]

Social welfare is measured as the aggregate of consumers' surplus plus producer profit. Since the utility is restricted to earning

[6] A good description is in Robin W. Boadway, Public Sector Economics (Cambridge, MA: Winthrop Publishers, Inc., 1979).

TABLE 4-3

INITIAL DATA USED IN PEAK, OFF-PEAK PRICING MODEL

UTILITY	GROUP	PERIOD	PEAK ELAS	OFF-PEAK ELAS	MARG COST	QUANTITY
1	R	P	0.25	-0.05	6.0	20
1	R	O	-0.05	0.15	3.0	40
1	C	P	0.35	-0.05	5.0	15
1	C	O	-0.05	0.25	2.5	25
1	I	P	0.60	-0.10	4.0	30
1	I	O	-0.10	0.50	2.0	60
2	R	P	0.25	-0.05	6.0	20
2	R	O	-0.05	0.15	3.0	40
2	C	P	0.35	-0.05	5.0	15
2	C	O	-0.05	0.25	2.5	25
2	I	P	0.60	-0.10	4.0	30
2	I	O	-0.10	0.50	2.0	60
3	R	P	0.25	-0.05	6.0	20
3	R	O	-0.05	0.15	3.0	40
3	C	P	0.35	-0.05	5.0	15
3	C	O	-0.05	0.25	2.5	25
3	I	P	0.60	-0.10	4.0	30
3	I	O	-0.10	0.50	2.0	60

EXPERIMENTAL DESIGN

RESIDENTIAL DEMAND ELASTICITY:	.25, .375	
INDUSTRIAL DEMAND ELASTICITY:	.7, 1.4	
FIXED COST:	30, 40, 50, 60	(APPROX. PERCENT)
DIFFERENCE IN FIXED COST:	7.5, 15	(BETWEEN JURISDICTIONS)
SIZE OF INDUSTRIAL MARKET:	50, 75	(PERCENT OF TOTAL SALES)

Source: Authors' calculations.

zero profits, however, the measure is simply consumers' surplus in this application. The analysis is static, and the relative efficiencies of various regulatory policies are measured as if they were carried out the same way forever. In practice, regulators can modify their pricing policies and adapt to the changing circumstances of the industries they oversee. Static welfare analysis is useful nonetheless because it suggests which policies are superior to others in the long run and it helps in understanding the complexity of the price discrimination issue.

In the following analysis, six separate pricing policies for meeting the revenue requirement are examined. In each, the utility's revenue requirement is satisfied. Five policies are intended to be plausible and ones that a state utility commission might consider in one form or another. These are described in the next section. The sixth is the benchmark for the other five in the sense that the efficiency of the other policies is measured in comparison to it.

The benchmark policy is an arrangement of prices across all markets, regardless of the jurisdiction, that covers aggregate fixed costs for all three utilities and has the highest aggregate consumers' surplus. In effect, the benchmark is based on the notion that prices are set as if all three utilities are integrated and a joint obligation to cover fixed costs exists regardless of the utility that incurred them.

There is no intent to advocate the unification of service territories by adopting this benchmark. Rather, the integrated system model establishes the highest possible level of social welfare that can be achieved while still recovering the revenue requirement. As such, all other pricing policies can be measured against the benchmark to find the welfare cost of each. Welfare cost is measured as the percent reduction in aggregate social welfare incurred as the result of a particular pricing policy.

The benchmark policy provides a common basis of comparison similar to the first-best benchmarks used in welfare cost estimates of the effect of proposed tax policies. Although it may be the best possible pricing policy that recovers the utilities' total cost, it is nonetheless in the class of second-best policies itself since the prices are constrained to recover fixed as well as variable cost. Here, therefore, the benchmark could be described as Ramsey pricing for the integrated system. By choosing a benchmark that includes recovery of fixed cost, as opposed to a first-best policy that does not, the welfare cost comparisons are more realistic, in the sense that any reduction in consumers' surplus is due to a pure reallocation effect from rearranging the pattern of prices among markets rather than due to an added burden of fixed cost recovery that a first-best benchmark policy would not share.

The measure of efficiency in this report, then, is the reduction in aggregate social welfare, as measured by consumers' plus producer's surplus, associated with each pricing policy. This is a traditional method of welfare analysis familiar to many readers.

In addition to efficiency, a measure of social fairness or equity is needed in order to assess whether and to what extent a particular pricing policy favors one group or another. Such a measure can help assess whether or not a pricing policy constitutes due or undue discrimination. For this purpose, this report uses the welfare weights implied by the concept of a weighted social welfare criterion.

The criterion specifies that aggregate social well-being is the weighted sum of consumers' surplus plus the utility's economic profits. The weights are subjective and represent a decision-maker's implicit comparison of the social worthiness of various consumer groups. So, for example, a willing regulator could express a preference for one group over another by assigning the preferred group a higher social welfare weight. The result would be a lower price for groups having larger welfare weights.

This report does not mean to suggest that regulators should assign such weights or that they explicitly do so now. Instead, the idea is to assess the degree of discrimination inherent in the prices that result from a particular policy by inferring the set of welfare weights that would be required for the observed prices to represent an optimum of the weighted social welfare criterion. The implicit welfare weight is a measure of the preference extended to the favored group. In this sense regulators can use it to assess the extent of the discrimination inherent in a proposed set of prices.

For the basic model (with one market for each customer group), finding the implied welfare weights requires information about the marginal cost and price elasticity of demand for each market. For each such market, determine a price markup as

$$E_i = \frac{P_i - C_i}{P_i}$$

where P_i is price and C_i is marginal cost for group i. Then form an elasticity-weighted markup as

$$\theta_i = - E_i \epsilon_i$$

where ϵ_i is the demand elasticity for group i. Select one group, say the residential sector, as the reference group that is assigned a welfare weight of unity. The implicit welfare weight for all other groups can be found as

$$w_i = \frac{1 - \theta_i}{1 - \theta_R} \qquad (1)$$

where the subscript R refers to the residential group. The formula for the weight, w_i, is derived in appendix A. It is essentially a ratio of elasticity-weighted price markups from two markets, based on the same principles as the so-called inverse-elasticity rule. In particular, the formula calculates the percentage deviation of price from marginal cost and then adjusts this percentage by the elasticity of demand for each market. Markets that have the same adjusted price deviation as the residential market have an implied welfare weight of unity. If the adjusted price deviation is smaller than that of the residential market, the resulting weight is larger than unity since a smaller θ_i is subtracted from 1 in the numerator of formula (1).[7]

Figure 4-1 is a zero-profits locus of pricing points similar to the one discussed in chapter 2. On the axes are the prices charged to any two of the customer groups, holding constant the prices in all remaining sectors. The vertical axis shows the price charged to industrial users who have relatively inelastic demand, while the horizontal axis depicts the residential price. The pricing combination associated with the Ramsey (or inverse-elasticity) rule is shown on the figure as point R. If the industrial welfare weight is unity, meaning no relative bias in favor of either group, the policy that maximizes aggregate weighted social welfare is simply the Ramsey rule. Hence, the Ramsey policy is neutral in the sense that no bias need be imparted to a weighted social welfare criterion to justify the pricing point R in figure 4-1.

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[7] Formula (1) is appropriate for the basic model in which each customer group has only one market. With a single customer class participating in multiple markets, the analysis becomes more complicated. It may not be possible to find any set of welfare weights that exactly corresponds to a weighted social welfare maximization. A good approximation can be made, however. Further discussion of this point, on both an intuitive and rigorous level, is in appendix A.

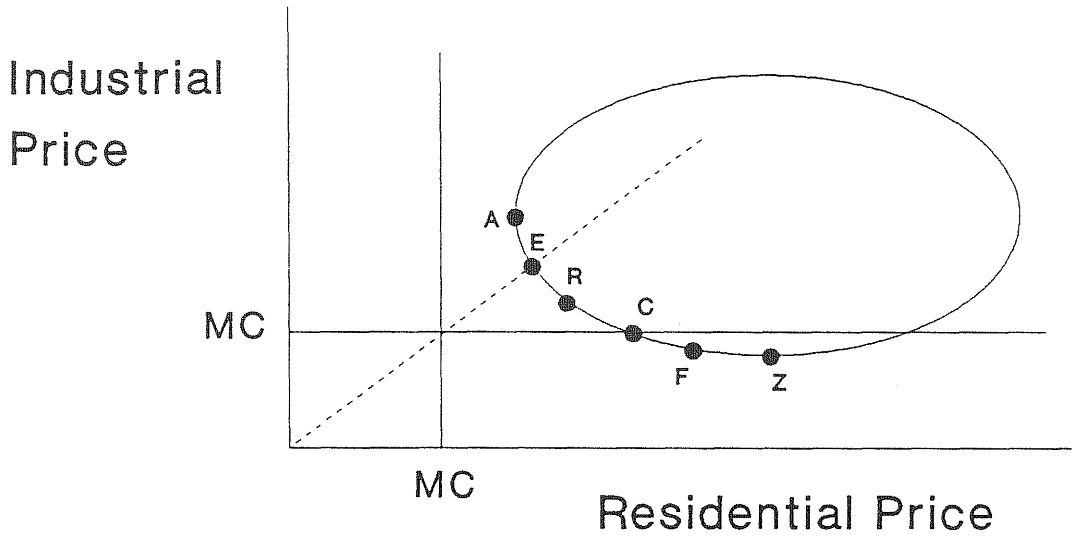

Fig. 4-1 Equity extremes along a zero profit locus

Recall that Ramsey pricing itself is considered discriminatory by many. In this report, discrimination or pricing preference means "more preferential" than Ramsey pricing, which is neutral in the important sense just described. That is, the degree of discrimination is measured as the social welfare weight needed to justify any observed deviation from the neutral point. As such, the report is an inquiry, in part, into what can be learned by adopting such a standard for price discrimination.

It is worth pausing to consider the fundamental implications of using the Ramsey solution, point R, as a discrimination benchmark as compared to a more traditional standard, such as an equi-proportional markup over marginal cost, point E in figure 4-1. In the figure, the sensible range of regulatory pricing outcomes that cover the revenue requirement is from point A (limited by monopoly pricing of industrial services) to point C (limited by marginal-cost pricing of industrial services). Point E falls between points A and the Ramsey benchmark, R, as it always will as long as industrial service is more sensitive to price than residential use. Depending on the relative elasticities of the two groups, point E can lie close to A, close to R, or (in more extreme but nonetheless plausible circumstances) it can lie beyond point A in the diagram's backward-bending portion. Using a point such as E as a benchmark for price discrimination means that monopoly pricing of industrial customers, points close to A, possibly could be judged nondiscriminatory. Indeed, as previously mentioned, if point E is located beyond point A, it would be possible to begin at this supposed nondiscriminatory point and lower the industrial price without making residential users any worse off while continuing to meet the revenue requirement.

The reason this happens is that a change in economic conditions (such as demand elasticity or fixed costs) moves the sensible region of regulated prices--those points between A and C--relative to the dashed line in figure 4-1. This dashed line, based on marginal costs alone, is the equi-proportional standard of price discrimination. The points between A and C form a complete list of the plausible and sensible pricing outcomes that a regulator might wish to consider. The use of the dashed line as a standard restricts the region in which prices would be considered nondiscriminatory, possibly in counter-intuitive ways. The no-loser case, already mentioned several times in this report, is an extreme example. The dashed line crossing the regulated pricing ellipse near point A, however, yields a outcome almost as paradoxical.

The dashed line in figure 4-1 can be thought of as an absolute standard of price discrimination, depending only on marginal costs. The Ramsey point, R, is a relative standard by comparison. This is because it lies more or less in the middle of the sensible region of regulated prices between points A and C. This region from A to C is shifted by changes in economic circumstances, and it carries the Ramsey point along with it. The absolute standard, point E, does not change in response to changes in demand elasticities or fixed costs, and consequently is liable to be a poor standard of price discrimination in regulated markets.

Cost standards, such as point E, are reliable indicators of discrimination in competitive markets where no need exists to recover fixed costs. Note that in the absence of fixed costs, the cost standard, E, and the Ramsey standard, R, would coincide at the point where the marginal-cost lines intersect in figure 4-1. Fixed cost recovery is the reason why the absolute cost standard and the relative standard of Ramsey pricing differ.

A reasonable question at this point might be: why study the relativistic Ramsey standard to begin with? Two answers come to mind. First, it is by no means clear that cost-based standards, such as the dashed line in figure 4-1, have answered all of the important questions regarding undue price discrimination in regulated markets. Indeed, the possibility of no-loser price discrimination that begins from such a standard suggests the opposite. Second, it is necessary to study the Ramsey pricing solution as a discrimination standard before it can be known what insights might be revealed. This study takes an initial step in this direction. Both standards, cost and Ramsey, may prove useful to regulators.

To interpret more fully the meaning of the Ramsey-based welfare weight, suppose a particular pricing policy implies that the industrial sector welfare weight is 1.2. This would signify that industrial users are 20 percent more socially worthy than residential customers. Or, more accurately, a regulator would have to be willing to assign 20 preference points to industrial users to justify the resulting price. Conversely, an industrial weight of .8 would indicate the opposite--a bias favoring the residential group. The purpose of tabulating the implied welfare weights is to assist policymakers in assessing whether a particular degree of discrimination is appropriate or not.

In figure 4-1, movements away from the Ramsey point, R, in the direction of point A are associated with a decreasing industrial weight. Here, residential customers are favored with a lower price at the expense of the industrial sector. At point A, the price an unregulated monopolist would charge, the implied industrial weight is zero. Conversely, a movement from point R toward Z results in a larger industrial weight. At Z, the monopoly price for residential users, the industrial weight is infinitely large. Point C in the diagram corresponds to marginal-cost pricing for the industrial sector. From the construction of this particular figure, the industrial weight at point C clearly is larger than one, meaning that such a pricing policy would discriminate in favor of industrial users. The extent of this discrimination cannot be assessed and so might be due or undue.

With this background, the reader should understand that the purpose of the welfare weight analysis is to measure the degree of price discrimination to assist policymakers in their judgment of these matters. The need for a quantitative measure stems from observation that most real-world instances of preferential pricing are "too close to call" on broad policy grounds, and that some additional method of evaluation is needed. There is no intent to substitute the judgment of the policy analyst for that of the regulator.

In one respect, however, this report adopts what may appear to be a curious perspective. It is that preferential treatment of a group can be a good thing--a perspective that is particularly prevalent in chapter 6. The reason for this perspective is to give the benefit of the doubt to pricing policies that deviate from the Ramsey standard, as they all do. That is, a particular pricing policy may result in an industrial welfare weight of 1.5. Perhaps it is the intent of policymakers to extend this amount of preference to the industrial sector. If so, the policymaker also needs to know the efficiency cost of achieving such an "equitable" result. The percentage reduction in aggregate economic well-being measures the loss in economic efficiency associated with the desire to help or favor a particular group. In this view, then, an "improvement" to social equity is measured as a welfare weight different from unity, and the loss of efficiency is the associated cost.

By adopting the notion that pricing preference can be a good thing, an analysis can be made of the trade-offs between efficiency and equity. If price discrimination were always considered bad, all policies other than Ramsey pricing would result in some degree of preference and loss of efficiency. Consequently, they would be inferior to the Ramsey solution on both counts. There would be no trade-off, and no assessment of the efficiency cost incurred in achieving a particular equitable result would be possible. From the economic viewpoint adopted here, undue price discrimination occurs when the efficiency cost of achieving a particular degree of preference becomes too high. Precisely when discrimination becomes unacceptable cannot be answered by the analyst. The quantitative tools provided in this report are intended to sharpen the regulator's judgment and bring him or her closer to that answer.

Description of the Pricing Policies

Five pricing policies are examined in this report, comparing each to the benchmark policy of Ramsey pricing for an integrated system. These policies are (1) Ramsey pricing for each jurisdiction separately, (2) prices that maximize sales volume or throughput, (3) fully allocated cost pricing, (4) interjurisdictional competition for industrial customers, and (5) a national tax on public utility services that cannot be escaped by a customer switching jurisdictions.

Jurisdictional Ramsey Pricing

The benchmark policy, described previously, is Ramsey pricing as if all three utilities could share fixed-cost obligations. In reality, the fixed costs incurred by one utility must be paid by the customers of that company. With that restriction, the best arrangement of prices is that associated with the Ramsey standard. If such a policy is pursued independently by all three jurisdictions in this analysis, the result will be a level of welfare slightly below that which could be achieved under full system integration. As such, the jurisdictional Ramsey model will provide the reader with (among other things) a sense of the magnitudes of efficiency losses that are encountered in these types of social welfare models. It is commonplace, for example, to find welfare losses on the order of one-tenth of one percent for modest distortions of economic efficiency. Losses on the order of 1 to 3 percent are quite large in this type of work. As reported later, the losses associated with some the policies examined here are as high as 10 to 15 percent; extraordinarily large, in the authors' view.

Maximize Sales

In figure 4-1, the point F may be the combination of prices for the residential and industrial sectors that maximizes sales or throughput. It is shown in the diagram as being below the marginal cost of the industrial users. It may lie there or in the region above marginal cost. As such, it cannot be said to be unduly discriminatory by the marginal-cost standard alone.

A policy of price discrimination among several customer groups to maximize throughput has not been advocated, to the authors' knowledge, in any textbook or major article in the field of public utility economics. Nonetheless, it is commonly discussed in other arenas, such as conferences, seminars, workshops, and in testimony before public utility commissions. FERC Commissioner Stalon, for one, believes it to be an important motivator of some interstate pipeline rate proposals.[8]

Briefly reviewing some economic theory generally thought to be correct, economists advocate time-of-use pricing for fixed facilities to ration the available capacity to those most willing to pay during peak usage times. When demand is slack relative to available capacity, no rationing is needed and the off-peak price can be as low as running cost. The congestion component of the peak price in such a policy is the same for all users, residential and industrial, at the same time of use.

A second theme of economic theory is that the result of competitive pressures on suppliers with increasing costs will be a competitive equilibrium characterized by a price equal to the lowest possible average cost. From these two themes, the following incorrect argument somehow emerges.

When there are idle public utility facilities, arrange prices in various markets to improve the utilization rate, that is, increase the throughput. In this way, the argument goes, the average cost of the facilities can be lowered, improving matters for all customers as a whole. Variations on this idea take the form that customers or groups of customers with high load factors should be given a low price because they are not responsible for the peak load.

This is a difficult argument to discredit; it "sounds correct" even though it has no basis in economic theory. At a general level, an economist can point out that peak-load pricing does not necessarily justify price discrimination in order to improve the use of idle capacity. Instead, the

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[8] Stalon, "Economic Regulation and Discrimination When Regulation and Competition Are Mixed."

intended conclusion is that all customers (with similar costs) should pay the same price during the same time period. Futhermore, a facility such as a pipeline, for example, that is temporarily used below capacity even during peak periods would not be assessed any capacity charges under first-best or marginal-cost pricing.

The pricing pattern that would emerge under a second-best, Ramsey policy would not necessarily promote throughput in the way suggested by advocates of the idea. In addition, nothing in economic theory suggests that average cost ought to be minimized. The fact that it tends to be minimized is the result of the social forces embodied in competition. But nowhere is it the objective of any economic agent in the theory. Marginal cost is the correct standard, not average cost.

Despite these theoretical arguments about the deficiencies of the maximize-sales objective, some practitioners appear unpersuaded. This exemplifies the limitations of policy arguments in the absence of facts. Part of the purpose of including this policy here is to examine its behavior under a variety of economic conditions and to determine the extent to which such a policy is preferential, and, if so, to assess the loss of economic efficiency suffered in achieving the goal. The empirical findings show that the maximize-sales policy consistently favors customers with more elastic demand: industrial users in this report. The remaining questions have to do with the degree of discrimination and the associated welfare cost. These are addressed in the following chapters.

Fully Allocated Cost Pricing

Traditional cost-of-service rate regulation of public utilities recovers a pro-rata share of common costs (those fixed costs remaining after any direct assignment) from all customers. A variety of regulatory formulas have been designed to accomplish this, including several variations of the peak-responsibility method, the average-and-excess method, and other kinds of average-cost pricing methods. Each can be justified on a variety of grounds.

Perhaps the most common is the equity argument that it seems socially fair to recover the same contribution to fixed cost per unit of use from all customers. Indeed, most social and athletic clubs use some variation of this idea to assess their members enough to cover the group's fixed expenses. The club analogy is a strong one and it is difficult to know the direction of the bias, if any, imparted to prices by this kind of average-cost pricing from abstract policy analysis alone.

Including fully allocated cost pricing in this empirical study should help to improve the regulator's understanding of these biases and the social price paid for them. The numerical results show that fully allocated cost pricing consistently favors less elastic customer groups: the residential and commercial users. The extent and nature of the price paid for this preference is examined later.

Interjurisdictional Competition for Industrial Customers

Some industrial or other large customers have an opportunity to switch between utilities and to choose the company that has the lowest prices. This freedom of choice typically is not available to other captive users such as residences and small commercial establishments. A system of regulation that allows such freedom for some but not all customers is a mixture of traditional regulation and competitive forces, discussed previously in chapter 2. The competition may be healthy in the sense of encouraging the public utilities to cut costs and otherwise engage in competitive behavior. On the other hand, the utility may be able to finance the attractive deals offered to fickle customers by the prices charged to captive users, and not from any cost-cutting savings, the objective of a competitive system.

Several important points can be made about the economic efficiency of this kind of mixed regulation-competitive system, in addition to those discussed in chapter 2.

First, as pointed out earlier, society may have little choice over adopting such a system, at least in the short term. An existing system of regulation may be eroded as customers find they have choices not previously available because of some technological advance. Abandoning the traditional framework of regulation entirely may be too severe a break of faith with the utilities and their currently captive customers. Consequently, regulators may have little choice but to accept some switching by customers or perhaps some threats, possibly idle, to do so.

Second, the elasticity of demand as perceived by the utility threatened with the loss of an important customer (or the addition of one under an economic development rate) is quite high, perhaps infinitely so. For a competitive company, its management properly should respond to the competition by sharpening its pencil and negotiating he best deal possible. It would be unrealistic to expect a partially regulated, partially competitive company to do otherwise.

Third, the elasticity of demand as perceived by the utility is not necessarily (and most likely is not) the elasticity that policymakers ought to find relevant. In the case of electricity, the relevant elasticity measures the response of the customer to changes in the price of energy (say), regardless of the supplier's identity. In the case of telephone, the relevant market is telecommunications services, and not simply those offered by the local phone company. The relevant elasticity for an aluminum smelter would measure the additional aluminum produced as the result of a drop in electricity rates, as opposed to the loss of load experienced by, for example, the Washington Water Power Company when a customer buys electricity from Bonneville Power Authority.

The reason for this is at once simple and complex. The simple reason is that supplier-switching does not by itself improve our efficiency in using our nation's resources. It can be the result of a search for lower average-cost prices, with no assurance that the marginal cost of service is lower for the winning utility. It may be lower or higher. If it is higher, overall economic efficiency actually has been reduced because a supplier with higher costs on the margin has replaced one with lower costs.

A more complex reason is suggested by the optimal commodity taxation literature in public finance economics.[9] One of the results of this strand of economic thinking is that if a particular commodity is to be taxed, then all of its close substitutes should be taxed also. After all, leaving close substitutes untaxed would allow consumers to escape the tax through freedom

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[9] See Diamond and Mirrlees, "Optimal Taxation and Public Production II: Tax Rules," 261-285.

of choice. If an important and pervasive reason exists for collecting the taxes to begin with, it is inefficient for the taxes to be paid by some and escaped by others through freedom of choice. Note that the argument is based on economic efficiency. An argument based on social equity could be developed, but would miss the point which is that there is a misallocation of resources associated with taxing a good but not its close substitutes.

The analogy to public utility economics is direct. It is inefficient to allow some customers the freedom to switch suppliers, while denying the same opportunity to captive users. The fairness of such asymmetrical freedom is not the issue here; resources are misallocated by such a policy. The reason is that the price offered to customers with competitive opportunities tends to be driven down toward marginal cost. The burden of paying for fixed costs is then left with the remaining captive customers. Their price is too high and they consume too little of the public utility's service as a result. Likewise, the industrial price is too low and too much of the service is used.

Consider the example of a large customer that can switch from natural gas to fuel oil. The possibility of such a switch cannot be ignored, but the resulting discounted price for natural gas is not likely to be economically efficient. A national energy policy to collect sufficient funds through a national energy tax to pay for the fixed costs of natural gas pipelines, among other things, would be levied on gas, oil, electricity, and other forms of energy. Such a tax could not be escaped by threatening to switch fuels if a discount is not forthcoming. There is no intent, here, to suggest that such a tax be adopted; instead, the purpose is to expand the reader's perspective to a level where it should be clear that overall economic efficiency is not necessarily enhanced by industrial discount programs.

Another example, intentionally unrealistic, might help. Suppose a U.S. Air Force bomber accidentally crashed into an expensive power plant and other facilities in Nova Scotia and the federal government agreed to pay Canada 100 billion dollars in damages. Because a power plant was involved, the United States' "less-than-optimal" commodity taxation czar (who does not understand the Diamond-Mirrlees article in footnote 9) decides to impose a tax on electric utilities nationwide. Each utility is responsible for collecting a fixed amount annually for the next fifty years, based on the amount of plant in service ten years ago. By threatening to switch electricity suppliers, all industrial customers reach an agreement with their local suppliers and regulators that has the effect of charging those customers for the marginal cost of electric supply only. The industrial customers thereby effectively escape what was intended to be a national tax on all customers and leave captive customers to make up the difference. A tax program, which was less than perfect to begin with, has been made even less efficient by the switching actions of some customers that allows them to avoid the tax burden.

The analogy to the fixed costs of real-world utilities should be clear. Allowing some customers freedom of choice while denying it to others is inefficient if it results (as it almost surely will) in incorrect price signals--too low for customers with competitive alternatives and too high for captive users.

As pointed out previously, regulators and other policymakers may have little choice in these matters and may be forced to accept the efficiency loss associated with a mixed regulated-competitive system. The fact that society has no choice, however, does not mean that the system is efficient, even if it appears that opening up competitive alternatives ought to improve matters. A purpose of including a policy of interjurisdictional competition for industrial customers in the empirical analysis in this report is to assess the degree of inefficiency associated with it, and the extent of the preference given to customers with supplier choices. The efficiency cost of such a policy may be acceptable, as implied by Braeutigam.[10]

In the analysis conducted for this report, competition for industrial customers is considered to drive down the industrial price to marginal cost.[11] The implications of this are studied by assuming that the interutility competition results in a particular long-run equilibrium. The equilibrium must be consistent with the facts concerning the marginal costs

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[10] See Braeutigam, "Optimal Pricing with Intermodal Competition."

[11] In the case of the single-price, peak and off-peak model discussed earlier, the effect of the competition is to drive the joint, single price down to the point where joint profits from the peak and off-peak markets are zero. See appendix A for details.

of the three utilities, previously assumed to be the same for all three industrial sectors. In these circumstances, a plausible equilibrium is that industrial prices are reduced through competition to marginal costs in all service territories, and in the end, no industrial customer actually switches between utilities. In other words, the threat to switch succeeds in driving price down to marginal cost without any customer actual changing suppliers.

This particular equilibrium is studied here because of its analytical simplicity. If one utility had a marginal-cost advantage over the others and industrial customers were free to switch, the low-cost utility would attract all of the industrial load if marginal cost were constant. Such an outcome is not sensible. To develop a more realistic model of switching behavior would require, at the least, rising marginal cost curves--a complication beyond the scope of this initial inquiry. The equilibrium examined here is not realistic in itself, but provides plausible estimates of the degree of inefficiency and discrimination inherent in a policy setting that has a mixture of regulation and competition. Its numerical importance might be smaller or larger in more realistic policy models, but the fundamental problem encountered when captive and noncaptive customers are jointly served from common facilities would remain the same.

In all of the economic circumstances studied, the result is a pricing preference that favors the industrial class. The extent of this preference is assessed as if all industrial customers had such competitive alternatives. If only a fraction actually had the opportunity to switch suppliers, the actual efficiency losses would be smaller than those reported here.

National Energy Tax

The reason why partial freedom of choice has inefficient outcomes has to do with the ability of some customers to escape a local fixed-cost burden by fleeing to a neighboring jurisdiction. The fifth and final pricing policy investigated in this report is intended to address this issue by supposing it was possible to levy a national energy tax on all kilowatthours of electricity (say) that no user could escape by switching suppliers. The proceeds of the tax would be returned to the utility from which they were collected and would be used to defray that utility's fixed-cost burden. Consequently, local ratepayers would continue to pay for local fixed costs.[12] The only difference would be that a national agreement would have been reached that competition for industrial customers would not be allowed to drive the industrial price down below the marginal cost of production, plus the tax.

Such a policy admittedly is unrealistic. The authors do not suggest that such a policy should be considered for adoption by anyone. The purpose of this analysis of the policy is to show, in a quantitative way, the magnitude of improvement that would be possible by attacking the difficulty at the national level. The problem, after all, has a distinctly national scope to it. One jurisdiction finds its self interests served by inducing a large manufacturing facility to relocate or to switch to a local supplier so that local residents are benefitted. A reason for the federal prohibition of electricity wheeling in the Federal Power Act is to help preserve franchised service territories and to prevent competition for wholesale customers. The framers of the Act understood that the temptation to attract large customers would not likely be resisted without some federal restrictions that make the practice difficult.

Some realism can be given to the idea of a national tax policy by examining an actual example of regulation from England. The English have made a national commitment to nuclear power. At the same time, the government is considering a privatization initiative, which, among other things, would allow generation companies to compete for the privilege of serving distributors and large industrial customers. Various forces, including intercompany competition as well as the availability of interruptible power contracts, may combine to drive industrial prices down to marginal cost.

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[12] Recall that in the simple equilibrium studied here no actual switching occurs, so that the identity of each local ratepayer is unambiguous.

In this context, the English intend to impose a national power tax to support the nuclear industry, in particular. Industrial customers will not be able to escape the tax by switching between competing power suppliers. It may be fair to say that the English recognize the fundamental incompatibility between a commitment to competition in the generation business and their national commitment to nuclear power, which involves a substantial amount of fixed costs.

The tax is a policy solution that effectively neutralizes inefficient sources of competition and creates a floor below which competition cannot force price. The tax helps to insure that the burden for paying for nuclear power plants is levied on all markets efficiently. Note that the fairness of the tax is not the issue. The tax may be fair or it may have been politically acceptable because it was justified on the grounds of fairness. Nonetheless, such a tax helps to improve allocative efficiency. This study provides a numerical assessment of this efficiency improvement in the context of some arbitrary examples.

For our purposes here, a national tax is imposed on all three utilities. No attempt is made to find the optimal level of such a tax, although it would be straightforward to do so. The point is that economic efficiency can be improved by such a tax, even if it is imperfect.

The tax is calculated as the smallest margin between the industrial price and marginal cost in the jurisdictional Ramsey model. Recall that the fixed-cost obligation varies among the three utilities, and consequently the relevant margin in the Ramsey model is not the same for all three companies. The smallest margin is used because any higher tax would result in the industrial price being higher for at least one utility in the national tax model than it is in the jurisdictional Ramsey pricing model. This would be inappropriate since the objective of the tax model is simply to increase industrial prices modestly, thereby reducing, but not necessarily eliminating, the effects of the competitive choices available to the favored industrial class.

In the empirical work, the national tax policy performs as expected and reduces the efficiency loss associated with the mixed freedom-of-choice system.

Evaluating Price Discrimination in Practice

Much of the preceding discussion uses concepts difficult to implement in practice, but useful, nonetheless, because they form the basis of the empirical work summarized in the following chapters. Some important and useful insights will emerge about the efficiency cost incurred in order to extend preferential treatment to a socially worthy group. In addition to their use in this report, however, it may be helpful to explore briefly some ways that the ideas discussed in this chapter might assist a regulator in evaluating price discrimination in reality.

The detection and evaluation of discriminatory pricing in regulated markets is not an easy task. From an economist's perspective, the job has at least three parts to it:

1. Tentatively identify pricing practices that may be unduly discriminatory,
2. Calculate both long-run and short-run versions of profit margins for all customer groups and services, and
3. Conduct a detailed investigation of prices and costs, and require the utility to justify prices that appear unduly discriminatory.

Identify Pricing Practices

In the first stage, pricing practices are identified that may be potentially discriminatory. These might include a policy on the part of a company to arrange relative prices among customer groups to maximize sales or usage, certain types of demand charges, certain types of interruptible pricing, the absence of time-of-use pricing, industrial incentive rates, and large price differentials that result from the interaction of regulation and competition. Extenuating circumstances, of course, would be relevant in assessing each of these.

Compute Profit Margins

In the second stage, a researcher collects and evaluates certain economic facts to compute profit margins for each utility service. If done properly, both long-run and short-run profit margins would be estimated, as well as their corresponding demand elasticities. Estimating demand elasticities, in particular, could be troublesome for most commissions. But without this information, a commission must rely on policy arguments with little, if any, data about actual market conditions. Recall that resource misallocation has to do with customers responding too much or too little to incorrect price signals. Lacking information about price elasticity prevents the policymaker from estimating the response that consumers make to distorted price signals.

The profit margin is the percentage difference between price and marginal cost. In the short run, this may be computed as the difference between the marginal price and the short-run marginal cost, divided by the marginal price. Marginal price refers to tail-block or usage-block prices in declining block rate structures. These short-run profit margins should differ from one another only to the extent of the inverse of the demand elasticities. Some short-run demand elasticities might be four to five times as large as others. Accordingly, a finding that short-term profit margins differed by more than a ratio of four to five would be evidence of discrimination that the regulator might wish to investigate further.

The short-term analysis of profit margins should be supplemented with some facts about longer term conditions. In particular, find the long-run profit margin as the difference between the average price and the long-run marginal cost divided by the average price. These long-term profit margins should differ from one another only to the extent of the inverse of the long-run demand elasticities. It is quite plausible that the variation among long-run demand elasticities would be smaller than those in the short-term. In any case, evidence of differences in long-run profit margins that exceed the corresponding demand elasticity would suggest price discrimination.

The reason for basing long-run profit margins on average, and not marginal, price is somewhat complicated. Briefly, there is a difficulty in knowing how to handle nonlinear price schedules such as declining block rate structures or front-end loaded customer charges. Does the customer's usage depend on such payments or not, given that this fixed portion of the bill does not change with additional usage? Most likely, short-run demand does not, responding, instead, to the marginal price.

The fixed portion of the customer's bill, however, is likely to influence longer term decisions about utility service for a couple of reasons. First, in the long run, customers (even homeowners) can make investment decisions about energy-using equipment for which total cost and average price are important. Second, it does not seem plausible that the fixed part of a customer's utility bill has no affect on economic efficiency whatsoever. If this were so, the nation has a potential source of financing for all sorts of public projects. Instead of imposing an efficiency-distorting income tax to finance national defense programs, we could impose an additional fixed component to our electric, natural gas, and telephone bills. The absurdity of this argument should be apparent.

The conclusion is that the fixed component of utility bills is important, at least in the long run. This would be incorporated in the analysis of long-term profit margins in identifying potentially discriminatory pricing patterns.

Coordinate Findings with the Utility Company

After the results of the price discrimination study have been compiled, the regulator could ask the utility's management for an explanation of the findings. The utility may be able to support its pricing policies with facts that the regulator has not yet considered. In addition, the utility may be able to improve upon the researcher's estimates of certain key economic parameters, such as demand elasticities and marginal costs. Some uncertainty about the estimation of these will always exist which can be accounted for by examining a range of plausible values.

Conclusion

Any study of price discrimination in public utility regulation must confront the uncertainty that surrounds key facts about the marketplace. It will not generally be possible to identify undue price discrimination on the basis of policy arguments alone. Even if these are supplemented with facts, the facts themselves are likely to become matters of dispute. The purpose of this report is to study a few broad pricing policies under a variety of economic circumstances to assess the cost in terms of reduced economic efficiency of pursuing a policy designed to give preferential treatment to one group or another. The following chapters summarize the findings of the quantitative study outlined in this one.

CHAPTER 5

AN EMPIRICAL DESCRIPTION OF FIVE ALTERNATIVE PRICING POLICIES

The empirical analysis of price discrimination conducted for this report required a numerical exploration of a multitude of economic circumstances. The entire set of quantitative results is not presented because of space limitations.[1] Instead, they are summarized in two steps, the first of which is taken in this chapter, the second in the next.

The intent of this chapter is to familiarize the reader with each of the pricing policies analyzed in this study. This is done in a series of tables and figures that shows the pricing solution for each and the behavior of that solution in response to changes in the economic environment. Each policy is described separately, thereby laying the foundation for comparing one to another--the second step in the presentation, which is the topic of the next chapter.

In this chapter, the view is adopted that price discrimination, as measured by the implied welfare analysis, is something that policymakers want to avoid, if possible. In the next chapter, this view is reversed and preferential pricing treatment becomes desirable as a matter of policy. Insights about price discrimination can be gleaned from both perspectives.

Pricing Policy Solutions: Basic Model

In much of the following analysis, a substantial amount of numerical detail is suppressed. It is important that the reader be familiar with the basic design of the various pricing models and know the relevance of the

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[1] The results could be replicated, however, by executing the GAUSS programs listed in appendix B.

principal measures of performance, economic efficiency and social equity used to summarize the outcome of each. In this section, the optimal pricing solution associated with each policy is tabulated for one set of economic conditions. Recall that four of the experimental parameters are studied at two levels, high and low. These parameters are (1) the industrial elasticity of demand, (2) the residential elasticity of demand, (3) the difference in fixed costs among the three jurisdictions, and (4) the size of the industrial market. The "high" value of the parameter setting has been chosen for the examples in this section. The fifth and final parameter is fixed costs, which is studied at four levels. One of the intermediate values has been chosen as the basis for the examples presented in this section.

These parameter values have been chosen to illustrate particular aspects of the pricing policies that are unique to each. In some cases, extreme examples have been chosen to make a point more clearly. The examples are not necessarily representative of the average behavior of any of the five pricing policies. Indeed, all of the examples are based on a set of circumstances that is a mixture of short-run and long-run conditions. Marginal costs are assumed to be higher for residential and commercial customers (similar to long-run marginal costs), and fixed costs are assumed to be relatively high (similar to short-run conditions). These assumptions make the revenue requirement somewhat difficult to fulfill. Consequently, the efficiency and discrimination properties of all of the pricing policies are tested severely in this chapter. This is done purposely and is meant to explore the limits of each of the five pricing policies. More representative averages and comparisons among the policies are the topics of the following chapter.

The Benchmark, Integrated System Model

The example studied in this section is one in which the utility in jurisdiction one has five-hundred units of fixed costs, while the one in the second jurisdiction has six-hundred units, and the third has seven-hundred units.[2] Requiring the customers in each service territory to be responsible for their own fixed costs, as is the current practice in the U.S., is eminently sensible, but has a small degree of inefficiency associated with it nonetheless.

To assess this source of inefficiency, a benchmark pricing model is solved in which optimal prices are found for all customer groups regardless of the jurisdiction in which they reside. That is, the aggregate fixed costs are spread over the customers of the three utilities as if they had merged. There is no intent here to suggest that such an organizational form be adopted--only that the associated inefficiency be recognized.

The total of the fixed costs in this example is eighteen-hundred units. The integrated model finds the best set of prices for the residential, commercial, and industrial markets served by all three utilities, irrespective of the jurisdictional identity. Table 5-1 shows the pricing solution for this case.

In the table, the identity of the utility or jurisdiction is in the first column, while the customer group is identified in the second. The price charged to each group is shown in the third. In this example, the demand elasticity and marginal cost for the residential group is the same in all three jurisdictions, so the optimal or Ramsey prices for the residential sector are the same for all three utilities. The same is true for the other customer groups as well. Note that the prices for each market are above marginal costs, which are 5, 4.5, and 3 for the residential, commercial, and industrial sectors, respectively.[3] At the bottom of the table, the level of aggregate social welfare is listed, as is the percent of total costs that are fixed.

The quantity demanded at the optimal price is given in the fourth column, and the elasticity at this point on the demand curve is shown in the fifth. Recall that the slope of the linear demand curve is an initial specification--the demand elasticity is in part the result of the optimal

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[2] The unit of measurement for fixed costs is not important here. The results are always converted into percentage terms (fixed costs as a percent of total cost) in describing the outcomes of the pricing exercises in this study. Fixed cost is specified in absolute terms for input to the model, however.

[3] See table 4-1 for a complete listing of parameter values.

TABLE 5-1

WELFARE MAXIMUM FOR INTEGRATED SYSTEM:
RAMSEY PRICING FOR THE BASIC MODEL

JURSDCTN	CUSTOMER	PRICE	QUANTITY	ELASTCTY	CONT FC	SURPLUS	WEIGHTS
1	RES	9.54	53.8	-0.53	244.6	483.8	1.00
1	COM	8.85	35.6	-0.51	154.9	306.4	1.00
1	IND	3.95	210.7	-1.05	200.4	396.5	1.00
2	RES	9.54	53.8	-0.53	244.6	483.8	1.00
2	COM	8.85	35.6	-0.51	154.9	306.4	1.00
2	IND	3.95	210.7	-1.05	200.4	396.5	1.00
3	RES	9.54	53.8	-0.53	244.6	483.8	1.00
3	COM	8.85	35.6	-0.51	154.9	306.4	1.00
3	IND	3.95	210.7	-1.05	200.4	396.5	1.00
ALL			900.7		1800.0	3560.3	

JURSDCTN	WELFARE	FC %
ALL	3560.37	36.10

Total social welfare is 3560.37, and the welfare loss is 0.00 %.

Source: Authors' calculations.

pricing equilibrium, and so is part endogenous and part exogenous. The next column shows the contribution to fixed costs, from prices that exceed marginal costs multiplied by the quantity demanded, for each market. The contribution made by all nine markets adds up to eighteen-hundred units, the overall amount of fixed costs across all three utilities.

The consumers' surplus that results from the pricing policy is given in the seventh column. The aggregate amount of consumers' surplus is that which is being maximized in this example. The total of this important measure is the overall economic efficiency achieved by the pricing policy. In this case, the integrated system model of Ramsey pricing yields an overall social welfare of 3,560.37. This becomes the efficiency benchmark against which all other pricing policies are compared for the set of economic circumstances adopted for this example.

The final column in the table, labeled "WEIGHTS," shows the implied welfare weight that would have to be associated with each customer group for the table's pricing pattern to have resulted from a weighted social welfare optimization problem. In this case, the prices have been calculated to maximize such a criterion where the weights are explicitly unity for all markets. Accordingly, when the calculation of the implied welfare weights is made, unity is found because the policy is one of Ramsey pricing to begin with.

Jurisdictional Ramsey Pricing

A somewhat more realistic pricing policy is to imagine prices arranged to maximize social welfare within the service territory of each utility separately, perhaps under a separate regulatory jurisdiction. If such a thing could be done, table 5-2 shows the prices and the associated diagnostics that would result.

TABLE 5-2

JURISDICTIONAL RAMSEY PRICES: BASIC MODEL

JURSDCTN	CUSTOMER	PRICE	QUANTITY	ELASTCTY	CONT FC	SURPLUS	WEIGHTS
1	RES	8.59	56	-0.45	203	536	1.00
1	COM	7.94	37	-0.44	129	339	1.00
1	IND	3.75	221	-0.95	167	439	1.00
1	ALL		316		500	1315	
2	RES	9.54	53	-0.53	244	483	1.00
2	COM	8.85	35	-0.51	154	306	1.00
2	IND	3.95	210	-1.05	200	396	1.00
2	ALL		300		600	1186	
3	RES	10.64	50	-0.63	285	426	1.00
3	COM	9.90	33	-0.61	180	269	1.00
3	IND	4.18	197	-1.18	233	349	1.00
3	ALL		281		700	1045	

JURSDCTN	WELFARE	FC %
1	1315.10	30.90
2	1186.79	36.10
3	1045.45	41.25

Total social welfare is 3547.34, and the welfare loss is 0.366 %.

Source: Authors' calculations.

Because the first utility now has less than the average amount of fixed costs, customers served by it receive a somewhat lower price under this policy than under the unified model. The table includes a subtotal for each utility, in a row labeled "ALL", which was unnecessary in the previous table. This new row shows that the contribution to fixed costs made by the customers in each jurisdiction adds up to those of the corresponding utility, five-hundred, six-hundred, and seven-hundred respectively. At the bottom of the table, these fixed costs are expressed as a percentage of total costs. In jurisdiction one, the five-hundred units of fixed cost works out to be 30.90 percent of all costs. In the remaining analysis, the principal measure of fixed cost is this type of percentage calculation.

The maximum amount of consumers' surplus that can be achieved by any pattern of prices under this restriction is that shown in the table. Because of the jurisdictional separation that prevents cross-payments for fixed costs, the overall level of social welfare that can be achieved is somewhat less than for the integrated system. It is 3,547.34 in table 5-2, compared to 3,560.37 in the integrated system example. This is a reduction of 0.366 percent, which is shown at the bottom of table 5-2 as the welfare loss. Accordingly, the efficiency or welfare loss associated with a policy of jurisdictional Ramsey pricing is, in our model, 0.366 percent of that achievable under the benchmark policy.

The welfare weights found under this policy are shown in the table to be unity for all markets. In this study, equity or social fairness is measured in terms of the prices found within a single jurisdiction. Since Ramsey or welfare maximizing prices have been found separately for each of the three jurisdictions, the implied welfare weight is unity for each of the three markets in each of the three utilities. No broader definition of social equity--perhaps comparing all of the markets across jurisdictions--is needed. The purpose of the welfare weight is to provide a measure of social equity in relation to a "fair" or "neutral" pricing pattern within the markets served by a single utility. The resulting weights provide a good measure of price discrimination within a utility's set of markets and are useful in describing the equity consequences of the pricing policies to follow.

Most observers would characterize Ramsey pricing itself as discriminatory, since residential price is marked up above marginal cost more than the industrial price. The degree of discrimination found in

Ramsey pricing, however, is good in the sense that it achieves a higher level of aggregate social welfare. While it is true that the residential users lose something in such an arrangement, the fact that overall social welfare is higher is taken here to be sufficient justification.

In the remainder of the report, jurisdictional Ramsey pricing has a small welfare loss because the integrated system model is the efficiency benchmark, and has no price discrimination at all because the jurisdictional Ramsey model is the equity benchmark. The remaining policies are compared to these benchmarks.

Prices that Maximize Sales

The first "practical" policy for setting regulated prices investigated in this study is one that arranges a pricing pattern among customer groups to maximize total sales or throughput. The idea is to fully utilize fixed facilities (represented by the fixed costs) that otherwise would remain idle. The pricing pattern that emerges for the illustrative economic circumstances used in this section is shown in table 5-3.

The contributions to fixed costs made by each utility's customer groups adds up to the required amount in each jurisdiction. To promote sales, elastic industrial customers are given a lower price, while the prices of the inelastic residential and commercial customers are raised relative to the welfare-maximizing, Ramsey prices just described. By comparison, the degree of discrimination found in the maximize sales policy is much higher by any standard. Inelastic customers have larger markups under this policy than those under a Ramsey rule.

The table provides the information a policymaker needs to assess the damage such a policy does to economic efficiency and the improvement or harm it does to social equity. Most important is the substantial loss of efficiency associated with the maximize-sales strategy. The resulting pattern of prices induces more than a 10 percent reduction in overall social welfare. As will be seen later, this is an extraordinarily high degree of welfare loss. In applied welfare analysis, a typical magnitude for this loss is 1 to 3 percent, and encountering a loss greater than 5 percent is unusual. Finding one equal to 10 percent is rare, indeed. Accordingly, it

TABLE 5-3

PRICES THAT MAXIMIZE SALES: BASIC MODEL

JURSDCTN	CUSTOMER	PRICE	QUANTITY	ELASTCTY	CONT FC	SURPLUS	WEIGHTS
1	RES	13.59	41	-0.98	358	290	1.00
1	COM	12.61	27	-0.94	225	186	1.04
1	IND	2.70	280	-0.54	-84	704	2.77
1	ALL		350		500	1181	
2	RES	13.92	40	-1.03	363	276	1.00
2	COM	12.94	27	-0.99	229	177	1.04
2	IND	3.03	262	-0.65	7	614	2.90
2	ALL		330		600	1069	
3	RES	14.30	39	-1.08	368	261	1.00
3	COM	13.32	26	-1.05	232	167	1.04
3	IND	3.41	240	-0.79	99	518	3.07
3	ALL		306		700	947	

JURSDCTN	WELFARE	FC %
1	1181.13	29.82
2	1069.38	35.02
3	947.34	40.24

Total social welfare is 3197.86, and the welfare loss is 10.182 %.

Source: Authors' calculations.

appears that the desire to utilize fixed public utility facilities more fully by rearranging relative prices among customer groups exacts an unusually high social welfare cost. As will be seen, this policy has the same general level of welfare loss for all of the economic circumstances studied for this report, although the conclusions are moderated slightly under short-run conditions, as described in the next chapter.

A separate dimension along which the maximize-sales doctrine can be evaluated is that of price discrimination. In table 5-3, the industrial price that results from such an approach is actually below the industrial marginal cost of 3.0 for the first utility. This price, 2.70 in this case, would be considered unduly discriminatory by most observers because it does not cover the variable costs of production incurred in the service of the industrial customers. The industrial contribution to fixed costs is negative in the first jurisdiction in the table. This fact is strong evidence that the inelastic residential and commercial users are subsidizing the industrial service.

Suppose that society or a regulatory commission actually desired to confer a substantial degree of preferential treatment on the industrial class and thought that a price of 2.70 was about right. How much preference would this represent? The final column in table 5-3 gives the answer. A regulator that assigned a social welfare weight of 2.77 to the industrial class would find that an industrial price of 2.70 (11.1 percent <u>below</u> marginal cost) and a residential price of 13.59 (63.2 percent <u>above</u> marginal cost) would maximize a weighted measure of social welfare. This means that the industrial class would be considered to be 2.77 times more socially worthy than the residential sector, or 177 percent as much. This degree of preference seems high by any standard although such a conclusion is best left to the judgment of regulators.

It is interesting to note a curious aspect of price discrimination, as it is measured in this study. In table 5-3, the prices for the first utility can be considered unduly discriminatory by the marginal-cost standard. Accordingly, the resulting welfare weight of 2.77 is indicative of undue discrimination since it is associated with a price below marginal cost. (This is independent of whether the preference embodied in the welfare weight "appears" high, which is a somewhat more subjective assessment.) Compare the results for utility one with those of the second and third that have more fixed costs to recover from their customers. The added fixed-cost burden requires all prices to be higher. The price paid by industrial customers in the service territory of the second utility is 3.03, which is above the marginal cost of 3.0. Such a price passes the marginal-cost test and proponents of such a standard would have to conclude that the price could not be deemed unduly discriminatory.

How discerning is such a standard, that is, how good is the standard in separating due from undue price discrimination? The welfare weight analysis provides a clue. The industrial price of utility one is 2.70, below marginal cost, and has a welfare weight of 2.77. The industrial price of utility two is 3.03, above marginal cost, and has a welfare weight of 2.90. According to the welfare weight analysis, the industrial price in the second company's territory is more preferential and discriminatory. A larger degree of preference must be extended to the industrial customers of the second utility in order to justify a price of 3.03 than must be given to those of the first utility to justify a price of 2.70.

The reason that the maximize-sales policy is more discriminatory in the case of the second utility is that its fixed costs are higher. A higher fixed cost burden on the set of residential, commercial, and industrial markets as a whole causes the trade-off among the consumers' surpluses in each market to become more delicate. There is a limit to the amount of fixed cost that can be extracted from a market or a set of markets. As an ever greater burden is levied on the markets, it becomes increasingly important to get the prices right. As prices begin to approach those that exhaust the markets' revenue extraction ability, small reductions in the favored industrial price away from the Ramsey standard result in a large penalty in terms of the amount of residential and commercial consumers' surplus given up. The third utility in table 5-3 extends the trend to an even higher level of fixed cost and the conclusion is the same. Indeed, it is true in all of the extensive numerical analysis conducted for this report that the degree of preference needed to justify the industrial prices under a maximize-sales policy is larger as fixed costs increase.

A way of thinking about this is that it is more and more difficult to extract additional revenue from even inelastic markets as either fixed costs grow or the residential burden increases in response to preference extended to other sectors. Accordingly, a larger and larger bias in favor of industrial users is needed to justify even small deviations away from Ramsey pricing as fixed obligations increase.

A basic lesson of this analysis is that price differences become unduly discriminatory when they stray too far from the Ramsey standard. In table 5-2, the Ramsey price for the industrial sector of utility one is 3.75. To reduce the price below this level requires that the regulator extend these customers some degree of preference. How much preference is a matter for the regulator's judgment. Perhaps twenty to fifty preference points (corresponding to a welfare weight of 1.2 and 1.5) might be appropriate. Regardless of the precise magnitude, the regulator does not really know a lot about the discriminatory nature of the approved prices if only the cost conditions, such as marginal cost, are known. A price above marginal cost in one circumstance can be more discriminatory than one below marginal cost in another. It is not possible to distinguish between the circumstances on the basis of cost conditions alone: customer response matters. As difficult as it is to know demand elasticities, not much progress in distinguishing due from undue discrimination is likely to be made until such information is incorporated into the regulation of prices.

Prices Based on Fully Allocated Costs

Traditional public utility regulation uses cost-of-service studies to allocate fixed and common costs to customers on the basis of some measure of sales.[4] A variety of cost allocation formulas have been used by regulatory commissions. In the context of the basic model only one of these can be represented, and that allocates the same amount of fixed cost per unit of sales to all customers, as described in the previous chapter.

The result of performing these allocations for the example presented in this section is shown in table 5-4. Other examples of cost allocation formulas are discussed in the following section in the context of the peak, off-peak pricing models. The purpose of the example in this section is to introduce the reader to the numerical analysis of cost allocation studied in this report. The following chapter examines the behavior of the fully allocated cost method under a variety of economic circumstances.

The results of the cost allocation procedure are quite different from those obtained under the maximize-sales policy. In one respect, the outcome is more or less the opposite. Fully allocated cost pricing results in preference being extended to the inelastic customer groups relative to that given to the industrial class. The amount of economic inefficiency encountered is quite high in this particular example, with a loss of 7.528 percent of overall social welfare. Although this welfare cost is not as high as that encountered for the maximize-sales policy, it is, nonetheless, significant. Price distortions must be quite large in order to reduce overall social welfare this much.

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[4] For additional discussion, see Brown and Sibley, The Theory of Public Utility Pricing.

TABLE 5-4

FULLY ALLOCATED COST PRICES: BASIC MODEL

JURSDCTN	CUSTOMER	PRICE	QUANTITY	ELASTCTY	CONT FC	SURPLUS	WEIGHTS
1	RES	6.94	61.6	-0.34	119.6	634.0	1.00
1	COM	6.44	40.6	-0.33	78.8	398.1	0.99
1	IND	4.94	155.3	-1.78	301.4	215.4	0.33
1	ALL		257.6		499.9	1247.6	
2	RES	7.98	58.5	-0.41	174.2	571.8	1.00
2	COM	7.48	38.5	-0.40	114.5	357.2	0.99
2	IND	5.36	132.0	-2.27	311.1	155.5	0.00
2	ALL		229.0		599.9	1084.6	
3	RES	9.30	54.5	-0.51	234.9	496.5	1.00
3	COM	8.80	35.7	-0.51	153.8	307.8	0.98
3	IND	5.36	132.0	-2.27	311.1	155.5	0.00
3	ALL		222.3		699.9	960.0	

JURSDCTN	WELFARE	FC %
1	1247.67	34.31
2	1084.62	41.04
3	960.06	45.76

Total social welfare is 3292.338, and the welfare loss is 7.528 %.

Source: Authors' calculations.

An indication of the magnitude of the distortion is the price charged to the first utility's industrial customers under fully allocated cost pricing. In table 5-4, this price is 4.94, which is 64.7 percent above marginal cost. By comparison, the Ramsey solution charges 3.75, which is 25 percent above marginal cost. To justify such a markup, a regulator would have to assign a welfare weight of .33 to the industrial sector, meaning that these customers have about one-third of the social worthiness that the regulator assigns to the residential sector. This is a 3 to 1 ratio of welfare weights, which is more or less the same order of magnitude that emerged from the maximize-sales policy, except in the opposite direction.

This is because the fully allocated cost pricing policy favors the inelastic users (residential and commercial in this report), while the maximize-sales policy favors the industrial class, when both are compared to the Ramsey standard. Throughout the numerous examples studied for this report, the efficiency loss associated with the maximize-sales policy is consistently higher than that from the fully allocated cost pricing policy. The following chapter makes this comparison more completely. Also, the degree of discrimination tends to smaller, although in the opposite direction.[5]

In table 5-4, notice that when the fixed-cost burden increases from five-hundred units for the first utility to six-hundred units for the second, the industrial price reaches an upper limit. This limit is discussed in the previous chapter and represents the price an unregulated monopolist would charge. Interpreted differently, it is the price at which the maximum contribution to fixed costs can be extracted from the industrial market.

This limit price is 5.36 for the economic circumstances represented by table 5-4, and forms the basis of the industrial price for both the second and third utilities, since both have more fixed costs than the level that triggers the limit price under the cost allocation formula. If a regulator attempted to set the price above 5.36, the price increase would be more than offset by a loss in sales, and the industrial contribution to fixed costs would be less, not more. In addition, the attempt might not prove successful in the first place since it likely would lead to a destructive "death spiral." The diagnostic in table 5-4 that shows the limit has been reached is that the welfare weight in the column is zero. As previously discussed, the monopoly price limit for a market has a welfare weight of zero under profit regulation.

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[5] Basically, industrial prices are made high in this example because all fixed costs are prorated evenly over all units of sales. Remaining in the context of cost allocation methods, a way to address this difficulty would be to directly "assign" fewer fixed costs to the industrial sector. An example from the regulation of the electric industry might be an arbitrary rule, perhaps close to the truth but nonetheless arbitrary, that industrial customers do not use the distribution system. With such a rule, the cost of generation and transmission assets would be spread over industrial, commercial, and residential sales, while those of the distribution system would be allocated to commercial and residential users only. This study does not address such rules because the intent is to assess the basic nature of the various policies. Whether the efficiency of the rules can be improved with such direct assignments is an interesting question, but is a topic for future research.

The conclusion is that the fully allocated cost procedure would have attempted to assign even more fixed costs to the industrial sector, but was prevented from doing so by the reaction of the industrial market; that is, the price elasticity of demand does matter. Because of the nature of this investigation--which is to explore a wide range of economic circumstances, some of which are near or beyond the limits of the market to pay for fixed costs--this situation is encountered frequently, whereby the industrial price is driven up to the monopoly level by a cost allocation formula. This is the only pricing policy studied for this report that had this characteristic. (Other policies have their own unique ways of breaking down under the pressure to recover fixed costs.) In this sense, the cost allocation method can be said to be unduly discriminatory in favor of residential and commercial customers.

The tendency of the fully allocated cost procedure to seek out such price limits is moderated somewhat in the peak, off-peak pricing models, described briefly in the next section. This is because these models have a richer set of sales dimensions on which costs can be allocated. Peak responsibility methods of allocating costs do not reach the limit price as readily, although the direction of the pricing bias remains in favor of the inelastic demand sectors under these more sophisticated cost allocation methods.

Prices That Result from Interjurisdictional Competition

If industrial customers have the opportunity to receive service from a competing utility, their price is likely to be deeply discounted in order for the traditional utility supplier to retain the customer's business. If carried far enough, the end result of this competition would be an industrial price driven down to marginal cost. In the examples examined here, competition for customers is studied by setting the industrial price equal to marginal cost in all jurisdictions (since the threat of leaving is equally effective in all). The prices for the remaining customers are set to maximize social welfare, which means that the relative prices among the captive customers are Ramsey-like. Note that interjurisdictional or interutility competition may be more limited in actual practice, with only a few large customers being in the position to threaten to switch suppliers. Nonetheless, the resulting discount is studied here as if all industrial customers had such an option. Two observations about this are relevant. First, if fewer have the option, the model can be revised to reflect this. To some extent, this is captured in the study's experimental design by varying the industrial market's size in relation to the captive customers, the results of which are described later. Second, supplier switching is by its very nature an extreme type of threat, resulting in an extreme type of discount. Accordingly, it is appropriately studied by carrying the argument to its logical conclusion and seeing what happens if all industrial users were to receive such a discount.

With this in mind, table 5-5 gives the pricing solution to the competition-for-customers model for the same economic circumstances studied for the other models in this section, with one exception--the fixed costs are one-hundred units smaller for each of the three utilities. This example has been chosen because the one corresponding to the previous level of fixed cost cannot be satisfied. That is, the pricing solution is infeasible if fixed cost is seven-hundred (the level recovered from the markets served by utility three, above) because this exceeds the amount that can be extracted from the residential and commercial markets. Accordingly, the fixed costs in table 5-5 are four-hundred, five-hundred and six-hundred for utilities one, two, and three respectively. The highest of these has a feasible solution under interutility competitive conditions. The reader should not compare this policy with the fully allocated cost example just discussed--the fixed costs are different. Recall that a purpose of this chapter was to explore the point where each pricing policy breaks down and is incapable of recovering the revenue requirement. Such a limit occurs at a lower fixed cost for the interjurisdictional competition model and so is studied using an example with smaller fixed costs.

Table 5-5 shows the industrial price in all three jurisdictions to be 3.0, or marginal cost. Accordingly, the industrial customers make no contribution to fixed cost, which must be paid instead by the residential and commercial customers in each jurisdiction. The competitive pressure to retain customers does not change their elasticity of demand with respect to real rearrangements of the nation's resources, and so the same demand

TABLE 5-5

PRICES THAT REFLECT INTERJURISDICTIONAL COMPETITION: BASIC MODEL

JURSDCTN	CUSTOMER	PRICE	QUANTITY	ELASTCTY	CONT FC	SURPLUS	WEIGHTS
1	RES	9.55	53.8	-0.53	244.8	483.4	1.00
1	COM	8.85	35.6	-0.52	155.1	306.2	1.00
1	IND	3.00	264.0	-0.64	0.0	622.2	1.34
1	ALL		353.5		400.0	1411.9	
2	RES	11.30	48.6	-0.70	306.1	393.7	1.00
2	COM	10.53	32.1	-0.68	193.8	249.4	1.00
2	IND	3.00	264.0	-0.64	0.0	622.2	1.64
2	ALL		344.7		500.0	1265.4	
3	RES	14.22	39.8	-1.07	367.3	264.4	1.00
3	COM	13.33	26.3	-1.05	232.6	167.5	1.00
3	IND	3.00	264.0	-0.64	0.0	622.2	3.27
3	ALL		330.2		600.0	1054.3	

JURSDCTN	WELFARE	FC %
1	1411.97	24.67
2	1265.45	29.77
3	1054.30	35.09

Total social welfare is 3731.718, and the welfare loss is 5.414 %.

Source: Authors' calculations.

responses are present in these mixed regulation-competition circumstances as in the previous policies discussed thus far. The efficiency and fairness of the policy are based on those demand responses.

Discounting the industrial price down to marginal cost results in a 5.414 percent reduction in overall social welfare, considering all three utilities simultaneously. This is a substantial welfare cost, although not as large as those encountered in the maximize-sales or fully allocated cost policies. This relative size pattern depends on the overall economic conditions, discussed in the next chapter.

The direction of the price discrimination is, of course, in favor of the industrial sector. The extent of the discrimination can be assessed by reference to the welfare weight column of table 5-5. In the case of the first utility with four-hundred units of fixed cost, the marginal cost price for industrial users could be justified if the regulator were willing to assign a welfare weight of 1.34 to this group, indicating that they are given 34 preference points or are 34 percent more socially deserving than the captive customers. To justify the same policy for the second utility that has five-hundred units of fixed costs requires 64 preference points in favor of the industriales. With six-hundred units of fixed costs, 227 preference points are required (the weight is 3.27 for the industrial customers of utility three).

The lesson is similar to that learned from the maximize-sales model--extending pricing preference to one group is more and more costly as the utility's fixed cost burden becomes larger. The degree of the welfare weight required is one indication, the size of the allocative inefficiency is another. A 5.414 percent welfare loss is a serious matter that calls into question the social wisdom of the interjurisdiction and interutility competitive process. Even so, state regulators may have little choice but to approve such discounts, since they run the risk of losing the large customer's business otherwise. Also, in some circumstances the welfare implications of this competition may be small and acceptable. Despite such rationalizations, there is a nagging question of whether alternative social arrangements could improve the outcome of this kind of interutility competition.

Prices Based on a National Energy Tax

A method of dealing with supplier switching or interjurisdictional competition for large customers would be to fashion some type of national energy tax that could not be escaped by switching between regulatory forums or fuels. Designing such a tax in practice would be a complicated national policy matter. It is not the intention of this report to address these or to recommend such a tax. The purpose is to inquire whether a simple tax, not optimal but based on a rule of thumb, with a national scope is capable of improving matters. If it is not, the subject should be dropped, of course. On the other hand, if it appears to be helpful the improvement to overall social welfare needs to be compared to the administrative costs of implementing such an idea. Even if the concept is inherently impossible to put into practice, it is worth knowing the general nature of the welfare costs that we inflict upon ourselves as a result of this particular aspect of our current practice of public utility regulation. The results of the national tax policy are given in table 5-6. Recall that the tax is calculated as the smallest industrial margin in the benchmark, integrated system model, which is about .753 (not shown here) in this case. The example follows the same pattern of fixed costs among the three utilities as presented in the previous discussion of interutility competition to facilitate comparison with it.

TABLE 5-6

PRICES THAT RESULT FROM A NATIONAL ENERGY TAX OF .753 CENTS: BASIC MODEL

JURSDCTN	CUSTOMER	PRICE	QUANTITY	ELASTCTY	CONT FC	SURPLUS	WEIGHTS
1	RES	7.36	60.4	-0.37	142.6	608.3	1.00
1	COM	6.76	39.9	-0.35	90.3	385.3	1.00
1	IND	3.75	221.8	-0.95	167.0	439.3	0.92
1	ALL		322.2		400.0	1433.1	
2	RES	8.59	56.7	-0.45	203.8	536.1	1.00
2	COM	7.94	37.5	-0.44	129.1	339.5	1.00
2	IND	3.75	221.8	-0.95	167.0	439.3	1.00
2	ALL		316.0		500.0	1315.1	
3	RES	10.07	52.2	-0.58	265.0	455.7	1.00
3	COM	9.35	34.6	-0.56	167.8	288.6	1.00
3	IND	3.75	221.8	-0.95	167.0	439.3	1.14
3	ALL		308.7		600.0	1183.8	

JURSDCTN	WELFARE	FC %
1	1433.10	25.85
2	1315.10	30.90
3	1183.80	35.66

Total social welfare is 3931.991, and the welfare loss is 0.337 %.

Source: Authors' calculations.

The national tax policy prevents the industrial price from falling below the individual utility's marginal cost plus the tax. In this case, then, the interutility competition results in an industrial price of 3.75 in all three jurisdictions. The result is a dramatic improvement to economic efficiency, in which the welfare loss has been reduced from 5.414 percent in the previous case to only .337 percent with the tax. An optimal tax would improve upon this slightly, but is likely not to be worth the trouble of estimating. Consequently, a roughly computed tax with a national scope is capable of creating a significant improvement in the allocation of the nation's resources. The efficiency gains are not always so large in other circumstances but they are always significant, a topic discussed further in the next chapter.

The degree of price discrimination has been reduced significantly by the tax policy also. The industrial class for utility one, with the smallest fixed costs, pays a somewhat higher price (3.75) under this policy than under the jurisdictional Ramsey pricing model (3.58, which is not shown). The reason has to do with the tax being computed from the integrated-system, benchmark model, instead of from the jurisdictional Ramsey pricing model. The integrated model computes industrial prices irrespective of the source of the fixed costs--only the aggregate matters. Consequently, the industrial prices in all three jurisdictions tend to reflect the average level of fixed costs in the integrated model. The average also tends to be the level associated with utility two in this analysis, with the result that the industrial price in the tax model (3.75 in table 5-6 where the average fixed cost is five-hundred) is approximately equal to the industrial price in the jurisdictional Ramsey pricing model (3.75 in table 5-2 for utility one that has five-hundred units of fixed costs). Because of the choice of the integrated-system model as the basis of the tax calculation, the welfare weight in table 5-6 for the industrial users of the second utility is unity. The weight that must be given to the industrial users of the third utility is 1.14, which is quite modest in comparison to those found in the maximize-sales and fully allocated cost policies.

Accordingly, the national tax policy in conjunction with interjurisdictional competition for industrial customers results in a pattern of regulated prices that has a relatively modest amount of economic inefficiency and a small degree of pricing preference in favor of large users who have competitive alternatives. This conclusion is reinforced by numerous other examples studied for this project.

Pricing Policy Solutions of the Peak, Off-Peak Models

The conclusions just described for the basic model with three markets for each utility are embellished, but basically unchanged, by expanding the model to consider peak and off-peak use of a public utility service. There is no need to present examples of all of the pricing policies, as was done in the previous section; however, it may useful to tabulate the results for two. The initial parameter values for the peak, off-peak pricing model are listed in table 3-3. The off-peak marginal cost is 3, 2.5, and 2 for the residential, commercial, and industrial sectors respectively, and the corresponding peak marginal costs are 6, 5, and 4. The pricing solution for the maximize sales strategy is shown in table 5-7.

The table is more complicated because of the additional markets that must be described. The third column, for example, records whether the market is peak (P) or off-peak (O). The sixth and seventh columns show the demand elasticities at the maximize-sales solution, and also the cross-price elasticities between the peak and off-peak markets for a single customer group. The next two columns present the same information as before: contribution to fixed cost and consumers' surplus.

The welfare weights are shown in the second-to-last column. Although the concept of an implied welfare weight needed to justify a pricing pattern is the same in this model as it was in the basic model, the implementation of the idea in this case is more complicated. The reason is touched upon in chapter 4 and described fully in appendix A. Briefly, this is the issue that customer participation in multiple markets combined with a pricing strategy that is inconsistent with Ramsey pricing may yield a pattern of prices that cannot be made consistent with weighted social welfare maximization, the source of the implied welfare weights. A good estimate of welfare weights that comes close to making the observed pattern of prices consistent with a weighted social welfare criterion can be found using regression analysis. The results of this calculation are reported in the final two columns of table 5-7. The estimated weights are in the next-to-last column. The same number is reported for both the peak and off-peak markets for a single user group, since the discrimination takes place

TABLE 5-7

PEAK-LOAD PRICES THAT MAXIMIZE SALES

JUR	GRP	PER	PRICE	QNTY	PK ELAS	OFF EL	CONT FC	SURPLUS	WEIGHTS	SDWT-R2
1	RES	P	21.18	12.7	-1.39	0.26	193.2	140.6	1.00	1.32
1	RES	O	13.15	26.7	0.34	-0.98	271.6	228.3	1.00	1.32
1	COM	P	15.85	10.0	-1.10	0.16	108.9	89.2	1.27	1.87
1	COM	O	8.60	18.4	0.16	-0.78	112.5	120.0	1.27	1.87
1	IND	P	4.65	67.6	-0.82	0.09	43.6	255.8	2.99	0.18
1	IND	O	0.85	200.4	0.05	-0.17	-230.1	578.2	2.99	0.18
1	ALL			336.1			500.0	1412.3		0.98
2	RES	P	21.50	12.5	-1.43	0.27	194.8	136.9	1.00	1.40
2	RES	O	13.46	26.2	0.36	-1.03	274.5	219.7	1.00	1.40
2	COM	P	16.16	9.8	-1.14	0.16	110.3	86.2	1.28	1.98
2	COM	O	8.92	17.9	0.17	-0.83	115.3	114.1	1.28	1.98
2	IND	P	4.96	65.1	-0.91	0.10	62.5	236.0	3.10	0.20
2	IND	O	1.17	189.1	0.07	-0.25	-157.6	515.8	3.10	0.20
2	ALL			320.9			600.0	1309.0		0.98
3	RES	P	21.85	12.4	-1.47	0.28	196.4	132.8	1.00	1.49
3	RES	O	13.81	25.6	0.37	-1.08	277.4	210.4	1.00	1.49
3	COM	P	16.51	9.7	-1.19	0.17	111.7	82.9	1.28	2.13
3	COM	O	9.27	17.4	0.18	-0.88	118.1	107.8	1.28	2.13
3	IND	P	5.31	62.3	-1.02	0.12	81.6	215.0	3.24	0.22
3	IND	O	1.52	176.5	0.10	-0.34	-85.3	450.6	3.24	0.22
3	ALL			304.1			700.0	1199.7		0.98

JURSDCTN	WELFARE	FC %
1	1412.38	35.10
2	1309.06	40.34
3	1199.76	45.28

Total social welfare is 3921.203, and the welfare loss is 12.374 %.

Source: Authors' calculations.

between customers and not markets. The final column contains some statistical diagnostics associated with the regression analysis. Next to each welfare weight is the standard error of estimating using regression analysis.

More interestingly, the R^2 of the regression is reported in the row labeled "ALL" in the last column. For example, the R^2 of the welfare weight regression for the first utility in table 5-7 is 98.4, indicating that 98.4 percent of the variation in the observed prices is consistent with the idea that the pricing pattern emerged from a weighted social welfare maximization problem to begin with. As such, it tends to validate the use of statistical averages (such as those embodied in regression analysis) to summarize the discrimination inherent in the observed prices. Notice that the R^2 becomes slightly smaller as fixed costs increase from utility one to utility three (declining from 98.4 percent to 98.0 percent) indicating that it is increasingly difficult to summarize the pricing pattern as fixed costs increase. This is generally true throughout the examples covered in this study--larger amounts of fixed costs results in pricing patterns that are more obstreperous.

The substantive results for this example of a policy to maximize throughput are essentially the same as those found for the basic model. (The values of the parameters are the same as those used in the previous section describing the basic model). The overall loss of economic efficiency is 12.374 percent, which is roughly the same magnitude as that in the basic model. The industrial customers are given pricing preference by this policy, with an implied welfare weight of 2.99 for the large users served by the first utility, and 3.10 and 3.24 for utilities two and three, respectively. These pricing preferences are similar to those observed in the basic model also.

Table 5-8 shows the results of the peak, off-peak pricing model for one example of fully allocated cost pricing policy. The economic circumstances are the same, except that the industrial elasticity of demand is lower than in the previous examples, although it is still higher than that of the residential and commercial sectors initially. Table 5-9, which shows the results of a fully allocated cost pricing formula applied to the case where peak and off-peak prices must be the same, is intended to be compared with table 5-8, and so has exactly the same initial specification of economic parameters.

In table 5-8, the average-and-excess method of cost allocation has been used. The result is that the industrial price is biased upward as before; however, it is not forced above the limit price as it was in the basic model discussed in the previous section. Otherwise, the results are similar to those found before: the welfare loss is 4.706 percent while the pricing preference is in favor of the residential group, although not as severely because of the choice of cost allocators.

TABLE 5-8

FULLY ALLOCATED COST PEAK-LOAD PRICES

JUR	GRP	PER	PRICE	QNTY	PK ELAS	OFF EL	CONT FC	SURPLUS	WEIGHTS	SDWT-R2
1	RES	P	10.02	18.9	-0.44	0.08	76.1	315.3	1.00	0.23
1	RES	O	3.91	41.5	0.07	-0.19	37.9	545.9	1.00	0.23
1	COM	P	9.02	13.8	-0.45	0.06	55.7	170.6	0.97	0.35
1	COM	O	3.41	25.8	0.05	-0.22	23.6	235.2	0.97	0.35
1	IND	P	8.02	47.7	-1.01	0.13	191.7	248.1	0.90	0.07
1	IND	O	2.91	125.7	0.12	-0.46	114.8	460.7	0.90	0.07
1	ALL			273.6			499.9	1976.0		0.95
2	RES	P	11.38	17.9	-0.53	0.09	96.2	285.6	1.00	0.33
2	RES	O	4.15	41.5	0.08	-0.20	47.5	540.9	1.00	0.33
2	COM	P	10.38	12.9	-0.56	0.07	69.7	150.6	0.96	0.52
2	COM	O	3.65	25.7	0.05	-0.24	29.4	231.0	0.96	0.52
2	IND	P	9.38	40.0	-1.41	0.15	215.2	180.9	0.88	0.11
2	IND	O	3.15	123.8	0.16	-0.51	141.8	439.4	0.88	0.11
2	ALL			261.9			599.9	1828.5		0.91
3	RES	P	19.67	11.0	-1.49	0.15	150.4	129.8	1.00	0.43
3	RES	O	4.18	44.1	0.13	-0.19	52.2	575.2	1.00	0.43
3	COM	P	17.11	8.2	-1.45	0.12	100.0	68.1	0.93	0.69
3	COM	O	3.68	26.8	0.08	-0.23	31.7	241.0	0.93	0.69
3	IND	P	10.23	35.0	-1.75	0.16	217.9	143.2	0.85	0.15
3	IND	O	3.18	124.8	0.18	-0.51	147.5	440.5	0.85	0.15
3	ALL			250.1			700.0	1598.0		0.88

JURSDCTN	WELFARE	FC %
1	1976.03	38.03
2	1828.54	43.83
3	1598.05	50.12

Total social welfare is 5402.622, and the welfare loss is 4.706 %.

Source: Authors' calculations.

Table 5-9 shows the fully allocated cost solution if the peak and off-peak prices are the same. The results again are qualitatively identical. The welfare loss is somewhat higher, 5.103 percent, although the difference is probably not significant. The welfare weights for the industrial users indicate that the discrimination inherent in the fully allocated pricing rule, which is based on the peak responsibility method, increases with the utility's fixed cost (comparing the three utilities in the table).

TABLE 5-9

FULLY ALLOCATED COST SINGLE PRICES

JUR	GRP	PER	PRICE	QNTY	PK ELAS	OFF EL	CONT FC	SURPLUS	WEIGHTS	SDWT-R2
1	RES	P	5.95	23.0	-0.22	0.06	-1.0	429.7	1.00	0.61
1	RES	O	5.95	36.0	0.09	-0.33	106.5	437.6	1.00	0.61
1	COM	P	5.59	16.6	-0.23	0.05	9.7	233.6	0.96	0.97
1	COM	O	5.59	21.5	0.06	-0.43	66.6	173.0	0.96	0.97
1	IND	P	5.16	69.3	-0.45	0.14	80.4	459.6	0.62	0.25
1	IND	O	5.16	75.1	0.15	-1.37	237.3	190.9	0.62	0.25
1	ALL			241.8			499.7	1924.6		0.20
2	RES	P	6.42	22.7	-0.23	0.06	9.6	420.0	1.00	0.86
2	RES	O	6.42	35.3	0.09	-0.36	120.7	419.9	1.00	0.86
2	COM	P	6.13	16.4	-0.26	0.05	18.4	225.3	0.94	1.37
2	COM	O	6.13	20.7	0.07	-0.49	75.3	161.0	0.94	1.37
2	IND	P	6.08	65.6	-0.56	0.21	136.7	404.9	0.43	0.41
2	IND	O	6.08	58.5	0.19	-2.08	238.9	121.7	0.43	0.41
2	ALL			219.4			599.8	1753.0		0.08
3	RES	P	7.37	22.3	-0.28	0.07	30.5	400.7	1.00	1.27
3	RES	O	7.37	33.7	0.11	-0.44	147.3	385.1	1.00	1.27
3	COM	P	7.24	15.8	-0.32	0.07	35.4	208.6	0.90	2.08
3	COM	O	7.24	19.1	0.08	-0.63	90.6	137.6	0.90	2.08
3	IND	P	7.05	61.8	-0.68	0.34	188.2	351.3	0.24	0.69
3	IND	O	7.05	41.1	0.23	-3.42	207.7	65.8	0.24	0.69
3	ALL			194.0			699.9	1549.4		0.12

JURSDCTN	WELFARE	FC %
1	1924.65	38.12
2	1753.04	44.23
3	1549.43	50.30

Total social welfare is 5227.117, and the welfare loss is 5.103 %.

Source: Authors' calculations.

It is interesting to note in table 5-9 that the R^2 of the regression used to estimate the welfare weights is low, ranging from 20.2 percent for utility one to 12.2 percent for utility three. As an average, the regression technique captures the behavior of the welfare weight well in the sense that it declines with fixed cost just as it did in the basic model where the welfare weight calculation was exact. Nonetheless, the overall goodness of fit of the regression model is not very strong, suggesting that restricting the peak and off-peak prices to be the same results in a noisy and unpredictable pattern of prices among the markets that is not easily summarized.

It will be difficult for regulators to give consistent policy signals to market participants under these conditions. Although the overall policy tends to favor the residential group, the low R^2 suggests that the preference may be ambiguous and misunderstood, possibly by the very group that the policy is intended to help. Residential consumers may complain about the relative price received in the peak period, even though the price paid for off-peak services is quite favorable.

Accordingly, a regulator who is strongly motivated by equity considerations runs the risk of being misinterpreted by constituents if the pricing policy does not give them a consistent indication of the preference being extended. The risk may be small if the customers react principally to the average bias in the policy. In any case, this type of preferential treatment risk is much higher for the policy that restricts prices in the peak and off-peak periods to be the same than it is for the one that allows these prices to be different.

The overall economic efficiency, also, is improved by the policy that allows this pricing freedom. Note that this is not an argument about peak-load pricing in the economist's sense. Both of the policies under comparison are based on fully allocated costs, not marginal costs. Freedom to vary prices among demand periods improves social welfare and makes any set of pricing preferences more consistent, even if the basis of the pricing policy is an arbitrary procedure for allocating fixed and common costs.

The Influence of Fixed Costs

The previous sections provide the background needed to understand how regulated prices under the various policies respond to different economic circumstances. Five economic parameters are systematically varied in the experimental design used for this report. One of these, fixed cost, is singled out for analysis in this section. The other four are treated in the following section. This organization reflects our belief that fixed cost is the most important dimension of this policy analysis, and that a thorough understanding of how the various policies behave in different common cost situations is the beginning of gaining wisdom about due and undue price discrimination.

Economic Efficiency

As fixed costs become larger as a percent of total costs, some economic efficiency is generally, but not always, lost in comparison to that achieved by the benchmark policy. Recall that the benchmark is a policy under which fixed costs are also recovered. The efficiency losses described in this section are the allocative costs of pricing patterns that recover the same amount of common costs, but do so in an inefficient manner.

Figure 5-1 shows the welfare loss for all five pricing policies in relation to fixed costs, for the particular assumptions used in this chapter. (Recall that more realistic assumptions are used in chapter 6.) The remaining four economic parameters, demand elasticities and so on, are set at their "high" values for this graph. The vertical axis is the percent of social welfare lost as a result of each pricing strategy, and the horizontal axis shows fixed cost as a percentage of total cost. With the economic conditions prescribed by the other parameters, it is not possible to extract a larger contribution to fixed costs than that represented by the 58 percent fixed cost level. Accordingly, the graph has a vertical limit on its right-hand edge. Several of the pricing policies have welfare loss lines in the figure that converge along this limit. The lines have a natural maximum and do not become arbitrarily large. That is, the vertical limitation at 58 percent fixed cost does not behave as an asymptote, with the welfare losses becoming infinitely large at points close to 58 percent. The welfare loss is never more than about 14 percent for this particular set of parameter values.

The most efficient pricing policy, not surprisingly, is the Ramsey rule which dominates all of the other pricing policies at every level of fixed costs. The next most efficient is the national tax policy that approximates the trajectory of the Ramsey rule quite closely with the largest deviation occurring at fixed costs of about 50 percent, or just before the fixed-cost limit of these markets.

The remaining three policies have more complicated graphs. At low levels of fixed cost, the interjurisdictional competition model that allows marginal-cost pricing for industrial customers is quite efficient. It

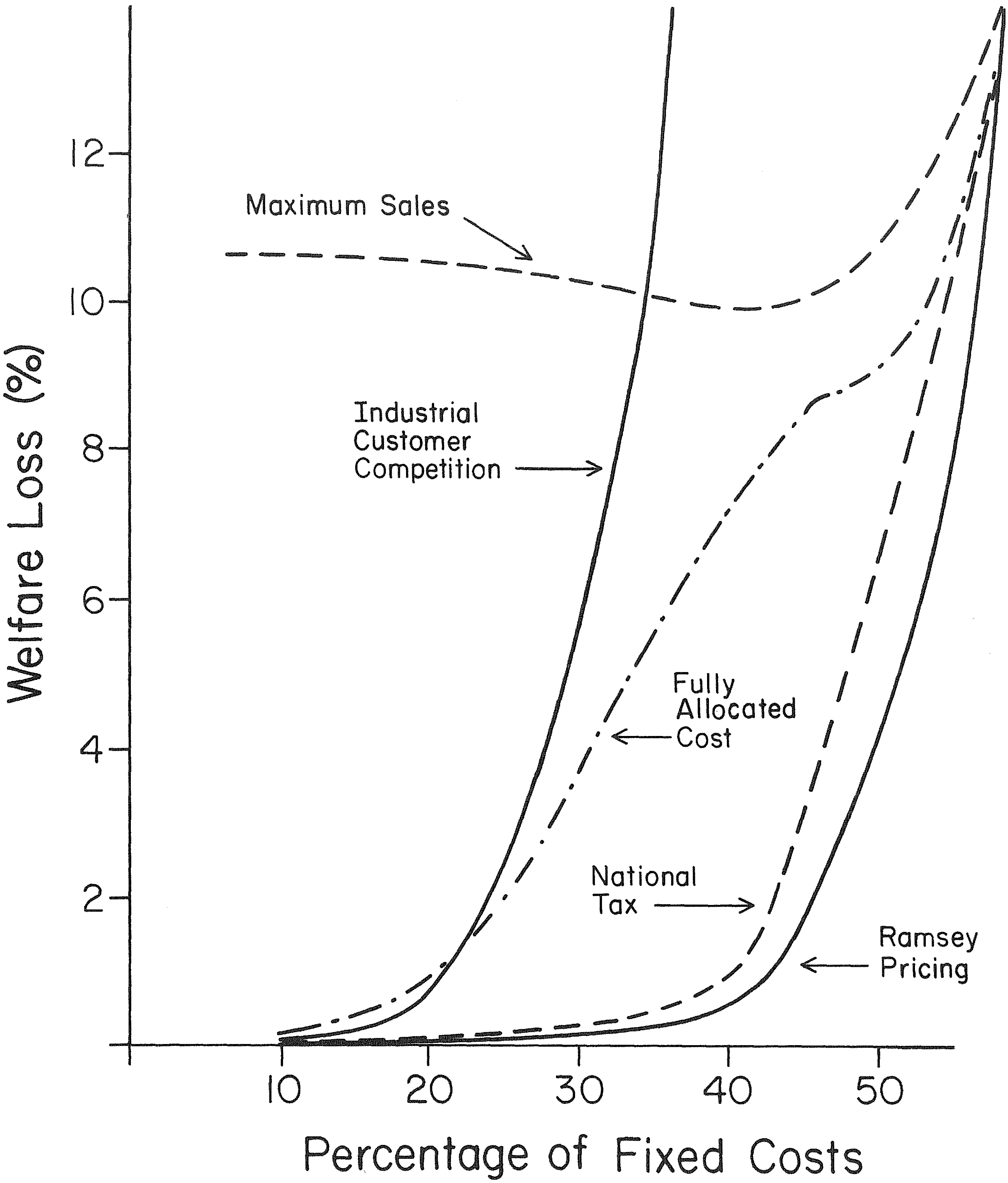

Fig. 5-1. Welfare Loss for five pricing policies in relation to fixed costs: basic model

rapidly becomes inefficient, however, when fixed costs exceed 25 to 30 percent of total costs. This policy is incapable of contributing sufficient revenue to a utility whose fixed costs are above about 36 percent, in this example. The reason for this more severe limit is that the industrial customers make no contribution at all to fixed costs, leaving the entire burden to the residential and commercial sectors. The 36 percent limit corresponds to the revenue support capacity of these markets.

In figure 5-1, the welfare losses experienced under fully allocated cost pricing are also low if the fixed-cost burden is light. The losses increase quickly beyond the 20 percent level of fixed costs, however. At moderate amounts of fixed cost, say 40 percent or so, the fully allocated cost policy has a welfare cost which is about seven times as large as that associated with either Ramsey pricing or the tax rule.

The efficiency losses experienced under the maximum sales policy are quite different from the other four policies. The welfare loss does not shrink in any significant way as fixed costs approach zero. For each of the other four policies, price is distorted away from variable cost, but only for the purpose of recovering fixed and common costs. With no fixed cost, there is no pricing distortion and no loss in allocative efficiency. This is not true for the policy that seeks to fully utilize fixed assets. The objective of increasing, indeed maximizing, the use of otherwise idle facilities tends to create a welfare loss that remains more or less the same, at about 10 to 10.5 percent in figure 5-1, for small to moderate levels of fixed cost. Only at very large levels of fixed cost does this policy behave in the expected way and increase in response to a larger burden of common-cost recovery. The behavior of the maximum-sales, welfare-loss graph, then, could be described as perverse for moderate fixed cost levels. Apart from this perverse tendency to persist for even low fixed cost burdens, the maximum-sales strategy has a large welfare cost in the moderate range of such costs. When 40 percent of costs are fixed, the policy incurs a loss of allocative efficiency roughly 10 times that of the Ramsey or tax rules. This is different by an order of magnitude and is not a trivial matter. A regulator could well ask what societal benefit is received in exchange for this substantial loss of well-being. The answer might be found in issues of social fairness, the reason we now turn to matters of price discrimination.

Price Discrimination

The reader may have noticed that we have avoided trying to "define" price discrimination. In our view, any effort to do so would be largely futile because a precise point separating due from undue discrimination cannot be found. Nonetheless, the idea of undue discrimination, in our opinion, is related to undue (and unnecessary) losses of social well-being suffered as a result of large price differences, not justified by corresponding cost differences. The least damage to social welfare of any zero-profit pricing policy is that incurred under the Ramsey rule, a good place to begin this inquiry.

The residential and industrial prices that result from the Ramsey rule to maximize overall social welfare are shown in figure 5-2 for various levels of fixed costs. The remaining parameters, such as the demand elasticities, are set at their high values, as in the previous subsection. The residential marginal cost is five in this example, while that of the industrial class is three. If there are no fixed costs to be recovered, the Ramsey rule results in each customer class paying its respective marginal cost. In the diagram, the prices paid by the two classes are not equal at the point where fixed costs are zero. The difference, however, reflects the respective marginal costs of service. Accordingly, the difference in prices at this level would be considered "due" by most observers.

As fixed costs increase, it is necessary to raise the prices of all customers above marginal cost. The trajectories of residential and industrial prices that result from increasing the fixed-cost burden under the Ramsey rule are shown in figure 5-2. The path extends from marginal cost, when there is no fixed cost, to the monopoly price level when fixed cost is at its maximum, about 58 percent of total cost in this example.

Because the residential market is relatively inelastic, the price paid by residents is marked up more than the industrial price as part of the effort to recover fixed costs. By following this inverse elasticity rule, the overall welfare loss suffered by society is kept to a minimum. In this

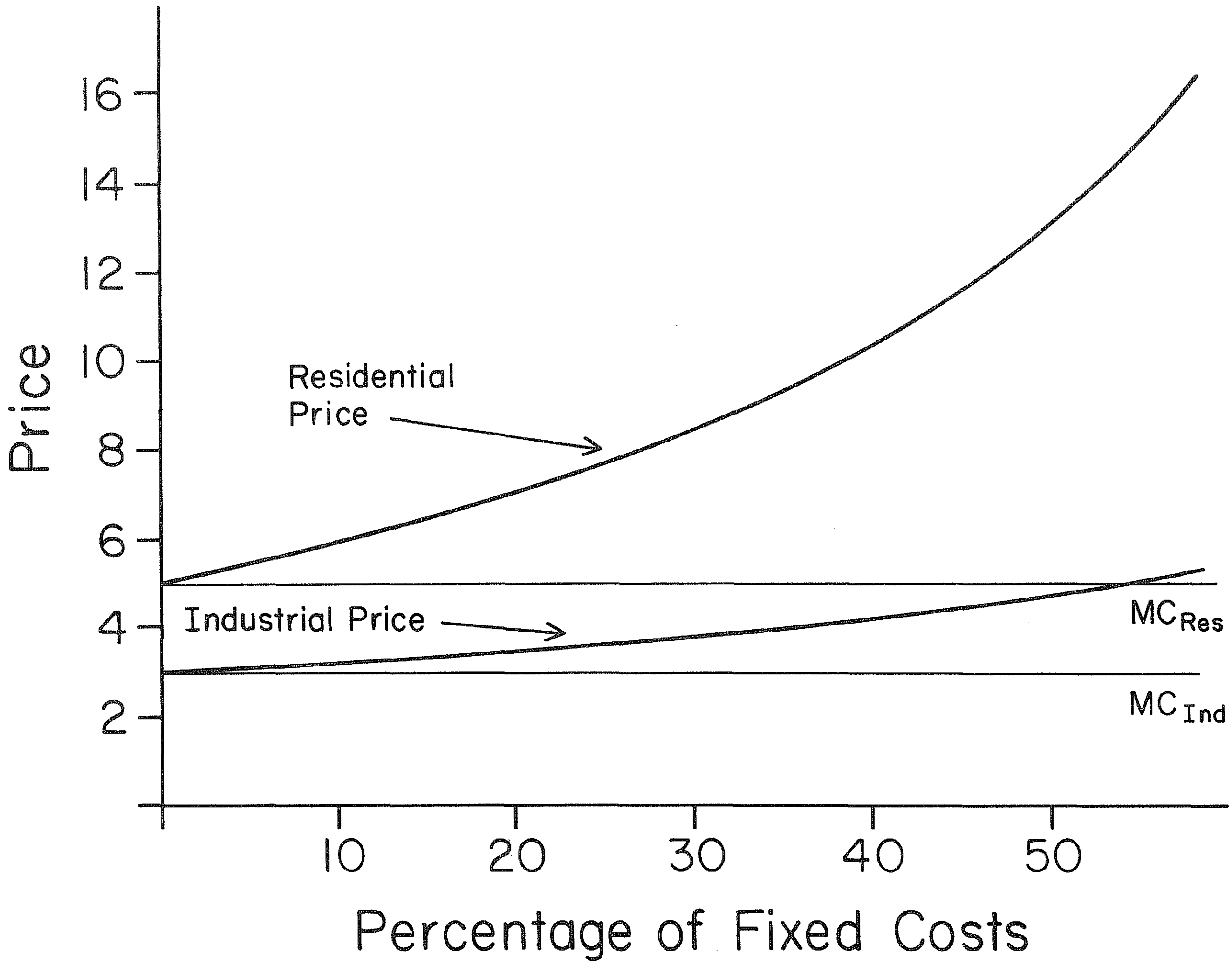

Fig. 5-2. Ramsey prices for residential and industrial users in relation to fixed costs: basic model

sense, the price difference between the two classes, which is discriminatory, is the efficient difference needed to recover the required level of fixed cost. Any other combination of residential and industrial prices that successfully recovers the common costs, regardless of whether the difference is larger or smaller, results in a larger social welfare loss. The pricing trajectories in figure 5-2, then, can be considered benchmarks against which the prices resulting from other policies can be compared. Excessive deviation from these efficient pricing patterns would be evidence of undue discrimination, in this view.

The prices that result from the maximize-sales policy are compared to the Ramsey prices in figure 5-3. The pattern that emerges is remarkable. As fixed costs decline to zero, Ramsey prices fall to marginal costs. This is not true of the maximize-sales policy. The difference between the residential and industrial prices is about as large when fixed costs are low as when they are high. Note that the maximize-sales prices are limited by the monopoly prices when fixed cost are about 58 percent of total costs, just as the Ramsey prices are.

In essence, the price discrimination inherent in the maximize-sales policy is about the same regardless of the need to recover fixed costs. More or less the same difference in residential and industrial prices occurs at high levels of common cost when there is a need to discriminate to minimize the overall social burden, as well as at low levels of common cost when there is no need at all to discriminate. The discrimination never disappears. This is perverse behavior for a pricing policy and accounts for why the welfare losses associated with this policy remain persistently high at even low fixed-cost levels.

At very high levels of fixed cost, the discrimination associated with the maximize-sales policy appears to become smaller, in comparison to the prices found under a Ramsey rule. The two policies converge to identical pricing points at the maximum level of fixed cost.

Despite this convergence, the reader is cautioned that the discrimination does not decline as it appears to in the diagram. As previously discussed, the welfare weight of the industrial class can be thought of as a measure of price discrimination. Table 5-3 shows that the industrial welfare weight continues to increase with higher amounts of fixed

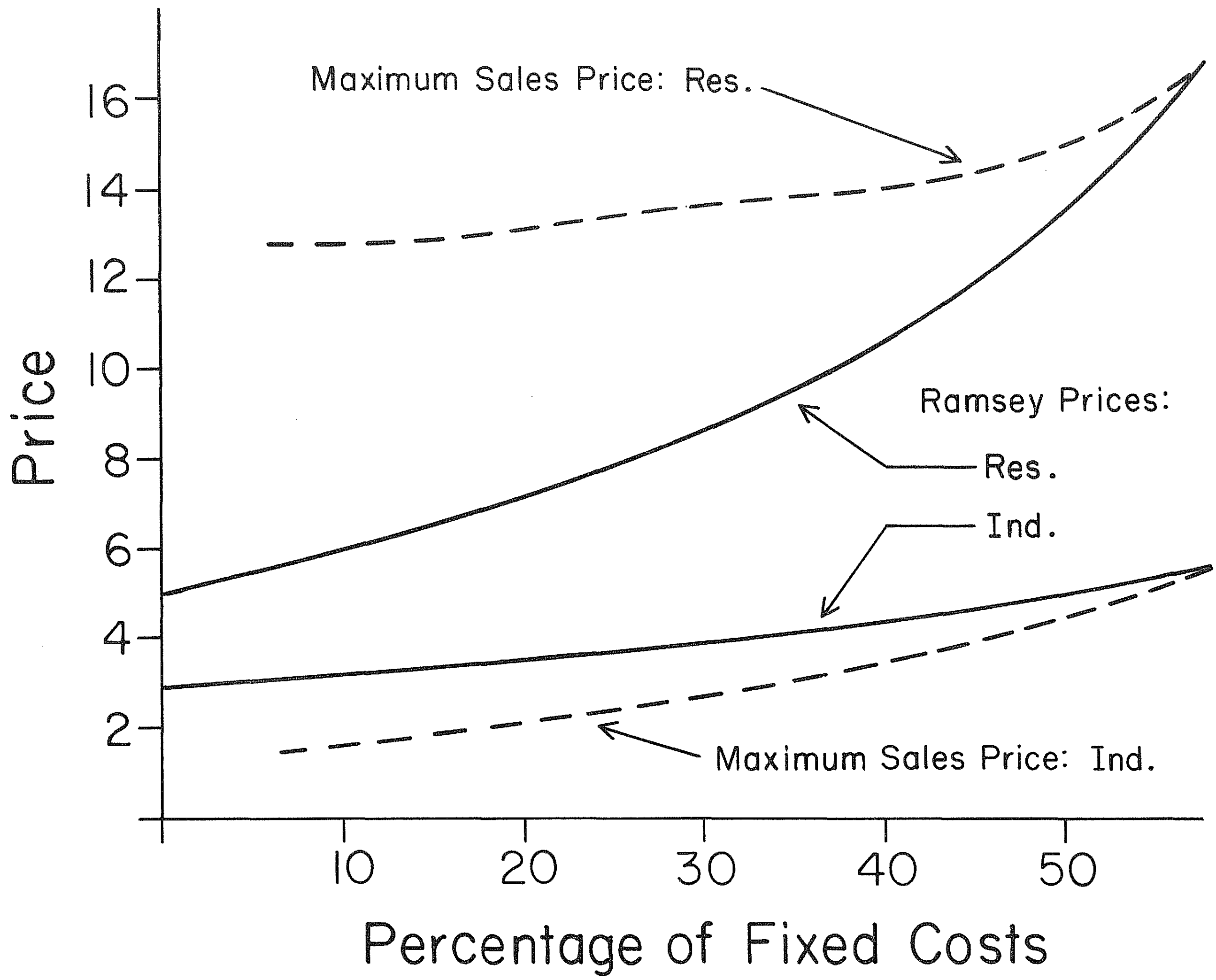

Fig. 5-3. Comparison of Ramsey and maximum sales prices

cost. This is true all along the price curves in figure 5-3 and in general for any other set of economic circumstances. The degree of price discrimination inherent in the maximize-sales policy continues to increase up to and including the point at which the monopoly pricing limit is reached. To make this point more clear, the discrimination embodied in the policy is visibly bad at low fixed-costs levels (as seen in figure 5-3) and becomes worse as fixed costs increase (as measured by the degree of preference in table 5-3 that must be extended to the industrial class to justify the industrial price). Viewed this way, the policy of arranging prices to fully utilize existing fixed facilities does not appear to be an attractive option for a regulator: welfare losses are high and the discrimination appears to be undue in comparison to the Ramsey standard. (The following chapter adopts the view that a regulator desires to extend pricing preference making the discrimination a good instead of a bad thing, and seeks to determine the welfare-loss-price paid for the resulting social fairness or equity.)

The price discrimination inherent in a fully allocated cost policy is in the opposite direction, as can be seen in figure 5-4, which compares Ramsey and fully allocated cost prices. A policy of proportional allocation of fixed costs to all sales reduces residential prices in comparison to the welfare maximizing, Ramsey standard, and increases those paid by the relatively elastic industrial class. The outcome is that the industrial price increases with fixed cost more rapidly than that found under the Ramsey formula.

There is a danger that more costs will be allocated to the industrial market than it can bear. This happens routinely in the numerous examples studied for this project, and is illustrated in figure 5-4 at about the 40 percent-of-fixed-cost level. At that point, the traditional regulatory cost allocation formula raises the industrial price up to what an unregulated monopolist would charge, which is the limit to what this particular market can bear. No more contribution to fixed and common costs can be extracted from these customers. Accordingly, the industrial price is capped for all higher levels of fixed cost: 5.36 in this case. (This accounts for the complicated curvature of the fully allocated cost, welfare-loss line in figure 5-1, which occurs at the point at which the industrial price is

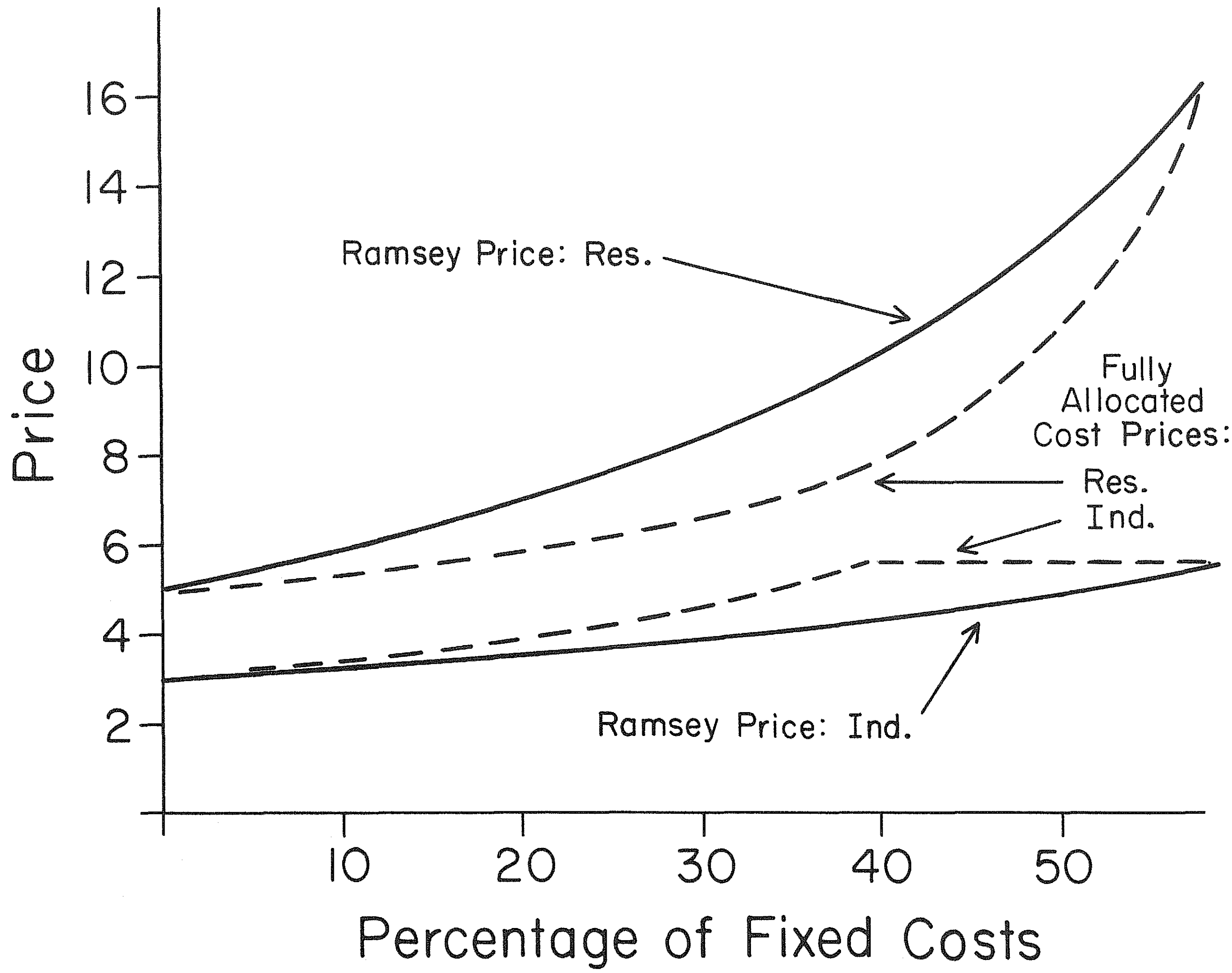

Fig. 5-4. Comparison of Ramsey and fully allocated cost prices

capped.) It is easy to correct the cost allocation formula for such price limits in this theoretical exercise because the analyst knows the demand conditions. In practice this is much more difficult, but no less important. Failure to limit the action of the cost allocation scheme in this way can result in a so-called "death spiral."[6]

Regulated cost allocation results in price discrimination in favor of the residential class consistently in all of the many examples studied here. Whether this is undue is a subjective matter, at least at fixed-cost levels short of the one that causes the industrial price to reach the monopoly limit. Beyond that limit, industrial users are charged an unregulated monopolistic price. As previously described, such a price is associated with an industrial welfare weight of zero, meaning that the residential class is considered infinitely more socially worthy than the industrial users. Such a price clearly constitutes undue discrimination, in our opinion, particularly if it were to persist for a lengthy time. For fixed cost amounts between zero and the limiting case, however, it is difficult to judge the discrimination from a graph such as figure 5-4. Table 5-4 gives an example for which the industrial welfare weight is .33, indicating a 3-to-1 preference in favor of the residential class. Whether this is unduly discriminatory is a matter for the regulator's judgment. The next chapter suggests how costly this amount of preferential treatment is.

The discrimination inherent in the two remaining policies is illustrated in figure 5-5. The outcome of a mixture of regulation and competition for industrial customers is that price is discounted to marginal cost for industrial customers, with the entire burden of paying for fixed costs resting on the residential and commercial markets. The pricing patterns associated with this competition are shown as dashed lines in the figure. The national tax policy, which is intended to correct for this interjurisdictional competition beyond the control of local regulators, is indicated with dash-dot-dash lines.

The industrial discounts that result from the interutility competition for customers run the risk that the captive markets will be unable to bear

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[6] For more discussion of this point, see Henderson, "Price Discrimination Limits in Relation to the Death Spiral."

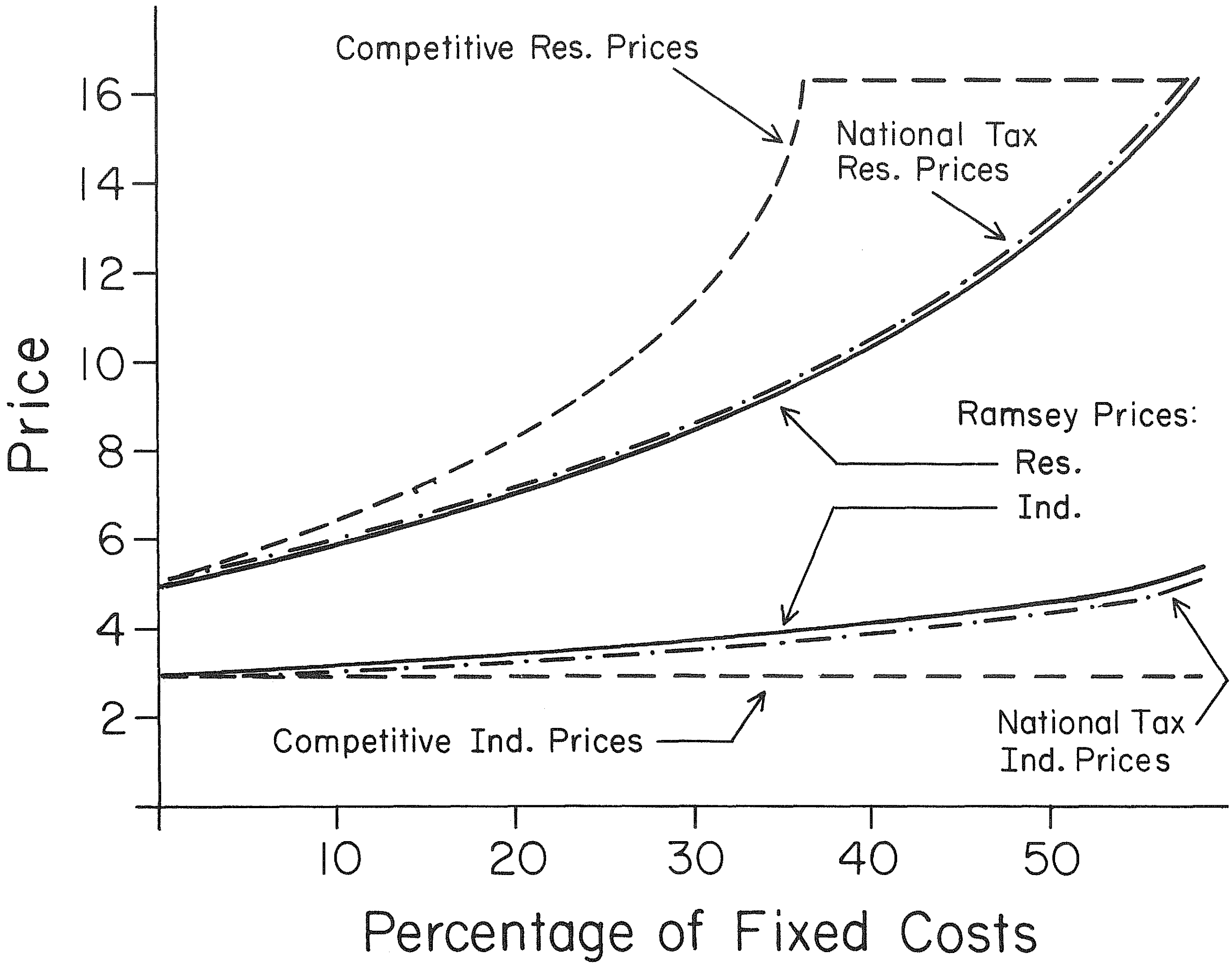

Fig. 5-5. Comparison of Ramsey pricing with those of the competitive and national tax models

the entire fixed-cost burden. Such a limit is reached in the example diagrammed in figure 5-5 at about the 37-percent-fixed-cost point. This exhausts the revenue extraction capacity of the captive residential and commercial customers. At such a point, the implicit welfare weight assigned to industrial customers is infinitely large, and so would be considered unduly discriminatory for the same reasons as a monopolistic price charged to an industrial user under a cost-allocation formula. This amount of preference extended to the industrial class is clearly excessive, in our opinion. The more important region in this analysis, however, is between zero fixed cost and the limit just described. The diagram does not help the policy maker assess the discrimination in this range, except to know that the preference in favor of the industrial users eventually becomes too large. Where this happens is the boundary between due and undue discrimination and is a matter for the regulator's judgment.

On the other hand, a policy of charging a national tax that industrial customers cannot escape by switching suppliers closely tracks the Ramsey pricing trajectories, and does not encounter any limit other than the natural one that even the Ramsey policy must respect. The direction of preference is in favor of the industrial users, although the extent of any discrimination appears slight in the diagram. This conclusion is confirmed by the welfare weight analysis (table 5-6 is a representative example), which shows the bias to be small in most of the cases studied for this project.

Peak-Pricing Model

The behavior of the peak-pricing model as fixed costs are varied is briefly described in figures 5-6 through 5-9. As with the basic model, the remaining economic parameters are set to their high values. This summary shows that the basic results and lessons learned from the analysis of the basic model remain the same when customers participate in multiple markets. No similar summary of the single price, peak and off-peak model is presented because little more can be learned from it.

The efficiency losses experienced under the five pricing policies are illustrated in figure 5-6 in relation to the percentage of fixed costs.

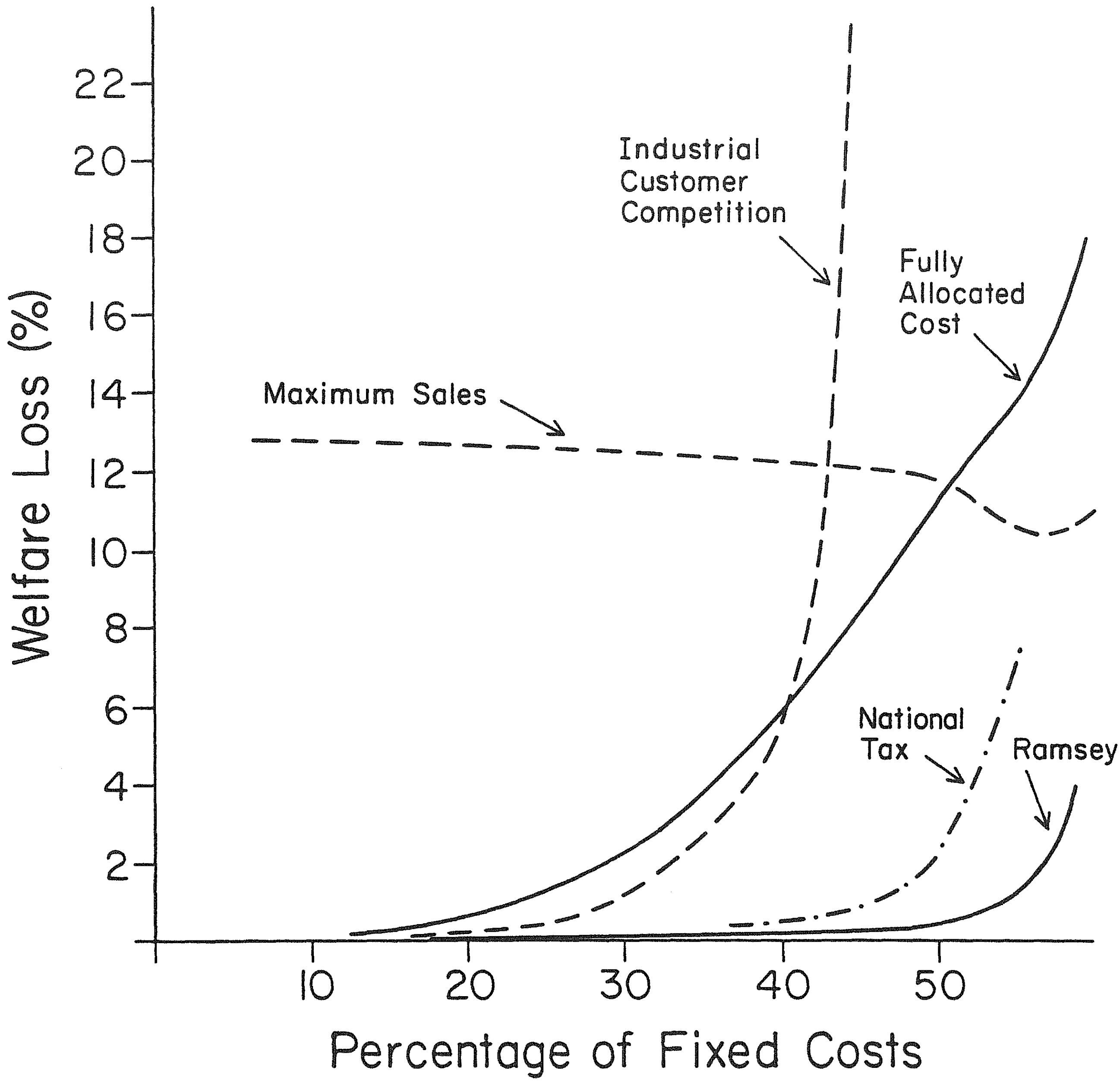

Fig. 5-6. Welfare loss for five pricing policies in relation to fixed costs: peak-period-pricing model

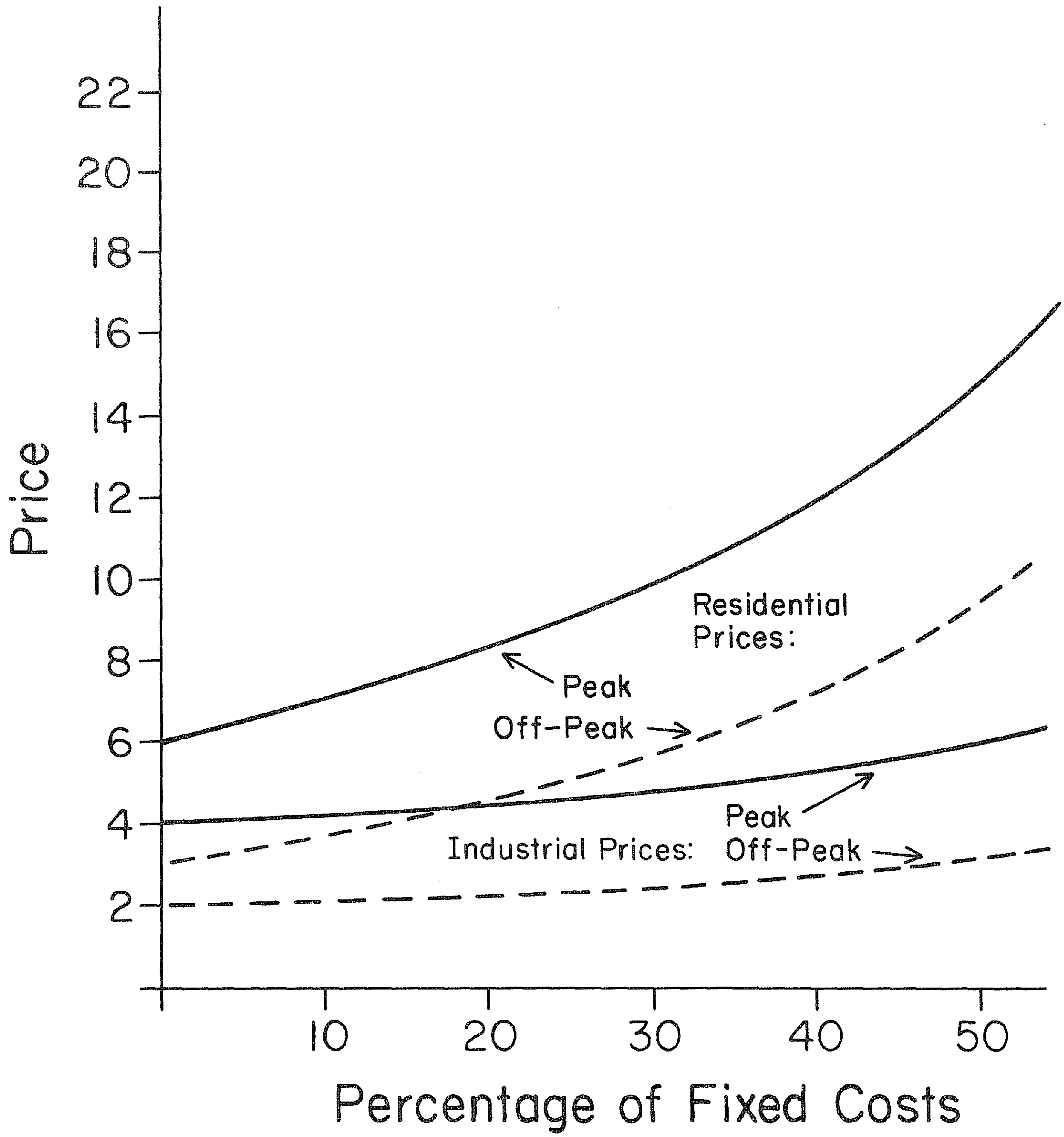

Fig. 5-7. Ramsey prices: peak-pricing model

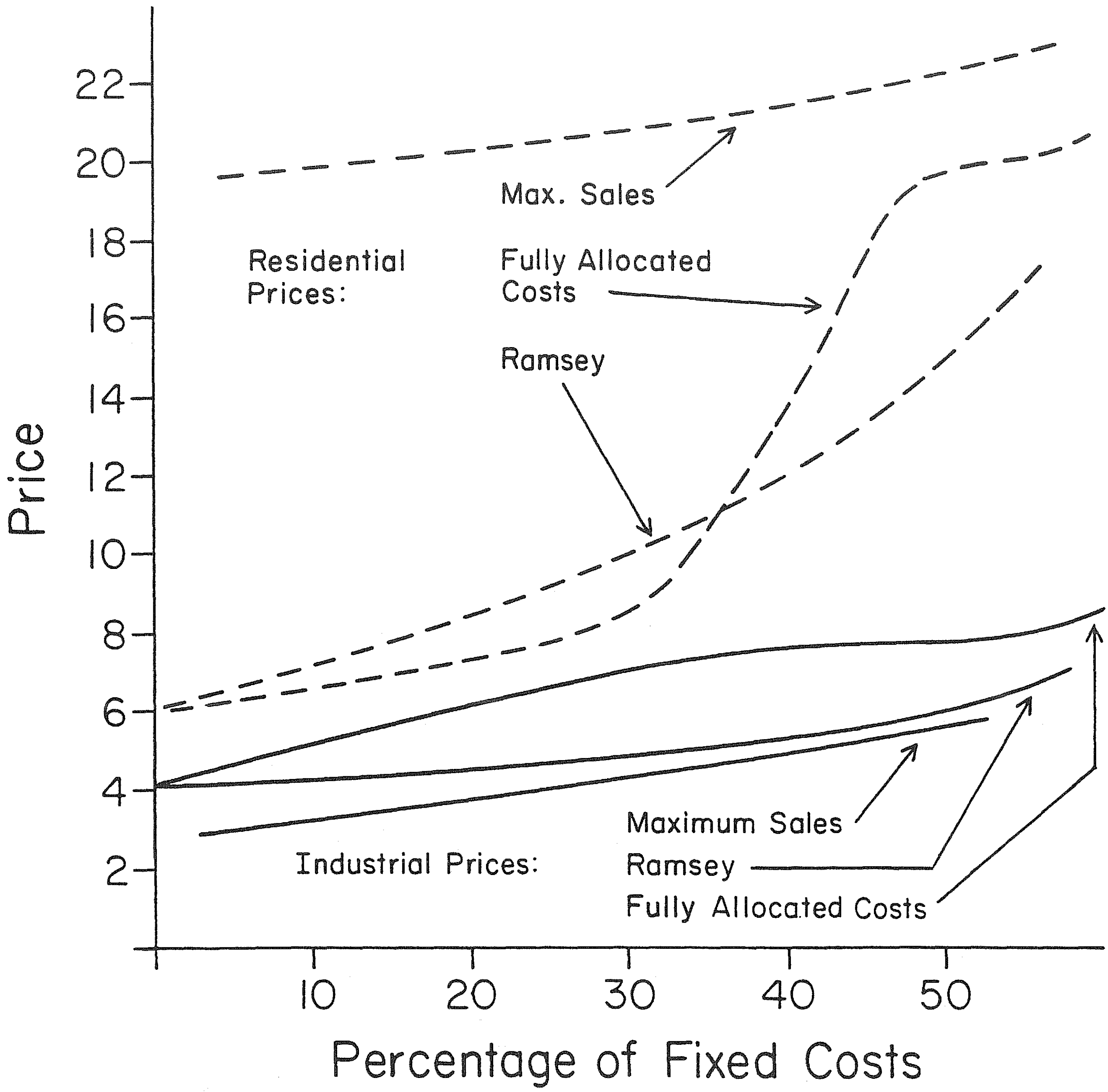

Fig. 5-8. Peak-period prices for three pricing policies

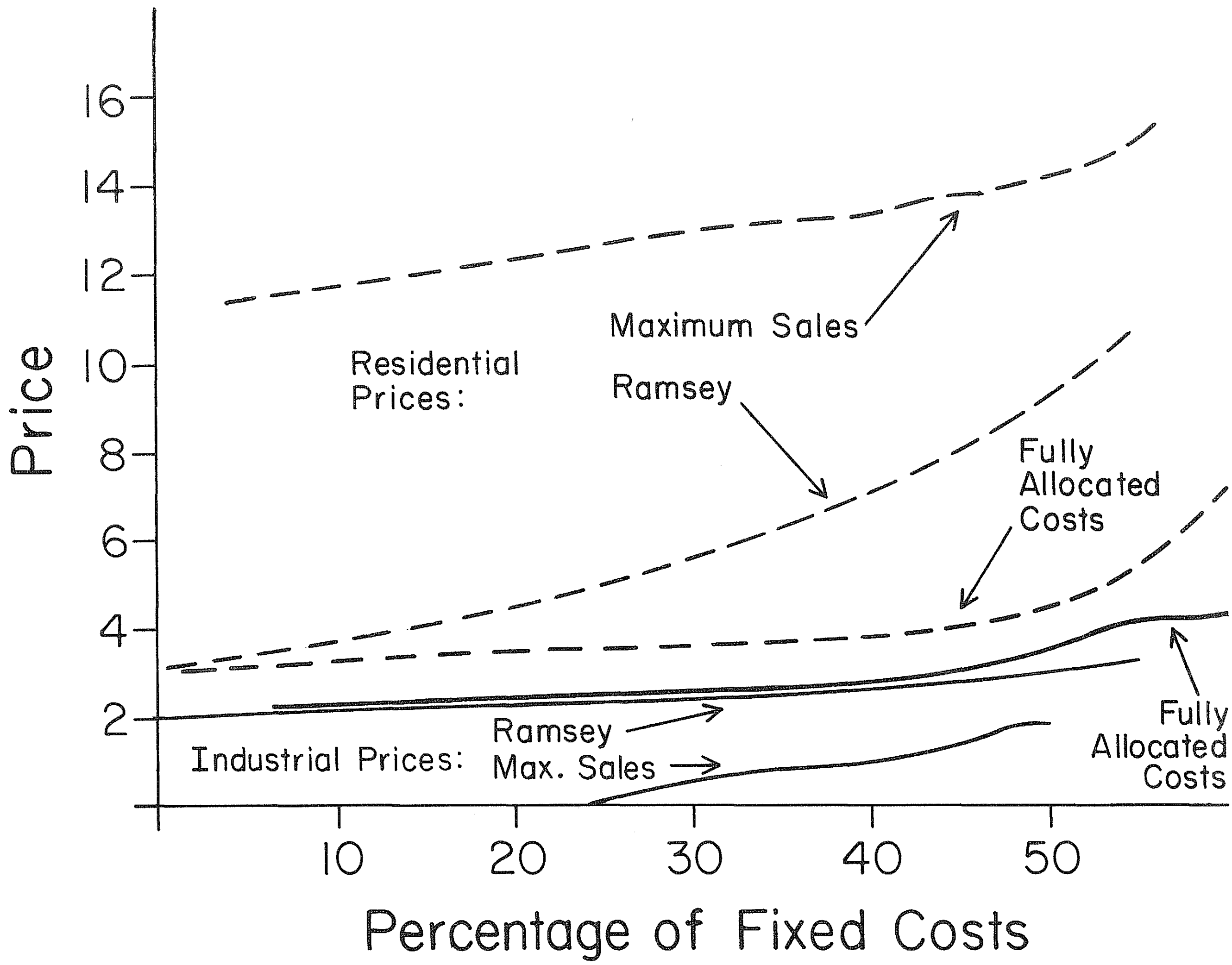

Fig. 5-9. Off-peak prices for three pricing policies

Although the example is similar to the one used in the previous discussion of the basic model, the freedom to set prices independently in the peak and off-peak markets enables a larger amount of fixed costs to be recovered from these markets. Accordingly, the diagram does not show the vertical limit on the right-hand side as does the corresponding figure 5-1 for the basic model. The limit merely occurs further to the right and off of the scale chosen for figure 5-6. The behavior of all five policies at that limit is the same as before, however.

The qualitative behavior of each of the five welfare-loss lines is essentially unchanged from that described for the basic model. The Ramsey policy dominates the other four at all levels of fixed cost, with the national tax policy a close second. The maximize-sales policy displays the same perverse tendency for welfare loss to be high even at low levels of fixed cost. The model in which utilities compete for industrial customers has a limit to the amount of fixed costs that can be recovered, which occurs at about 45 percent of fixed costs in this example, instead of 37 percent in the basic model described before. The fully allocated cost policy has substantially higher welfare losses at moderate levels of fixed costs. These are only somewhat higher than Ramsey pricing when fixed costs are either very low or very high.

The issue of price discrimination, as before, is best understood in relation to the Ramsey standard, which is shown in figure 5-7 for the peak pricing model. The peak market prices are shown as solid lines for both the residential and industrial customers, and the off-peak price lines are dashed. Each of the four lines begins at the market's respective marginal cost when fixed cost is zero, and rises to a monopolistic pricing point, not shown on the diagram. The relative mark-up reflects the inverse of each market's sensitivity to price. There is discrimination in both the peak and off-peak markets between the prices charged to the residential and industrial classes. By the overall social welfare standard, this degree of discrimination could be considered "good" or "due".

The discrimination inherent in the maximize-sales policy and the fully allocated cost policy is shown in figure 5-8 for the peak period, and figure 5-9 for the off-peak period. As before, the maximize-sales policy maintains essentially the same difference between the residential and industrial prices regardless of the amount of fixed costs. This is true in both the peak and off-peak markets. The result is an industrial price below marginal costs for small amounts of fixed costs, in both the peak and off-peak markets. Combined with the welfare weight analysis in table 4-7, this pricing pattern certainly appears to be unduly discriminatory for the same reasons discussed in the case of the basic model.

The fully allocated cost prices that emerge in the peak period, in particular, are more complicated than those encountered in the basic model. In figure 5-8, the residential peak price is below the Ramsey line for small amounts of fixed cost, meaning that the residential peak market is favored by the cost allocation formula (which is the average-and-excess method). As fixed cost increases, however, the price in this market increases rapidly to a point above the Ramsey trajectory where it remains as fixed costs approach their limit.

The reason for this complicated behavior whereby two peak pricing trajectories (Ramsey and fully allocated cost) for the residential market cross stems from a strong interaction between the price sensitivity in the residential and industrial markets and the nature of the cost allocation formula. The high price for the industrial peak market eventually reduces sales in this market so that a relatively small contribution to fixed cost is made. The action of the cost allocation formula is somewhat moderated from that encountered in the basic model, and although the peak industrial price is driven upward by the allocation procedure, the monopoly pricing limit is not reached. This is because the average-and-excess formula loads much of the fixed cost burden onto off-peak markets, thereby shielding those in the peak period. Consequently, the peak industrial price remains below the limit, but peak industrial sales are small and do not contribute much to fixed cost recovery. The cost allocation formula implicitly gives the largest preference to the inelastic market; the residential off-peak market in this case.

Figure 5-9 shows that the residential off-peak price remains below the Ramsey trajectory throughout the range of fixed costs. Residential customers receive preferential treatment as a result. Accordingly, as fixed costs increase, the allocation formula increases the burden on the residential peak market, since the industrial market has little additional ability to pay for fixed costs, even though the monopoly price limit is not encountered in this example. The result of seemingly "fair" cost allocation methods can be complicated pricing patterns that bear little resemblance to those that maximize overall social welfare.

The Influence of Other Economic Parameters

Apart from fixed costs, an analysis of the response of each pricing policy to four other types of changes in the economic environment can be conducted within the context of the experimental design used in this study. These other parameters are (1) the industrial elasticity of demand, (2) the residential elasticity of demand, (3) the size of the industrial market, and (4) the range of fixed costs among the three utilities.

Summarizing the volume of data represented by this experiment is difficult. A complete and accurate representation would require more space than can be allotted here. In lieu of such a description, some statistical averages are presented in this section. As in any such summary, some smoothing is necessary. Consequently, the reader will not be able to appreciate the finer points of the pricing patterns. This is not a trivial matter in this work because, as we have already seen, the prices that emerge under various conditions take on complicated and abrupt changes in response to changes in market circumstances. Such smoothing cannot be avoided, however, so the reader should be aware of this limitation.

Perhaps the most important element in the smoothing is that averages are taken only of those pricing outcomes that are in no way constrained either by a monopoly price limit or by an inability to extract the required level of fixed costs. In this way, we can examine the response of the pricing policies in regions of the economic parameters where complete freedom of adjustment is available. A possible way to supplement this type of analysis would be to conduct a separate study of the forces that change the limit prices and the revenue limits of the markets, a topic for future research not developed here.

In all, sixty-four combinations of economic circumstances were examined for this study under a variety of long- and short-term conditions and assumptions about cost allocation methodologies. This section reports on the behavior found when marginal costs differ from one another (as in the long run) while fixed costs are relatively high (as in the short run.) As before, the intent is to study the policies under relatively extreme conditions in which fixed cost recovery is difficult.

The two most important measures of the performance of each pricing policy are economic efficiency (the percentage loss of welfare) and equity (the implied welfare weight). Welfare loss is measured over the aggregate of the markets served by the three utilities. The welfare weight is that of the industrial class for the second utility, which has an intermediate level of fixed cost. The industrial welfare weight is always less than unity for the fully allocated cost policy and is always greater than or equal to one for the others. If the welfare weight is less than unity, its inverse is recorded for the purposes of this analysis--in this way, the resulting welfare weight measures the degree of pricing preference, with larger numbers indicating more preference.

The best way to summarize the results of this experiment is by means of a regression analysis. In this way, the economic efficiency of each pricing strategy can be related to the five market conditions that form the basis of the experiment. Likewise, the social equity embodied in the implied welfare weight can be predicted from an equation that relates it to the set of five market parameters.

Although a regression analysis may simplify matters considerably, a simple linear equation turned out to be an inadequate description of the policies' behavior. Accordingly, a logarithmic functional form was chosen. In particular, the logarithm of the dependent variable (either the welfare loss or the implied welfare weight) was related to the logarithms of the five independent variables, fixed cost, demand elasticities, and so on.

Table 5-10 gives the log-log equations that predict the welfare loss for each policy. The numbers in the table are the estimated regression coefficients, which can be interpreted as elasticities that show the sensitivity of the welfare loss incurred under all five pricing strategies to variations in market conditions. That is, the coefficients represent the percentage change in the welfare criterion in response to a 1 percent change in each of the variables, which reflect economic circumstances such as fixed costs, size of the industrial market, and sensitivity of demand to

To summarize the results for the Ramsey pricing policy, all of the exogenous market influences affect social welfare in the expected way. Larger amounts of fixed cost for a single utility or larger fixed cost differences among utilities reduce aggregate social welfare, as does greater price sensitivity of either the residential or industrial classes. A larger industrial market will spread fixed costs more easily, thereby increasing overall social well-being.

The remaining four pricing policies are remarkably similar to the Ramsey policy in their conclusions regarding their response to exogenous market conditions. In table 5-10, the other four equations, one for each remaining policy, show the same pattern of signs as the first equation. Some quantitative differences exist among the results; however, the overall impression of the table is that the alternative pricing policies, although substantially less efficient in an absolute sense, nonetheless respond to external circumstances in more or less the same way as the Ramsey rule. This is a somewhat surprising finding. It is only true to the first-order approximation embodied in the estimation reported in table 5-10, but suggests that a regulator following any one of these rules would react to changes in market circumstances in a way similar to that appropriate for an efficient pricing rule.

Despite this first-order similarity, some important differences can be discerned from the results presented thus far. The influence of fixed costs on the welfare loss of the maximize-sales policy is much smaller than for that of all the other policies. The reason is that the relation between welfare loss and fixed cost is one that first decreases and then increases in a complicated way not captured by the simple first-order model in table 5-10. Also, the effect of the residential demand elasticity on the welfare loss of the maximize-sales policy is much smaller than in the Ramsey model. This is because the maximize-sales strategy creates a large pricing distortion among the customer classes to more fully utilize the fixed facilities. The distortion cannot be made significantly worse if the residential sector is more sensitive to price, which would be the normal effect if the initial distortion were smaller.

Scanning down the column corresponding to the difference in fixed costs among the utilities, the Ramsey and national tax models have similar positive coefficients, indicating that these differences are an important source of economic inefficiency. The effect in the three remaining models is also positive, but less than one-half the magnitude. Relative conditions of fixed cost among the utilities does not have the same importance in determining overall social welfare under these policies. The inefficiency of both the Ramsey and national tax policies would disappear if all utilities had the same fixed costs. This is not true of the other policies, reflected in a smaller sensitivity to the dispersion of the fixed costs.

In general, the welfare loss associated with the fully allocated cost method of setting prices is less sensitive to outside influences than that of the efficient Ramsey rule. The effects of the residential demand elasticity and the size of the industrial market are only about 60 percent as large as the corresponding effects under the Ramsey rule. The relative magnitude of the influence exerted by the industrial elasticity is higher than this, while that of the dispersion of fixed costs is somewhat lower. Overall, however, these exogenous influences are muted, some more than others. The reason has to do with the initial distortion created by the fully allocated cost policy being larger than that of the Ramsey model. There is less room left to distort regulated prices further, given that the distortion is large to begin with. In these circumstances, the response of the inefficient pricing rule to exogenous shocks is less sharp and somewhat subdued in comparison to an efficient rule that allows the regulator more leeway.

The reaction of the interutility-competition model is different from that of the other policies in that the industrial demand elasticity and the size of the industrial market have no important influence on the efficiency of the policy. The reason is simple. Given that the industrial price has been reduced to marginal cost through competition, the slope of the demand curve does not matter at that point and the size of the industrial market is inconsequential. The pricing distortion causing the allocative inefficiency associated with this policy occurs in the residential and commercial markets that are the utility's captives. The fixed-cost conditions and the demand elasticity of the captive customers are important determinants of the relative inefficiency of this industrial discount program, but industrial market circumstances are irrelevant if these customers are given the maximum discount.

The inefficiency associated with a policy of instituting a national tax on public utility services behaves in essentially the same way to outside influences as does the Ramsey rule. This is not surprising since the tax policy has been shown to track closely the efficient pricing policy in several figures discussed previously.

A similar comparative analysis can be conducted for the pricing preference implicit in the five policies. Table 5-11 reports the results of a similar regression analysis of the relation between the industrial welfare weight (or its inverse in the case of the fully allocated cost policy) and the five exogenous factors. The Ramsey rule always has an implied welfare of unity, regardless of the market conditions, and so all of the estimated coefficients are simply zero in the table. Likewise, the preferences extended under the tax rule are essentially invariant to outside circumstances because the policy is so similar to the neutral Ramsey rule. Accordingly, a neutral pricing policy is not affected by changes in market circumstances, and remains neutral and beyond the influence of outside shocks.

This is not the case for the nonneutral policies where pricing preferences must respond to market conditions. It simply is not possible for a regulator to continue to extend the same degree of preferential treatment when economic circumstances change. Under the maximize-sales rule, the preference given to the industrial class increases if these customers' market demand is more sensitive to price. The opposite occurs if residential demand is more elastic. The degree of preference also becomes larger if the industrial market is larger.

This last effect means that utilities with a small set of elastic industrial users would create a smaller degree of pricing preference by pursuing a policy of maximizing throughput than a utility with a relatively large number of such customers. All of these conclusions are conventional and expected, but have not been quantitatively analyzed heretofore.

TABLE 5-11

WELFARE WEIGHT EQUATIONS FOR FIVE PRICING POLICIES: ESTIMATED ELASTICITIES AND THE CORRESPONDING t-RATIO

	CNST	IND EL	RES EL	FC(%)	FC DIFF	IND SIZE	R2
RAMSEY PRICING MODEL							
	-0.000	0.000	0.000	0.000	0.000	0.000	0.030
	-1.391	0.068	0.376	0.172	0.632	1.786	
MAXIMUM SALES MODEL							
	-0.929	0.456	-0.916	0.004	-0.061	0.220	0.463
	-1.580	6.316	-7.428	0.085	-0.840	3.051	
FULLY ALLOCATED COST MODEL							
	24.163	-3.267	3.205	-4.938	-0.247	1.260	0.385
	3.307	-3.644	2.091	-7.532	-0.275	1.406	
INTERJURISDICTIONAL COMPETITION MODEL							
	-39.895	0.000	4.118	7.305	0.843	-0.000	0.646
	-7.079	0.000	3.483	14.446	1.220	-0.000	
NATIONAL TAX MODEL							
	0.017	0.015	0.165	0.094	0.030	-0.102	0.237
	0.068	0.463	3.073	4.104	0.963	-3.227	

Source: Authors' calculations.

Interestingly, fixed cost (of one utility or its dispersion among many) has a negligible effect on the pricing preference extended under the maximize-sales policy, which may be an unexpected result to many readers.

The reason is somewhat subtle. Even though the ostensible purpose of this policy is to increase the utilization of fixed facilities, fixed cost really is not very important to the outcome. The policy creates the maximum degree of price discrimination (that of an unregulated monopolist) regardless of fixed cost and essentially maintains this as fixed costs become larger and more burdensome. Accordingly, the pricing preference increases slightly with fixed costs (the elasticity of this effect is .004

in table 5-11), but basically the policy is one of maximum discrimination, which is unchanged by larger amounts of fixed costs. Ironically, then, the policy is justified on the grounds that it makes everyone better off by spreading the costs of the fixed facilities over more sales, and yet the pricing preference embodied in the idea does not disappear even if there are no fixed facilities at all.

The traditional regulatory approach of fully allocating fixed costs gives the preferential treatment to the residential class. The amount of the preference is larger if the residential demand is more elastic and is smaller if the industrial demand is more elastic, according to the results reported in table 5-11. Both effects are expected, in the sense that the favored group enjoys a larger advantage if its own demand is more sensitive or if the other group is less sensitive to price. These results have been estimated over a restricted number of elasticity combinations, however, and clearly cannot be true everywhere. The fully allocated cost rule gives the advantage to the less elastic group, regardless of the identity. If the industrial demand elasticity fell below that of the residential sector, the pricing preference would shift to it. At some point short of this switch, the residential preference would have to decrease rather than increase as suggested by table 5-11.

The advantage enjoyed by the residential class under fully allocated cost pricing is reduced by larger amounts of fixed cost. This is because the preference becomes more difficult to maintain as fixed costs approach the point where the markets' ability to pay for fixed costs is saturated. Thus, the negative coefficient in table 5-11 reflects the first-order effect of high levels of fixed cost that are approaching this point of maximum revenue extraction. At very low levels of fixed cost, the fully allocated cost method has only a small amount of pricing preference, which initially increases in response to more fixed cost. The negative effect in the table, then, should be interpreted as an estimate of the first-order local influence exerted by fixed costs on the residential advantage enjoyed under this traditional regulatory treatment.

Table 5-11 shows that the preference extended to the industrial users under the interjurisdictional-competition model does not depend on the industrial market at all, either its elasticity or its size, which is expected, of course. The degree of preference inherent in this policy is larger if the captive customer demand is more elastic. This is because more sensitive residential demand should receive more favorable treatment, which is impossible given that the industrial sector is enjoying the maximum discount. The implied preference, then, is higher when the group having no competitive alternatives is more sensitive to price.

Likewise, the industrial preference implied by the interutility competition for large customers is stronger when there is a larger need to recover fixed costs. This places a greater burden on the captive users, and the resulting greater distortion of their prices implies the advantage enjoyed by large users is correspondingly greater.

The analysis of table 5-11 shows that nonneutral pricing policies react to exogenous forces in ways that sometimes increase the implied preference and sometimes reduce it. The neutral policies, on the other hand, are more or less immune to such shocks, remaining neutral throughout. This distinction is relevant to policymakers and their ability to sustain some forms of price discrimination. Market events beyond the control of the utility or its regulators may rearrange matters to make a previously sensible policy of preferential treatment obsolete.

This chapter has provided a description of the five regulated pricing policies, including the reaction of each to exogenous market conditions. The reader is now in a position to abstract from these details and compare the efficiency and equity outcomes of the policies to one another.

CHAPTER 6

EFFICIENCY AND EQUITY COMPARISONS AMONG THE FIVE PRICING POLICIES

A major theme of this report has been that it is difficult to evaluate whether or not regulated prices are unduly discriminatory in the absence of factual knowledge of market conditions. Broad policy arguments are not enough--some quantification is needed. Estimating the relevant market parameters is inexact and if attempted will tend to make the regulatory process murky. Nonetheless, some understanding of how markets respond to prices is essential to avoiding misallocation of the nation's resources. Indeed, allocative inefficiency is nothing more than arrangements of prices that do not properly account for the markets' sensitivity to them.

A degree of inefficiency may be justified if some other social goal is achieved, such as a more equitable or fair allocation. At times in this chapter, the view is adopted that the pricing preference implicit in each of the regulated pricing policies studied in this report is intentional and a good thing. As such, the method used in this study provides a quantitative measure of the degree of preference extended to the group favored by the regulator or, more generally, by the social-will embodied in the pricing strategy. The degree of preference can be compared to the overall inefficiency induced by the pricing policy to assess how much allocative damage is done to achieve the implied pricing preference. The design of the analysis in this report allows this comparison to be made consistently for each of the pricing strategies for a variety of economic circumstances. The results are summarized in this chapter from several perspectives.

The first section reports the averages of a measure of the combined size of the efficiency and equity outcomes for each pricing policy. The following section reports various averages that show the magnitude of the trade-off between efficiency and equity. The third section suggests how the pricing policies are arranged along an efficiency-equity frontier, and which policies tend to dominate others.

Throughout this chapter, the intent is to describe the average or representative behavior of each of the pricing policies. This is distinct from the previous chapter, where part of the purpose was to examine the behavior of the pricing policies under extreme circumstances. The analysis in this chapter is conducted from both a short- and long-run perspective. The short-run is characterized as having the same marginal costs (three units) for all three customer groups and relatively high fixed costs. Fixed costs are studied at four levels within the short-run framework, all of which are higher than the levels studied for the long-term cases. The long-term also has different marginal costs (those shown in tables 4-1, 4-2, and 4-3) for the three customer groups, with the residential and commercial marginal costs being about 60 percent larger than those of the industrial class.

A Combined Measure of Efficiency and Equity

For any one set of economic circumstances, each of the five pricing policies can be summarized by two numbers--its loss of social welfare (in percentage terms) and its degree of pricing preference (the implied welfare weight of the industrial class using the residential class as the benchmark).

Imagine these two numbers graphed on a diagram, such as figure 6-1,[1] whose vertical axis is the welfare loss and the horizontal axis is the welfare weight. The Ramsey policy is one that has a very high efficiency, so that the welfare loss would be small in most cases. Likewise, the Ramsey policy is implicitly the benchmark of the measure of price discrimination--the welfare weight of the industrial class is unity. In a graph of the two numbers, the welfare weight and the welfare loss, the remaining policies would have higher efficiency losses and larger welfare weights, indicating a higher degree of price discrimination.[2] An interesting way to summarize the positions of the pricing policies in such a diagram, relative to that of the

[1] <u>Infra.</u>, p. 164.

[2] Recall that the reciprocal of the welfare weight is used if it is initially less than one. The intent is to measure pricing preference, regardless of whether it is in favor of the residential or industrial class.

Ramsey policy, would be to measure the distance between the point representing each policy and the point representing the Ramsey policy.

This section reports this average distance measure for a variety of economic circumstances. This measure can be thought of alternatively as the mean-square average of the efficiency and equity dimensions for each pricing policy. In any case, the measure is one that increases with larger values of the welfare loss (larger inefficiency) and also with larger values of the welfare weight (larger pricing preference). Consequently, price discrimination is "bad" when measured this way--a larger pricing preference results in a policy being further away from the Ramsey benchmark.

A specific example of the efficiency and equity results for the basic model under short-run cost conditions is given in table 6-1. The exogenous conditions are shown at the top of the table and correspond to the "low" values of the parameters (in the experimental design of this study) for each factor. The second and third columns give the efficiency and equity outcomes for each policy. The next two columns rank these from the smallest to the largest welfare loss and pricing preference. The final column shows the distance of each policy from the Ramsey benchmark. By this measure, the maximize-sales policy is the farthest away from the efficient Ramsey policy and would be considered the worst policy when measured in this way. The tax policy is quite close to the Ramsey standard, as expected. In these circumstances, the fully allocated cost policy is superior to the interjurisdictional competition model, having a mean-square distance roughly 35 percent as large.

In the following analysis, the national tax policy is always quite close to the Ramsey benchmark, and the maximize-sales policy is almost always the farthest away. The positions of the fully allocated cost and interjurisdictional competition policies are generally in between; however, their positions relative to one another are sometimes reversed from that shown in the table. An interesting aspect of this study is to determine the conditions under which one is superior to the other. As is usual in this type of study there are no easy answers.

Table 6-1 is one of sixty-four circumstances examined for the short-run conditions using the basic model that has no peak and off-peak market

TABLE 6-1

EXAMPLE OF EFFICIENCY AND EQUITY DISTANCE MEASURE:
BASIC MODEL, SHORT-RUN CONDITIONS

EXOGENOUS VARIABLES				
INDUST ELAS	RES ELAS	FIXED COST(%)	DIFF IN FC	SIZE OF IND MKT
0.70	0.25	29.55	9.38	0.50

	POLICY INDICATORS		POLICY RANKINGS		EFFICIENCY-
	WELFARE LOSS	IND WEIGHT	WELFARE LOSS	IND WEIGHT	EQUITY DISTANCE
RAMSEY	0.05	1.00	1.00	1.00	----
SALES	3.79	1.67	5.00	5.00	3.80
FAC	0.34	1.15	3.00	3.00	0.33
COMP	0.93	1.22	4.00	4.00	0.91
TAX	0.08	1.00	2.00	2.00	0.03

Source: Authors' calculations.

distinctions. The entire set of sixty-four cases is summarized in table 6-2, which shows the average distance measure for each pricing policy, as results of a regression analysis intended to summarize how this distance changes in various economic conditions.[3] These averages have been found for those subsets (N) of the sixty-four cases for which each pricing policy encounters no restraint, such as a monopoly pricing limit in the case of fully allocated costing or an inability to recover all of the revenue requirement in the case of competition for industrial customers. The number of cases included in each subset is indicated in the table.

Over the fifty-nine cases where it can be computed, the maximize-sales policy lies 4.57 units, on average, away from the Ramsey policy. These units can be interpreted as percentage points of welfare loss or as points of pricing preference. The fully allocated cost policy is 2.28 percentage points worse than the Ramsey policy according to this measure. The

[3] The regression is log-log, that is, logarithms of both the dependent and independent variables are involved. The estimated coefficients can be interpreted as the percentage change in the measurement of distance that is induced by a 1 percent change in the corresponding exogenous factor.

TABLE 6-2

AVERAGE DISTANCE OF COMBINED EFFICIENCY AND EQUITY MEASURES: BASIC MODEL, SHORT-RUN CONDITIONS

THE MAXIMIZE SALES POLICY

DISTANCE	MEAN	MIN	MAX	STD-DEV	N
	4.57	1.34	9.02	2.42	59.00

THE DETERMINANTS OF THE DISTANCE MEASURE*

CNST	IND EL	RES EL	FC(%)	FC DIFF	IND SIZE	R2
0.545	1.469	-1.380	-0.271	-0.036	-0.512	0.970
2.465	34.597	-19.920	-4.367	-0.919	-4.203	

THE FULLY ALLOCATED COST POLICY

DISTANCE	MEAN	MIN	MAX	STD-DEV	N
	2.28	0.09	25.39	3.82	47.00

THE DETERMINANTS OF THE DISTANCE MEASURE

CNST	IND EL	RES EL	FC(%)	FC DIFF	IND SIZE	R2
-15.928	2.775	-0.833	4.477	0.004	0.640	0.933
-19.238	17.920	-3.575	19.283	0.032	1.581	

INTERJURISDICTIONAL COMPETITION POLICY

DISTANCE	MEAN	MIN	MAX	STD-DEV	N
	1.83	0.83	2.81	0.68	16.00

THE DETERMINANTS OF THE DISTANCE MEASURE

CNST	IND EL	RES EL	FC(%)	FC DIFF	IND SIZE	R2
-8.361	-0.130	1.637	3.963	0.224	5.018	0.941
-10.886	-1.379	7.482	12.501	2.041	10.790	

NATIONAL TAX POLICY

DISTANCE	MEAN	MIN	MAX	STD-DEV	N
	0.37	0.02	3.43	0.63	56.00

THE DETERMINANTS OF THE DISTANCE MEASURE

CNST	IND EL	RES EL	FC(%)	FC DIFF	IND SIZE	R2
-16.298	0.449	1.258	3.655	2.292	4.536	0.826
-13.172	1.993	3.377	10.732	10.391	6.864	

Source: Authors' calculations.
* The following numbers are estimated regression coefficients for each exogenous factor, beneath which are the associated t-statistics.

interutility competitive model results in an average distance of 1.83 percentage points by comparison. A policy of instituting a national energy tax to partially pay for public utility fixed costs results in a much smaller distortion, only .37 percentage points worse than the Ramsey benchmark. From these simple averages, it is clear that the tax policy dominates the other three policies. It is also clear that the maximize-sales policy is the least attractive.

The relative positions of the cost allocation and competition policies in table 6-2 are not immediately apparent. The average distance is larger for the fully allocated cost policy than for the competitive one. This suggests that the competitive policy might be superior. In addition to the average distance, however, table 6-2 shows that the range of the outcomes is much larger for the cost allocation policy, having a smaller minimum value and larger maximum value. Accordingly, the cost allocation policy tends to be more volatile, a finding discussed in greater depth in the third section of this chapter. In addition, note that the average distance for the competitive policy can be computed for only sixteen out of sixty-four cases, because the competitive policy cannot always recover the utility's entire fixed cost. A more detailed examination of the sixty-four cases, reported in the third section, shows that the two policies can be directly compared in fifteen circumstances, and that the cost allocation policy is superior to the competitive model in twelve of these. Consequently, a fully allocated cost methodology tends to be more efficient and less discriminatory than the interutility competitive equilibrium using a framework of short-term cost conditions.

The regression analysis reported in table 6-2 suggests how these averages change in different economic circumstances. The maximize sales policy is less efficient and more discriminatory when the price elasticity of the industrial market is larger, and when the price elasticity of the residential market is smaller. This is consistent with the analysis of the previous chapter that showed the sales maximization policy to be one that seeks the largest possible degree of pricing differences among the three customer classes to achieve the maximum reduction in the price of the elastic class, and thereby obtain the largest possible sales. By comparison, the amount of fixed costs, or differences in fixed costs among the three utilities has a relatively small impact on the outcome.

Likewise, the fully allocated cost policy becomes less efficient and more discriminatory as the industrial price elasticity becomes larger and as the residential elasticity becomes smaller. This is because a policy of cost allocation does not account for changes in demand conditions when dividing cost responsibility, whereas the Ramsey policy does. In addition, table 6-2 shows that a greater amount of fixed costs moves the cost allocation policy farther away from the Ramsey benchmark. Differences in fixed costs among the three utilities have almost no effect on the relative position of this policy, and the size of the industrial sector has only a modest positive influence on this distance.

The price elasticities of the industrial and residential sectors have opposite influences on the distance of the competitive model from the Ramsey benchmark. In effect, the competitive policy ignores the relative price elasticity of the two sectors, much as the fully allocated cost policy does. When these important parameters change, the position of the Ramsey policy is shifted while the competitive policy is not much affected. An increase in the industrial demand elasticity, for example, brings the Ramsey policy closer to the industrial marginal cost point. The competitive policy is positioned at the industrial marginal cost regardless of this elasticity. At higher values of elasticity, then, the competitive policy is closer to the Ramsey policy closing the distance between them. The opposite effect occurs when the residential demand is more elastic--the competitive policy becomes less efficient and more discriminatory, compared to the Ramsey benchmark. An increase in fixed costs causes the competitive policy to be further from the Ramsey policy, meaning that the efficiency and equity consequences of the competitive policy are more severe when the revenue requirement is larger and more difficult to recover. Larger industrial sectors that are subject to this kind of competition also place this policy farther away from the Ramsey standard.

Both the maximize-sales and the industrial competition policies lie on the same side of the Ramsey policy--favoring the industrial class--and yet the distance of the two policies responds in opposite ways to changes in the demand elasticities. The reason is that the maximize-sales policy carefully considers demand elasticity, while the industrial competition policy mostly ignores it.

Indeed, the maximize-sales strategy overreacts to changes in price sensitivity of demand, moving more than the Ramsey policy. That is, an increase in the industrial demand elasticity moves the Ramsey policy in the direction of pricing at the industrial marginal cost and moves the maximize sales strategy in the same direction by an even larger amount, thereby increasing the distance between them. The effect of the industrial demand elasticity on the distance between policies, then, is positive for the sales maximization policy because it overreacts relative to the Ramsey standard, and it is negative for the industrial competition model because it underreacts by comparison.

The policy to impose a national energy tax to assist in collecting revenue for public utility fixed costs moves farther away from the Ramsey model as the elasticity of demand in either sector increases. The same is true as fixed costs become larger, as the differences in fixed costs among the three utilities becomes larger, and as the industrial sector with competitive alternatives becomes larger. Basically, a positive increase in any one of the five exogenous factors makes the recovery of fixed costs more difficult. As the self-financing constraint becomes more constricting, the national tax policy deviates farther from the Ramsey solution. This is because the tax is calculated on an ad-hoc basis. Any ad-hoc solution such as this becomes more severely tested when fixed costs are difficult to recover. Despite the increasing distance between the two solutions, the tax policy remains close to the Ramsey outcome in all circumstances in comparison to the other pricing policies.

The short-run conditions just described are ones in which the recovery of fixed costs places a rather severe burden on the ability of the markets to self-finance the public utility. From a long-run perspective, such a burden is eased because long-run incremental costs include the cost of expansion, which appears as a fixed cost in the short-term. Consequently, the need to raise prices above marginal costs is smaller in a long-run framework than in the short term. Both perspectives are valid. As discussed in chapter 2, an analysis of price discrimination in practice would benefit from an examination of price markups when compared to both short- and long-run standards.

Table 6-3 shows the distance of the four pricing policies from the Ramsey standard using a long-run analysis in which the marginal costs of serving the three customer groups are different and the fixed costs are relatively small. The average distance of all of the pricing policies is much closer to the Ramsey solution in the long run than in the short-run, with the exception of the maximize-sales policy. This policy is more than twice as far away from the Ramsey policy in the long-run than in the short-term. The reason has to do with the insensitivity of this policy to fixed costs, as illustrated in figure 5-1. At low values of fixed cost, the Ramsey policy has only small distortions of prices away from marginal costs, whereas large price differences are sought in the sales maximization policy in order to increase throughput. The relative distance between the Ramsey and sales maximization policies is larger as a consequence under long-run circumstances when the fixed-cost burden is smaller.

Across all sixty-four circumstances studied under long-run conditions using the basic model, the tax policy is quite close to the Ramsey benchmark, with an average of only .02 percentage points separating the two policies. The interjurisdictional competition policy is .25 percentage points away from the Ramsey solution on average, while the distance of the fully allocated cost policy is .44. Under the long-run circumstances of table 6-3, the fixed-cost burden is small in relation to the ability of these markets to support the utility's fixed costs. The averages in table 6-3 have been computed over all sixty-four cases for all of the pricing policies. No constraints were encountered. In these circumstances, then, the table indicates that the interutility competitive model is superior to the practice of fully allocated cost pricing. This is borne out by a more detailed analysis of the sixty-four individual cases, which shows that the competitive solution is superior to the cost allocation pricing method in forty out of sixty-four situations. Consequently, the conclusion as to whether the competitive or cost allocation model is superior depends fundamentally on the cost conditions under consideration. In both short- and long-term conditions, the results are mixed with one policy judged better than the other in some, but not all, circumstances. Overall, the cost allocation method of setting regulated prices tends to dominate (in terms of the cases where the two policies can be directly compared) in short-run conditions, while the competitive model tends to be better in the long-term.

Between the long- and short-term perspectives, this is the only comparison that changes in any important way. In all other respects, the

TABLE 6-3

AVERAGE DISTANCE OF
COMBINED EFFICIENCY AND EQUITY MEASURES:
BASIC MODEL, LONG-RUN CONDITIONS

THE MAXIMIZE SALES POLICY

DISTANCE	MEAN	MIN	MAX	STD-DEV	N
	9.88	5.41	15.01	3.25	64.00

THE DETERMINANTS OF THE EFFICIENCY-EQUITY MEASURE

CNST	IND EL	RES EL	FC(%)	FC DIFF	IND SIZE	R2
1.293	0.910	-0.774	-0.006	-0.001	-0.372	0.987
22.972	59.649	-30.575	-0.336	-0.043	-8.641	

THE FULLY ALLOCATED COST POLICY

DISTANCE	MEAN	MIN	MAX	STD-DEV	N
	0.44	0.03	2.47	0.48	64.00

THE DETERMINANTS OF THE EFFICIENCY-EQUITY MEASURE

CNST	IND EL	RES EL	FC(%)	FC DIFF	IND SIZE	R2
-7.961	1.774	-0.149	2.316	0.233	0.281	0.988
-51.530	42.336	-2.144	47.739	5.263	2.383	

INTERJURISDICTIONAL COMPETITION POLICY

DISTANCE	MEAN	MIN	MAX	STD-DEV	N
	0.25	0.04	0.83	0.19	64.00

THE DETERMINANTS OF THE EFFICIENCY-EQUITY MEASURE

CNST	IND EL	RES EL	FC(%)	FC DIFF	IND SIZE	R2
-4.928	-0.217	1.407	2.198	0.212	3.195	0.984
-36.687	-5.949	23.278	52.109	5.493	31.122	

NATIONAL TAX POLICY

DISTANCE	MEAN	MIN	MAX	STD-DEV	N
	0.02	0.00	0.05	0.02	64.00

THE DETERMINANTS OF THE EFFICIENCY-EQUITY MEASURE

CNST	IND EL	RES EL	FC(%)	FC DIFF	IND SIZE	R2
-8.044	-0.268	1.553	0.983	2.005	3.606	0.984
-51.280	-6.305	22.008	19.947	44.566	30.071	

Source: Authors' calculations.

conclusions and insights from the long-term analysis remain the same as those described for the short-term. This includes the manner in which all four of the policies respond to changes in exogenous factors. The regression analysis results in table 6-3 are qualitatively the same as those previously discussed in conjunction with table 6-2.

The above analysis of short- and long-term implications of each pricing policy was conducted for the peak-pricing model, as well as for the single-price, peak- and off-peak-period model. The results were similar in many respects and so the details are omitted for brevity. The important insights to be gained from this larger exercise are summarized in table 6-4. The table shows the average distance of (1) the fully allocated cost policy, (2) the industrial-competition policy, and (3) the maximize-sales policy in the short-run (SR) and long-run (LR) for each of the three pricing models. The national energy tax policy is consistently close to the Ramsey policy so there is no need to include it in the table.

TABLE 6-4

SUMMARY OF MEAN-SQUARE DISTANCE ANALYSIS

	MARGINAL	FIXED		AVERAGE DISTANCE		
MODEL	COST	COST	PERIOD	FAC	COMP	SALES
BASIC	SAME	HIGH	SR	2.28	1.83	4.57
BASIC	DIFF	LOW	LR	.44	.25	9.88
PEAK	SAME	HIGH	SR	3.96	1.67	9.17
PRICING	DIFF	LOW	LR	.46	.16	11.87
SINGLE	SAME	HIGH	SR	4.00	1.74	5.35
PRICE	DIFF	LOW	LR	1.54	.08	9.58

Source: Authors' calculations.

The relative standings of the three pricing policies in table 6-4 is more or less the same in the more complicated peak-period models, as in the basic model with a single time period. The average distance is larger for short-run circumstances in comparison to those in the long-term for the fully allocated cost policy and the industrial competition policy. The opposite is true for the maximize-sales policy because of its severe distortion of efficiency when fixed costs are small, as in the long-term. The relative attractiveness of the cost allocation and the competitive methods of pricing is somewhat hidden within the averages reported in table

6-4. As explained previously and as developed further in table 6-9, the traditional regulatory practice of cost allocation enjoys an advantage (in terms of frequency of dominance) over the interutility competition policy in the short-term. This frequency pattern (not evident in table 6-4) is maintained in the peak pricing model, but not in the model with a single price prevailing in both the peak and off-peak periods. In the single price model, the competitive policy generally is superior to that of allocating costs according to the peak responsibility method. This is likely to be due to the difficulty of using the same price in peak and off-peak markets. The fully allocated cost policy does a relatively poor job of conveying correct price signals when a single price must be computed to substitute for two separate ones. The interutility competitive policy encounters the same difficulty, but copes with it better because the meaning of charging industrial customers a price equal to marginal cost is more or less the same irrespective of peak and off-peak distinctions.

The Trade-offs between Efficiency and Equity

An alternative way to assess the efficiency and equity consequences of the alternative pricing policies is to examine the amount of efficiency sacrificed to achieve an additional degree of pricing preference. In such a view, price discrimination is a good thing--the only question is the social cost of obtaining it. The analysis conducted for this study provides an excellent opportunity to evaluate price discrimination from this perspective.

Table 6-5 shows the efficiency and equity trade-offs for one example of the long-run version of the basic model. The trade-off is calculated as the incremental loss of economic efficiency (by comparison to the Ramsey policy) divided by the incremental gain in pricing preference. In the table, for example, the trade-off associated with the maximize-sales policy is shown in the last column as 7.79. This means that 7.79 percentage points of economic efficiency are sacrificed to give industrial customers (in this case) one additional unit of pricing preference. (A unit of pricing preference refers to the difference between a welfare weight of unity and a weight of two, for example.) Such a difference is quite large. If this were broken down into a finer measurement, it could be thought of as one-hundred preference points. In these terms, the trade-off for the maximize-sales policy means that .779 percentage points of aggregate social welfare are given up to extend ten percentage points of pricing preference to the industrial class. The policymaker's judgment is needed to assess whether or not this is an acceptable price to pay. This assessment might include the incremental sacrifice of overall social welfare, .779 percentage points of efficiency for each increment of ten preference points, as well as the total number of the preference points as a measure of the extent of the price discrimination.

TABLE 6-5

EXAMPLE OF EFFICIENCY AND EQUITY TRADE-OFFS:
BASIC MODEL, LONG-RUN CONDITIONS

EXOGENOUS VARIABLES				
INDUST ELAS	RES ELAS	FIXED COST(%)	DIFF IN FC	SIZE OF IND MKT
0.60	0.25	10.68	9.82	0.50

	POLICY INDICATORS		POLICY RANKINGS		EFFICIENCY-
	WELFARE LOSS	IND WEIGHT	WELFARE LOSS	IND WEIGHT	EQUITY TRADEOFF
RAMSEY	0.01	1.00	1.00	5.00	----
SALES	8.73	2.12	5.00	1.00	7.79
FAC	0.06	1.05	4.00	2.00	1.00
COMP	0.04	1.04	3.00	3.00	.75
TAX	0.02	1.00	2.00	4.00	----

Source: Authors' calculations.

The trade-offs between economic efficiency and social equity computed in this manner were found for each of the sixty-four combinations of economic conditions. The averages of these trade-offs are reported in table 6-6 for the basic model under long-run circumstances.

On average, 7.15 percentage points of economic efficiency are sacrificed for each unit of pricing preference under the maximize-sales policy. This represents .715 percentage points of loss for each increment of ten preference points. By comparison, the fully allocated cost policy

TABLE 6-6

EFFICIENCY AND EQUITY TRADE-OFFS:
BASIC MODEL, LONG-RUN CONDITIONS

THE MAXIMIZE SALES POLICY

TRADE-OFF	MEAN	MIN	MAX	STD-DEV	N
	7.15	5.67	9.18	0.90	64.00

THE DETERMINANTS OF THE EFFICIENCY-EQUITY TRADE-OFF

CNST	IND EL	RES EL	FC(%)	FC DIFF	IND SIZE	R2
2.061	0.113	0.241	-0.087	0.001	-0.857	0.941
47.139	9.513	12.248	-6.370	0.046	-25.655	

THE FULLY ALLOCATED COST POLICY

TRADE-OFF	MEAN	MIN	MAX	STD-DE	N
	1.91	0.73	3.62	0.65	64.00

THE DETERMINANTS OF THE EFFICIENCY-EQUITY TRADE-OFF

CNST	IND EL	RES EL	FC(%)	FC DIFF	IND SIZE	R2
-1.650	0.532	0.172	0.859	0.304	1.073	0.940
-12.864	15.299	2.989	21.327	8.264	10.942	

INTERJURISDICTIONAL COMPETITION POLICY

TRADE-OFF	MEAN	MIN	MAX	STD-DEV	N
	2.00	0.60	4.11	0.82	64.00

THE DETERMINANTS OF THE EFFICIENCY-EQUITY TRADE-OFF

CNST	IND EL	RES EL	FC(%)	FC DIFF	IND SIZE	R2
-0.863	-0.284	0.904	1.097	0.287	2.335	0.977
-9.190	-11.163	21.417	37.207	10.645	32.546	

NATIONAL TAX POLICY

TRADE-OFF	MEAN	MIN	MAX	STD-DEV	N
	742.07	31.59	19774.83	2517.38	64.00

THE DETERMINANTS OF THE EFFICIENCY-EQUITY TRADE-OFF

CNST	IND EL	RES EL	FC(%)	FC DIFF	IND SIZE	R2
-0.070	-0.519	0.618	1.068	2.196	3.567	0.543
-0.061	-1.658	1.190	2.946	6.634	4.044	

Source: Authors' calculations.

loses .191 percentage points of efficiency to extend ten pricing preference points, while the interutility competitive framework has a trade-off of .20. Both of these policies have an average trade-off that is roughly 26 percent as large as that encountered to maximize sales. The national tax policy has an average trade-off of 74.2 measured in this way. This is a large sacrifice on a per-unit basis; however, the tax policy results in very little discrimination in the first place meaning the absolute size of the efficiency loss is small. Consequently, the trade-offs encountered for the tax policy are not particularly interesting--the average distance analysis in the previous section is more relevant.

The regression results reported in table 6-6 describe how the efficiency-equity trade-off changes with economic circumstances. The social cost of price discrimination under the maximize-sales policy is larger if either the residential or industrial markets are more price elastic. The coefficients in table 6-6 suggest that these effects are not particularly large, but nonetheless mean that pricing preference has greater efficiency ramifications if markets are sensitive to price in the first place. The amount of fixed costs does not affect the efficiency-equity trade-off under the maximize-sales policy, but a larger industrial sector reduces it significantly. The negative effect of the size of the industrial market is due to the policy being relatively more efficient (less inefficient) when industrial sales are large.

The efficiency-equity trade-offs for the fully allocated cost and the interutility competition policies react in similar ways in response to changes in fixed costs and the size of the industrial sector. In each instance, the response is positive and significant. Consequently, greater fixed costs and more industrial sales raise the social cost of price discrimination for these two policies. The reaction to market price elasticity is somewhat different. In one respect, both policies are similar--when the elasticity of the group discriminated against is larger, the trade-off increases and a larger social price must be paid for any discrimination. Larger values of price elasticity for the favored group, however, increases the trade-off under the fully allocated cost policy, while decreasing it in the case of the competitive policy.

The negative coefficient for the industrial competition is the unusual case and is the result of the relative improvement in efficiency that accompanies a larger industrial demand elasticity for this policy. For both policies, the elasticity of the favored group does not matter as much as that of the group discriminated against. The effect of the latter is to increase the efficiency that must be sacrificed for each unit of pricing preference.

In general, economic circumstances that create difficulties in recovering the revenue requirement serve to increase the efficiency-equity trade-off and raise the stakes in price discrimination matters. Higher levels of fixed costs, larger differences in fixed costs among utilities, larger industrial sectors, and more price-elastic demand conditions (particularly for the group discriminated against) make the efficiency consequences of price discrimination larger and more important. Regulators are more likely to be attracted to price discrimination in the first place when the revenue requirement is difficult to meet. Under these conditions, this analysis suggests that the payoff to a careful crafting of the necessary price discrimination is likely to be the greatest, and the danger from errors will be the largest. This conclusion has been illustrated using the data from the long-run, basic model. It remains essentially unchanged under short-term conditions also, as well as for the other peak-period models examined in this study.

The effects of long- and short-term cost conditions and of the complications introduced by the peak-period pricing models on the efficiency-equity trade-off are illustrated in table 6-7. In the table, the average trade-off is generally higher under short-term cost conditions than when long-term conditions prevail, with the exception of the maximize-sales policy. This is consistent with the observation made previously that the social cost of price discrimination tends to be higher when the revenue requirement is more difficult to meet. Short-term conditions have relatively high fixed costs in this study.

The other major finding from table 6-7 is that the efficiency given up for a unit of price discrimination is much larger for the fully allocated cost policy when peak and off-peak markets are considered. The complications introduced by multiple markets with separate marginal costs are not tracked as consistently by the cost allocation procedures in comparison to the other policies. The result is a relatively high loss of economic efficiency in exchange for the favored price treatment of the

TABLE 6-7

SUMMARY OF EFFICIENCY-EQUITY TRADE-OFF ANALYSIS

MODEL	MARGINAL COST	FIXED COST	PERIOD	AVERAGE TRADE-OFF FAC	COMP	SALES
BASIC	SAME	HIGH	SR	2.94	5.18	4.77
BASIC	DIFF	LOW	LR	1.91	2.00	7.15
PEAK	SAME	HIGH	SR	16.44	4.46	8.33
PRICING	DIFF	LOW	LR	5.07	1.55	7.73
SINGLE	SAME	HIGH	SR	6.34	3.61	3.93
PRICE	DIFF	LOW	LR	2.67	1.75	5.06

Source: Authors' calculations.

residential and commercial classes. The average trade-offs for the industrial-competition and maximize-sales policies remain more or less the same when the complication of peak and off-peak markets is added to the analysis. This suggests that cost-allocation procedures are likely to have a high social welfare cost per unit of pricing preference when complicated market circumstances are encountered.

An Efficiency-Equity Frontier

An alternative approach in examining the positions of the five pricing policies relative to one another is to construct a so-called "efficiency-equity" frontier. Such an exercise begins by graphing the efficiency and equity of each policy for a single set of economic circumstances. Figure 6-1 shows the results for the example in table 6-5, which is the outcome of the basic model under long-run cost conditions. The vertical axis measures the loss in economic efficiency while the horizontal axis is the welfare weight that gauges price discrimination.

An efficiency-equity frontier is constructed from the subset of these five pricing policies that are not dominated by any other policy. One policy dominates another if it is strictly superior in both the efficiency and equity dimensions. In the vertical direction, a superior policy is one

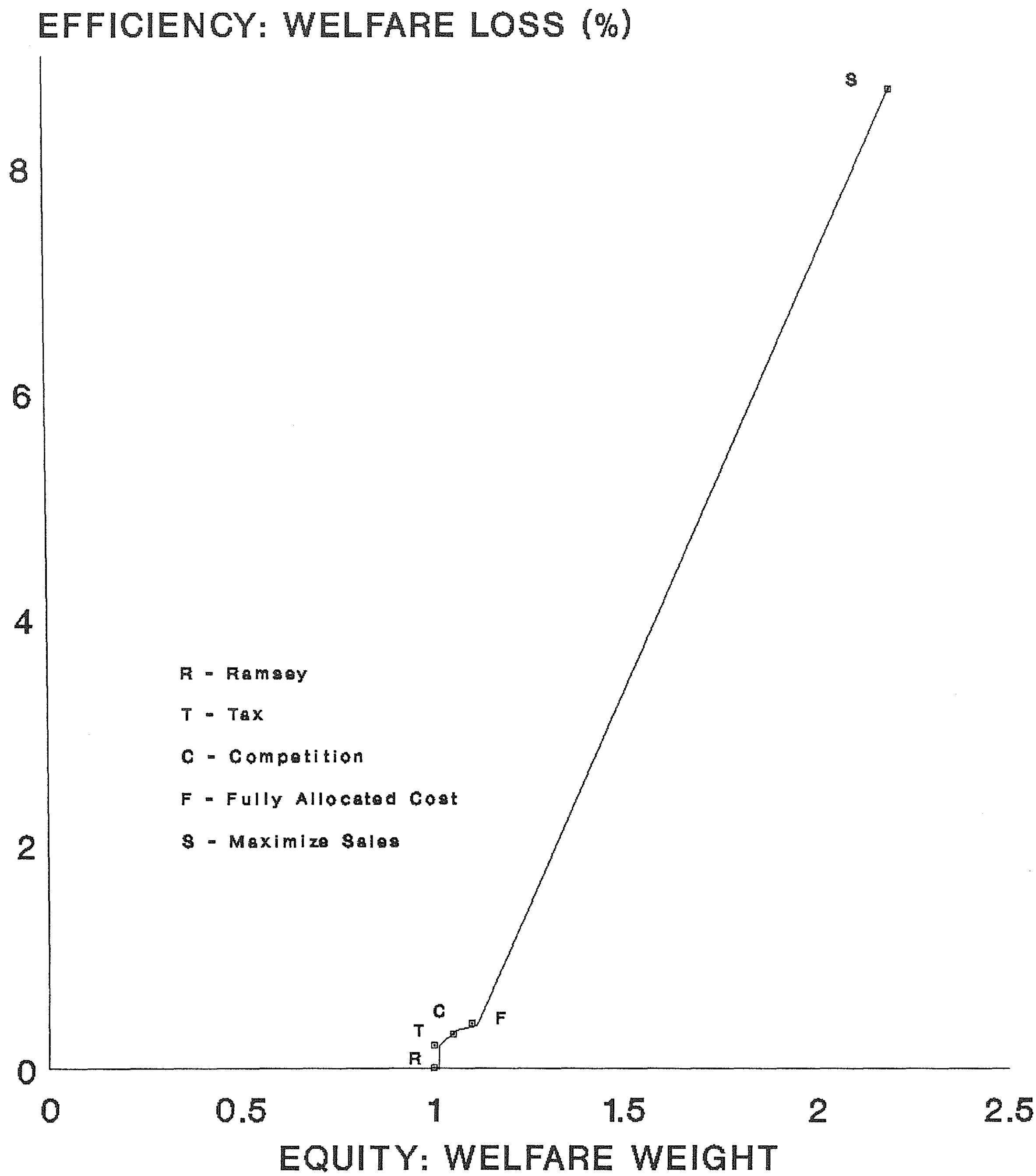

Fig. 6-1. An efficiency-equity frontier for the basic model under long-run cost conditions

that has a smaller welfare loss, which shows up as a smaller vertical component in the diagram. In the horizontal direction, it is necessary to interpret price discrimination as a good thing, meaning that more of it is better. As a result, a superior policy in the equity dimension is one that has a larger horizontal component. All of the points in the example illustrated in figure 6-1 are on the frontier, since none is better than any other in both policy evaluation dimensions.

To give substance to the concept of a "frontier," it is necessary to interpret price discrimination as a good, as opposed to a bad, thing. If one were to view the price discrimination as bad, policies with less inefficiency and less discrimination would dominate others. In this study, the Ramsey solution would always dominate all the other policies from such a perspective, and the concept of a frontier would be meaningless.

The frontier establishes an ordering of the policies, from which the frequency with which particular orderings occur can be studied, as well as the economic conditions that gave rise to them. For this purpose, it is convenient to list the policies in the order they occur along the frontier beginning in the southwest and proceeding toward the northeast in the diagram. This results in the Ramsey policy always being listed in the "first" place, that is, the farthest southwest. This placement is partly a normative judgment that the Ramsey policy is both efficient and equitable. More importantly it serves to create a stable anchor for the frontier. This is useful in assessing how the remaining policies shuffle their relative positions in response to changes in economic circumstances.[4]

The efficiency-equity frontiers were found for each of the sixty-four economic conditions examined in this study under long- and short-run cost conditions for the basic model and for both of the peak-period pricing models. The previous two sections reported on the position of each policy in relation to the Ramsey standard in terms of the average distance between

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[4] This role for the Ramsey policy is similar to the use made by economists of so-called "first-best" pricing. It is a benchmark against which the social welfare costs of two admittedly "second-best" policies are measured. The ultimate purpose is to compare the policies. The initial comparison of each to the "first-best" benchmark is an analytical convenience. The analysis is valid even if the benchmark policy cannot be implemented in practice or is otherwise unacceptable.

them, and in terms of the average trade-off between efficiency and equity in comparison to the Ramsey solution. Some additional insights are found by examining the ordering along the frontier. This will reveal, among other things, any tendency of the policies to switch relative positions with one another.

Table 6-8 shows all of the orderings and their frequency of occurrence for the sixty-four conditions studied for the long-run cost conditions of the basic model. For this particular scenario, only three different orderings are observed. The orderings are indicated in the table by an ordinal number for each of the five policies. For example, the first row in table 6-8 shows that one pattern followed by the policies is Ramsey, first; maximize sales, fifth; fully allocated cost, fourth; interutility competition, third; and national tax policy, second. This particular ordering occurred in forty out of the sixty-four cases studied. The remaining columns show the average value of the exogenous variables for these forty cases. The next two rows show the only two other patterns of the frontier that occurred out of the sixty-four cases examined. The pattern described in the third row contains an asterisk for the interutility competition policy. The asterisk indicates that a policy is not on the frontier for some reason. Possible reasons for this include (1) the policy is dominated by some other policy, (2) the pricing solution for the policy is infeasible because the markets have an insufficient capacity for fixed-cost payments, or (3) the pricing solution is constrained by the monopoly pricing limit described previously. In any case, the policy is not a viable alternative for one reason or another.

In all of the sixty-four sets of circumstances examined, the Ramsey policy is in the first or left-most position (which is not a finding since it is preordained by the method used in this report), the national tax policy is in the second position, and the maximize-sales policy is at the right-most end of the frontier in fifth and last position. This means that the maximize-sales policy is the least efficient and most discriminatory policy without exception under long-term cost conditions. This is consistent with the analysis presented in the first section of this chapter, which shows that the average distance from the Ramsey to the maximize-sales policy is much larger than the distance to any of the other three policies.

TABLE 6-8

TABULATION OF ORDERINGS ALONG THE FRONTIER:
BASIC MODEL, LONG-RUN CONDITIONS

POLICY ORDER						AVERAGE VALUE OF THE EXOGENOUS FACTORS				
RAMSEY	SALES	FAC	COMP	TAX	FREQ	IND ELAS	RES ELAS	FIXED COST	FC DIFF	IND SIZE
1	5	4	3	2	40	1.08	0.30	16.77	11.17	0.60
1	5	3	4	2	19	0.60	0.32	14.60	10.35	0.64
1	4	3	*	2	5	0.60	0.38	22.92	12.92	0.50

Source: Authors' calculations.
* An asterisk denotes that the policy is not on the frontier.

This enumeration of frontiers shows that this relationship holds for each individual set of economic conditions and not merely for the average of the sixty-four. If the discrimination as measured in this study is considered to be a bad thing, the maximize-sales policy is dominated by all of the remaining policies in all of the long-run circumstances examined. If the price discrimination is a good thing and the maximize-sales policy is a viable alternative, the analysis of the efficiency-equity trade-off as presented in the previous chapter would be relevant to a policymaker in judging the relative merits of the pricing policies.

Likewise, the national tax policy is consistently next to the Ramsey policy in second place. As such, the policy is more efficient and less discriminatory than all of the remaining policies, other than the benchmark Ramsey solution. Accordingly, the tax policy is not merely better than the others in an average sense--it improves upon them in each of the sixty-four cases examined if price discrimination is considered as something to be avoided.

The fully allocated cost policy and the interutility competition for industrial customer policy are in the middle of the frontier in third and fourth positions. Interestingly, their relative positions are sometimes switched. In forty out of fifty-nine circumstances in which a direct comparison between the two policies is possible, the interutility competitive policy is more efficient and is in the third position along the frontier.

Examination of the last five columns of table 6-8 shows that the interjurisdictional competition policy is likely to be relatively efficient compared to the traditional cost allocation procedure when the industrial demand is more elastic. This is consistent with the analysis in table 6-3 showing that this policy becomes more attractive in an average-distance sense when industrial demand is more elastic. Of the remaining four exogenous variables, only the size of the industrial market appears to influence the relative positions of the two policies in any important way. A larger industrial market tends to cause a greater increase in the inefficiency of the interutility competition policy than in the inefficiency that it also happens to induce in the cost allocation procedure. Consequently, the fully allocated cost policy is in the more favorable position relative to the competitive policy when industrial sales are larger. Competition for industrial customers is superior to traditional cost allocation when a utility has a relatively small and elastic industrial sector.

This conclusion has been drawn under long-term cost conditions. Frequently, policymakers must make such choices using a short-term cost perspective. In such circumstances, a much richer set of policy frontiers is found. Those encountered for the basic model in this study are listed in table 6-9.

The table has eleven rows indicating that eleven separate patterns of policy orderings occurred out of the sixty-four cases studied. For the short-run cost conditions underlying table 6-9, several instances exist in which a policy is not on the frontier for one reason or another. This occurs much more commonly under short-run than long-run cost conditions. The reason has to do with the increased stress placed on regulated markets under the larger fixed-cost burdens associated with short-run cost conditions. Because of this, the table is more complicated and difficult to interpret than the previous one. For instance, one of the patterns consists

TABLE 6-9

TABULATION OF ORDERINGS ALONG THE FRONTIER:
BASIC MODEL, SHORT-RUN CONDITIONS

POLICY ORDER						AVERAGE VALUE OF THE EXOGENOUS FACTORS				
RAMSEY	SALES	FAC	COMP	TAX	FREQ	IND ELAS	RES ELAS	FIXED COST	FC DIFF	IND SIZE
1	5	3	4	2	12	0.93	0.28	26.35	9.50	0.63
1	4	3	*	2	22	0.92	0.32	35.17	10.74	0.63
1	3	4	*	2	9	1.09	0.32	45.48	9.94	0.60
1	2	3	*	*	3	0.93	0.33	50.57	18.51	0.57
1	5	4	3	2	2	1.40	0.25	30.18	13.37	0.55
1	*	4	3	2	1	1.40	0.25	36.66	8.30	0.55
1	*	3	*	2	7	1.40	0.29	43.11	12.78	0.57
*	*	*	*	*	5	1.26	0.35	58.02	12.50	0.53
1	3	2	*	*	1	0.70	0.38	24.97	14.13	0.66
1	2	*	*	*	1	0.70	0.38	43.98	12.08	0.66
1	4	3	*	2	1	1.40	0.38	28.23	9.59	0.54

Source: Authors' calculations.
* An asterisk denotes that the policy is not on the frontier.

entirely of asterisks, meaning that no solution was found for any of the five pricing policies. The table indicates that this happened in five out of the sixty-four cases studied.

Apart from the asterisk-only pattern, there are three other patterns in the table for which the national tax policy has an asterisk. In each case, the tax policy is dominated by one of the other pricing policies. The maximize-sales and the fully allocated cost policies both dominate the tax policy in three out of the sixty-four cases (the pattern shown in the fourth row), and each of these two policies individually dominates the tax policy once (shown in the ninth and tenth rows respectively).

All five cases are anomalies, although only the last two are interesting. The circumstances in the first three cases (row four) impose a larger burden of fixed costs on the third utility than the tax policy can deal with. In the remaining two cases, either the maximize-sales or the fully allocated cost policy has a smaller welfare loss and a larger degree of price discrimination than the tax policy. It is the lower loss of economic efficiency that is anomalous. These are the only instances of such a result found in this study. Ordinarily, the tax policy has a small welfare loss and is in the second position along the frontier, as it is defined here. It is displaced from this position on these two occasions because the tax is ad hoc and not optimal. By improving the basis for computing the tax, it can be made to be very close to the Ramsey pricing solution, which would prevent any of the remaining policies from having a smaller efficiency loss. Under such a computation no other policy would be able to dominate the tax strategy.

Recall that the particular ad hoc tax definition chosen for this study is the median industrial price markup that would be appropriate under a unified public utility system. This definition does not perform well when several conditions coincide. These are (1) when short-term cost conditions prevail, (2) when the difference in industrial and residential demand elasticities is small, (3) when the industrial sector is relatively large, and (4) when the differences in the fixed-cost responsibility among individual utilities or jurisdictions are relatively large. The combination of the tax and interutility competition for industrial customers makes industrial prices the same in all jurisdictions. The large fixed-cost burden associated with short-term cost conditions and the large differences in this burden among the several jurisdictions mean that the tax policy has a wider range of residential prices among the three utilities than does the efficient Ramsey policy. This creates some inefficiency, which is usually small, although it increases as the individual jurisdictions have a greater diversity of fixed-cost burdens. When the demand elasticities of residential and industrial customers are similar, the inefficiencies associated with the maximize-sales policy and the fully allocated cost policy are smaller.

The four circumstances listed above serve to increase the first source of inefficiency and to reduce the second. This places the tax policy at a relative disadvantage when compared to either of the other two policies. Consequently, the simple, ad-hoc tax rule adopted here is more appropriate when residential and industrial demand elasticities are different from one another and when the fixed-cost responsibility is relatively homogenous among utilities. When these conditions are violated, as in the five anomalous cases shown in table 6-9, either the ad-hoc tax calculation must be improved or more traditional, jurisdictional-specific pricing policies are appropriate.

If interutility competition for industrial customers is a fact of life, the regulatory system is placed under great strain in each of the five anomalous cases, and ultimately it breaks down. This is the reason for the asterisks under the competition column in table 6-9 that correspond to each of the five anomalies. This means that the destructive competition for industrial load would lead to a complete death spiral and an inability to recover the revenue requirement for the utility with the greatest fixed-cost burden. In such circumstances, jurisdiction-specific policies are not adequate. The regulator must address the destructive competition either by cooperative agreements among the jurisdictions to end raids on one another's territory, or by some other type of super-jurisdictional action such as an improved tax policy capable of recovering all fixed costs. In the absence of some type of super-jurisdictional regulatory policy, one of the utilities could be driven into bankruptcy. The ultimate outcome is difficult to predict, of course. If it were to take the form of a merger, however, the differential of fixed costs among the utilities would be smoothed and a solution closer to the integrated model studied here would be feasible. Accordingly, private market action facilitated by appropriate merger policy is to some extent a substitute for the tax policy studied here. The tax policy tends to fail in circumstances when a merger would be appropriate.

In addition to these anomalous results regarding the tax policy, the remaining comparisons among the policy alternatives show a richer range of behavior under short-term cost conditions than the previous long-term analysis revealed. In table 6-9, fourteen direct comparisons between the competitive and maximize-sales policies can be made. In each case, the partial competition policy lies closer to the Ramsey solution. Hence, these two policies do not switch places along the frontier in the wide variety of conditions studied here. The competitive policy is always better than the maximize-sales strategy if price discrimination is considered as something to be avoided. This is consistent with the average distance analysis shown in table 6-2, except that this shows the comparison does not change with any of the specific economic conditions examined.

Fifteen direct comparisons between the competitive and fully allocated cost policies can be made in table 6-9. Of these, three are favorable to the competitive model, while the cost allocation procedure is closer to the Ramsey benchmark in the remaining twelve. As is the case in the long-term analysis, the fully allocated cost method tends to lie closer to the Ramsey ideal when the industrial demand elasticity is smaller and the industrial sector is larger. That is, interutility competition for industrial customers creates less disruption and less discrimination when the industrial sector is small and sensitive to price.

Fifty comparisons between the fully allocated cost method of setting prices and the maximum sales policy can be made in table 6-9. Of these, thirty-eight favor the fully allocated cost policy. The twelve cases where the maximize sales policy is better are those with very high fixed-cost obligations as well as high industrial demand elasticities and relatively small industrial sectors.

Overall, more kinds of policy switching occur in short-run cost conditions than when long-term circumstances are considered. In the short-run, the fully allocated cost policy can switch places with either the competitive policy or the maximize-sales policy. The competitive policy and the maximize-sales policy do not switch, however.

In addition, a small number of anomalous situations were found in which the tax policy was less efficient than either the cost allocation method or the maximize-sales policy, and thereby was forced off the frontier. In the long-run, by contrast, the fully allocated cost policy occasionally switches with the competitive policy. This is the only type of switching observed. Consequently, the short-term tends to be more chaotic than the longer-term.

On the one hand, this suggests that the policy milieu is more complicated and difficult to deal with when viewed, as all regulators must, from the short-run perspective of day-to-day decision making. It is nonetheless important, on the other hand, to realize that longer-term policy options are more orderly than they may appear when decisions must be made. From the examples studied here, both the maximize-sales and the fully allocated cost policies tend to be less attractive as options in the long run than in the short run. Nonetheless, the fully allocated cost policy, in particular, can be quite attractive in some long-run circumstances. It becomes less attractive to the extent that a utility has a small, price-elastic set of industrial customers, in which case a policy of partial competition is more efficient and less discriminatory.

Which of these two policies, fully allocated cost or partial competition, a decision maker prefers may depend upon his or her view about the long-term trends in economic conditions. Those who think that customer group elasticities are growing closer together and that fixed costs are growing in importance may see wisdom in using a fully allocated cost method for regulating public utility prices. Those who see elasticities of captive and noncaptive customers being driven apart while fixed-cost recovery becomes less important (perhaps because long-run incremental cost pricing coincidentally happens to recover the embedded-cost revenue requirement) may view partial competition as superior to traditional rate-making methods. Those who think the partial competition solution is better or that it will assert itself in any case must contend with the ultimate division of fixed-cost responsibility associated with the policy--captive customers pay most, if not all, of the fixed costs. The national tax policy studied here is intended to address the residual inefficiency due to this outcome.

The ebb and flow of economic circumstances surrounding public utility regulation has profound effects on the relative merits of one pricing policy versus another. Policies appropriate in one set of conditions may not work well in another. To some extent, the relative efficiency and degree of discrimination associated with alternative pricing policies are the dimensions along which the policies compete with one another. As circumstances change and the relative positions of the policies switch, there will be a tendency for policy makers to choose the alternative having a better set of characteristics. Such a process of winnowing out and sifting through policy alternatives can be ponderous and uncertain. Policy analysis such as this serves to focus attention on matters that assist the process.

CHAPTER 7

CONCLUSIONS

In many respects, the conclusions drawn from this report are likely to disappoint readers who are looking for a definitive distinction between due and undue price discrimination in public utility regulation. The answer given in this report is "It all depends!," which is not particularly satisfying to practitioners who must contend with potentially discriminatory pricing situations daily. The virtue of this study is that it delves deeply into the factors on which undue price discrimination does depend and strives to explain their importance in an understandable way.

Two major sources of law on price discrimination are public utility and antitrust laws. Public utility law contains explicit and implicit limits on price discrimination. The explicit limit is found in statutory provisions prohibiting undue or unreasonable price discrimination. The prohibition requires that like customers receiving like service are charged the same price, which is achieved by grouping customers into customer classes. The primary consideration in determining whether rate differentials among customer classes are unduly discriminatory was and remains the cost of service. However, value of service can be taken into consideration to determine whether rates are unduly discriminatory. Where cost-based rates will not allow a utility to recover its revenue requirement, some value-based pricing is permitted. State commissions apply this standard by prohibiting price discrimination that varies significantly from the cost of service unless it can be shown that the variation is in the public interest.

State commissions usually apply this public interest standard in a variety of ways. Some states allow price discounts to retain a customer who would otherwise leave the system. Other states allow price discrimination to serve such socio-economic goals as promoting growth in the local economy. Most of these states still require the favored customer to pay a price above variable costs, so that some contribution to capital is made. State commissions split on whether the prohibition against unduly discriminatory rates permits rate preferences that favor one class of customers while burdening another. Many commissions require utility stockholders to bear all or part of any revenue requirement deficiencies that result for discount rates. Because the public interest standard is applied in a variety of ways, it is difficult to summarize a general rule about the explicit prohibition against undue discrimination. It can be safely said, however, that most states would consider pricing below variable costs to be unduly discriminatory.

Public utility law's implicit limit on price discrimination is the requirement that rates be just and reasonable. For this to happen, rates must be set within the zone of reasonableness. To be within this zone, rates may not be less than the variable costs, but must be set lower than what would be considered excessive. Admittedly this is a vague standard.

Antitrust law's implicit limits on price discrimination are found in the Sherman Act's prohibition against predatory pricing. The Act would be violated only if a utility engaged in extreme price discrimination, where a customer was charged less than variable costs. Even so, a utility might have a state-action defense if there is an affirmatively stated, clearly articulated, and an actively supervised state policy allowing such pricing. Antitrust law's explicit limits on price discrimination are contained in the Robinson-Patman Act. The Act contains many defenses, so that a violation of the act is likely to occur only when prices are set below variable costs. Otherwise, a utility probably can avoid the provisions of the act or successfully make an affirmative defense.

The law provides general but important limits on price discrimination, within which commissions must use their judgment to distinguish duly from unduly discriminatory rates. Our purpose has been to provide some additional guidance from one economic perspective. A regulated pricing pattern becomes unduly discriminatory, in our opinion, when it results in a larger distortion to allocative economic efficiency than can be justified by the pricing advantage created by the policy itself. That is, price discrimination favors one group or another. Legitimate social reasons may exist for extending preferential treatment to a favored set of customers. The social equity objectives of the regulator or society at large are reflected in the price advantage given to such consumers. These kinds of equitable outcomes can be arranged in society, but not freely. They have a social price, in terms of the overall misallocation of the nation's resources induced as people respond to distorted prices.

A public utility regulator, in principle, is interested in knowing the economic efficiency sacrificed to achieve the social equity goals encompassed in a favorable pricing arrangement. The standard suggested in this report is that prices become unduly discriminatory when they create more social damage, measured as the loss of overall economic efficiency, than can be justified by the degree of preference the regulator is able to give one group or another, measured by the implied welfare weight of that group. This report has presented a way to weigh these efficiency and equity consequences of a pricing policy, and has used it to evaluate five pricing policies, some more discriminatory than others.

The core of the idea can be appreciated by concentrating on the word "allocation." Whether a resource allocation is efficient or not has to do with the way that prices signal people to consume goods and services. A misallocation or distortion occurs when the signals are wrong in some way. In order to judge, estimate, or evaluate the size of the misallocation requires that we consider how people respond to price signals. If they do not respond at all, demand is perfectly inelastic and no misallocation can result from any incorrect price signal, of course. Short of this, the use of our national resources can be distorted by wrong prices. To evaluate the allocative consequences of such prices, then, means that policy analysis should include demand elasticity information. Allocative distortion does not exist apart from the customer's response to price. A regulator must assess cost conditions, to be sure; however, this is not enough if undue price discrimination is to be understood. The price elasticity of demand is relevant also.

This report has shown how to combine information about the marginal cost and demand elasticity of each regulated market to evaluate the economic efficiency and the degree of equitable pricing preference incorporated in any set of prices. The key to the analysis is the development of a so-called welfare weight, one that is implied by the pricing arrangement itself, which measures the degree of preference. This indicator of policy equity is combined with a conventional measure of economic efficiency to evaluate the performance of five pricing rules under a variety of economic circumstances.[1] In each instance, the utility's overall revenue requirement constrains the pricing choices. Discount rates and incentive rates that are financed, in effect, by the utility's shareholders are not studied in this report.

An important conclusion of this study is that all market conditions, including fixed costs, marginal costs, and demand elasticities, matter as to whether an observed degree of price discrimination is due or undue. A price that is less than marginal cost in one set of circumstances (fixed costs are small, for example) can be less discriminatory in the sense of implying a smaller degree of pricing preference than a price above marginal cost in other conditions (with larger fixed costs). If the first price is unduly discriminatory, as most regulators, economists, and legal observers would conclude, then the second price is also unduly discriminatory, since it is more preferential in terms of the specific conditions that pertain to it.

This may be a disturbing conclusion to many, since it means, among other things, that marginal or variable cost--measures that are appropriate in antitrust analysis--are not sufficient standards by which undue price discrimination can be judged in public utility markets. Other market conditions are important also. In particular, the need to recover fixed costs distinguishes the private markets in antitrust analysis from public utility markets studied here.

Indeed, a stronger conclusion can be reached: no cost standard exists, by itself, that is capable of distinguishing due from undue discrimination. This includes a policy of embedded cost pricing. Fully allocated cost

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[1] The evaluation takes place in the region of substantive choices in figure 2-1. Prices in the backward-bending portion of the diagram are not studied. By initially beginning at a point in the backward-bending region, where participants in at least one market are paying a higher price than would be charged by an unregulated monopolist, no-loser price discrimination is possible. Regulators having the fortuitous opportunity of beginning at such a point should reduce the price that is above the monopoly limit, of course, and incidently make everyone else better off also. Regulators should not expect such opportunities to be commonplace, however. Once the regulator has positioned the markets within the substantive choice region, the analysis of this report becomes relevant.

pricing is shown by the examples used in this report to favor the inelastic users always. The degree of preference is sometimes very large, enough so as to be more preferential than prices below marginal cost in other circumstances, and presumably, therefore, unduly discriminatory. In other conditions cost allocation procedures are only moderately discriminatory. No general conclusion can be drawn, such as that fully allocated cost pricing always is or never is unduly discriminatory.

Some readers may find these conclusions disturbing, since they suggest that the cost-of-service information familiar to regulatory commissions is inadequate to differentiate due from undue price discrimination. Others may recognize the important role played by market conditions, identified in this report, as a reason why the distinction has eluded us heretofore.

To make further progress in recognizing undue price discrimination requires detailed empirical examinations of regulated markets and prices. These could be directed towards real-world situations, in which case the procedure described in the final section of chapter 4 might be a starting point. Alternatively, theoretical studies can be conducted for pricing policies in addition to those examined for this report. More research along both of these avenues is needed.

In the theoretical exercise conducted for this study, five pricing policies were investigated under a wide variety of market conditions. The efficiency and equity performance of most of the policies was mixed, at times good and at times poor. The policy whose objective it is to maximize sales or throughput, however, deserves special mention here. It is difficult to know precisely the weight of evidence needed to conclude that a pricing policy is unduly discriminatory, in general. Its performance must be very poor, indeed, to warrant such a conclusion.

In the authors' opinion, the maximize-sales strategy should be classified as unduly discriminatory in almost all circumstances. The degree of pricing difference between customers groups under this policy is essentially the same when fixed costs are high (and the unregulated monopolist's pricing choices are approached) as when fixed costs are low (and there is no need to discriminate at all). Furthermore, the degree of preference given implicitly to the elastic customer group is greater when the industrial price is above marginal cost (because fixed costs are large) than it is when the price is below marginal cost (because fixed costs are low). The overall economic inefficiency induced by such a policy is more or less the same at low levels of fixed cost (when inefficiency is easily avoided by prices that are close to marginal costs) as when fixed cost are high (and some resource misallocation is inevitable). The distortion to economic efficiency is large by any standard, usually in the order of 5 to 15 percent losses of overall social welfare--numbers significantly larger than those found in other applied welfare analyses of taxation, for example. In addition, the social price paid for the pricing preference embodied in the maximize-sales policy typically was higher (but not always) than that found for the other four pricing policies studied here.

These conclusions are essentially unchanged whether a short- or long-term cost perspective is adopted. As studied here, the maximize-sales policy resulted in industrial prices below marginal costs if fixed costs are relatively low. Our conclusions would be moderated at low levels of fixed cost if the policy were constrained so as not to allow such predatory-type pricing, but the fundamental character of the policy would remain the same--the degree of price discrimination is as large as possible, as large even as that which an unregulated monopolist would charge to markets that can be successfully segmented. This is strong and conclusive evidence. If such an outcome is not unduly discriminatory, certainly no other would be.

None of the remaining pricing policies seems as discriminatory as the maximize-sales strategy. The partial-competition framework, in which utilities compete for large industrial load, as well as the fully allocated cost pricing policy are both substantially less discriminatory and more efficient than the maximize-sales policy. The cost-allocation method consistently favors the inelastic customer groups, while the partial-competition model has the opposite effect of favoring the elastic users. When the inherent discrimination of each is placed on equal terms (that is, measured relative to the Ramsey standard) the result is more or less the same order of magnitude of implicit pricing preference.

This conclusion is borne out in a large number of hypothetical cases, but it is somewhat sensitive to the specific economic circumstances surrounding the comparison. Utilities with smaller, more elastic industrial sectors, for example, are likely to have more efficient and less discriminatory prices under a partial-competition policy than a traditional cost-allocation exercise. With the reversed circumstances, fully allocated cost pricing would be superior. In addition, the relative attractiveness of these two policies depends on the policymaker's perspective regarding cost conditions. In short-run cost circumstances, the traditional cost allocation method is usually better than the interutility-competition outcome. In the longer run, when more costs are variable, the partial-competition solution tends to yield a more efficient and less discriminatory outcome. Consequently, a policymaker's assessment of the relative merits of these two important pricing policies is likely to depend on both the current and future conditions surrounding the regulation of jurisdictional utilities.

A drawback to the partial-competition framework for public utility regulation is that captive customers tend to pay an inefficiently large fraction of society's aggregate fixed costs. If carried to the logical conclusion, captive customers would pay all such costs and industrial customers with the opportunity to switch jurisdictions would escape this cost responsibility. The previous comparison between the interutility competition model and the traditional cost-allocation procedure suggests that the partial-competition framework can be superior at times, particularly in the long run, even if the fixed cost burden is placed entirely on captive customers. This is as far as state regulators may wish to go.

To the extent that society wishes to address the remaining inefficiency and price discrimination associated with the distinction between captive and noncaptive customers in the partial competition paradigm, the scope of policy making must be expanded to a national level. This was the purpose of studying a national tax that cannot be avoided by the action of a customer switching suppliers or regulatory jurisdictions. The analysis shows that an imperfect, ad-hoc tax (not optimal) is capable of significantly reducing the aggregate economic inefficiency incurred because of the localized regulation. The intent of studying such a national tax was not to advocate its adoption, we repeat. It was, rather, to make the reader aware that national resource allocation is important. Although industrial discount programs may be unavoidable since there is no way to prevent some kinds of supplier switching, the programs ought not to be justified by the argument that they are economically efficient.

At the beginning of this report, a no-loser price discrimination test was suggested as a way of winnowing naive from sensible definitions of undue price discrimination. A regulator could apply the reasoning presented in this report and conclude that a pricing structure is unduly discriminatory if it implies a welfare weight for industrial customers larger than some number, say 1.5, or smaller than its reciprocal, 0.66 in this instance. Price structures with preferential weights between 0.66 and 1.5 would be acceptable by such a standard.

Two features of this standard are worth mentioning. First, it passes the "no-loser price discrimination" test of naivete. The only way to fail the test is for a pricing point to be located on the backward-bending portion of the pricing ellipse in figure 2-1. In that region, the industrial welfare weight is more extreme than that of an unregulated monopolist, which is zero. Accordingly, the weight there is negative, another indication of the pathological nature of this region. The regulator's standard to maintain prices so that any preference falls within some range around unity automatically indicates an interest only in sensible pricing points in the A to Z portion of the pricing ellipse. These are not dominated by any others, so no-loser price discrimination is not possible.

Second, such a standard would not automatically ensure that all prices are above their respective marginal costs. If this is judged to be a separate, important criterion, it can be imposed independently. This would tend to narrow the range of acceptable preferential treatment. The new range could be computed and treated as additional information by the regulator.

There is a substantial gray area in assessing price discrimination and determining whether it is acceptable or not. The law provides little guidance to regulators in recognizing undue discrimination, and yet they are charged with preventing it. This study suggested that we are unable to distinguish due from undue discrimination because the concept is inherently linked to all of the circumstances surrounding a market, not merely cost conditions. To make further progress appears to require an effort to understand and estimate the market's response to prices. This is disheartening because it would require testimony about demand elasticity in regulatory proceedings, an unlikely forum in which truth about such matters would be revealed. Nonetheless, progress in identifying undue price discrimination seems to depend on a rudimentary knowledge of demand elasticity. The alternative is to remain ignorant of such matters and rely on the marginal-cost standard used in antitrust matters. This may be attractive for many purposes. The question is whether the additional insights about discriminatory pricing revealed through a study of the price sensitivity of demand is worth the administrative cost of unraveling competing testimony from expert witnesses. This study should serve as an example of what can be learned from taking a step in this direction.

APPENDIX A

ANALYTICAL FORMULATION OF THE OPTIMAL PRICING MODELS

This appendix contains the analytical details of the optimal pricing models that form the basis of the empirical work described in the text. In most cases, there is little insight that can be gained from the formulas themselves, because they tend to be complicated. The object of this appendix is to set out the optimization problems that must be solved, show the first order conditions, and give the solution in matrix algebra terms. These equations, then, can be used directly in the programming language GAUSS, a microcomputer software package that manipulates matrix representations of equation systems.

Constrained Social Welfare Maximization

Demand is considered to be a linear function of price for all markets. The inverse demand functions for a system of markets can be written as

$$
\begin{aligned}
p_1 &= b_1 - a_{11}q_1 - a_{12}q_2 - a_{13}q_3 \\
p_2 &= b_2 - a_{21}q_1 - a_{22}q_2 - a_{23}q_3 \\
p_3 &= b_3 - a_{31}q_1 - a_{32}q_2 - a_{33}q_3
\end{aligned}
$$

where p_i is the price in market i, q_i is the quantity demanded in market i, b_i is the intercept term for market i, and a_{ij} is the slope of the inverse demand function. The possibility that a_{ij} (for i not equal to j) is not zero allows interaction between the markets so that goods can be substitutes or complements. The above system of linear demand relations can be conveniently expressed in matrix terms as

$$p = b - Aq \ ,$$

where p is a vector of prices, b is a vector of intercept terms, q is a vector of quantities, and A is a positive definite matrix of inverse demand curve slopes. If market demands are independent, the off-diagonal elements of A are zero. In the peak, off-peak models described in chapter 4, interrelated demands for the same customer group are represented by appropriate nonzero entries in the off-diagonal positions of A.

The cost structure of the utility is represented by the linear function

$$C = c'q + F ,$$

where C is total cost, c is a vector of marginal costs for each market, and F is fixed cost, a scaler.

Overall social welfare associated with the set of markets is measured as the sum of consumers' surplus over all markets plus the utility's profits. This can be written as

$$W = \oint_0^q p(h)dh - C(q)$$

where the line integral of the set of demand curves must be evaluated and the cost function subtracted. The line integral portion of this expression is easily shown to equal $b'q - (1/2)q'Aq$, so that social welfare is

$$W = (b - c)'q - (1/2)q'Aq - F . \qquad \text{(A-1)}$$

Profit regulation requires that revenue equal cost or

$$\pi = R - C = (b - c)'q - q'Aq - F = 0 . \qquad \text{(A-2)}$$

In addition, the regulator may be interested in restricting prices in some fashion, such as requiring that peak and off-peak prices be equal, or that the industrial price equal marginal cost plus a predetermined tax rate. All of these are linear restrictions and can be expressed as

$$R'p = t \text{ or } R'(b - Aq) = t \quad , \qquad \text{(A-3)}$$

where R is an n-by-r nonsquare matrix of restriction coefficients, with n equal to the number of markets and r equal to the number of pricing restrictions. The vector t is used to incorporate the idea of taxes into the pricing restrictions.

The problem of the regulator is to maximize social welfare, in equation (A-1), subject to the revenue requirement, in equation (A-2), and any pricing restrictions, in equation (A-3). The Lagrangian expression for this optimization problem is

$$L = (b - c)'q - (1/2)q'Aq - F + \lambda'[R'b - R'Aq - t] + \gamma[(b - c)'q - q'Aq - F] \quad ,$$

where λ is an r-by-1 vector of Lagrangian multipliers associated with pricing restrictions, and γ is the scaler Lagrangian multiplier associated with the revenue requirement. The first-order conditions for this problem require

$$\partial L/\partial q' = b - c - Aq - AR\lambda + \gamma[b - c - 2Aq] = 0 \;, \qquad \text{(A-4)}$$

$$\partial L/\partial \lambda' = R'b - R'Aq - t = 0 \;, \text{ and} \qquad \text{(A-5)}$$

$$\partial L/\partial \gamma = (b - c)'q - q'Aq - F = 0 \quad . \qquad \text{(A-6)}$$

The solution to these equations is first to find

$$\gamma = -(1/2) + (1/2)\sqrt{\frac{H_1}{H_1 - 4H_2}} \qquad \text{(A-7)}$$

where $H_1 = (b - c)'[A^{-1} - R(R'AR)^{-1}R'](b - c)$, and (A-8)

$H_2 = F + (R'b - t)'(R'AR)^{-1}(R'c - t)$. (A-9)

From this, we can determine

$$\lambda = -(R'AR)^{-1}[\gamma R'(b - c) + (1 + 2\gamma)(R'c - t)] \;, \qquad \text{(A-10)}$$

and $q = [(1 + \gamma)A^{-1}(b - c) - R\lambda]/(1 + 2\gamma)$. (A-11)

Knowing the optimal value for q, prices can be found as $p = b - Aq$. These equations are embodied in the GAUSS programs listed in appendix B. In these, the number of markets depends on the specific situation. Regardless, the solution is given by equations (A-7) to (A-11). Note that these are the relevant equations for the models of Ramsey pricing, interjurisdictional competition for industrial customers, and the national energy tax.

Note, also, that the solution to the welfare maximization problem is imaginary if the radical in equation (A-7) is negative. This corresponds to the maximum contribution to fixed costs that can be made by the entire set of markets. There is, then, a maximum amount of fixed costs that can be recovered from a specific set of markets. In the numerical analysis conducted for this study, it is important to know this limitation. The maximum level of fixed costs can be found by finding the F in equation (A-9) such that $H_1 - 4H_2 = 0$. The prices associated with this level are those that an unregulated monopolist would charge.

Constrained Sales Maximization

To find the set of prices that maximizes throughput or sales means to maximize the sum of quantities sold across all markets. Define the vector i to consist of all ones, so that vector multiplication by it results in the summation of another vector. Accordingly, the objective is to maximize $i'q$ subject to the revenue requirement in equation (A-2) and the pricing restrictions in equation (A-3). The Lagrangian expression for this problem is

$$L = i'q + \gamma[(b - c)'q - q'Aq - F] + \lambda'R'[b - Aq - t] \quad .$$

The first order conditions are

$$\partial L/\partial q' = i + \gamma[b - c - 2Aq] + AR\lambda = 0 \quad ,$$

plus the restrictions. The solution to this problem is first to find

$$\gamma = \sqrt{\frac{i'H_0 i}{H_1 - 4H_2}} \qquad \text{(A-12)}$$

where $H_0 = A^{-1} - R(R'AR)^{-1}R$. (A-13)

Next, find

$$\lambda = -(R'AR)^{-1}[\gamma R'(b - c) + 2\gamma(R'c - t) - R'i] \qquad \text{(A-14)}$$

and then

$$q = [A^{-1}(i + \gamma(b - c)) - R\lambda]/2\gamma \quad . \qquad \text{(A-15)}$$

Equations (A-12) to (A-15) are incorporated into the computer programs listed in the following appendix. Notice that the expression for determining the maximum level of fixed costs is the same in this problem as in the welfare maximization problem. There is no difference between a sales maximizing monopolist and an unregulated profit maximizing one if fixed costs are so high as to cause profits to be zero at the monopolistic pricing level.

Fully Allocated Cost Pricing

Basic Model

In the basic model with one market for each customer group, fully allocated cost pricing assigns the same amount of fixed cost per unit of output to all prices. That is

$$p_i = c_i + \frac{F}{\Sigma q_i}$$

In vector notation,

$$p = c + (F/\Sigma q_j)i \quad . \qquad \text{(A-16)}$$

To solve for the combination of p and q that satisfy (A-16) and the demand functions, substitute (A-16) into the demand equation to find

$$q = A^{-1}[b - p] \quad . \qquad \text{(A-17)}$$

A solution to these equations can be found from an initial point by finding the prices that satisfy the regulated supply function (A-16), substituting these into the demand functions to determine an updated level of demand, and iterating between equations (A-16) and (A-17) until the process converges.

It is important that the iteration process not exceed the monopoly pricing point for any single price. If it does, the result is a numerical instability that prevents convergence, which corresponds to the concept of a "death spiral".[1] The problem can be prevented by checking to see if any component of the updated price vector exceeds (1/2)(b + c), which is the unrestricted monopoly price vector. If it does, the offending price is appropriately limited, a calculation is made of the maximum contribution to fixed cost that can be extracted from the restricted market, and the remainder of the fixed cost is raised from the remaining markets.

Single-Price, Peak- and Off-Peak Market Model

In the case where each customer group participates in peak and off-peak markets, although the same price prevails in both, fully allocated cost pricing is somewhat more complicated. The multiple market provides a richer set of possible cost allocation schemes. The one chosen for this study is the peak-responsibility method, in which customers are assigned the same level of fixed cost per unit of peak demand. Letting the subscript p denote the peak period and o denote the off-peak period, we can specify for any particular customer group that where the summation is taken over the markets

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[1] For a discussion of the relation between the monopoly pricing points and the instability associated with a death spiral, see J. Stephen Henderson, "Price Discrimination Limits in Relation to the Death Spiral," The Energy Journal, July, 1986.

$$p(q_p + q_o) = c_p q_p + c_o q_o + \frac{q_p F}{\sum_p q_i} \qquad \text{(A-18)}$$

in the peak period. The single price for that particular customer group is found by dividing by the group's total demand. As before, a solution can be found by iterating between the regulated supply function, equation (A-18), and the demand equation, beginning with an initial guess and continuing until convergence.

Checking for price limits in order to prevent a death spiral in this model is also somewhat more complicated. The prices associated with the maximum level of fixed costs could be found, in theory, using the point at which the maximize-sales solution or the welfare maximum solution becomes imaginary. A computation difficulty is encountered, however, in practice. It is that as the imaginary solution is approached, γ increases without bound. So it is difficult to evaluate the limit of the restricted prices using equations such as (A-12) through (A-14). Instead, this limit can be found by solving an ancillary profit-maximization problem in which the monopolist adheres to the pricing restrictions, but no revenue requirement is imposed. There is no need to completely specify the problem, the solution to which is

$$p = (1/2)[I - AR(R'AR)^{-1}R'](b + c) \qquad \text{(A-19)}$$

where I is an appropriately sized identity matrix. These prices are checked in the iterative algorithm, and if they are exceeded, the appropriate limit is imposed and fixed costs are spread over the remaining markets as in the basic model.

Peak and Off-Peak Pricing Model

For the peak pricing model, fully allocated cost prices were developed using the average-and-excess method, in which half of the fixed costs are spread over the peak markets and the remaining half are spread over all markets. The idea is that sales during the peak period represent a maximum rate of demand for each group, and half of the capacity costs are assigned to prices that have the appearance of demand charges. The remaining fixed costs are spread over all energy sales, which include all markets in this analysis. Clearly, there are many alternative allocation schemes. Using the one chosen for this project, peak prices for each group are

$$p_i = c_i + (1 - \alpha)F/(\sum_p q_i) + \alpha F/(\Sigma q_i) \quad \text{(peak)} \qquad \text{(A-20)}$$

where the first summation is taken over peak markets and the second includes all markets. Similarly, off-peak prices are

$$p_i = c_i + \alpha F/(\Sigma q_i) \quad . \qquad \text{(off-peak)} \qquad \text{(A-21)}$$

The prices from these equations are combined with the demand functions to form an iterative process as before.

Suppressing a death spiral in this model is complicated by the interrelation between the markets for a particular group of consumers. That is, the existence of a cross-elasticity of demand changes the monopolistic price limits. The maximum contribution to fixed costs that can be extracted from the residential peak market, for example, depends on the price charged for residential off-peak demand. As part of the iterative process, these price limits must be recalculated at each step. An analytical expression for these can be found by solving an ancillary optimization problem that finds the unregulated monopolist's optimal price for each market, holding constant the prices in the remaining markets. Let the subscript 1 denote those markets whose prices are fixed, and that of 2 signify the price limit found through the optimization model. The limit price is given by

$$p_2 = (1/2)[b_2 + c_2 - A_{21}A_{11}^{-1}(b_1 + c_1 - 2p_1)] \qquad \text{(A-22)}$$

where the submatrices A_{21} and A_{11} are formed so as to isolate the market of interest. With six markets in all, for example, A_{11} is a five-by-five submatrix containing the "own" demand slopes. A_{21} is a one-by-five submatrix of A containing the "cross" market demand slopes between the market of interest and all remaining ones. The solution to equation (A-22) is found for each market. As before, the iterative process is checked for violations of these limit prices and the usual remedy applied if any are discovered.

Weighted Social Welfare Analysis

The measure of pricing preference extended to any customer group in this report is the social welfare weight that would have to be assigned to the group for the set of prices to represent the optimum of a weighted social welfare maximization problem. To infer such welfare weights requires that a weighted social welfare problem be formulated and the first-order conditions set out. The nature of the inference is more complicated if each customer group participates in multiple markets. To begin, we work through the simpler problem of a single market for each.

One Market per Customer Group

Suppose the regulator is interested in knowing the solution to a weighted social welfare maximization problem in which each customer group is assigned a welfare weight, w_i. If w_i is greater than unity, the group is given favorable pricing treatment, and vice versa. The measure of social welfare is the weighted sum of consumers' surpluses over all customer groups plus the utility's profits. The welfare function can be written as

$$W = \sum_i w_i [{}_0\int^{q_i} p_i(h)\ dh - p_i(q_i)q_i] + \sum_i p_i(q_i)q_i - C(q_1, \ldots, q_n)$$

and the Lagrangian for the constrained maximization problem is

$$L = W + \gamma[\sum_i p_i q_i - C(q)] \quad .$$

To find the first-order conditions, differentiate with respect to q_i,

$$\partial L/\partial q_i = w_i[p_i - p_i - q_i p_i'] + p_i + q_i p_i' - c_i + \gamma[p_i + q_i p_i' - c_i] = 0$$

This can be rearranged to yield

$$\frac{p_i - c_i}{p_i} = \frac{1}{\epsilon_i} \frac{(1 + \gamma - w_i)}{(1 + \gamma)} \quad .$$

If we define

$$E_i = \frac{p_i - c_i}{p_i}$$

and let the welfare weight of group one be unity, then the welfare weight for any other group is

$$w_i = \frac{1 + E_i \epsilon_i}{1 + E_1 \epsilon_1} \quad . \qquad \text{(A-23)}$$

The welfare weight implied by any proposed set of prices can be found using equation (A-23). The analyst must have information about the price elasticity of demand for each customer group and also the marginal cost of serving the group. In practice, these important economic parameters must be estimated and are likely to be the topic of some dispute. Nonetheless, these are the vital pieces of information needed to assess the degree of pricing preference under a proposed set of prices or an alternative regulatory pricing policy. Note that at the monopolist's pricing point,

$$E_i = - (1/\epsilon_i) \ ,$$

so that the implied welfare weight is zero, from equation (A-23). The formula is incorporated into the computer program for the basic pricing model, listed in the following appendix.

Multiple Markets for Each Customer Group

When a single customer or group of customers participates in several markets, it is not generally possible to derive a unique welfare weight that describes the preference extended to the group. This is because the customer is the entity towards whom preference is extended, and not the markets it trades in. A single customer has at most a single welfare weight. If it were assigned a particular value for that weight and the solution to the weighted social welfare problem were computed, the result would be a set of prices (for all of the goods that he buys) that together have the effect of giving the customer some preference with respect to other customers. In working the problem the other way around, a unique welfare weight cannot be inferred from an arbitrary set of prices.

There are a couple of ways to circumvent this difficulty. One way, suggested by the nature of the basic problem, would be to compute a welfare weight for each of the customer's markets separately. That is, the preference extended to the customer in the peak market might imply a welfare weight of 1.2, while that in the off-peak market might imply a weight of 1.36. These separately calculated weights could then be averaged, yielding a single number, 1.28 in this example. This seems to the authors to be a sensible procedure that should yield acceptable results. The idea is somewhat flawed, however, since information about preference in one market is not used in evaluating preference in another.

An alternative procedure is adopted in this report. It is to use ordinary least squares (OLS), or regression analysis, to compute the weights implied by the entire array of customer groups and markets. This is merely a sophisticated version of averaging that uses all of the information across all markets simultaneously. It is easy to show that the first-order conditions for the weighted social welfare problem require that the quantities sold to each customer group should obey the following:

$$q_i = \frac{(1 + \gamma)}{(2 + 2\gamma - w_i)} A_i^{-1}(b_i - c_i) \qquad \text{(A-24)}$$

where the subscript i on the matrix A (and the vectors b and c) denotes a submatrix containing the relevant information for all the markets in which group i participates. Define

$$h_i = A_i^{-1}(b_i - c_i)$$

and rewrite equation (A-24) as

$$2q_i - h_i = [w_i/(1 + \gamma)]\ q_i \quad . \tag{A-25}$$

For a single customer group i, equation (A-25) cannot be satisfied exactly, so append an additive error term, e_i, to the equation as

$$2q_i - h_i = [w_i/(1 + \gamma)]\ q_i + e_i \quad . \tag{A-26}$$

There are several equations, one for each market, in (A-26). To estimate the w_i for all customer groups, the equations for all groups can be "stacked" so that

$$2q - h = w'/(1 + \gamma)\ D\ .\!*\ q + e \quad , \tag{A-27}$$

where the operator .* denotes element-by-element multiplication, D is a "dummy variable" matrix of zeros and ones corresponding to the number of customer groups, and w is a vector of welfare weights that are to be estimated in the regression analysis. There is a column in the matrix D for each customer group. The column has a one in a particular position if the position corresponds to one that is occupied by the customer group in the stack; otherwise, the column has a zero at that position. The effect of the element-by-element multiplication, then, is to create a matrix whose columns have the quantities sold for group i in the positions corresponding those in the stack occupied by that group and zeros elsewhere. The outcome is a series of dummy-like variables upon which the regression analysis is performed. The estimated coefficient for the residential sector is taken to be an estimate of $w_R/(1 + \gamma)$. To find the imputed welfare weight for any other group in relation to the residential sector, divide the coefficient estimated using OLS for that group by the one estimated for the residential sector. In this way, the $(1 + \gamma)$ term, which is common to both estimates, cancels when finding the ratio of coefficients.

This procedure for imputing the welfare weights from multiple markets has some advantages over a simple averaging method. The R^2 goodness of fit statistic, which is commonly found in regression analysis, is a measure of how well the observed set of prices over all groups and markets conforms to the ideal of having been the result of some ancillary weighted social welfare maximization to begin with. That is, the statistic is an internal check on whether the entire exercise has validity within the meaning of weighted social welfare analysis. A very low R^2 would suggest that the weights that have been averaged are a poor representation of the idea that is being used to measure social fairness or equity in this report. For most policies and economic circumstances studied in this report R^2 is quite high, normally in excess of 90 percent, indicating that the inference procedure is valid. In some cases, discussed in the text, the procedure seems flawed, although not fatally so, in our opinion.

APPENDIX B

LISTING OF COMPUTER PROGRAMS FOR OPTIMAL PRICING POLICIES

This appendix contains a listing of the three computer programs used to calculate the pricing solutions for the three models discussed in the text--the basic model, the single price peak and off-peak model, and the peak-load pricing model. The programs are written in the language GAUSS Version 1.49B and were run on an IBM XT microcomputer. The programs are not user friendly, in that input data must be inserted into the main GAUSS program--there has been no attempt to fashion pull-down menus, for example.

THE BASIC PRICING MODEL

```
/* PRICE.V2 -- A PROGRAM TO FIND OPTIMAL PRICE VECTORS FOR
VARIOUS REGULATORY JURISDICTIONS, CUSTOMER GROUPS, AND MARKETS.
SEVERAL VERSIONS OF OPTIMAL REGULATORY POLICY ARE FOUND, SO AS
TO STUDY PRICE DISCRIMINATION.  */

/* Set up the initial data */
timebeg = hsec;
output file=price31.out on;
maxfc = 1;                 @ Maxfc = 0 -- full analysis, no max fc
                                   = 1 -- max fc, then full analysis
                                   = 2 -- max fc only @
nj = 3;                    @ No. of jurisdictions @
let ng = 3 3 3;            @ No. of groups in each jurisdiction @
nfcs = 4;                  @ Number of iterations for fc combos @
let fmats = 300 400 500 600;   @ Fixed cost in each juristiction @
nm = sumc(ng);             @ No. of total markets @
let csav =  5 4.5 3           @ Residential variable costs by juris. @
         5 4.5 3           @ Commercial variable costs by juris. @
         5 4.5 3;            @ Industrial variable costs by juris. @
let q0s = 60  40 90        @ Initial res. demand @
          60  40 90        @ Initial comm. demand @
          60  40 90;       @ Initial ind. demand @
let eiis = .25  .35 .7      @ Res elasticity at initial condition @
           .25  .35 .7      @ Comm elasticity at initial condition @
           .25  .35 .7;    @ Ind elasticity at initial condition@
xr = zeros(1,5); yr = zeros(1,4);
xs = zeros(1,5); ys = zeros(1,4);
xf = zeros(1,5); yf = zeros(1,4);
xc = zeros(1,5); yc = zeros(1,4);
xt = zeros(1,5); yt = zeros(1,4);
xo = zeros(1,5); yo = zeros(1,4);
let kp1 = 1.5 1 1 1.5 1 1 1.5 1 1;
let kp2 = 1 1 2 1 1 2 1 1 2;
let kp3 = 1 1 2 1 1 2 1 1 2;
k1 = 1;
do while k1 le 2;
    if k1 eq 2; eiis1 = eiis.*kp1;
    output file=price31.out off; output file=price32.out on;
    else; eiis1 = eiis; endif;
k2 = 1;
do while k2 le 2;
    if k2 eq 2; eiis1 = eiis1.*kp2; endif;
k3 = 1;
do while k3 le 2;
    if k3 eq 2; q0s1 = q0s.*kp3;
    else; q0s1 = q0s; endif;
k4 = 1;
do while k4 le 2;
    if k4 eq 2; add = 100;
    else; add = 50; endif;
    fmat = fmats~(fmats + add)~(fmats + 2*add);
```

```
maxfc = 1;
aii = 1.5*csav ./ (eiis1 .* q0s1);
c = csav;
beep = "\g"; screen on; format 6,0;
print " k1, k2, k3, and k4 are " k1 k2 k3 k4; screen off;
let mask1[1,8] = 1 0 1 1 1 1 1 1;
let mask2[1,8] = 1 0 1 1 1 1 1 1;
let fmt[8,3] = "*.*lg"   9 0 "*.*s" 8 8 "*.*lf" 9 2 "*.*lf" 9 2 "*.*lf" 9 2
  "*.*lf" 9 2 "*.*lf" 9 2 "*.*lf"   9 2;
z = zeros (nm,nm);
a = diagrv(z,aii);       @ Creates a diagonal aij matrix @
b = 1.5*c + a*q0s1;     @ Linear intercept deduced from initial cond @
let juri = 1 1 1 2 2 2 3 3 3;
let custi = "R" "C" "I" "R" "C" "I" "R" "C" "I";

/* ROUTINE TO PRINT OUT INITIAL CONDITIONS */
let varnames = "JURSDCTN" "GROUP" "ELASTCTY" "MAR COST" "QUANTITY";
indata = juri~custi~eiis1~c~q0s1;
print "                  MODELS OF GROUPS WITH A SINGLE MARKET";
print "                   INITIAL DATA USED IN THIS ANALYSIS";
print; format 8,8; print $varnames';
let mask3[1,5]= 1 0 1 1 1;
let fmt2[5,3] = "*.*lg" 8 0 "*.*s"  8 8 "*.*lg" 9 2
  "*.*lg" 9 2 "*.*lg" 9 2;
d = printfm(indata,mask3,fmt2);
maxfcu = 0;      @ Will collect unrestricted max fc by juri @
maxfcr = 0;      @ Will collect restricted max fc by juri @
if maxfc eq 0; maxfci = 0; else; maxfci = 1; endif;
if maxfc ge 1; nfc = 1; goto fcan; endif;
fcloop:
    maxfc = 0; nfc = nfcs;
    if maxfci eq 0; goto fcan; endif;
    maxfcu = trimr(maxfcu,1,0);
    maxfcr = trimr(maxfcr,1,0);
/* The following sets up a matrix of fixed cost values based
on the maximum rents that can be extracted from each market --
from 20 to 99 percent of the rent amount with restrictions and then
33 to 99 percent of the excess between the unrestricted and restricted
amounts.  Over ride this code by "commenting out", if desired.
  let per1[5,3] = .15 .20 .25
                  .35 .40 .45
                  .55 .60 .65
                  .75 .80 .85
                  .97 .98 .99;
  let per2[3,3] = .25 .33 .40
                  .60 .66 .75
                  .97 .98 .99;
    fmat1 = per1 .* maxfcr';
    fmat2 = per2 .*(maxfcu - maxfcr)' + maxfcr';
    fmat = fmat1|fmat2;  */      @ Place "comment out" here, if desired @
    fc1 = seqa(1,1,nfcs);
    fmat = submat(fmat,fc1,0);
```

```
print; print "              FIXED COST COMBINATIONS ANALYZED";
print "                        JURISDICTION";
print "            1              2              3";
format 15,0; print fmat; print;

/* LOOP FOR FIXED COST ANALYSIS */
fcan: fci = 1;
do while fci <= nfc;
fm = fmat[fci,.];            @ Picks off a row of fixed cost values @
if maxfc ge 1; goto jurprob; endif;
/* Find overall welfare maximum  */
aj = a; ajinv = inv(a); bj = b; cj = c; fj = sumc(fm');
gosub ramsey; pop qj;
cstrepm = zeros(1,8); jurrepm = zeros(1,3);
jj =juri; custcd = custi; j = 0;
gosub packer(cstrepm,jurrepm); pop jurrepm; pop cstrepm;
print; print "WELFARE MAXIMUM FOR INTEGRATED SYSTEM";
welmax = (bj - cj)'*qj - .5*qj'*aj*qj - fj;   @ Social welfare @
gosub report(cstrepm,jurrepm,xo,yo); pop yo; pop xo;
mar = bj - aj*qj - cj;                        @ Margin between p and c @
tax = minc(mar);                              @ Tax is smallest margin @
tax = round(tax*1000)/1000;
/* print "Computed tax is " tax; */
print;
format 8,3; print "The overall social welfare maximum is " welmax;
jurprob:
/* Set up for jurisdictional analysis */
cstrepr = zeros(1,8); jurrepr = zeros(1,3);
cstreps = zeros(1,8); jurreps = zeros(1,3);
cstrepf = zeros(1,8); jurrepf = zeros(1,3);
cstrepc = zeros(1,8); jurrepc = zeros(1,3);
cstrept = zeros(1,8); jurrept = zeros(1,3);

/* For each jurisdiction */
j = 1;
jlist = seqa(1,1,nm);
do while j <= 3;
    jcd = juri .eq j;   @ Creates a mask of 1's and 0's for jurisdiction j @
    jj = jcd .* juri;      @ Creates a list of J indices @
    jj = miss(jj,0);       @ Defines 0 to be missing or M @
    jj = packr(jj);        @ Removes missing indices @
    jcd = jcd .* jlist;    @ Creates a list of markets for this juri @
    jcd = miss(jcd,0);     @ Defines 0 to be missing or M @
    jl = packr(jcd);       @ Removes missing indices @
    aj = submat(a,jl,jl);  @ Extracts a submatrix for jurisdiction j @
    ajinv = inv(aj);
    bj = submat(b,jl,0);
    cj = submat(c,jl,0);
    fj = fm[1,j];
    fjsave = fj;
    custcd = submat(custi,jl,0);
    if maxfc ge 1; goto rl; endif;
```



```
    if maxfci eq 0; goto rl; endif;
        if fjsave ge maxfcu[j,1];          @ These are executed only if
                                             maxfc = 0 and maxfci = 1 @
        fj = maxfcu[j,1] - .000001;
        endif;
rl: gosub ramsey; pop qj;
    if maxfc eq 0; goto policyl;      @ Roadmap for max FC option @
        else; goto compxx; endif;
policyl:                              @ FC option roadmap @
    gosub packer(cstrepr,jurrepr); pop jurrepr; pop cstrepr;
    gosub sales;
    gosub packer(cstreps,jurreps); pop jurreps; pop cstreps;
    gosub fac;
    gosub packer(cstrepf,jurrepf); pop jurrepf; pop cstrepf;
compxx:
    gosub comp;                       @ FC option roadmap @
    if maxfc eq 0; goto policy2;
        else; goto next; endif;
policy2:                              @ FC option roadmap @
    gosub packer(cstrepc,jurrepc); pop jurrepc; pop cstrepc;
    fj = fm[1,j];
    gosub tax;
    gosub packer(cstrept,jurrept); pop jurrept; pop cstrept;
next:
    j = j+1;
endo;
if maxfc eq 0; goto full;             @ Fixed cost option roadmap @
    else; goto endprg; endif;
full:
print; print "JURISDICTIONAL RAMSEY PRICES ";
gosub report(cstrepr,jurrepr,xr,yr); pop yr; pop xr;
print; print "PRICES THAT MAXIMIZE SALES ";
gosub report(cstreps,jurreps,xs,ys); pop ys; pop xs;
print; print "FULLY ALLOCATED COST PRICES ";
gosub report(cstrepf,jurrepf,xf,yf); pop yf; pop xf;
print; print "PRICES THAT REFLECT INTERJURISDICTIONAL COMPETITION ";
gosub report(cstrepc,jurrepc,xc,yc); pop yc; pop xc;
print; format 6,4;
print "PRICES THAT RESULT FROM A NATIONAL ENERGY TAX OF " tax " CENTS";
gosub report(cstrept,jurrept,xt,yt); pop yt; pop xt;
fci = fci + 1; endo;
endprg: if maxfc eq 1; goto fcloop; endif;
k4 = k4 + 1; endo; k3 = k3 + 1; endo;
k2 = k2 + 1; endo; kl = kl + 1; endo;
xr = trimr(xr,1,0); yr = trimr(yr,1,0); xs = trimr(xs,1,0);
ys = trimr(ys,1,0); xf = trimr(xf,1,0); yf = trimr(yf,1,0);
xc = trimr(xc,1,0); yc = trimr(yc,1,0); xt = trimr(xt,1,0);
yt = trimr(yt,1,0);
save xrbsc3 = xr, yrbsc3 = yr, xsbsc3 = xs, ysbsc3 = ys, xfbsc3 = xf,
  yfbsc3 = yf, xcbsc3 = xc, ycbsc3 = yc, xtbsc3 = xt, ytbsc3 = yt;
screen on; timend = hsec; extime = (timend - timebeg)/6000;
format 7,2; print "Execution time was " extime " minutes"; beep; end;
```

```
/*  SUBROUTINE TO CALCULATE RAMSEY PRICES */

RAMSEY:
h1 = (bj - cj)'*ajinv*(bj - cj);  @ A scalar constant in a quadratic eq. @
fcdum = h1/4;
if maxfc eq 0; goto norml;
    else;
       maxfcu = maxfcu|fcdum; format 8,2;
       print "Maximum fixed cost for juri" j " is " fcdum;
    endif;
norml:
h2 = fj;                              @ A second scalar constant @
if fj > fcdum; goto esc; endif;        @ Testing for imaginary roots @
gam = -.5 + .5*sqrt(h1/(h1 - 4*h2));     @ Solution to quadratic equation @
qj = ((1 + gam)/(1 + 2*gam))*ajinv*(bj - cj);  @ Solution for quantities @
return(qj);
esc: print "Gamma is imaginary for jurisdiction" j;
return(h1/4);

/* SUBROUTINE TO PACK A REPORT MATRIX FOR EACH POLICY OPTION */
PACKER:
pop jrep; pop repmat;
pj = bj - aj*qj;                                          @ Prices @
vc = cj .* qj;                                            @ Var. cost @
revn = pj .* qj;                                          @ Revenue @
cont = revn - vc;                                         @ Cont. to FC @
tcont = sumc(cont);
wel = (bj - cj)'*qj - .5*qj'*aj*qj - tcont;               @ Social welfare @
cs = .5*(aj*qj).*qj;
gosub weights; pop el; pop wt;
repm = jj~custcd~pj~qj~el~cont~cs~wt;                      @ Report matrix @
trev = sumc(revn); tvc = sumc(vc); tcs = sumc(cs); tqj = sumc(qj);
let all = "ALL"; zz = 0;
totr = zz~all~zz~tqj~zz~tcont~tcs~zz;
repmat = repmat|repm|totr;
tc = tvc + tcont; fjper = 100*tcont/tc;
jrep1 = j~wel~fjper; jrep = jrep|jrep1;
push repmat,jrep; return;

/* SUBROUTINE TO REPORT RESULTS */
REPORT:
pop yd; pop xd; pop jrep; pop repmat;
jrep = trimr(jrep,1,0);
repmat = trimr(repmat,1,0);
format 8,8;
let colname = "JURSDCTN" "CUSTOMER" "PRICE" "QUANTITY"
 "ELASTCTY" "CONT FC" "SURPLUS" "WEIGHTS";
if j eq 0; mask = mask2;
    else; mask = mask1;
    endif;
print;
print $colname';
d = printfm(repmat,mask,fmt);
twel = sumc(jrep);
let dum1 = 0 1 0;
twel = twel'*dum1;
tcont = sumc(repmat[.,6])/2;
tfc = sumc(fmat[fci,.]');
if tcont lt .99*tfc;
    loss = 10000;
    else; loss = 100*(welmax - twel)/welmax;
    endif;
let colname2 = "JURSDCTN" "WELFARE" "FC %";
print; print $colname2';
format 8,3; print jrep;
print /rd "Total social welfare is " twel " and Welfare loss % is " loss;
isize = repmat[7,4]/repmat[8,4];
nr = rows(jrep);
if nr eq 1;
goto skipover; endif;
fcdif = jrep[3,3] - jrep[1,3];
row = repmat[7,5]~repmat[5,5]~jrep[2,3]~fcdif~isize;
xd = xd|row;
iwt = repmat[7,8];
if iwt gt 0; recip = 1/iwt; else; recip = 1000; endif;
if iwt lt 1; iwt = recip; endif;
if tcont lt .99*tfc; iwt = 1; endif;
iwtdif = repmat[11,8] - repmat[3,8];
row = loss~iwt~iwtdif~repmat[1,8]; yd = yd|row;
skipover: push xd, yd; return;

/* SUBROUTINE TO CALCULATE MAXIMUM SALES PRICES */
SALES:
nr = rows(aj); fj = fjsave;
i1 = ones(nr,1);
h3 = i1'*ajinv*i1;
if fj > h1/4; goto esc2; endif;
gam2 = sqrt(h3/(h1-4*fj));
qj = .5*ajinv*(bj - cj) + ajinv*i1/(2*gam2);
return;
esc2:
return;

/* SUBROUTINE TO CALCULATE FULLY ALLOCATED COST PRICES */
FAC:
let alpha = 1 1 1;  @ These are weights for customer groups @
qj0 = ajinv*(bj - cj); nr = rows(aj); i1 = ones(nr,1);
ok = i1; bad = .not ok; fj = fjsave;
pm = .5*(bj + cj);
qm = ajinv*(bj - pm); maxcont = (pm - cj).*qm;
totmax = maxcont'*i1;
if fj gt totmax; fj = totmax - .000001; endif;
iter = 1;
```

```
do while iter <= 40;
    qstar = alpha.*qj0; qoksum = qstar'*ok;
    fjrem = fj - maxcont'*bad;
    if qoksum gt 0; fjaddl = (fjrem/qoksum)*(qstar./qj0);
        else; fjaddl = 0; endif;
    pj = cj + fjaddl; pj = ok.*pj + bad.*pm;
    ok = pj .lt pm; bad = .not ok;
    qjl = ajinv*(bj - pj); diff = abs((qjl - qj0)./qj0);
    if diff < .0001; goto conv; endif;
    qj0 = qjl; iter = iter + 1;
endo;
print "FAC iterative algorithm did not converge,
jurisdiction " j " qjl is " qjl " and qj0 is " qj0; return;
conv: qj = qjl; return;

/* SUBROUTINE TO IMPUTE WELFARE WEIGHTS */
WEIGHTS:
format 6,3; ajj = diag(aj);
el = -pj./(ajj.*qj); pdev = (pj - cj)./pj;
wt = (1 + el.*pdev)/(1 + el[1,1]*pdev[1,1]); return(wt,el);

/* SUBROUTINE TO FIND THE EFFECTS OF INTERJURISDICTIONAL COMPETITION  */
COMP:
rj = custcd .eq "I"; tj = rj'*cj; fj = fjsave; gosub restrict; return;

/* SUBROUTINE TO FIND EFFECTS OF A NATIONAL ENERGY TAX */
TAX:
tj = tj + tax; fj = fjsave; gosub restrict; return;

/* SUBROUTINE TO FIND LINEAR AND QUADRATIC RESTRICTED RAMSEY PRICES */
RESTRICT:
rarinv = inv(rj'*aj*rj);
hl = (bj - cj)'*(ajinv - rj*rarinv*rj')*(bj - cj);
fjadd = (rj'*bj - tj)'*rarinv*(rj'*cj - tj);
h2 = fj + fjadd;
if maxfc eq 0; goto norm2;
    else; fcm = hl/4 - fjadd; maxfcr = maxfcr|fcm;
    format 8,2;
    print "Maximum FC with restrictions for juri" j " is " fcm;
    endif;
norm2:
if 4*h2 ge hl;
    h2 = hl/4 - .000001; fj = hl/4 -fjadd - .000001;
endif;
gam3 = -.5 + .5*sqrt(hl/(hl - 4*h2));
lam = -rarinv*(gam3*rj'*(bj - cj) + (1 + 2*gam3)*(rj'*cj - tj));
qj = ((1 + gam3)/(1 + 2*gam3))*ajinv*(bj - cj) - rj*lam/(1 + 2*gam3);
return;
esc3:
    format 2,0;
    print "Restricted price solution is imaginary, jurisdiction " j;
return;
```

THE SINGLE PRICE PEAK, OFF-PEAK PRICING MODEL

```
/* MPRICE.V2 -- A PROGRAM TO FIND OPTIMAL PRICE VECTORS FOR
VARIOUS REGULATORY JURISDICTIONS, CUSTOMER GROUPS, AND MARKETS.
THIS IS THE MULTI-MARKET VERSION THAT FINDS OPTIMAL SINGLE PRICES
FOR GROUPS THAT HAVE MULTIPLE USES (PEAK, OFF-PEAK) OF A PUBLIC
UTILITY SERVICE. SEVERAL VERSIONS OF OPTIMAL REGULATORY POLICY
ARE FOUND, SO AS TO STUDY PRICE DISCRIMINATION.  */

/* Set up the initial data */
timebeg = hsec;
output file=price33.tst on;
maxfc = 1;                @ Maxfc = 0 -- full analysis, no max fc
                                  = 1 -- max fc, then full analysis
                                  = 2 -- max fc only @
tax = 0;
nj = 3;                   @ No. of jurisdictions @
let ng = 6 6 6;           @ No. of groups in each jurisdiction @
nfcs = 4;                 @ Number of iterations for fc combos @
let fmats = 300 400 500 600;  @ Fixed cost in each juristiction @
nm = sumc(ng);            @ No. of total markets @
let csav = 6 3 5 2.5 4 2;     @ Variable costs vector @
let q0s = 20 40 15 25 30 60;  @ Initial demand vector @
let eijs[6,6] =
       .25 -.05   0  0  0  0    @ Res elasticity at initial condition @
      -.05 .15    0  0  0  0
        0   0   .35 -.05 0  0   @ Comm elasticity at initial condition @
        0   0   -.05 .25 0  0
        0   0     0  0 .6 -.1   @ Ind elasticity at initial condition @
        0   0     0  0 -.1 .5;
xr = zeros(1,5); yr = zeros(1,4);
xs = zeros(1,5); ys = zeros(1,4);
xf = zeros(1,5); yf = zeros(1,4);
xc = zeros(1,5); yc = zeros(1,4);
xt = zeros(1,5); yt = zeros(1,4);
xo = zeros(1,5); yo = zeros(1,4);
let kp1 = 1.5 1.5 1 1 1 1;
let kp2 = 1 1 1 1 2 2;
let kp3 = 1 1 1 1 2 2;
kk1 = 1;
do while kk1 le 2;
    if kk1 eq 2; eijs1 = eijs.*kp1;
    output file=price33.out off; output file=price34.out on;
    else; eijs1 = eijs; endif;
kk2 = 1;
do while kk2 le 2;
    if kk2 eq 2; eijs1 = eijs1.*kp2; endif;
kk3 = 1;
do while kk3 le 2;
    if kk3 eq 2; q0s1 = q0s.*kp3;
    else; q0s1 = q0s; endif;
```

```
kk4 = 1;
do while kk4 le 2;
    if kk4 eq 2; add = 100;
    else; add = 50; endif;
    fmat = fmats~(fmats + add)~(fmats + 2*add);
maxfc = 1;
i3 = eye(3); aijinv = (eijsl .* q0sl)./(1.5*csav');
aijinv = (aijinv + aijinv')/2; aj = inv(aijinv);
a = i3 .*. aj;         @Kronecker product to create block diagonal
                              18 x 18 matrix @
beep = "\g"; screen on; format 6, 0;
print " kl, k2, k3, k4 are " kkl kk2 kk3 kk4; screen off;
let mask[1,11] = 1 0 0 1 1 1 1 1 1 1 1;
let fmt[11,3] = "*.*lg"  4 0  "*.*s"   5 5 "*.*s"    4 4
 "*.*lf"   6 2  "*.*lf"   8 2  "*.*lf"   8 2 "*.*lf"   8 2
 "*.*lf"   8 2  "*.*lf"   8 2 "*.*lf"   8 2 "*.*lf"   8 3;
let juri = 1 1 1 1 1 1 2 2 2 2 2 2 3 3 3 3 3 3;
let custi = "R" "R" "C""C" "I" "I" "R" "R" "C" "C" "I" "I"
     "R" "R" "C" "C" "I" "I";
let mark = "P" "O" "P" "O" "P" "O" "P" "O" "P" "O" "P" "O"
     "P" "O" "P" "O" "P" "O";
/* ROUTINE TO PRINT OUT INITIAL CONDITIONS */
let varnames = "JURSDCTN" "GROUP" "PERIOD" "PK ELAS"
  "OFF ELAS" "MAR COST" "QUANTITY";
eij = eijsl; gosub eijrtn(6); pop eijrep;
il = ones(3,1); eijrep = il .*. eijrep;
c = il .*. csav; q0 = il .*. q0sl;
b = 1.5*c + a*q0;     @ Linear intercept deduced from initial cond @
indata = juri~custi~mark~eijrep~c~q0;
print "            MODELS OF SINGLE PRICE FOR PEAK, OFF-PEAK PERIODS";
print "                   INITIAL DATA USED IN THIS ANALYSIS";
print; format 8,8; print $varnames';
let mask3[1,7]= 1 0 0 1 1 1 1;
let fmt2[7,3] = "*.*lg" 8 0  "*.*s"  8 8  "*.*s"  8 8 "*.*lg" 9 2
 "*.*lg" 9 2  "*.*lg" 9 2  "*.*lg" 9 2;
d = printfm(indata,mask3,fmt2); print;
maxfcr = 0;        @ Will collect restricted max fc by juri @
if maxfc eq 0; maxfci = 0; else; maxfci = 1; endif;
if maxfc ge 1; nfc = 1; goto fcan; endif;
fcloop:
    maxfc = 0;
    nfc = nfcs;
    if maxfci eq 0; goto fcan; endif;
    fcl = seqa(1,1,nfcs);
    fmat = submat(fmat,fcl,0);
print;
print "              FIXED COST COMBINATIONS ANALYZED";
print "                          JURISDICTION";
print "               1                2              3";
format 15,0; print fmat; print;
```

```
/* LOOP FOR FIXED COST ANALYSIS */
fcan:
fci = 1;
do while fci <= nfc;
fm = fmat[fci,.];             @ Picks off a row of fixed cost values @
if maxfc ge 1; goto jurprob; endif;
/* Find overall welfare maximum  */
aj = a; ajinv = inv(a); bj = b; cj = c; fj = sumc(fm');
gosub resmat(custi,mark);
   pop rs; pop rj;
tj = zeros(9,1);
jcdl = juri .eq 1;jcd2 = juri .eq 2;jcd3 = juri .eq 3;
rj = jcdl .* rj~jcd2 .* rj~jcd3 .* rj;
rs = jcdl .* rs~jcd2 .* rs~jcd3 .* rs;
gosub restrict; pop qj;
cstrepm = zeros(1,11); jurrepm = zeros(1,3);
jj =juri; custcd = custi; markj = mark; nmj = nm; j = 0;
gosub packer(cstrepm,jurrepm); pop jurrepm; pop cstrepm;
print; print "WELFARE MAXIMUM FOR INTEGRATED SYSTEM";
welmax = (bj - cj)'*qj - .5*qj'*aj*qj - fj;   @ Social welfare @
gosub report(cstrepm,jurrepm,xo,yo); pop yo; pop xo;
jurprob:
/* Set up for jurisdictional analysis */
cstrepr = zeros(1,11); jurrepr = zeros(1,3);
cstreps = zeros(1,11); jurreps = zeros(1,3);
cstrepf = zeros(1,11); jurrepf = zeros(1,3);
cstrepc = zeros(1,11); jurrepc = zeros(1,3);
cstrept = zeros(1,11); jurrept = zeros(1,3);

/* For each jurisdiction */
j = 1;
jlist = seqa(1,1,nm); ps = 0;
do while j <= 3;
    gosub jurmat; pop rs; pop rj;
    gosub restrict; pop qj;
    if maxfc eq 0; goto policyl;      @ Roadmap for max FC option @
        else; goto compxx; endif;
policyl:                              @ FC option roadmap @
    gosub packer(cstrepr,jurrepr); pop jurrepr; pop cstrepr;
    gosub sales; gosub packer(cstreps,jurreps); pop jurreps; pop cstreps;
gosub fac; gosub packer(cstrepf,jurrepf); pop jurrepf; pop cstrepf; compxx:
gosub comp;                       @ FC option roadmap @
    if maxfc eq 0; goto policy2;
        else; goto next; endif;
policy2:                              @ FC option roadmap @
    gosub packer(cstrepc,jurrepc); pop jurrepc; pop cstrepc;
next: j = j + 1; endo;
if maxfc eq 0; goto full; else; goto endprg; endif;
full:
ind = cstrepm[.,2] .eq "I"; indpm = packr(miss(ind.*cstrepm[.,4],0));
ind = cstrepc[.,2] .eq "I"; indpc = packr(miss(ind.*cstrepc[.,4],0));
tax = minc(indpm - indpc); ps = trimr(ps,1,0);
```

```
j = 1; do while j <= 3;
    gosub taxrtn;
    gosub packer(cstrept,jurrept); pop jurrept; pop cstrept;
    j = j+1;
endo;
print;
print "JURISDICTIONAL SINGLE RAMSEY PRICES ";
gosub report(cstrepr,jurrepr,xr,yr); pop yr; pop xr;
print;
print "SINGLE PRICES THAT MAXIMIZE SALES ";
gosub report(cstreps,jurreps,xs,ys); pop ys; pop xs;
print;
print "FULLY ALLOCATED COST SINGLE PRICES ";
gosub report(cstrepf,jurrepf,xf,yf); pop yf; pop xf;
print;
print "SINGLE PRICES THAT REFLECT INTERJURISDICTIONAL COMPETITION ";
gosub report(cstrepc,jurrepc,xc,yc); pop yc; pop xc;
print; format 6,4;
print "SINGLE PRICES THAT RESULT FROM A NATIONAL ENERGY TAX OF " tax "
CENTS";
gosub report(cstrept,jurrept,xt,yt); pop yt; pop xt;
fci = fci + 1;
endo;
endprg:
    if maxfc eq 1; goto fcloop; endif;
kk4 = kk4 + 1; endo;
kk3 = kk3 + 1; endo;
kk2 = kk2 + 1; endo;
kk1 = kk1 + 1; endo;
xr = trimr(xr,1,0); yr = trimr(yr,1,0); xs = trimr(xs,1,0);
ys = trimr(ys,1,0); xf = trimr(xf,1,0); yf = trimr(yf,1,0);
xc = trimr(xc,1,0); yc = trimr(yc,1,0); xt = trimr(xt,1,0);
yt = trimr(yt,1,0);
save xrsngl3 = xr, yrsngl3 = yr, xssngl3 = xs, yssngl3 = ys, xfsngl3 = xf,
  yfsngl3 = yf, xcsngl3 = xc, ycsngl3 = yc, xtsngl3 = xt, ytsngl3 = yt;
screen on; timend = hsec; extime = (timend - timebeg)/6000;
format 7,2; print "Execution time was " extime " minutes"; beep; end;

/* SUBROUTINE TO EXTRACT JURISDICTION-SPECIFIC MATRICES */
JURMAT:
    jcd = juri .eq j;   @ Creates a mask of 1's and 0's for jurisdiction j @
    jj = packr(miss(jcd.*juri,0));      @ Packs nonmissing juri values@
    jl = packr(miss(jcd.*jlist,0));     @ Packs nonmissing list of market
                                          indices @
    markj = packr(miss(jcd.*mark,0));  @ Packs nonmissing peak indicators @
    aj = submat(a,jl,jl);        @ Extracts a submatrix for jurisdiction j @
    peak = markj .eq "P"; nmj = ng[j,1];
    ajinv = inv(aj); bj = submat(b,jl,0);
    cj = submat(c,jl,0); fj = fm[1,j];
    fjsave = fj; custcd = submat(custi,jl,0);
    gosub resmat(custcd,markj);
    pop rs; pop rj; tj = zeros(3,1); return(rj,rs);
```



```
/* SUBROUTINE TO PACK A REPORT MATRIX FOR EACH POLICY OPTION */
PACKER:
pop jrep; pop repmat;
pj = bj - aj*qj;                                              @ Prices @
vc = cj .* qj;                                                @ Var. cost @
revn = pj .* qj;                                              @ Revenue @
cont = revn - vc;                                             @ Cont. to FC @
tcont = sumc(cont);
wel = (bj - cj)'*qj - .5*qj'*aj*qj - tcont;                   @ Social welfare @
cs = .5*(aj*qj).*qj;  @ This attributes 1/2 of shared CS to each market @
gosub weights;
pop r2; pop el; pop varwt; pop wt;
repm = jj~custcd~markj~pj~qj~el~cont~cs~wt~varwt;          @ Report matrix @
trev = sumc(revn); tvc = sumc(vc); tcs = sumc(cs); tqj = sumc(qj);
let all = "ALL"; zz = 0;
totr = zz~all~zz~zz~tqj~zz~zz~tcont~tcs~zz~r2;
repmat = repmat|repm|totr;
tc = tvc + tcont; fjper = 100*tcont/tc;
jrepl = j~wel~fjper; jrep = jrep|jrepl;
push repmat,jrep;
return;

/* SUBROUTINE TO REPORT RESULTS */
REPORT:
pop yd; pop xd; pop jrep; pop repmat;
jrep = trimr(jrep,1,0); repmat = trimr(repmat,1,0);
let colname = "JUR" "GRP" "PER" "PRICE" "QNTY"
 "PK ELAS" "OFF EL" "CONT FC" "SURPLUS" "WEIGHTS" " SDWT-R2";
print; cmask = zeros(1,11);
let fmtc[11,3] = "*.*s" 4 4 "*.*s" 5 5 "*.*s" 4 4
 "*.*s" 6 6 "*.*s" 8 8 "*.*s" 8 8 "*.*s" 8 8
 "*.*s" 8 8 "*.*s" 8 8 "*.*s" 8 8 "*.*s" 8 8;
d1 = printfm(colname',cmask,fmtc); print;
d2 = printfm(repmat,mask,fmt);
twel = sumc(jrep);
let duml = 0 1 0; twel = twel'*duml;
tcont = sumc(repmat[.,8])/2; tfc = sumc(fmat[fci,.]');
if tcont lt .99*tfc;
/*    aj = a; ajinv = inv(a); bj = b; cj = c; fj = tcont;
    gosub resmat(custi,mark); pop rs; pop rj;
    rj = jcd1.*rj~jcd2.*rj~jcd3.*rj;
    tj = zeros(9,1); gosub restrict; pop qj;
    welmax2 = (bj - cj)'*qj - .5*qj'*aj*qj - tcont;
    else; welmax2 = welmax; */
    loss = 10000;
    else; loss = 100*(welmax - twel)/welmax;
    endif;
/* loss = 100*(welmax2 - twel)/welmax2; */
let colname2 = "JURSDCTN" "WELFARE" "FC %";
format 8,8; print; print $colname2';
format 8,3; print jrep;
```

```
print /rd "Total social welfare is " twel " and Welfare loss % is " loss;
isize = (repmat[12,5] + repmat[13,5])/repmat[14,5];
nr = rows(jrep); if nr eq 1; goto skipover; endif;
fcdif = jrep[3,3] - jrep[1,3];
row = repmat[12,6]~repmat[8,6]~jrep[2,3]~fcdif~isize;
xd = xd|row;
iwt = repmat[12,10];
if iwt gt 0; recip = 1/iwt; else; recip = 1000; endif;
if iwt lt 1; iwt = recip; endif;
if tcont lt .99*tfc; iwt = 1; endif;
iwtdif = repmat[19,10] - repmat[5,10];
row = loss~iwt~iwtdif~repmat[14,11]; yd = yd|row;
skipover: push xd, yd; return;

/* SUBROUTINE TO CALCULATE MAXIMUM SALES PRICES */
SALES:
nr = rows(aj); fj = fjsave;
il = ones(nr,1); rarinv = inv(rj'*aj*rj);
h0 = ajinv - rj*rarinv*rj'; h1 = (bj - cj)'*h0*(bj - cj);
fjadd = (rj'*bj - tj)'*rarinv*(rj'*cj - tj);
h2 = fjadd + fj;
if 4*h2 > h1; h2 =h1/4 -.000001;
    fj = h1/4 -fjadd -.000001; endif;
gam = sqrt(il'*h0*il/(h1-4*h2));
lam = -rarinv*(gam*rj'*(bj - cj) + 2*gam*(rj'*cj - tj) - rj'*il);
qj = .5*ajinv*(il/gam + bj - cj) - rj*lam/(2*gam);
return;

/* SUBROUTINE TO CALCULATE FULLY ALLOCATED COST PRICES */
FAC:
qj0 = ajinv*(bj - cj); nr = rows(aj); il = ones(nr,1);
ok = il; bad = .not ok; ii = eye(nr);
rarinv = inv(rj'*aj*rj);
pm = .5*(ii - aj*rj*rarinv*rj')*(bj + cj);
qm = ajinv*(bj - pm); maxcont = (pm - cj).*qm;
totmax = maxcont'*il; fj = fjsave;
if fj gt totmax; fj = totmax - .000001; endif;
iter = 1;
do while iter <= 40;
    fjok = (fj - maxcont'*bad)/(peak'*(qj0.*ok));
    pj = rs*((rs'*(cj.*qj0) + (rs.*peak)'*qj0*fjok)./(rs'*qj0));
    pj = ok.*pj + bad.*pm;
    ok = pj .lt pm; bad = .not ok;
    qj1 = ajinv*(bj - pj);
    diff = abs((qj1 - qj0)./qj0);
    if diff < .001; goto conv; endif;
    qj0 = qj1; iter = iter + 1;
endo;
print "FAC iterative algorithm did not converge,
jurisdiction " j " qj1 is " qj1 " and qj0 is " qj0;
return;
conv: qj = qj1; return;

/* SUBROUTINE TO IMPUTE WELFARE WEIGHTS */
WEIGHTS:
hj = ajinv*(bj - cj);
y = 2*qj - hj; x = qj .* rs;
wt = y/x; e = y - x*wt;
ssr = e'*e; sst = y'*y - (sumc(y)^2/rows(x));
R2 = (sst - ssr)/sst;
s2 = ssr/(rows(x) - 3); covarwt = s2*inv(x'*x);
if wt[1,1] ne 0; bench = wt[1,1];
    elseif wt[2,1] ne 0; bench = wt[2,1];
    elseif wt[3,1] ne 0; bench = wt[3,1];
    else; bench = 1; endif;
varwt = sqrt(diag(covarwt))/bench; wt = wt/bench;
wt = rs *wt; varwt = rs * varwt; eij = -(pj'.*ajinv)./qj;
gosub eijrtn(nmj); pop el;
push wt, varwt, el, R2;
return;

/* SUBROUTINE TO FIND THE EFFECTS OF INTERJURISDICTIONAL COMPETITION  */
COMP:
let jl = 5 6;
bjs = bj; cjs =cj; ajinvs =ajinv; fjs = fjsave;
ajs = aj; bi =submat(bj,jl,0); ci = submat(cj,jl,0);
aiinv = submat(ajinv,jl,jl);
let il = 1 1;
k1 = il'*aiinv*il; k2 = il'*aiinv*(bi + ci);
k3 = ci'*aiinv*bi; rad = sqrt(k2^2 - 4*k1*k3);
pi1 = (k2 + rad)/(2*k1); pi2 = (k2 - rad)/(2*k1);
ps = ps|pi2; qi = aiinv*(bi - pi2*il); let jl = 1 2 3 4;
bj = submat(bjs,jl,0); cj = submat(cjs,jl,0);
ajinv = submat(ajinvs,jl,jl);
aj = submat(ajs,jl,jl);
let jc = 1 2; rjs = rj;
rj = submat(rj,jl,jc); tj = zeros(2,1);
gosub restrict; pop qj;
qj = qj|qi;
bj = bjs; cj = cjs;
ajinv = ajinvs; rj = rjs;
aj = ajs; fj = fjsave;
return;

/* SUBROUTINE TO FIND EFFECTS OF A NATIONAL ENERGY TAX */
TAXRTN:
gosub jurmat; pop rs; pop rj;
let rji[6,2] = 0 0 0 0 0 0 0 0 1 0 0 1;
rj = rj[.,1 2]~rji;
pstax = ps[j,1] + tax;
let tj = 0 0 1 1; tj = tj*pstax;
gosub restrict; pop qj;
return;
```

```
/* SUBROUTINE TO FIND LINEAR AND QUADRATIC RESTRICTED RAMSEY PRICES */
RESTRICT:
rarinv = inv(rj'*aj*rj);
h1 = (bj - cj)'*(ajinv - rj*rarinv*rj')*(bj - cj);
fjadd = (rj'*bj - tj)'*rarinv*(rj'*cj - tj);
h2 = fj + fjadd;
if maxfc eq 0; goto norm2;
    else; fcm = h1/4 - fjadd; maxfcr = maxfcr|fcm;
    format 8,2;
    print "Maximum FC with restrictions for juri" j " is " fcm;
    endif;
norm2: if 4*h2 ge h1;
    h2 = h1/4 - .000001; fj = h1/4 -fjadd - .000001; endif;
gam3 = -.5 + .5*sqrt(h1/(h1 - 4*h2));
lam = -rarinv*(gam3*rj'*(bj - cj) + (1 + 2*gam3)*(rj'*cj - tj));
qj = ((1 + gam3)/(1 + 2*gam3))*ajinv*(bj - cj) - rj*lam/(1 + 2*gam3);
return(qj);
esc3: format 2,0;
    print "Restricted price solution is imaginary, jurisdiction " j;
return(qj);

/* SUBROUTINE TO CONSTRUCT A MATRIX OF RESTRICTIONS */
RESMAT:
pop marks; pop custs;
rjres = custs .eq "R"; rjcom = custs .eq "C";
rjind = custs .eq "I"; rs = rjres~rjcom~rjind;
opeak = marks .eq "O"; peak = marks .eq "P";
rj = rs .* (peak - opeak);
push rj, rs; return;

/* SUBROUTINE TO DISPLAY PEAK AND OFF-PEAK DEMAND ELASTICITIES */
EIJRTN:
pop nms;
jei = 1; eijrep = zeros(1,2); eij = miss(eij,0);
do while jei <= nms; row = packr(eij[.,jei]);
eijrep = eijrep|row'; jei = jei + 1;
endo;
eijrep = trimr(eijrep,1,0);
return(eijrep);
```


THE PEAK-LOAD PRICING MODEL

```
/* PKPRICE.V2 -- A PROGRAM TO FIND OPTIMAL PRICE VECTORS FOR
VARIOUS REGULATORY JURISDICTIONS, CUSTOMER GROUPS, AND MARKETS.
THIS IS THE MULTI-MARKET VERSION THAT FINDS OPTIMAL PEAK-LOAD
PRICES FOR GROUPS THAT HAVE MULTIPLE USES (PEAK, OFF-PEAK) OF
A PUBLIC UTILITY SERVICE. SEVERAL VERSIONS OF OPTIMAL
REGULATORY POLICY ARE FOUND, SO AS TO STUDY PRICE DISCRIMINATION. */

/* Set up the initial data */
timebeg = hsec;
output file=price35.out on;
maxfc = 1;                  @ Maxfc = 0 -- full analysis, no max fc
                                    = 1 -- max fc, then full analysis
                                    = 2 -- max fc only @
tax = 0;
nj = 3;                     @ No. of jurisdictions @
let ng = 6 6 6;             @ No. of groups in each jurisdiction @
nfcs = 4;                   @ Number of iterations for fc combos @
let fmats = 400 500 600 700;     @ Fixed cost in each juristiction @
nm = sumc(ng);              @ No. of total markets @
let csav =  6 3 5 2.5 4 2;       @ Variable costs vector @
let q0s = 20 40 15 25 30 60;  @ Initial demand vector @
let eijs[6,6] =
       .25 -.05   0  0  0  0    @ Res elasticity at initial condition @
      -.05  .15   0  0  0  0
        0   0   .35 -.05  0  0   @ Comm elasticity at initial condition @
        0   0   -.05  .25 0  0
        0   0     0  0 .6 -.1   @ Ind elasticity at initial condition @
        0   0     0  0 -.1 .5;
xr = zeros(1,5); yr = zeros(1,4);
xs = zeros(1,5); ys = zeros(1,4);
xf = zeros(1,5); yf = zeros(1,4);
xc = zeros(1,5); yc = zeros(1,4);
xt = zeros(1,5); yt = zeros(1,4);
xo = zeros(1,5); yo = zeros(1,4);
let kp1 = 1.5 1.5 1 1 1 1;
let kp2 = 1 1 1 1 2 2;
let kp3 = 1 1 1 1 2 2;
k1 = 1;
do while k1 le 2;
    if k1 eq 2; eijs1 = eijs.*kp1;
    output file=price35.out off; output file=price36.out on;
    else; eijs1 = eijs; endif;
k2 = 1;
do while k2 le 2;
    if k2 eq 2; eijs1 = eijs1.*kp2; endif;
k3 = 1;
do while k3 le 2;
    if k3 eq 2; q0s1 = q0s.*kp3;
    else; q0s1 = q0s; endif;
```

```
k4 = 1;
do while k4 le 2;
    if k4 eq 2; add = 100;
    else; add = 50; endif;
    fmat = fmats~(fmats + add)~(fmats + 2*add);
maxfc = 1;
i3 = eye(3); aijinv = (eijsl .* q0sl)./(1.5*csav');
aijinv = (aijinv + aijinv')/2; aj = inv(aijinv);
a = i3 .*. aj;         @Kronecker product to create block diagonal
                        18 x 18 matrix @
beep = "\g"; screen on; format 6, 0;
print " k1, k2, k3, k4 are " k1 k2 k3 k4; screen off;
let mask[1,11] = 1 0 0 1 1 1 1 1 1 1 1;
let fmt[11,3] = "*.*lg"  4 0  "*.*s"    5 5 "*.*s"    4 4
 "*.*lf"   6 2  "*.*lf"   8 2  "*.*lf"  8 2 "*.*lf"   8 2
 "*.*lf"   8 2  "*.*lf"   8 2 "*.*lf"   8 2 "*.*lf"   8 3;
let juri = 1 1 1 1 1 1 2 2 2 2 2 2 3 3 3 3 3 3;
let custi = "R" "R" "C""C" "I" "I" "R" "R" "C" "C" "I" "I"
     "R" "R" "C" "C" "I" "I";
let mark = "P" "O" "P" "O" "P" "O" "P" "O" "P" "O" "P" "O"
     "P" "O" "P" "O" "P" "O";
/* ROUTINE TO PRINT OUT INITIAL CONDITIONS */
let varnames = "JURSDCTN" "GROUP" "PERIOD" "PK ELAS"
  "OFF ELAS" "MAR COST" "QUANTITY";
eij = eijsl; gosub eijrtn(6); pop eijrep;
i1 = ones(3,1); eijrep = i1 .*. eijrep;
c = i1 .*. csav; q0 = i1 .*. q0sl;
b = 1.5*c + a*q0;    @ Linear intercept deduced from initial cond @
indata = juri~custi~mark~eijrep~c~q0;
print "                           PEAK-LOAD PRICING MODELS";
print "                        INITIAL DATA USED IN THIS ANALYSIS";
print; format 8,8; print $varnames';
let mask3[1,7]= 1 0 0 1 1 1 1;
let fmt2[7,3] = "*.*lg" 8 0  "*.*s"  8 8  "*.*s"  8 8 "*.*lg" 9 2
 "*.*lg" 9 2  "*.*lg" 9 2  "*.*lg" 9 2;
d = printfm(indata,mask3,fmt2); print;
maxfcr = 0;       @ Will collect restricted max fc by juri @
if maxfc eq 0; maxfci = 0; else; maxfci = 1; endif;
if maxfc ge 1; nfc = 1; goto fcan; endif;
fcloop:
    maxfc = 0; nfc = nfcs;
    if maxfci eq 0; goto fcan; endif;
/*    maxfcr = trimr(maxfcr,1,0);  */
    fcl = seqa(1,1,nfcs);
    fmat = submat(fmat,fcl,0);
print;
print "                FIXED COST COMBINATIONS ANALYZED";
print "                              JURISDICTION";
print "                1                 2                 3";
format 15,0;
print fmat; print;
```

```
/* LOOP FOR FIXED COST ANALYSIS */
fcan:
fci = 1;
do while fci <= nfc;
fm = fmat[fci,.];            @ Picks off a row of fixed cost values @
if maxfc ge 1; goto jurprob; endif;
/* Find overall welfare maximum  */
aj = a; ajinv = inv(a); bj = b; cj = c; fj = sumc(fm');
gosub resmat(custi,mark); pop rs; pop rj;
gosub ramsey; pop qj;
cstrepm = zeros(1,11); jurrepm = zeros(1,3);
jj =juri; custcd = custi; markj = mark; nmj = nm; j = 0;
gosub packer(cstrepm,jurrepm); pop jurrepm; pop cstrepm;
print; print "WELFARE MAXIMUM FOR INTEGRATED SYSTEM";
welmax = (bj - cj)'*qj - .5*qj'*aj*qj - fj;   @ Social welfare @
mar = bj - aj*qj - cj;                          @ Margin between p and c @
tax = minc(mar);                                @ Tax is smallest margin @
tax = round(tax*1000)/1000;
gosub report(cstrepm,jurrepm,xo,yo); pop yo; pop xo;
jurprob:
/* Set up for jurisdictional analysis */
cstrepr = zeros(1,11); jurrepr = zeros(1,3);
csteps = zeros(1,11); jurreps = zeros(1,3);
cstrepf = zeros(1,11); jurrepf = zeros(1,3);
cstrepc = zeros(1,11); jurrepc = zeros(1,3);
cstrept = zeros(1,11); jurrept = zeros(1,3);

/* For each jurisdiction */
j = 1;
jlist = seqa(1,1,nm); ps = 0;
do while j <= 3;
    gosub jurmat; pop rs; pop rj;
    gosub ramsey; pop qj;
    if maxfc eq 0; goto policy1;      @ Roadmap for max FC option @
        else; goto compxx; endif;
policy1:                              @ FC option roadmap @
    gosub packer(cstrepr,jurrepr); pop jurrepr; pop cstrepr;
    gosub sales; gosub packer(cstreps,jurreps); pop jurreps; pop cstreps;
gosub fac; gosub packer(cstrepf,jurrepf); pop jurrepf; pop cstrepf;
compxx: gosub comp;                          @ FC option roadmap @
    if maxfc eq 0; goto policy2;
        else; goto next; endif;
policy2:                              @ FC option roadmap @
    gosub packer(cstrepc,jurrepc); pop jurrepc; pop cstrepc;
    gosub taxrtn;
    gosub packer(cstrept,jurrept); pop jurrept; pop cstrept;
next: j = j+1;
endo;
if maxfc eq 0; goto full; else; goto endprg; endif;
full: print;
print "JURISDICTIONAL PEAK-LOAD RAMSEY PRICES ";
gosub report(cstrepr,jurrepr,xr,yr); pop yr; pop xr;
```

```
print;
print "PEAK-LOAD PRICES THAT MAXIMIZE SALES ";
gosub report(cstreps,jurreps,xs,ys); pop ys; pop xs;
print;
print "FULLY ALLOCATED COST PEAK-LOAD PRICES ";
gosub report(cstrepf,jurrepf,xf,yf); pop yf; pop xf;
print;
print "PEAK-LOAD PRICES THAT REFLECT INTERJURISDICTIONAL COMPETITION ";
gosub report(cstrepc,jurrepc,xc,yc); pop yc; pop xc;
print; format 6,4;
print "PEAK-LOAD PRICES FROM A NATIONAL ENERGY TAX OF " tax "CENTS";
gosub report(cstrept,jurrept,xt,yt); pop yt; pop xt;
fci = fci + 1;
endo;
endprg:
    if maxfc eq 1; goto fcloop; endif;
k4 = k4 + 1; endo;
k3 = k3 + 1; endo;
k2 = k2 + 1; endo;
k1 = k1 + 1; endo;
xr = trimr(xr,1,0); yr = trimr(yr,1,0); xs = trimr(xs,1,0);
ys = trimr(ys,1,0); xf = trimr(xf,1,0); yf = trimr(yf,1,0);
xc = trimr(xc,1,0); yc = trimr(yc,1,0); xt = trimr(xt,1,0);
yt = trimr(yt,1,0);
save xrpk3 = xr, yrpk3 = yr, xspk3 = xs, yspk3 = ys, xfpk3 = xf, yfpk3 = yf,
    xcpk3 = xc, ycpk3 = yc, xtpk3 = xt, ytpk3 = yt;
timend = hsec; extime = (timend - timebeg)/6000;
format 7,2; print "Execution time was " extime " minutes";
screen on; beep; end;

/* SUBROUTINE TO EXTRACT JURISDICTION-SPECIFIC MATRICES */
JURMAT:
    jcd = juri .eq j;   @ Creates a mask of 1's and 0's for jurisdiction j @
    jj = packr(miss(jcd.*juri,0));      @ Packs nonmissing juri values@
    j1 = packr(miss(jcd.*jlist,0));     @ Packs nonmissing list of market
                                          indices @
    markj = packr(miss(jcd.*mark,0));  @ Packs nonmissing peak indicators @
    aj = submat(a,j1,j1);       @ Extracts a submatrix for jurisdiction j @
    peak = markj .eq "P";
    opeak = markj .eq "O";
    nmj = ng[j,1];
    ajinv = inv(aj);
    bj = submat(b,j1,0);
    cj = submat(c,j1,0);
    fj = fm[1,j];
    fjsave = fj;
    custcd = submat(custi,j1,0);
    gosub resmat(custcd,markj);
    pop rs; pop rj;
    tj = zeros(3,1);
    return(rj,rs);
```



```
/* SUBROUTINE TO PACK A REPORT MATRIX FOR EACH POLICY OPTION */
PACKER:
pop jrep; pop repmat;
pj = bj - aj*qj;                                        @ Prices @
vc = cj .* qj;                                          @ Var. cost @
revn = pj .* qj;                                        @ Revenue @
cont = revn - vc;                                       @ Cont. to FC @
tcont = sumc(cont);
wel = (bj - cj)'*qj - .5*qj'*aj*qj - tcont;             @ Social welfare @
cs = .5*(aj*qj).*qj;  @ This attributes 1/2 of shared CS to each market @
gosub weights;
pop r2; pop el; pop varwt; pop wt;
repm = jj~custcd~markj~pj~qj~el~cont~cs~wt~varwt;      @ Report matrix @
trev = sumc(revn); tvc = sumc(vc); tcs = sumc(cs); tqj = sumc(qj);
let all = "ALL"; zz = 0;
totr = zz~all~zz~zz~tqj~zz~zz~tcont~tcs~zz~r2;
repmat = repmat|repm|totr;
tc = tvc + tcont; fjper = 100*tcont/tc;
jrep1 = j~wel~fjper; jrep = jrep|jrep1;
push repmat,jrep;
return;

/* SUBROUTINE TO REPORT RESULTS */
REPORT:
pop yd; pop xd; pop jrep; pop repmat;
jrep = trimr(jrep,1,0); repmat = trimr(repmat,1,0);
let colname = "JUR" "GRP" "PER" "PRICE" "QNTY"
 "PK ELAS" "OFF EL" "CONT FC" "SURPLUS" "WEIGHTS" " SDWT-R2";
print; cmask = zeros(1,11);
let fmtc[11,3] = "*.*s" 4 4 "*.*s" 5 5 "*.*s" 4 4
 "*.*s" 6 6 "*.*s" 8 8 "*.*s" 8 8 "*.*s" 8 8
 "*.*s" 8 8 "*.*s" 8 8 "*.*s" 8 8 "*.*s" 8 8;
d1 = printfm(colname',cmask,fmtc); print;
d2 = printfm(repmat,mask,fmt); twel = sumc(jrep);
let duml = 0 1 0; twel = twel'*duml;
tcont = sumc(repmat[.,8])/2; tfc = sumc(fmat[fci,.]');
if tcont lt .99*tfc;
    loss = 10000;
    else; loss = 100*(welmax - twel)/welmax; endif;
let colname2 = "JURSDCTN" "WELFARE" "FC %";
format 8,8; print; print $colname2'; format 8,3; print jrep;
print /rd "Total social welfare is " twel " and Welfare loss % is " loss;
isize = (repmat[12,5] + repmat[13,5])/repmat[14,5];
nr = rows(jrep); if nr eq 1; goto skipover; endif;
fcdif = jrep[3,3] - jrep[1,3];
row = repmat[12,6]~repmat[8,6]~jrep[2,3]~fcdif~isize;
xd = xd|row; iwt = repmat[12,10];
if iwt gt 0; recip = 1/iwt; else; recip = 1000; endif;
if iwt lt 1; iwt = recip; endif; if tcont lt .99*tfc; iwt = 1; endif;
iwtdif = repmat[19,10] - repmat[5,10];
row = loss~iwt~iwtdif~repmat[14,11]; yd = yd|row;
skipover: push xd, yd; return;
```

```
/*  SUBROUTINE TO CALCULATE RAMSEY PRICES */
RAMSEY:
h1 = (bj - cj)'*ajinv*(bj - cj);    @ A scalar constant in a quadratic eq. @
fcdum = h1/4;
if maxfc eq 0; goto norml;
    else;
       format 8,2;
       print "Maximum fixed cost for juri" j " is " fcdum;
    endif;
norml:
h2 = fj;                                @ A second scalar constant @
if fj > fcdum; h2 = fcdum - .000001; endif;  @ Testing for imaginary roots @
gam = -.5 + .5*sqrt(h1/(h1 - 4*h2));      @ Solution to quadratic equation @
qj = ((1 + gam)/(1 + 2*gam))*ajinv*(bj - cj);  @ Solution for quantities @
return(qj);
esc:
print "Gamma is imaginary for jurisdiction" j;
return(h1/4);

/* SUBROUTINE TO CALCULATE MAXIMUM SALES PRICES */
SALES:
fj = fjsave; nr = rows(aj); i1 = ones(nr,1); h3 = i1'*ajinv*i1;
if fj > h1/4; fj = h1/4 - .000001; endif;
gam2 = sqrt(h3/(h1-4*fj));
qj = .5*ajinv*(bj - cj) + ajinv*i1/(2*gam2);
return;

/* SUBROUTINE TO CALCULATE FULLY ALLOCATED COST PRICES */
FAC:
let rvrs[2,2] = 0 1
                1 0;
i3 = eye(3); rvrs = i3 .*. rvrs; @ 6 by 6 reversing matrix @
adiag = diag(aj); temp = rvrs*aj; across = diag(temp);
   /* Prior code is used to calculate the updated max price as the
   FAC procedure converges.  We need to find
   (b(j)+c(j)-2p(j))a(ij)/a(jj) for each p(i). */
qj0 = ajinv*(bj - cj); nr = rows(aj); i1 = ones(nr,1);
ok = i1; bad = .not ok;
pm = .5*(bj + cj);
qm = ajinv*(bj - pm); maxcont = (pm - cj).*qm;
totmax = maxcont'*i1; fj = fjsave;
if fj gt totmax; fj = totmax - .000001; endif;
iter = 1;
do while iter <= 40;
    qpok = peak'*(qj0.*ok); qok = qj0'*ok;
    fjrem = fj - maxcont'*bad; alpha = .5;
    if qpok gt 0; fjpok = .5*(fj - maxcont'*bad)/qpok;
        else; fjpok = 0; alpha = 1; endif;
    if qok gt 0; fjok = alpha*(fj - maxcont'*bad)/qok;
        else; fjok = 0; endif;
    pj = cj + fjpok*peak + fjok*i1;
    addvec = rvrs*((bj + cj -2*pj).*across./adiag);
    pm = .5*(bj + cj - addvec);
    pj = ok.*pj + bad.*pm;
    ok = pj .lt pm; bad = .not ok;
    qj1 = ajinv*(bj - pj);
    maxcont = (pm - cj).*(qm.*ok + qj1.*bad);  @ Interelated markets causes
                                   maxcont(i) to change with new q vector @
    diff = abs((qj1 - qj0)./qj0);
    if diff < .0001; goto conv; endif;
    qj0 = qj1; iter = iter + 1;
endo;
print "FAC iterative algorithm did not converge,
jurisdiction " j " qj1 is " qj1 " and qj0 is " qj0;
return;
conv: qj = qj1; return;

/* SUBROUTINE TO IMPUTE WELFARE WEIGHTS */
WEIGHTS:
hj = ajinv*(bj - cj);
y = 2*qj - hj; x = qj .* rs;
wt = y/x; e = y - x*wt;
ssr = e'*e; sst = y'*y - (sumc(y)^2/rows(x));
R2 = (sst - ssr)/sst;
s2 = ssr/(rows(x) - 3); covarwt = s2*inv(x'*x);
if wt[1,1] ne 0; bench = wt[1,1];
    elseif wt[2,1] ne 0; bench = wt[2,1];
    elseif wt[3,1] ne 0; bench = wt[3,1];
    else; bench = 1; endif;
varwt = sqrt(diag(covarwt))/bench;
wt = wt/bench;
wt = rs *wt;
varwt = rs * varwt;
eij = -(pj'.*ajinv)./qj;
gosub eijrtn(nmj); pop el;
push wt, varwt, el, R2;
return;

/* SUBROUTINE TO FIND THE EFFECTS OF INTERJURISDICTIONAL COMPETITION  */
COMP:
rjind = custcd .eq "I"; fj =fjsave;
rj = rjind.*peak~rjind.*opeak;
tj = packr(miss(rjind.*cj,0));
gosub restrict;
return;

/* SUBROUTINE TO FIND EFFECTS OF A NATIONAL ENERGY TAX */
TAXRTN:
tj = tj + tax;
fj = fjsave;
gosub restrict;
return;
```

```
/* SUBROUTINE TO FIND LINEAR AND QUADRATIC RESTRICTED RAMSEY PRICES */
RESTRICT:
rarinv = inv(rj'*aj*rj);
h1 = (bj - cj)'*(ajinv - rj*rarinv*rj')*(bj - cj);
fjadd = (rj'*bj - tj)'*rarinv*(rj'*cj - tj);
h2 = fj + fjadd;
if maxfc eq 0; goto norm2;
    else; fcm = h1/4 - fjadd; maxfcr = maxfcr|fcm;
    format 8,2;
    print "Maximum FC with restrictions for juri" j " is " fcm;
    endif;
norm2: if 4*h2 ge h1;
    h2 = h1/4 - .000001; fj = h1/4 - fjadd - .000001; endif;
gam3 = -.5 + .5*sqrt(h1/(h1 - 4*h2));
lam = -rarinv*(gam3*rj'*(bj - cj) + (1 + 2*gam3)*(rj'*cj - tj));
qj = ((1 + gam3)/(1 + 2*gam3))*ajinv*(bj - cj) - rj*lam/(1 + 2*gam3);
return;
esc3: format 2,0;
    print "Restricted price solution is imaginary, jurisdiction " j;
return;

/* SUBROUTINE TO CONSTRUCT A MATRIX OF RESTRICTIONS */
RESMAT:
pop marks; pop custs;
rjres = custs .eq "R"; rjcom = custs .eq "C";
rjind = custs .eq "I"; rs = rjres~rjcom~rjind;
opeak = marks .eq "O"; peak = marks .eq "P";
rj = rs .* (peak - opeak);
push rj, rs; return;

/* SUBROUTINE TO DISPLAY PEAK AND OFF-PEAK DEMAND ELASTICITIES */
EIJRTN:
pop nms;
jei = 1; eijrep = zeros(1,2); eij = miss(eij,0);
do while jei <= nms; row = packr(eij[.,jei]);
eijrep = eijrep|row'; jei = jei + 1;
endo;
eijrep = trimr(eijrep,1,0);
return(eijrep);
```

APPENDIX C

LISTING OF EFFICIENCY-EQUITY FRONTIERS: BASIC MODEL, LONG-RUN CONDITIONS

This Appendix contains a complete listing of the 64 efficiency-equity frontiers associated with the basic model under long-run cost conditions. This means that the marginal cost of serving residential and commercial customers is about 60 percent higher than the marginal cost of industrial service. In addition, fixed costs are relatively low. The exogenous variables are listed along with the resulting frontier for each of the 64 combinations of exogenous factors.

EXOGENOUS VARIABLES				
INDUST ELAS	RES ELAS	FIXED COST(%)	DIFF IN FC	SIZE OF IND MKT
0.60	0.25	10.68	9.82	0.50

	POLICY INDICATORS		POLICY RANKINGS		EFFICIENCY-
	WELFARE LOSS	IND WEIGHT	WELFARE LOSS	IND WEIGHT	EQUITY TRADEOFF
RAMSEY	0.01	1.00	1.00	5.00	1.00
SALES	8.73	2.12	5.00	1.00	8.13
FAC	0.06	1.05	4.00	2.00	1.10
COMP	0.04	1.04	3.00	3.00	0.63
TAX	0.02	1.00	2.00	4.00	133.77

AVERAGE TRADE-OFF WITH MAX SALES: 7.92 R2 = 1.00
AVERAGE TRADE-OFF EXCL MAX SALES: 0.78 R2 = 0.98

EXOGENOUS VARIABLES

INDUST ELAS	RES ELAS	FIXED COST(%)	DIFF IN FC	SIZE OF IND MKT
0.60	0.25	15.38	9.07	0.50

	POLICY INDICATORS WELFARE LOSS	IND WEIGHT	POLICY RANKINGS WELFARE LOSS	IND WEIGHT	EFFICIENCY-EQUITY TRADEOFF
RAMSEY	0.01	1.00	1.00	5.00	1.00
SALES	8.73	2.14	5.00	1.00	8.17
FAC	0.11	1.09	4.00	2.00	1.37
COMP	0.07	1.06	3.00	3.00	0.97
TAX	0.02	1.00	2.00	4.00	216.08

AVERAGE TRADE-OFF WITH MAX SALES: 7.82 R2 = 1.00
AVERAGE TRADE-OFF EXCL MAX SALES: 1.10 R2 = 0.99

EXOGENOUS VARIABLES

INDUST ELAS	RES ELAS	FIXED COST(%)	DIFF IN FC	SIZE OF IND MKT
0.60	0.25	19.74	8.41	0.50

	POLICY INDICATORS WELFARE LOSS	IND WEIGHT	POLICY RANKINGS WELFARE LOSS	IND WEIGHT	EFFICIENCY-EQUITY TRADEOFF
RAMSEY	0.02	1.00	1.00	5.00	1.00
SALES	8.72	2.16	5.00	1.00	8.24
FAC	0.21	1.13	4.00	2.00	1.61
COMP	0.13	1.08	3.00	3.00	1.34
TAX	0.02	1.00	2.00	4.00	66.55

AVERAGE TRADE-OFF WITH MAX SALES: 7.69 R2 = 0.99
AVERAGE TRADE-OFF EXCL MAX SALES: 1.44 R2 = 1.00

EXOGENOUS VARIABLES

INDUST ELAS	RES ELAS	FIXED COST(%)	DIFF IN FC	SIZE OF IND MKT
0.60	0.25	23.79	7.83	0.50

	POLICY INDICATORS WELFARE LOSS	IND WEIGHT	POLICY RANKINGS WELFARE LOSS	IND WEIGHT	EFFICIENCY-EQUITY TRADEOFF
RAMSEY	0.02	1.00	1.00	5.00	1.00
SALES	8.70	2.19	5.00	1.00	8.34
FAC	0.35	1.18	4.00	2.00	1.78
COMP	0.21	1.11	3.00	3.00	1.73
TAX	0.02	1.00	2.00	4.00	91.55

AVERAGE TRADE-OFF WITH MAX SALES: 7.54 R2 = 0.99
AVERAGE TRADE-OFF EXCL MAX SALES: 1.76 R2 = 1.00

EXOGENOUS VARIABLES

INDUST ELAS	RES ELAS	FIXED COST(%)	DIFF IN FC	SIZE OF IND MKT
0.60	0.25	15.38	18.22	0.50

	POLICY INDICATORS WELFARE LOSS	IND WEIGHT	POLICY RANKINGS WELFARE LOSS	IND WEIGHT	EFFICIENCY-EQUITY TRADEOFF
RAMSEY	0.06	1.00	1.00	5.00	1.00
SALES	8.76	2.14	5.00	1.00	8.14
FAC	0.19	1.09	4.00	2.00	1.83
COMP	0.14	1.06	3.00	3.00	1.05
TAX	0.08	1.00	2.00	4.00	875.87

AVERAGE TRADE-OFF WITH MAX SALES: 7.80 R2 = 1.00
AVERAGE TRADE-OFF EXCL MAX SALES: 1.36 R2 = 0.98

EXOGENOUS VARIABLES

INDUST ELAS	RES ELAS	FIXED COST(%)	DIFF IN FC	SIZE OF IND MKT
0.60	0.25	19.74	16.90	0.50

	POLICY INDICATORS WELFARE LOSS	IND WEIGHT	POLICY RANKINGS WELFARE LOSS	IND WEIGHT	EFFICIENCY-EQUITY TRADEOFF
RAMSEY	0.07	1.00	1.00	5.00	1.00
SALES	8.76	2.16	5.00	1.00	8.19
FAC	0.30	1.13	4.00	2.00	1.96
COMP	0.20	1.08	3.00	3.00	1.43
TAX	0.09	1.00	2.00	4.00	270.24

AVERAGE TRADE-OFF WITH MAX SALES: 7.67 R2 = 0.99
AVERAGE TRADE-OFF EXCL MAX SALES: 1.68 R2 = 0.99

EXOGENOUS VARIABLES

INDUST ELAS	RES ELAS	FIXED COST(%)	DIFF IN FC	SIZE OF IND MKT
0.60	0.25	23.79	15.74	0.50

	POLICY INDICATORS WELFARE LOSS	IND WEIGHT	POLICY RANKINGS WELFARE LOSS	IND WEIGHT	EFFICIENCY-EQUITY TRADEOFF
RAMSEY	0.08	1.00	1.00	5.00	1.00
SALES	8.75	2.19	5.00	1.00	8.27
FAC	0.46	1.18	4.00	2.00	2.10
COMP	0.30	1.11	3.00	3.00	1.85
TAX	0.10	1.00	2.00	4.00	372.55

AVERAGE TRADE-OFF WITH MAX SALES: 7.51 R2 = 0.99
AVERAGE TRADE-OFF EXCL MAX SALES: 2.00 R2 = 1.00

EXOGENOUS VARIABLES

INDUST ELAS	RES ELAS	FIXED COST(%)	DIFF IN FC	SIZE OF IND MKT
0.60	0.25	27.57	14.71	0.50

	POLICY INDICATORS		POLICY RANKINGS		EFFICIENCY-
	WELFARE LOSS	IND WEIGHT	WELFARE LOSS	IND WEIGHT	EQUITY TRADEOFF
RAMSEY	0.09	1.00	1.00	5.00	1.00
SALES	8.73	2.21	5.00	1.00	8.42
FAC	0.69	1.26	4.00	2.00	2.18
COMP	0.44	1.14	3.00	3.00	2.30
TAX	0.11	1.00	2.00	4.00	422.51

AVERAGE TRADE-OFF WITH MAX SALES: 7.32 R2 = 0.98
AVERAGE TRADE-OFF EXCL MAX SALES: 2.30 R2 = 1.00

EXOGENOUS VARIABLES

INDUST ELAS	RES ELAS	FIXED COST(%)	DIFF IN FC	SIZE OF IND MKT
0.60	0.25	7.89	7.44	0.67

	POLICY INDICATORS		POLICY RANKINGS		EFFICIENCY-
	WELFARE LOSS	IND WEIGHT	WELFARE LOSS	IND WEIGHT	EQUITY TRADEOFF
RAMSEY	0.01	1.00	1.00	5.00	1.00
SALES	7.89	2.25	5.00	1.00	6.47
FAC	0.03	1.03	3.00	3.00	0.60
COMP	0.04	1.04	4.00	2.00	2.80
TAX	0.01	1.00	2.00	4.00	49.71

AVERAGE TRADE-OFF WITH MAX SALES: 6.38 R2 = 1.00
AVERAGE TRADE-OFF EXCL MAX SALES: 0.80 R2 = 0.95

EXOGENOUS VARIABLES

INDUST ELAS	RES ELAS	FIXED COST(%)	DIFF IN FC	SIZE OF IND MKT
0.60	0.25	11.50	7.03	0.67

	POLICY INDICATORS		POLICY RANKINGS		EFFICIENCY-
	WELFARE LOSS	IND WEIGHT	WELFARE LOSS	IND WEIGHT	EQUITY TRADEOFF
RAMSEY	0.01	1.00	1.00	5.00	1.00
SALES	7.89	2.27	5.00	1.00	6.46
FAC	0.06	1.05	3.00	3.00	0.94
COMP	0.09	1.06	4.00	2.00	4.36
TAX	0.01	1.00	2.00	4.00	171.15

AVERAGE TRADE-OFF WITH MAX SALES: 6.32 R2 = 1.00
AVERAGE TRADE-OFF EXCL MAX SALES: 1.17 R2 = 0.96

EXOGENOUS VARIABLES

INDUST ELAS	RES ELAS	FIXED COST(%)	DIFF IN FC	SIZE OF IND MKT
0.60	0.25	14.92	6.65	0.67

	POLICY INDICATORS		POLICY RANKINGS		EFFICIENCY-
	WELFARE LOSS	IND WEIGHT	WELFARE LOSS	IND WEIGHT	EQUITY TRADEOFF
RAMSEY	0.01	1.00	1.00	5.00	1.00
SALES	7.88	2.28	5.00	1.00	6.43
FAC	0.11	1.07	3.00	3.00	1.28
COMP	0.15	1.08	4.00	2.00	6.51
TAX	0.02	1.00	2.00	4.00	141.88

AVERAGE TRADE-OFF WITH MAX SALES: 6.25 R2 = 1.00
AVERAGE TRADE-OFF EXCL MAX SALES: 1.56 R2 = 0.96

EXOGENOUS VARIABLES

INDUST ELAS	RES ELAS	FIXED COST(%)	DIFF IN FC	SIZE OF IND MKT
0.60	0.25	18.16	6.31	0.67

	POLICY INDICATORS		POLICY RANKINGS		EFFICIENCY-
	WELFARE LOSS	IND WEIGHT	WELFARE LOSS	IND WEIGHT	EQUITY TRADEOFF
RAMSEY	0.01	1.00	1.00	5.00	1.00
SALES	7.87	2.30	5.00	1.00	6.38
FAC	0.18	1.10	3.00	3.00	1.62
COMP	0.26	1.11	4.00	2.00	9.49
TAX	0.02	1.00	2.00	4.00	98.22

AVERAGE TRADE-OFF WITH MAX SALES: 6.16 R2 = 1.00
AVERAGE TRADE-OFF EXCL MAX SALES: 1.96 R2 = 0.96

EXOGENOUS VARIABLES

INDUST ELAS	RES ELAS	FIXED COST(%)	DIFF IN FC	SIZE OF IND MKT
0.60	0.25	11.50	14.09	0.67

	POLICY INDICATORS		POLICY RANKINGS		EFFICIENCY-
	WELFARE LOSS	IND WEIGHT	WELFARE LOSS	IND WEIGHT	EQUITY TRADEOFF
RAMSEY	0.04	1.00	1.00	5.00	1.00
SALES	7.91	2.27	5.00	1.00	6.43
FAC	0.11	1.05	3.00	3.00	0.92
COMP	0.14	1.06	4.00	2.00	5.71
TAX	0.06	1.00	2.00	4.00	691.92

AVERAGE TRADE-OFF WITH MAX SALES: 6.31 R2 = 1.00
AVERAGE TRADE-OFF EXCL MAX SALES: 1.37 R2 = 0.92

EXOGENOUS VARIABLES

INDUST ELAS	RES ELAS	FIXED COST(%)	DIFF IN FC	SIZE OF IND MKT
0.60	0.25	14.92	13.34	0.67

	POLICY INDICATORS WELFARE LOSS	IND WEIGHT	POLICY RANKINGS WELFARE LOSS	IND WEIGHT	EFFICIENCY-EQUITY TRADEOFF
RAMSEY	0.04	1.00	1.00	5.00	1.00
SALES	7.91	2.28	5.00	1.00	6.40
FAC	0.16	1.07	3.00	3.00	1.29
COMP	0.21	1.08	4.00	2.00	7.84
TAX	0.06	1.00	2.00	4.00	574.21

AVERAGE TRADE-OFF WITH MAX SALES: 6.23 R2 = 1.00
AVERAGE TRADE-OFF EXCL MAX SALES: 1.75 R2 = 0.94

EXOGENOUS VARIABLES

INDUST ELAS	RES ELAS	FIXED COST(%)	DIFF IN FC	SIZE OF IND MKT
0.60	0.25	18.16	12.66	0.67

	POLICY INDICATORS WELFARE LOSS	IND WEIGHT	POLICY RANKINGS WELFARE LOSS	IND WEIGHT	EFFICIENCY-EQUITY TRADEOFF
RAMSEY	0.05	1.00	1.00	5.00	1.00
SALES	7.90	2.30	5.00	1.00	6.34
FAC	0.24	1.10	3.00	3.00	1.65
COMP	0.32	1.11	4.00	2.00	11.00
TAX	0.07	1.00	2.00	4.00	398.02

AVERAGE TRADE-OFF WITH MAX SALES: 6.15 R2 = 1.00
AVERAGE TRADE-OFF EXCL MAX SALES: 2.15 R2 = 0.95

EXOGENOUS VARIABLES

INDUST ELAS	RES ELAS	FIXED COST(%)	DIFF IN FC	SIZE OF IND MKT
0.60	0.25	21.23	12.04	0.67

	POLICY INDICATORS WELFARE LOSS	IND WEIGHT	POLICY RANKINGS WELFARE LOSS	IND WEIGHT	EFFICIENCY-EQUITY TRADEOFF
RAMSEY	0.05	1.00	1.00	5.00	1.00
SALES	7.89	2.32	5.00	1.00	6.27
FAC	0.34	1.13	3.00	3.00	2.01
COMP	0.48	1.14	4.00	2.00	15.77
TAX	0.08	1.00	2.00	4.00	4919.03

AVERAGE TRADE-OFF WITH MAX SALES: 6.05 R2 = 1.00
AVERAGE TRADE-OFF EXCL MAX SALES: 2.57 R2 = 0.95

EXOGENOUS VARIABLES

INDUST ELAS	RES ELAS	FIXED COST(%)	DIFF IN FC	SIZE OF IND MKT
1.20	0.25	10.04	9.31	0.55

	POLICY INDICATORS WELFARE LOSS	IND WEIGHT	POLICY RANKINGS WELFARE LOSS	IND WEIGHT	EFFICIENCY-EQUITY TRADEOFF
RAMSEY	0.02	1.00	1.00	5.00	1.00
SALES	14.91	2.87	5.00	1.00	8.34
FAC	0.13	1.10	4.00	2.00	1.53
COMP	0.04	1.04	3.00	3.00	0.51
TAX	0.02	1.00	2.00	4.00	63.57

AVERAGE TRADE-OFF WITH MAX SALES: 8.07 R2 = 1.00
AVERAGE TRADE-OFF EXCL MAX SALES: 1.17 R2 = 0.96

EXOGENOUS VARIABLES

INDUST ELAS	RES ELAS	FIXED COST(%)	DIFF IN FC	SIZE OF IND MKT
1.20	0.25	14.52	8.67	0.55

	POLICY INDICATORS WELFARE LOSS	IND WEIGHT	POLICY RANKINGS WELFARE LOSS	IND WEIGHT	EFFICIENCY-EQUITY TRADEOFF
RAMSEY	0.02	1.00	1.00	5.00	1.00
SALES	14.89	2.91	5.00	1.00	8.42
FAC	0.29	1.18	4.00	2.00	1.89
COMP	0.07	1.06	3.00	3.00	0.79
TAX	0.02	1.00	2.00	4.00	49.16

AVERAGE TRADE-OFF WITH MAX SALES: 7.94 R2 = 1.00
AVERAGE TRADE-OFF EXCL MAX SALES: 1.55 R2 = 0.98

EXOGENOUS VARIABLES

INDUST ELAS	RES ELAS	FIXED COST(%)	DIFF IN FC	SIZE OF IND MKT
1.20	0.25	18.71	8.11	0.55

	POLICY INDICATORS WELFARE LOSS	IND WEIGHT	POLICY RANKINGS WELFARE LOSS	IND WEIGHT	EFFICIENCY-EQUITY TRADEOFF
RAMSEY	0.02	1.00	1.00	5.00	1.00
SALES	14.87	2.95	5.00	1.00	8.62
FAC	0.57	1.30	4.00	2.00	2.14
COMP	0.11	1.08	3.00	3.00	1.10
TAX	0.02	1.00	2.00	4.00	31.59

AVERAGE TRADE-OFF WITH MAX SALES: 7.77 R2 = 0.99
AVERAGE TRADE-OFF EXCL MAX SALES: 1.87 R2 = 0.99

EXOGENOUS VARIABLES

INDUST ELAS	RES ELAS	FIXED COST(%)	DIFF IN FC	SIZE OF IND MKT
1.20	0.25	22.63	7.61	0.55

	POLICY INDICATORS WELFARE LOSS	POLICY INDICATORS IND WEIGHT	POLICY RANKINGS WELFARE LOSS	POLICY RANKINGS IND WEIGHT	EFFICIENCY-EQUITY TRADEOFF	
RAMSEY	0.02	1.00	1.00	5.00	1.00	
SALES	14.83	3.00	5.00	1.00	9.15	
FAC	1.02	1.49	4.00	2.00	2.20	
COMP	0.18	1.11	3.00	3.00	1.43	
TAX	0.03	1.00	2.00	4.00	149.09	
AVERAGE TRADE-OFF WITH MAX SALES:				7.52	R2 =	0.97
AVERAGE TRADE-OFF EXCL MAX SALES:				2.05	R2 =	1.00

EXOGENOUS VARIABLES

INDUST ELAS	RES ELAS	FIXED COST(%)	DIFF IN FC	SIZE OF IND MKT
1.20	0.25	14.52	17.42	0.55

	POLICY INDICATORS WELFARE LOSS	POLICY INDICATORS IND WEIGHT	POLICY RANKINGS WELFARE LOSS	POLICY RANKINGS IND WEIGHT	EFFICIENCY-EQUITY TRADEOFF	
RAMSEY	0.07	1.00	1.00	5.00	1.00	
SALES	14.93	2.91	5.00	1.00	8.36	
FAC	0.45	1.18	4.00	2.00	2.61	
COMP	0.13	1.06	3.00	3.00	0.86	
TAX	0.08	1.00	2.00	4.00	199.48	
AVERAGE TRADE-OFF WITH MAX SALES:				7.92	R2 =	1.00
AVERAGE TRADE-OFF EXCL MAX SALES:				2.09	R2 =	0.97

EXOGENOUS VARIABLES

INDUST ELAS	RES ELAS	FIXED COST(%)	DIFF IN FC	SIZE OF IND MKT
1.20	0.25	18.71	16.28	0.55

	POLICY INDICATORS WELFARE LOSS	POLICY INDICATORS IND WEIGHT	POLICY RANKINGS WELFARE LOSS	POLICY RANKINGS IND WEIGHT	EFFICIENCY-EQUITY TRADEOFF	
RAMSEY	0.08	1.00	1.00	5.00	1.00	
SALES	14.91	2.95	5.00	1.00	8.52	
FAC	0.78	1.30	4.00	2.00	2.76	
COMP	0.19	1.08	3.00	3.00	1.18	
TAX	0.10	1.00	2.00	4.00	128.45	
AVERAGE TRADE-OFF WITH MAX SALES:				7.75	R2 =	0.99
AVERAGE TRADE-OFF EXCL MAX SALES:				2.37	R2 =	0.98

EXOGENOUS VARIABLES

INDUST ELAS	RES ELAS	FIXED COST(%)	DIFF IN FC	SIZE OF IND MKT
1.20	0.25	22.63	15.28	0.55

	POLICY INDICATORS WELFARE LOSS	POLICY INDICATORS IND WEIGHT	POLICY RANKINGS WELFARE LOSS	POLICY RANKINGS IND WEIGHT	EFFICIENCY-EQUITY TRADEOFF	
RAMSEY	0.09	1.00	1.00	5.00	1.00	
SALES	14.88	3.00	5.00	1.00	8.97	
FAC	1.34	1.49	4.00	2.00	2.78	
COMP	0.28	1.11	3.00	3.00	1.53	
TAX	0.11	1.00	2.00	4.00	607.83	
AVERAGE TRADE-OFF WITH MAX SALES:				7.50	R2 =	0.97
AVERAGE TRADE-OFF EXCL MAX SALES:				2.55	R2 =	0.99

EXOGENOUS VARIABLES

INDUST ELAS	RES ELAS	FIXED COST(%)	DIFF IN FC	SIZE OF IND MKT
1.20	0.25	26.32	14.40	0.55

	POLICY INDICATORS WELFARE LOSS	POLICY INDICATORS IND WEIGHT	POLICY RANKINGS WELFARE LOSS	POLICY RANKINGS IND WEIGHT	EFFICIENCY-EQUITY TRADEOFF	
RAMSEY	0.11	1.00	1.00	5.00	1.00	
SALES	14.84	3.05	5.00	1.00	10.91	
FAC	2.17	1.89	4.00	2.00	2.36	
COMP	0.40	1.14	3.00	3.00	1.92	
TAX	0.13	1.00	2.00	4.00	10000.00	
AVERAGE TRADE-OFF WITH MAX SALES:				6.90	R2 =	0.91
AVERAGE TRADE-OFF EXCL MAX SALES:				2.31	R2 =	1.00

EXOGENOUS VARIABLES

INDUST ELAS	RES ELAS	FIXED COST(%)	DIFF IN FC	SIZE OF IND MKT
1.20	0.25	7.21	6.86	0.71

	POLICY INDICATORS WELFARE LOSS	POLICY INDICATORS IND WEIGHT	POLICY RANKINGS WELFARE LOSS	POLICY RANKINGS IND WEIGHT	EFFICIENCY-EQUITY TRADEOFF	
RAMSEY	0.01	1.00	1.00	5.00	1.00	
SALES	13.32	3.17	5.00	1.00	6.26	
FAC	0.08	1.06	4.00	2.00	1.67	
COMP	0.04	1.04	3.00	3.00	0.74	
TAX	0.02	1.00	2.00	4.00	70.05	
AVERAGE TRADE-OFF WITH MAX SALES:				6.18	R2 =	1.00
AVERAGE TRADE-OFF EXCL MAX SALES:				1.07	R2 =	0.96

EXOGENOUS VARIABLES

INDUST ELAS	RES ELAS	FIXED COST(%)	DIFF IN FC	SIZE OF IND MKT
1.20	0.25	10.56	6.55	0.71

	POLICY INDICATORS WELFARE LOSS	POLICY INDICATORS IND WEIGHT	POLICY RANKINGS WELFARE LOSS	POLICY RANKINGS IND WEIGHT	EFFICIENCY-EQUITY TRADEOFF
RAMSEY	0.01	1.00	1.00	5.00	1.00
SALES	13.31	3.21	5.00	1.00	6.23
FAC	0.17	1.10	4.00	2.00	2.14
COMP	0.08	1.06	3.00	3.00	1.13
TAX	0.02	1.00	2.00	4.00	96.36

AVERAGE TRADE-OFF WITH MAX SALES: 6.09 R2 = 1.00
AVERAGE TRADE-OFF EXCL MAX SALES: 1.51 R2 = 0.98

EXOGENOUS VARIABLES

INDUST ELAS	RES ELAS	FIXED COST(%)	DIFF IN FC	SIZE OF IND MKT
1.20	0.25	13.76	6.26	0.71

	POLICY INDICATORS WELFARE LOSS	POLICY INDICATORS IND WEIGHT	POLICY RANKINGS WELFARE LOSS	POLICY RANKINGS IND WEIGHT	EFFICIENCY-EQUITY TRADEOFF
RAMSEY	0.01	1.00	1.00	5.00	1.00
SALES	13.30	3.25	5.00	1.00	6.18
FAC	0.31	1.15	4.00	2.00	2.56
COMP	0.14	1.08	3.00	3.00	1.55
TAX	0.02	1.00	2.00	4.00	33.18

AVERAGE TRADE-OFF WITH MAX SALES: 6.00 R2 = 1.00
AVERAGE TRADE-OFF EXCL MAX SALES: 1.96 R2 = 0.98

EXOGENOUS VARIABLES

INDUST ELAS	RES ELAS	FIXED COST(%)	DIFF IN FC	SIZE OF IND MKT
1.20	0.25	16.82	5.99	0.71

	POLICY INDICATORS WELFARE LOSS	POLICY INDICATORS IND WEIGHT	POLICY RANKINGS WELFARE LOSS	POLICY RANKINGS IND WEIGHT	EFFICIENCY-EQUITY TRADEOFF
RAMSEY	0.02	1.00	1.00	5.00	1.00
SALES	13.27	3.29	5.00	1.00	6.13
FAC	0.53	1.21	4.00	2.00	2.90
COMP	0.24	1.11	3.00	3.00	2.00
TAX	0.02	1.00	2.00	4.00	94.57

AVERAGE TRADE-OFF WITH MAX SALES: 5.89 R2 = 1.00
AVERAGE TRADE-OFF EXCL MAX SALES: 2.40 R2 = 0.99

EXOGENOUS VARIABLES

INDUST ELAS	RES ELAS	FIXED COST(%)	DIFF IN FC	SIZE OF IND MKT
1.20	0.25	10.56	13.12	0.71

	POLICY INDICATORS WELFARE LOSS	POLICY INDICATORS IND WEIGHT	POLICY RANKINGS WELFARE LOSS	POLICY RANKINGS IND WEIGHT	EFFICIENCY-EQUITY TRADEOFF
RAMSEY	0.05	1.00	1.00	5.00	1.00
SALES	13.34	3.21	5.00	1.00	6.20
FAC	0.25	1.10	4.00	2.00	2.87
COMP	0.14	1.06	3.00	3.00	1.23
TAX	0.07	1.00	2.00	4.00	390.09

AVERAGE TRADE-OFF WITH MAX SALES: 6.08 R2 = 1.00
AVERAGE TRADE-OFF EXCL MAX SALES: 1.91 R2 = 0.96

EXOGENOUS VARIABLES

INDUST ELAS	RES ELAS	FIXED COST(%)	DIFF IN FC	SIZE OF IND MKT
1.20	0.25	13.76	12.54	0.71

	POLICY INDICATORS WELFARE LOSS	POLICY INDICATORS IND WEIGHT	POLICY RANKINGS WELFARE LOSS	POLICY RANKINGS IND WEIGHT	EFFICIENCY-EQUITY TRADEOFF
RAMSEY	0.05	1.00	1.00	5.00	1.00
SALES	13.33	3.25	5.00	1.00	6.14
FAC	0.42	1.15	4.00	2.00	3.19
COMP	0.21	1.08	3.00	3.00	1.66
TAX	0.08	1.00	2.00	4.00	134.51

AVERAGE TRADE-OFF WITH MAX SALES: 5.98 R2 = 1.00
AVERAGE TRADE-OFF EXCL MAX SALES: 2.33 R2 = 0.98

EXOGENOUS VARIABLES

INDUST ELAS	RES ELAS	FIXED COST(%)	DIFF IN FC	SIZE OF IND MKT
1.20	0.25	16.82	12.01	0.71

	POLICY INDICATORS WELFARE LOSS	POLICY INDICATORS IND WEIGHT	POLICY RANKINGS WELFARE LOSS	POLICY RANKINGS IND WEIGHT	EFFICIENCY-EQUITY TRADEOFF
RAMSEY	0.06	1.00	1.00	5.00	1.00
SALES	13.31	3.29	5.00	1.00	6.08
FAC	0.67	1.21	4.00	2.00	3.48
COMP	0.32	1.11	3.00	3.00	2.13
TAX	0.09	1.00	2.00	4.00	384.04

AVERAGE TRADE-OFF WITH MAX SALES: 5.88 R2 = 1.00
AVERAGE TRADE-OFF EXCL MAX SALES: 2.77 R2 = 0.99

EXOGENOUS VARIABLES

INDUST ELAS	RES ELAS	FIXED COST(%)	DIFF IN FC	SIZE OF IND MKT
1.20	0.25	19.75	11.53	0.71

	POLICY INDICATORS WELFARE LOSS	IND WEIGHT	POLICY RANKINGS WELFARE LOSS	IND WEIGHT	EFFICIENCY-EQUITY TRADEOFF
RAMSEY	0.07	1.00	1.00	5.00	1.00
SALES	13.28	3.33	5.00	1.00	6.02
FAC	1.04	1.30	4.00	2.00	3.70
COMP	0.47	1.14	3.00	3.00	2.63
TAX	0.10	1.00	2.00	4.00	1623.21

AVERAGE TRADE-OFF WITH MAX SALES: 5.75 R2 = 1.00
AVERAGE TRADE-OFF EXCL MAX SALES: 3.20 R2 = 0.99

EXOGENOUS VARIABLES

INDUST ELAS	RES ELAS	FIXED COST(%)	DIFF IN FC	SIZE OF IND MKT
0.60	0.38	10.58	9.79	0.50

	POLICY INDICATORS WELFARE LOSS	IND WEIGHT	POLICY RANKINGS WELFARE LOSS	IND WEIGHT	EFFICIENCY-EQUITY TRADEOFF
RAMSEY	0.02	1.00	1.00	5.00	1.00
SALES	5.94	1.71	5.00	1.00	8.78
FAC	0.06	1.04	3.00	3.00	0.71
COMP	0.07	1.05	4.00	2.00	5.21
TAX	0.03	1.00	2.00	4.00	93.03

AVERAGE TRADE-OFF WITH MAX SALES: 8.48 R2 = 1.00
AVERAGE TRADE-OFF EXCL MAX SALES: 0.88 R2 = 0.97

EXOGENOUS VARIABLES

INDUST ELAS	RES ELAS	FIXED COST(%)	DIFF IN FC	SIZE OF IND MKT
0.60	0.38	15.30	9.10	0.50

	POLICY INDICATORS WELFARE LOSS	IND WEIGHT	POLICY RANKINGS WELFARE LOSS	IND WEIGHT	EFFICIENCY-EQUITY TRADEOFF
RAMSEY	0.02	1.00	1.00	5.00	1.00
SALES	5.93	1.73	5.00	1.00	8.85
FAC	0.11	1.07	3.00	3.00	1.08
COMP	0.13	1.07	4.00	2.00	41.78
TAX	0.03	1.00	2.00	4.00	151.86

AVERAGE TRADE-OFF WITH MAX SALES: 8.35 R2 = 0.99
AVERAGE TRADE-OFF EXCL MAX SALES: 1.28 R2 = 0.97

EXOGENOUS VARIABLES

INDUST ELAS	RES ELAS	FIXED COST(%)	DIFF IN FC	SIZE OF IND MKT
0.60	0.38	19.68	8.49	0.50

	POLICY INDICATORS WELFARE LOSS	IND WEIGHT	POLICY RANKINGS WELFARE LOSS	IND WEIGHT	EFFICIENCY-EQUITY TRADEOFF
RAMSEY	0.03	1.00	1.00	5.00	1.00
SALES	5.92	1.75	5.00	1.00	9.01
FAC	0.20	1.11	3.00	2.00	1.45
COMP	0.24	1.11	4.00	3.00	0.00
TAX	0.03	1.00	2.00	4.00	293.98

AVERAGE TRADE-OFF WITH MAX SALES: 8.08 R2 = 0.99
AVERAGE TRADE-OFF EXCL MAX SALES: 1.50 R2 = 1.00

EXOGENOUS VARIABLES

INDUST ELAS	RES ELAS	FIXED COST(%)	DIFF IN FC	SIZE OF IND MKT
0.60	0.38	23.79	7.96	0.50

	POLICY INDICATORS WELFARE LOSS	IND WEIGHT	POLICY RANKINGS WELFARE LOSS	IND WEIGHT	EFFICIENCY-EQUITY TRADEOFF
RAMSEY	0.03	1.00	1.00	5.00	1.00
SALES	5.91	1.76	5.00	1.00	9.21
FAC	0.33	1.16	3.00	2.00	1.81
COMP	0.41	1.15	4.00	3.00	0.00
TAX	0.04	1.00	2.00	4.00	179.55

AVERAGE TRADE-OFF WITH MAX SALES: 7.85 R2 = 0.97
AVERAGE TRADE-OFF EXCL MAX SALES: 1.85 R2 = 1.00

EXOGENOUS VARIABLES

INDUST ELAS	RES ELAS	FIXED COST(%)	DIFF IN FC	SIZE OF IND MKT
0.60	0.38	15.30	18.28	0.50

	POLICY INDICATORS WELFARE LOSS	IND WEIGHT	POLICY RANKINGS WELFARE LOSS	IND WEIGHT	EFFICIENCY-EQUITY TRADEOFF
RAMSEY	0.09	1.00	1.00	5.00	1.00
SALES	5.99	1.73	5.00	1.00	8.78
FAC	0.20	1.07	3.00	3.00	1.14
COMP	0.23	1.07	4.00	2.00	55.45
TAX	0.12	1.00	2.00	4.00	620.31

AVERAGE TRADE-OFF WITH MAX SALES: 8.32 R2 = 0.99
AVERAGE TRADE-OFF EXCL MAX SALES: 1.56 R2 = 0.94

EXOGENOUS VARIABLES

INDUST ELAS	RES ELAS	FIXED COST(%)	DIFF IN FC	SIZE OF IND MKT
0.60	0.38	19.68	17.06	0.50

	POLICY INDICATORS WELFARE LOSS	IND WEIGHT	POLICY RANKINGS WELFARE LOSS	IND WEIGHT	EFFICIENCY-EQUITY TRADEOFF
RAMSEY	0.10	1.00	1.00	5.00	1.00
SALES	5.99	1.75	5.00	1.00	8.94
FAC	0.31	1.11	3.00	2.00	1.54
COMP	0.36	1.11	4.00	3.00	0.00
TAX	0.14	1.00	2.00	4.00	1204.98

AVERAGE TRADE-OFF WITH MAX SALES: 8.05 R2 = 0.99
AVERAGE TRADE-OFF EXCL MAX SALES: 1.71 R2 = 0.97

EXOGENOUS VARIABLES

INDUST ELAS	RES ELAS	FIXED COST(%)	DIFF IN FC	SIZE OF IND MKT
0.60	0.38	23.79	15.99	0.50

	POLICY INDICATORS WELFARE LOSS	IND WEIGHT	POLICY RANKINGS WELFARE LOSS	IND WEIGHT	EFFICIENCY-EQUITY TRADEOFF
RAMSEY	0.12	1.00	1.00	5.00	1.00
SALES	5.99	1.76	5.00	1.00	9.10
FAC	0.47	1.16	3.00	2.00	1.94
COMP	0.56	1.15	4.00	3.00	0.00
TAX	0.16	1.00	2.00	4.00	739.19

AVERAGE TRADE-OFF WITH MAX SALES: 7.81 R2 = 0.98
AVERAGE TRADE-OFF EXCL MAX SALES: 2.08 R2 = 0.99

EXOGENOUS VARIABLES

INDUST ELAS	RES ELAS	FIXED COST(%)	DIFF IN FC	SIZE OF IND MKT
0.60	0.38	27.65	15.06	0.50

	POLICY INDICATORS WELFARE LOSS	IND WEIGHT	POLICY RANKINGS WELFARE LOSS	IND WEIGHT	EFFICIENCY-EQUITY TRADEOFF
RAMSEY	0.14	1.00	1.00	5.00	1.00
SALES	5.98	1.78	5.00	1.00	9.39
FAC	0.71	1.22	3.00	2.00	2.31
COMP	0.87	1.20	4.00	3.00	0.00
TAX	0.19	1.00	2.00	4.00	538.48

AVERAGE TRADE-OFF WITH MAX SALES: 7.49 R2 = 0.96
AVERAGE TRADE-OFF EXCL MAX SALES: 2.43 R2 = 0.99

EXOGENOUS VARIABLES

INDUST ELAS	RES ELAS	FIXED COST(%)	DIFF IN FC	SIZE OF IND MKT
0.60	0.38	7.84	7.42	0.66

	POLICY INDICATORS WELFARE LOSS	IND WEIGHT	POLICY RANKINGS WELFARE LOSS	IND WEIGHT	EFFICIENCY-EQUITY TRADEOFF
RAMSEY	0.01	1.00	1.00	5.00	1.00
SALES	5.39	1.78	5.00	1.00	7.26
FAC	0.03	1.03	3.00	3.00	0.44
COMP	0.07	1.05	4.00	2.00	2.07
TAX	0.02	1.00	2.00	4.00	84.10

AVERAGE TRADE-OFF WITH MAX SALES: 7.03 R2 = 1.00
AVERAGE TRADE-OFF EXCL MAX SALES: 1.07 R2 = 0.89

EXOGENOUS VARIABLES

INDUST ELAS	RES ELAS	FIXED COST(%)	DIFF IN FC	SIZE OF IND MKT
0.60	0.38	11.45	7.03	0.66

	POLICY INDICATORS WELFARE LOSS	IND WEIGHT	POLICY RANKINGS WELFARE LOSS	IND WEIGHT	EFFICIENCY-EQUITY TRADEOFF
RAMSEY	0.01	1.00	1.00	5.00	1.00
SALES	5.39	1.79	5.00	1.00	7.32
FAC	0.06	1.04	3.00	3.00	0.81
COMP	0.14	1.07	4.00	2.00	2.91
TAX	0.02	1.00	2.00	4.00	290.98

AVERAGE TRADE-OFF WITH MAX SALES: 6.96 R2 = 0.99
AVERAGE TRADE-OFF EXCL MAX SALES: 1.58 R2 = 0.91

EXOGENOUS VARIABLES

INDUST ELAS	RES ELAS	FIXED COST(%)	DIFF IN FC	SIZE OF IND MKT
0.60	0.38	14.87	6.68	0.66

	POLICY INDICATORS WELFARE LOSS	IND WEIGHT	POLICY RANKINGS WELFARE LOSS	IND WEIGHT	EFFICIENCY-EQUITY TRADEOFF
RAMSEY	0.01	1.00	1.00	5.00	1.00
SALES	5.38	1.80	5.00	1.00	7.35
FAC	0.10	1.06	3.00	3.00	1.17
COMP	0.27	1.11	4.00	2.00	3.84
TAX	0.02	1.00	2.00	4.00	90.37

AVERAGE TRADE-OFF WITH MAX SALES: 6.86 R2 = 0.99
AVERAGE TRADE-OFF EXCL MAX SALES: 2.12 R2 = 0.92

EXOGENOUS VARIABLES

INDUST ELAS	RES ELAS	FIXED COST(%)	DIFF IN FC	SIZE OF IND MKT
0.60	0.38	18.13	6.37	0.66

	POLICY INDICATORS WELFARE LOSS	IND WEIGHT	POLICY RANKINGS WELFARE LOSS	IND WEIGHT	EFFICIENCY-EQUITY TRADEOFF
RAMSEY	0.02	1.00	1.00	5.00	1.00
SALES	5.38	1.82	5.00	1.00	7.35
FAC	0.16	1.09	3.00	3.00	1.53
COMP	0.45	1.15	4.00	2.00	4.81
TAX	0.03	1.00	2.00	4.00	188.74

AVERAGE TRADE-OFF WITH MAX SALES: 6.73 R2 = 0.99
AVERAGE TRADE-OFF EXCL MAX SALES: 2.70 R2 = 0.92

EXOGENOUS VARIABLES

INDUST ELAS	RES ELAS	FIXED COST(%)	DIFF IN FC	SIZE OF IND MKT
0.60	0.38	11.45	14.10	0.66

	POLICY INDICATORS WELFARE LOSS	IND WEIGHT	POLICY RANKINGS WELFARE LOSS	IND WEIGHT	EFFICIENCY-EQUITY TRADEOFF
RAMSEY	0.05	1.00	1.00	5.00	1.00
SALES	5.42	1.79	5.00	1.00	7.26
FAC	0.11	1.04	3.00	3.00	0.49
COMP	0.22	1.07	4.00	2.00	3.86
TAX	0.09	1.00	2.00	4.00	1182.88

AVERAGE TRADE-OFF WITH MAX SALES: 6.93 R2 = 1.00
AVERAGE TRADE-OFF EXCL MAX SALES: 1.88 R2 = 0.84

EXOGENOUS VARIABLES

INDUST ELAS	RES ELAS	FIXED COST(%)	DIFF IN FC	SIZE OF IND MKT
0.60	0.38	14.87	13.40	0.66

	POLICY INDICATORS WELFARE LOSS	IND WEIGHT	POLICY RANKINGS WELFARE LOSS	IND WEIGHT	EFFICIENCY-EQUITY TRADEOFF
RAMSEY	0.06	1.00	1.00	5.00	1.00
SALES	5.42	1.80	5.00	1.00	7.27
FAC	0.16	1.06	3.00	3.00	0.94
COMP	0.36	1.11	4.00	2.00	4.71
TAX	0.10	1.00	2.00	4.00	368.07

AVERAGE TRADE-OFF WITH MAX SALES: 6.83 R2 = 0.99
AVERAGE TRADE-OFF EXCL MAX SALES: 2.43 R2 = 0.88

EXOGENOUS VARIABLES

INDUST ELAS	RES ELAS	FIXED COST(%)	DIFF IN FC	SIZE OF IND MKT
0.60	0.38	18.13	12.77	0.66

	POLICY INDICATORS WELFARE LOSS	IND WEIGHT	POLICY RANKINGS WELFARE LOSS	IND WEIGHT	EFFICIENCY-EQUITY TRADEOFF
RAMSEY	0.06	1.00	1.00	5.00	1.00
SALES	5.42	1.82	5.00	1.00	7.23
FAC	0.23	1.09	3.00	3.00	1.36
COMP	0.57	1.15	4.00	2.00	5.68
TAX	0.11	1.00	2.00	4.00	770.56

AVERAGE TRADE-OFF WITH MAX SALES: 6.70 R2 = 0.99
AVERAGE TRADE-OFF EXCL MAX SALES: 3.03 R2 = 0.90

EXOGENOUS VARIABLES

INDUST ELAS	RES ELAS	FIXED COST(%)	DIFF IN FC	SIZE OF IND MKT
0.60	0.38	21.24	12.20	0.66

	POLICY INDICATORS WELFARE LOSS	IND WEIGHT	POLICY RANKINGS WELFARE LOSS	IND WEIGHT	EFFICIENCY-EQUITY TRADEOFF
RAMSEY	0.07	1.00	1.00	5.00	1.00
SALES	5.41	1.83	5.00	1.00	7.13
FAC	0.32	1.11	3.00	3.00	1.76
COMP	0.88	1.20	4.00	2.00	6.72
TAX	0.12	1.00	2.00	4.00	465.06

AVERAGE TRADE-OFF WITH MAX SALES: 6.54 R2 = 0.99
AVERAGE TRADE-OFF EXCL MAX SALES: 3.68 R2 = 0.91

EXOGENOUS VARIABLES

INDUST ELAS	RES ELAS	FIXED COST(%)	DIFF IN FC	SIZE OF IND MKT
1.20	0.38	9.97	9.31	0.54

	POLICY INDICATORS WELFARE LOSS	IND WEIGHT	POLICY RANKINGS WELFARE LOSS	IND WEIGHT	EFFICIENCY-EQUITY TRADEOFF
RAMSEY	0.02	1.00	1.00	5.00	1.00
SALES	11.89	2.29	5.00	1.00	9.78
FAC	0.14	1.09	4.00	2.00	1.79
COMP	0.06	1.05	3.00	3.00	0.75
TAX	0.03	1.00	2.00	4.00	116.31

AVERAGE TRADE-OFF WITH MAX SALES: 9.36 R2 = 1.00
AVERAGE TRADE-OFF EXCL MAX SALES: 1.25 R2 = 0.96

EXOGENOUS VARIABLES

INDUST ELAS	RES ELAS	FIXED COST(%)	DIFF IN FC	SIZE OF IND MKT
1.20	0.38	14.47	8.73	0.54

	POLICY INDICATORS WELFARE LOSS	IND WEIGHT	POLICY RANKINGS WELFARE LOSS	IND WEIGHT	EFFICIENCY-EQUITY TRADEOFF
RAMSEY	0.03	1.00	1.00	5.00	1.00
SALES	11.88	2.33	5.00	1.00	9.95
FAC	0.31	1.16	4.00	2.00	2.17
COMP	0.12	1.07	3.00	3.00	1.16
TAX	0.03	1.00	2.00	4.00	174.55

AVERAGE TRADE-OFF WITH MAX SALES: 9.18 R2 = 0.99
AVERAGE TRADE-OFF EXCL MAX SALES: 1.70 R2 = 0.98

EXOGENOUS VARIABLES

INDUST ELAS	RES ELAS	FIXED COST(%)	DIFF IN FC	SIZE OF IND MKT
1.20	0.38	18.70	8.22	0.54

	POLICY INDICATORS WELFARE LOSS	IND WEIGHT	POLICY RANKINGS WELFARE LOSS	IND WEIGHT	EFFICIENCY-EQUITY TRADEOFF
RAMSEY	0.03	1.00	1.00	5.00	1.00
SALES	11.85	2.36	5.00	1.00	10.32
FAC	0.61	1.27	4.00	2.00	2.42
COMP	0.21	1.11	3.00	3.00	1.62
TAX	0.04	1.00	2.00	4.00	51.50

AVERAGE TRADE-OFF WITH MAX SALES: 8.91 R2 = 0.98
AVERAGE TRADE-OFF EXCL MAX SALES: 2.11 R2 = 0.99

EXOGENOUS VARIABLES

INDUST ELAS	RES ELAS	FIXED COST(%)	DIFF IN FC	SIZE OF IND MKT
1.20	0.38	22.69	7.78	0.54

	POLICY INDICATORS WELFARE LOSS	IND WEIGHT	POLICY RANKINGS WELFARE LOSS	IND WEIGHT	EFFICIENCY-EQUITY TRADEOFF
RAMSEY	0.04	1.00	1.00	5.00	1.00
SALES	11.81	2.40	5.00	1.00	11.29
FAC	1.12	1.45	4.00	2.00	2.46
COMP	0.36	1.15	3.00	3.00	2.13
TAX	0.05	1.00	2.00	4.00	75.09

AVERAGE TRADE-OFF WITH MAX SALES: 8.45 R2 = 0.95
AVERAGE TRADE-OFF EXCL MAX SALES: 2.36 R2 = 1.00

EXOGENOUS VARIABLES

INDUST ELAS	RES ELAS	FIXED COST(%)	DIFF IN FC	SIZE OF IND MKT
1.20	0.38	14.47	17.53	0.54

	POLICY INDICATORS WELFARE LOSS	IND WEIGHT	POLICY RANKINGS WELFARE LOSS	IND WEIGHT	EFFICIENCY-EQUITY TRADEOFF
RAMSEY	0.11	1.00	1.00	5.00	1.00
SALES	11.94	2.33	5.00	1.00	9.84
FAC	0.50	1.16	4.00	2.00	3.05
COMP	0.23	1.07	3.00	3.00	1.30
TAX	0.13	1.00	2.00	4.00	714.62

AVERAGE TRADE-OFF WITH MAX SALES: 9.14 R2 = 0.99
AVERAGE TRADE-OFF EXCL MAX SALES: 2.29 R2 = 0.97

EXOGENOUS VARIABLES

INDUST ELAS	RES ELAS	FIXED COST(%)	DIFF IN FC	SIZE OF IND MKT
1.20	0.38	18.70	16.51	0.54

	POLICY INDICATORS WELFARE LOSS	IND WEIGHT	POLICY RANKINGS WELFARE LOSS	IND WEIGHT	EFFICIENCY-EQUITY TRADEOFF
RAMSEY	0.13	1.00	1.00	5.00	1.00
SALES	11.92	2.36	5.00	1.00	10.14
FAC	0.88	1.27	4.00	2.00	3.19
COMP	0.35	1.11	3.00	3.00	1.79
TAX	0.16	1.00	2.00	4.00	211.75

AVERAGE TRADE-OFF WITH MAX SALES: 8.87 R2 = 0.98
AVERAGE TRADE-OFF EXCL MAX SALES: 2.68 R2 = 0.98

EXOGENOUS VARIABLES

INDUST ELAS	RES ELAS	FIXED COST(%)	DIFF IN FC	SIZE OF IND MKT
1.20	0.38	22.69	15.62	0.54

	POLICY INDICATORS WELFARE LOSS	IND WEIGHT	POLICY RANKINGS WELFARE LOSS	IND WEIGHT	EFFICIENCY-EQUITY TRADEOFF
RAMSEY	0.15	1.00	1.00	5.00	1.00
SALES	11.89	2.40	5.00	1.00	10.96
FAC	1.52	1.45	4.00	2.00	3.20
COMP	0.54	1.15	3.00	3.00	2.35
TAX	0.19	1.00	2.00	4.00	310.47

AVERAGE TRADE-OFF WITH MAX SALES: 8.43 R2 = 0.96
AVERAGE TRADE-OFF EXCL MAX SALES: 2.97 R2 = 1.00

EXOGENOUS VARIABLES

INDUST ELAS	RES ELAS	FIXED COST(%)	DIFF IN FC	SIZE OF IND MKT
1.20	0.38	26.47	14.85	0.54

	POLICY INDICATORS WELFARE LOSS	IND WEIGHT	POLICY RANKINGS WELFARE LOSS	IND WEIGHT	EFFICIENCY-EQUITY TRADEOFF
RAMSEY	0.18	1.00	1.00	5.00	1.00
SALES	11.86	2.45	5.00	1.00	15.08
FAC	2.51	1.83	4.00	2.00	2.69
COMP	0.82	1.20	3.00	3.00	2.98
TAX	0.23	1.00	2.00	4.00	566.84

AVERAGE TRADE-OFF WITH MAX SALES: 7.33 R2 = 0.86
AVERAGE TRADE-OFF EXCL MAX SALES: 2.78 R2 = 1.00

EXOGENOUS VARIABLES

INDUST ELAS	RES ELAS	FIXED COST(%)	DIFF IN FC	SIZE OF IND MKT
1.20	0.38	7.17	6.86	0.70

	POLICY INDICATORS WELFARE LOSS	IND WEIGHT	POLICY RANKINGS WELFARE LOSS	IND WEIGHT	EFFICIENCY-EQUITY TRADEOFF
RAMSEY	0.02	1.00	1.00	5.00	1.00
SALES	10.57	2.47	5.00	1.00	7.40
FAC	0.08	1.05	4.00	2.00	1.56
COMP	0.07	1.05	3.00	3.00	1.01
TAX	0.02	1.00	2.00	4.00	154.11

AVERAGE TRADE-OFF WITH MAX SALES: 7.27 R2 = 1.00
AVERAGE TRADE-OFF EXCL MAX SALES: 1.13 R2 = 0.99

EXOGENOUS VARIABLES

INDUST ELAS	RES ELAS	FIXED COST(%)	DIFF IN FC	SIZE OF IND MKT
1.20	0.38	10.53	6.57	0.70

	POLICY INDICATORS WELFARE LOSS	IND WEIGHT	POLICY RANKINGS WELFARE LOSS	IND WEIGHT	EFFICIENCY-EQUITY TRADEOFF
RAMSEY	0.02	1.00	1.00	5.00	1.00
SALES	10.56	2.50	5.00	1.00	7.38
FAC	0.17	1.09	4.00	2.00	1.83
COMP	0.14	1.07	3.00	3.00	1.55
TAX	0.03	1.00	2.00	4.00	154.68

AVERAGE TRADE-OFF WITH MAX SALES: 7.16 R2 = 1.00
AVERAGE TRADE-OFF EXCL MAX SALES: 1.63 R2 = 1.00

EXOGENOUS VARIABLES

INDUST ELAS	RES ELAS	FIXED COST(%)	DIFF IN FC	SIZE OF IND MKT
1.20	0.38	13.75	6.31	0.70

	POLICY INDICATORS WELFARE LOSS	IND WEIGHT	POLICY RANKINGS WELFARE LOSS	IND WEIGHT	EFFICIENCY-EQUITY TRADEOFF
RAMSEY	0.02	1.00	1.00	5.00	1.00
SALES	10.55	2.53	5.00	1.00	7.34
FAC	0.31	1.13	4.00	2.00	2.03
COMP	0.26	1.11	3.00	3.00	2.13
TAX	0.03	1.00	2.00	4.00	68.22

AVERAGE TRADE-OFF WITH MAX SALES: 7.04 R2 = 1.00
AVERAGE TRADE-OFF EXCL MAX SALES: 2.15 R2 = 1.00

EXOGENOUS VARIABLES

INDUST ELAS	RES ELAS	FIXED COST(%)	DIFF IN FC	SIZE OF IND MKT
1.20	0.38	16.84	6.08	0.70

	POLICY INDICATORS WELFARE LOSS	IND WEIGHT	POLICY RANKINGS WELFARE LOSS	IND WEIGHT	EFFICIENCY-EQUITY TRADEOFF
RAMSEY	0.02	1.00	1.00	5.00	1.00
SALES	10.52	2.56	5.00	1.00	7.30
FAC	0.54	1.19	4.00	2.00	2.15
COMP	0.44	1.15	3.00	3.00	2.75
TAX	0.03	1.00	2.00	4.00	609.28

AVERAGE TRADE-OFF WITH MAX SALES: 6.88 R2 = 0.99
AVERAGE TRADE-OFF EXCL MAX SALES: 2.68 R2 = 1.00

EXOGENOUS VARIABLES

INDUST ELAS	RES ELAS	FIXED COST(%)	DIFF IN FC	SIZE OF IND MKT
1.20	0.38	10.53	13.17	0.70

	POLICY INDICATORS WELFARE LOSS	IND WEIGHT	POLICY RANKINGS WELFARE LOSS	IND WEIGHT	EFFICIENCY-EQUITY TRADEOFF
RAMSEY	0.07	1.00	1.00	5.00	1.00
SALES	10.60	2.50	5.00	1.00	7.33
FAC	0.27	1.09	4.00	2.00	2.49
COMP	0.23	1.07	3.00	3.00	1.73
TAX	0.10	1.00	2.00	4.00	630.31

AVERAGE TRADE-OFF WITH MAX SALES: 7.14 R2 = 1.00
AVERAGE TRADE-OFF EXCL MAX SALES: 2.02 R2 = 0.98

EXOGENOUS VARIABLES

INDUST ELAS	RES ELAS	FIXED COST(%)	DIFF IN FC	SIZE OF IND MKT
1.20	0.38	13.75	12.65	0.70

	POLICY INDICATORS WELFARE LOSS	POLICY INDICATORS IND WEIGHT	POLICY RANKINGS WELFARE LOSS	POLICY RANKINGS IND WEIGHT	EFFICIENCY-EQUITY TRADEOFF
RAMSEY	0.08	1.00	1.00	5.00	1.00
SALES	10.59	2.53	5.00	1.00	7.28
FAC	0.44	1.13	4.00	2.00	2.57
COMP	0.37	1.11	3.00	3.00	2.34
TAX	0.12	1.00	2.00	4.00	278.71

AVERAGE TRADE-OFF WITH MAX SALES: 7.00 R2 = 1.00

AVERAGE TRADE-OFF EXCL MAX SALES: 2.53 R2 = 0.99

EXOGENOUS VARIABLES

INDUST ELAS	RES ELAS	FIXED COST(%)	DIFF IN FC	SIZE OF IND MKT
1.20	0.38	16.84	12.19	0.70

	POLICY INDICATORS WELFARE LOSS	POLICY INDICATORS IND WEIGHT	POLICY RANKINGS WELFARE LOSS	POLICY RANKINGS IND WEIGHT	EFFICIENCY-EQUITY TRADEOFF
RAMSEY	0.09	1.00	1.00	5.00	1.00
SALES	10.57	2.56	5.00	1.00	7.22
FAC	0.70	1.19	4.00	2.00	2.64
COMP	0.58	1.15	3.00	3.00	3.01
TAX	0.14	1.00	2.00	4.00	2497.56

AVERAGE TRADE-OFF WITH MAX SALES: 6.85 R2 = 0.99

AVERAGE TRADE-OFF EXCL MAX SALES: 3.07 R2 = 1.00

EXOGENOUS VARIABLES

INDUST ELAS	RES ELAS	FIXED COST(%)	DIFF IN FC	SIZE OF IND MKT
1.20	0.38	19.83	11.77	0.70

	POLICY INDICATORS WELFARE LOSS	POLICY INDICATORS IND WEIGHT	POLICY RANKINGS WELFARE LOSS	POLICY RANKINGS IND WEIGHT	EFFICIENCY-EQUITY TRADEOFF
RAMSEY	0.10	1.00	1.00	5.00	1.00
SALES	10.55	2.60	5.00	1.00	7.15
FAC	1.10	1.27	4.00	2.00	2.66
COMP	0.89	1.20	3.00	3.00	3.74
TAX	0.16	1.00	2.00	4.00	293.29

AVERAGE TRADE-OFF WITH MAX SALES: 6.66 R2 = 0.99

AVERAGE TRADE-OFF EXCL MAX SALES: 3.62 R2 = 0.99