

A TALE OF TWO PRICING HYPOTHESES IN THE NHL

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B.A. (Hons), University of Regina, 1986

A THESIS SUBMITTED IN PARTIAL FULFILLMENT

OF THE REQUIREMENTS FOR THE DEGREE OF

ACCEPTED

MASTER OF ARTS

FACULTY OF GRADUATE STUDIES

in the Department

of

Economics

May 10, 1989

DEAN

DATE

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Abstract

Many economists place a great deal of trust in the rules of supply and demand in the analysis of simple commodity markets. In microeconomic theory, profit maximizing firms interact with utility maximizing consumers in a Walrasian auction where prices adjust over time to balance the demand with supply. When the price mechanism is allotted sufficient time, these rules of supply and demand generally work in most markets.

There are however, several examples of markets where the price never seems to adjust to its equilibrium level. For example, the black market price for Cabbage Patch dolls, tickets to the Final Four, or tickets to see Wayne Gretzky and the Los Angeles Kings play in Edmonton, are higher than the prices set by Cooleco, the NCAA, and the Edmonton Oilers respectively. Predictably, demand persistently exceeds supply in each of the above markets. There is no satisfactory explanation in microeconomic theory to account for this behaviour. It is this apparent economic anomaly which is of interest here.

In a more specific example, much of the literature suggests (Jones, 1976, Noll, 1974b to name a few) that National Hockey League (NHL) teams set ticket prices to maximize profits. Some NHL teams like the Montreal Canadiens however, continually face excess demand at hockey games but do not raise the price. The hypothesis that these teams set prices at their profit maximizing levels is inconsistent with their market behaviour.

Other authors (Thaler, 1985, Knetsch et al., 1986) have suggested that this microeconomic anomaly results from consumers having standards for fairness in pricing. For example, consumers have perceptions of what is a fair price for a Cabbage Patch Kid, a Final Four ticket, or a hockey game ticket. Teams or firms which price commodities unfairly might be punished by discontinued patronage. In response, if demand is sufficiently great, teams and firms in these markets set prices below the market clearing level.

Hitherto, neither pricing hypothesis has been supported with substantial empirical evidence. The chief contribution of this study to the literature is the provision of a theoretical framework which allows for the direct statistical evaluation of each pricing hypothesis.

Simple demand systems encompassing an attendance and a price equation form the basis of the analytical framework. Restrictions within and between the price and attendance equations are created by the imposition of a particular pricing hypothesis. The form of these restrictions is often non-linear in nature and necessitates the use of non-linear estimation techniques. Testing whether these restrictions do or do not bind denotes a test of the particular pricing hypothesis. The likelihood ratio test statistic is the specific criterion for evaluation used in this study. Suitable models of the two pricing hypotheses are developed using this framework and empirically evaluated using three seasons of game by game data from the NHL.

The statistical results of this study suggest that perhaps revenue maximizing ticket prices are constrained by considerations of fairness. The scope of this study was primarily methodological and not empirical so these statistical results are somewhat qualified. The purpose of this study, however, was not necessarily to provide empirical support for a particular pricing hypothesis in the NHL. The intent of this study was to lay the theoretical groundwork so that the empirical analysis of pricing hypotheses might even occur in the future.

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ACKNOWLEDGEMENTS

I would like to thank my advisor, Don Ferguson, whose patience, guidance and encouragement were invaluable to me in the formation of this final product. It was a privilege to have him as my advisor. I wish him all the best of luck in his future ventures. I have always failed, however, to fully appreciate his enjoyment of Jalepeno peppers.

I would also like to acknowledge Ken Stewart whose timely advice saved me an immeasurable amount of time on the econometric work in this study.

I would further like to thank David Gartrell whose advice on the earlier drafts of the thesis greatly enhanced this study.

I appreciate all my parents have done towards furthering my education. They were patient and never discouraged me in my endeavors. Too often, I have taken their love for granted. I hope this simple thank you in some way begins to pay back the gratitude I feel to them.

I would especially like to thank Carole. My only wish is that if she mentions me in her thesis, that she spells my name with a capital "Q".

INTRODUCTION

On November 11, 1988 all available seats for a game between the Vancouver Canucks and Montreal Canadiens had been sold. The price for one of these seats usually sells at about \$25. If fans were willing to pay upwards of \$30 then tickets could be purchased from scalpers. This alternative market for tickets had developed because the Canucks were pricing below the market clearing level.

Much of the literature on the economics of professional sports contends that the Canucks, like other professional sports teams, are profit maximizers. As such, ticket prices are set at the profit maximizing levels. It seems anomalous, however, that the Canucks would allow a scalper to exploit their excess demand at the Canadiens game.

This apparent divergence between assumed and actual behaviour makes the ticket pricing behaviour of professional sports teams an interesting economic phenomena¹. Up to this point, however, much of the investigation into the pricing of sporting events has

1. Although it is certainly not the case that this apparent underpricing of a commodity is unique only to professional sports markets. For example, there was excess demand for Atari video games over the Christmas 1988 shopping season, and the price never seemed to approach the market clearing level.

been of a nonempirical nature. This study seeks to enhance the literature in this area, by providing a framework which allows for a more direct empirical approach for studying this pricing behaviour. The particular pricing market investigated in this study is that of tickets for games in the National Hockey League. The methodology used in this study, however, could just as easily be applied to other markets. As a result, the contribution of this study is primarily methodological and, to a lesser extent, empirical.

The first chapter will outline two possible pricing hypotheses for the NHL. The first pricing hypothesis is profit maximization. This hypothesis has received wide support in the literature, but has been corroborated by only slight empirical evidence. The second hypothesis suggests that NHL teams are constrained from setting ticket prices at their optimal profit levels. This hypothesis contends that exploiting excess demand would be judged unfair, and fans would not attend future games. The support for this pricing hypothesis is largely obtained from survey results. It will become evident in the first chapter that there is a need for a more cohesive analytical framework for evaluating pricing behaviour in the NHL.

The purpose of this study is to provide a framework which allows for a more direct empirical analysis of the two pricing hypotheses. This will be presented in Chapter 2. Firstly, simple demand systems encompassing an attendance and a price equation are formed. Each pricing hypothesis creates specific restrictions within and between the price and attendance equations. The form of these restrictions entails the use of nonlinear estimation techniques. Testing whether these restrictions do or do not bind provides a test of the particular pricing hypothesis. Suitable models are developed using this framework, and then empirically evaluated with three seasons of game by game data from the NHL.

The third chapter subsequently reports the results of the empirical analysis. The statistical criterion to be used here for evaluating the pricing hypotheses is the likelihood ratio test statistic. Concerns raised in Chapter 2 about sufficient variation in the data, and/or correct specification of the models will be addressed accordingly in Chapter 3.

Chapter 1

TWO TICKET PRICING HYPOTHESES

1.1 Ticket Pricing in the National Hockey League

There are many examples of markets which apparently fail to clear at the stated market prices. For example, Super Bowl tickets are sold by the National Football League for about \$50, but scalpers can receive over \$300 for a good ticket on game day. Superficially, it would appear to be difficult to explain this behaviour using the microeconomic assumption that firms seek to maximize profits. The NFL is clearly not setting Super Bowl ticket prices at their profit maximizing levels.

Whether it be high demand restaurants or extremely popular video cassettes, this is not an economic anomaly unique to the NFL. To date there has been relatively little investigation into the pricing mechanism employed in these markets. The purpose of this study is to present a framework which allows for the empirical analysis of pricing hypotheses. In particular, this study will investigate the pricing behaviour for teams in the National Hockey League (NHL). Although the market discussed here is the NHL, the analytical framework used

could just as easily be applied to any of the other markets mentioned above.

The NHL consists of 21 teams in 4 divisions (the Patrick Division has 6 teams) and 2 conferences. These divisions and conferences are formed on the basis of geographical proximity. This cuts down on travel costs, as intradivisional games between teams encompass 40% to 50% of each team's schedule depending upon which division the team is in (The National Hockey League Official Guide, 1987-1988). Each team plays 80 regular season games along with an unspecified number of preseason exhibition games. The top four teams from each division make the playoffs and are allowed to compete for the prestigious Stanley Cup, donated by Lord Stanley in 1893 (Tremblay, 1967, p 12).

The following examples illustrate that the primary source of income for NHL teams is ticket revenue:

Estimated average revenue from tickets in the 1981 season for the Philadelphia Flyers was \$16 million. In 1987 a \$24.175 million television deal was signed by the NHL with ESPN. Split 21 ways this is a pittance in comparison with ticket revenues. Further, a recent report on the financial status of the Winnipeg Jets estimated

that 75% of their revenue came from ticket sales (York, March 1, 1989, p.A11). Likewise the projected ticket income for the Edmonton Oilers this season is over \$14 million. This compares with \$2.5 million of projected television revenue. (Strachen, March 3, 1989, p.A14).

At the beginning of each season, ticket prices are set for the upcoming season. Prices vary from season to season (see Appendix Table A), but ostensibly the price of a given seat, for any game during a particular season, is the same throughout that season. The following two examples refer to the ticket prices charged this season by the Canadiens and Maple Leafs respectively.

"All but about 3,400 of the 16,000 odd seats, ranging in price from \$28.50 for the best reds to \$9.50 for the 1,500 standing room places..." (Elchin, Feb. 27, 1989, p.A10). "Seat prices range from \$29 down to \$11, about middle of the pack in the National Hockey League. But team officials know they could charge top dollar ... " (Milner, Feb. 28, 1989, p.A14).

The mechanism for arriving at this price is the point at issue. Are the Leafs and Canadiens profit maximizing? Could these teams raise ticket prices and accumulate

greater revenue? To answer these questions requires greater insight into how NHL ticket prices are determined. This study will investigate two different ticket pricing hypotheses as they pertain to NHL teams.

A large part of the literature suggests that ticket prices are set to maximize profits. Contrary to this contention, however, are several examples of non-profit maximizing ticket pricing behaviour. These incidents are not uncommon in the league as can be observed in the following occurrences.

Ticket prices for Wayne Gretzky's first game as a Los Angeles King in Victoria were set at \$20 a piece. On September 16, however, tickets purchased for \$20 were being offered for double their face value (\$40) in the Victoria Times Columnist. The original ticket sellers had failed to exploit excess demand contrary to the assumptions of profit maximization. Likewise, when the L.A. Kings visited the Northlands Coliseum for the first time this season, scalpers, who are assumed not to be employees of the Edmonton Oilers, were receiving \$50 a ticket. Certainly, the owner of the Edmonton Oilers could not classify this as profit maximizing ticket pricing.

These are examples of excess demand occurring at particular games. As such these events might be dismissed as unanticipated flukes. Of potentially more interest are teams like the Canadiens and the Leafs which have consistent excess demand over the entire season. For these teams the one price per season is clearly in violation of the assumption that NHL teams seek to maximize profits.

Knetsch et al. (1986) have suggested that these two events accord with their ticket pricing hypothesis. Briefly, Knetsch et al. state that fans have a concept of what a fair ticket price is. Although ticket price setters may wish to raise prices to maximize profits, fans may judge this action as unfair and thus not attend future games. Hockey teams wish to avoid this retaliation by the fan and thus price tickets "fairly".

It is extremely difficult to judge from the available research in this area how ticket prices are actually arrived at in the NHL. A broader description of the two pricing hypotheses alluded to earlier, and an elaboration of the supporting evidence for each is now presented.

1.2 The Assumption of Profit Maximization

The consensus assumption in the literature, is that the primary consideration for setting ticket prices in the NHL is the maximization of profits.

"In this respect we assume that the teams seek to maximize profits" (Ferguson and Jones, 1988, p.445)

"The pricing policies ... of teams do not appear to be motivated by any goal other than profits" (Noll, 1974(b), p.154)

"The principle of supply and demand operates in the amount of admission charged for athletic events. If sports were truly a game rather than a business, the most successful teams would charge the lowest prices, but this is not the case" (Eitzen et al., 1978, p.203).

Although the profit maximization assumption has not been tested, it is not difficult to ascertain from the available evidence why the assumption is so widely accepted. Traditional price theory suggests that essentially prices are determined by the motivation of firms and the market structure within which they exist

(Mason, 1939, pp. 61-74). In short, if profit maximizing NHL teams exist in a structure amenable to profit maximization, then teams will indeed profit maximize¹. It is not difficult to verify this assertion using a similar analytical framework² to that employed by Mason.

Richard Gruneau interviewed several executives and upper management in the NHL in the mid-seventies. One of his objectives was to ascertain the goals of the owners and management of NHL teams (Gruneau, 1976, p.232). His results were not published in a useful form but in conversation he did make some comments on how he interpreted his interviews.

"I recall hearing a lot about the necessity of a sound economic return - indeed a maximum return" (Gruneau, letter, August 9, 1988)

"We are a business, ... the last ticket manager was fired because he did not feel justified in raising ticket prices" (Glen Ringdahl, executive Vancouver Canucks, in a telephone interview Oct. 5, 1988).

1. Ostensibly, this is the procedure employed by Jones (1976) to validate his contention that individual NHL teams profit maximize.

2. This entails showing that conduct and market structure will produce a predictable performance (in this case pricing behaviour) for NHL teams (see Koch, 1980, p.91).

"In short Zeigler (president of the NHL) acts as if he cares only about profits...on his goals upon becoming league president he wanted to see every owner making money before his tenure is through" (Strachen, June 11, 1988 p.A22).

The objective of NHL teams would, therefore, seem to be profit maximization. Traditional industrial organization theory maintains that profit maximizing goals are achievable when the objectives are reconciled with a conducive organizational structure. It is likely no coincidence that the organizational structure of the NHL does not restrict a team from pricing tickets at their profit maximizing levels.

Each team in the NHL is located within an exclusive market. The profit maximizing pricing practices of any one team should not be constrained by the pricing practices of another team. Articles 4.3, 4.4, 3.3, and 3.5 of the NHL bylaws³ restrict the entry into the league, and the movements of NHL teams from one location to another⁴. It follows from traditional industrial

3 The NHL bylaws were signed by the original 6 teams and have been signed by each team entering the league since. Of particular interest here is article 2 of the bylaws "the NHL is an unincorporated non-profit association established to promote and organise hockey in the United States and Canada" (Barnes, 1988, p.174).

4 Evidence of the NHL's willingness to enforce this particular barrier to entry is the \$5million fee the New

organization theory, therefore, that NHL teams are profit maximizers⁵. Further, this should imply that NHL teams price tickets in order to maximize profits, since ticket revenue is the primary source of income for NHL teams.

The implications of profit maximizing pricing behaviour have been thoroughly established in microeconomics.⁶ In short, a rise in demand for hockey games will lead to a rise in prices⁷.

For example, in the 1977-1978 hockey season the average price of a hockey game ticket was estimated at \$7.87. The average price for a ticket to see the Montreal Canadiens that same season was a full \$2 higher than the league average (Eitzen, 1979, p.328). It is not a

York Islanders had to pay the New York Rangers upon entering the league within the 50 mile radius of the Rangers. It is also no coincidence Hamilton is having difficulty obtaining a franchise given that's cities proximity to Toronto (see the Globe and Mail, "Hamilton's Copps Arena Thriving Without Having NHL Team", p.A15, Nov. 28, 1988).

5. In particular, Jones (1976) is able to accord observations of behavior in the NHL with this prediction.

6 See for example Henderson and Quandt, 1980, p.155, or Russell and Wilkerson, 1979, p.222.

7. This implicitly assumes the unlikelihood of decreasing marginal costs for hockey games. This would imply that the supply curve for hockey is not only downward sloping but extremely price inelastic, an unlikely occurrence (see Noll, 1974a, p.25).

coincidence that the Canadiens were on a drive to a fourth Stanley Cup.⁸

Another example is the Calgary Flames. "Tickets for the 20,002 seats at the Olympic Saddledome will increase \$5 for the Smythe Division semi-final and final. They will increase another \$5 should Calgary advance to the Campbell Conference Final and the Stanley Cup championship" (Globe and Mail, Feb. 17, 1989, p.A12).

These are examples of apparent profit maximizing ticket pricing in the NHL. Observations of individual incidents, however, do not constitute an empirical proof of profit maximizing pricing in the NHL. In truth, the entire preceding discussion of profit maximizing pricing in the NHL has only illustrated that NHL teams would probably like to profit maximize - not that they do.

There has, however, been some limited empirical research into the validity of profit maximizing pricing in professional sports. In general, these empirical investigations estimate the price elasticity of demand and then assert a particular pricing behaviour based on the elasticity estimate. Specifically, a highly price

8. The positive correlation between winning and attendance is not a contentious issue in the literature, see Noll, 1974(b), or Jones, 1984.

elastic value would be seen as support for profit maximizing pricing. The seller achieves their maximum return in this scenario.

For example, Noll (1974b) estimated the price elasticity of demand in professional hockey.⁹ His estimated elasticity value was not significantly different from one. This is not only inconclusive, but it is also debatable whether the profit maximizing pricing hypothesis is actually being tested using elasticity values.

More importantly, it would seem that none of the research to date has addressed the phenomena alluded to at the beginning of the chapter. Some teams in the NHL experience persistent excess demand when prices are supposedly set to maximize profits.

There are at least two possible explanations which may be able to reconcile this divergence between profit maximization intentions and profit maximization behaviour¹⁰.

9. Several other studies involving other sports estimated the price elasticity of demand. Almost unanimously these studies reported inelastic values (see Jennet et al., p.15)

10. A third possible explanation for this apparent contradiction can be found in Eaton and Donaldson (1981). Applying their hypothesis to the NHL it could be asserted that teams wish to maximize seasonal profits by

First, it might be suggested that teams are surprised when attendance rises over capacity. Yet Glen Ringdahl, an executive with the Vancouver Canucks, claimed that average attendance for any NHL game last season was 76% of capacity, but when Wayne Gretzky plays in town average attendance rises to 96% of capacity. The executives of the NHL teams are keenly aware what generates increases in demand, yet the ticket prices for these games are not raised.

Second, it is possible that administrative costs associated with changing the ticket prices are higher than the projected revenue from doing so. Major cinemas in London, England such as the Empire Cinema in Leicester Square, seem to have little difficulty in raising prices when the demand to view the evening movies starts to verge on the capacity constraint. The matinee price is 3 pounds, the evening price is 4 pounds and if the movie is an especially high demand premiere, the price might be 5 pounds. Further, like NHL teams these cinemas issue

maximizing season ticket sales. Briefly, potential season ticket buyers are assumed to have high valuations of time and a high valuation of viewing a particular game. Game day ticket prices are set low enough that season ticket buyers feel compelled to purchase season tickets so as not to miss a particular game. Where it is relevant, this hypothesis can accord game by game excess demand with the assumption of profit maximization. A description of the general hypothesis can be found in Eaton and Donaldson (1981), and Knox-Levell and Wertz (1985).

tickets and not just cash receipts. The administrative costs do not seem to hamper the ability of these cinemas to behave in a fashion consistent with the hypothesis of profit maximization. Further, the smaller venues make the added administrative costs closer to the economic margin for the cinema. It is improbable that NHL teams can justify their non-profit maximizing behaviour by either unexpected increases in demand or prohibitive administrative costs.

It could be that the explanation for the absence of price changes in the face of excess demand, lies not with the team, but with the fan. Is it possible, as was mentioned earlier, that those who set ticket prices, fear reprisal from fans who judge the raising of ticket prices for particularly popular games to be unfair?

1.3 Fairness as a Constraint in Ticket Pricing

"The difficulty in trying to explain this apparent neoclassical conflict is the underlying assumption that demand and supply carry equal weight in the market...in the pricing of sporting events which are characterized by marked variation of demand but where there is no perceived change in cost from game to game (regardless of

attendance); charging the market clearing price (when excess demand exists) would be judged unfair" (Knetsch et al., 1986(a), p 738).

The inability of the club to predict a fan's reaction to a perceived unfair ticket price fluctuation, might explain a club's reluctance to alter ticket prices in response to excess demand. The following experimental example by Knetsch et al. (1986(a)) illustrates the predicament of NHL teams, and other similar firms.

"A hardware store has been selling snow shovels for \$15. The morning after a large snowstorm, the store raises the price to \$20. Do you think this is fair?" (Knetsch et al., 1986(a), p 729). 82% of the survey responded that this would be unfair.

It is difficult to claim that hockey game tickets can be directly compared to snow shovels,¹¹ but the situations are undeniably somewhat similar. A hockey team which raises its game day ticket price in the face of increased demand from the visit of the L.A. Kings might be judged to be unfair by its fans.

¹¹ Although in rural Saskatchewan it is certainly the case that the game doesn't begin until the pond has been cleared.

Another survey experiment by Knetsch et al. (1986(b)) would seem to add substance to this contention. "A football team normally sells some tickets on the day of their games. Recently, interest in the next game has increased greatly, and tickets are in great demand. The team owners can distribute the tickets in one of three ways (1) auction, (2) lottery, and (3) queue (Knetsch et al. 1986(b), p S288). The following was the survey response:

Method	Most Fair (%)	Least Fair (%)
Auction	4	75
Lottery	28	18
Queue	68	7

These results suggest that fans may judge profit maximizing pricing as unfair. Should an NHL team, or hardware store owner, fear retaliation from their patrons in the form of decreased future demand, then it is doubtful that either would raise the price. The violation of the profit maximization assumption would appear to be explained by the concept of fairness operating on the demand side of the market.

The link between demand and price is well established in microeconomic profit maximization literature. Here it has been severed by the power of the consumer. The question is, of course, why?

Thaler (1985 p.210) asserts that fans suffer transaction disutility when ticket prices are raised without apparent cause. In other words, the market clearing price may well be higher than the reference price, last seasons' prices or even the ticket price at the last game, but the consensus among the fans is that the market clearing price would be an injustice. Since the NHL team has an ongoing pecuniary relationship with the fan, the team is unwilling to face the possible penalty for allowing the fan to suffer transaction disutility. As support for this hypothesis Thaler offers the following question and survey results:

"Imagine you are going to a sold out Cornell hockey game and you have an extra ticket to sell or give away. The price marked on the ticket is \$5 which is what you paid for each ticket. For how much would you sell the ticket to a friend? to a stranger?" Thaler, 1985, p. 206.

The results show that, on average, the respondents would charge the stranger significantly more for the

ticket. There is no ongoing relationship with the stranger, therefore there is no constraint in charging the market clearing price. Analogously, the fan is a friend of the NHL team.

Should a fan not have a well established reference price, and not have an ongoing financial relationship with the team, then the pricing behaviour might be more amenable to the assumption of profit maximization. The prices charged to watch the Spinks vs. Tyson fight is evidence of this.

It should be apparent that the support for the fairness in pricing hypothesis is based on the results of surveys. There is no direct evidence that fairness in pricing is a legitimate explanation of actual pricing behaviour in the NHL,¹² or any other similar market for that matter.

It can only be suggested at this point that a fan's perception of fairness may act as a constraint on profit maximizing pricing when NHL teams sell out. The data used

12. It could be suggested that the New York Islanders priced tickets fairly over the time period of the data used in this study (see Appendix Table A). Despite consistently winning the Stanley Cup over this time period the proximity of the New York Rangers may have forced the Islanders to price tickets at the fair level and not the revenue maximizing level.

in this study (see Appendix Table A), however, illustrates that, on average, many teams don't sell out. In this scenario what then dictates the pricing behaviour of teams?

It is difficult to determine the actual ticket pricing mechanism in the NHL from the arguments presented to this point. A clearer understanding of the pricing practices of NHL teams should be apparent from actually discussing the issue with those who make these decisions. Such a discussion could also be useful in explaining the pricing mechanism in markets similar to the NHL.

It is an understatement, however, that it is difficult to obtain information about the NHL. I sent letters to every NHL team, every newspaper in the cities where NHL teams are located, various magazines, and the managing executives of the NHL, and I received little or no response to my requests for information. My sole source of information in this regard was an extensive telephone interview with Glen Ringdahl, an executive with the Vancouver Canucks, which I conducted on October 5, 1988.

1.4 An Interview with a Ticket Price Setter

Although certainly pleasant my telephone conversation with Mr. Ringdahl could not be described as particularly conclusive. On the topic of profit maximization Mr. Ringdahl explained that above all else, the Canucks were a business. This is not proof of any specific pricing behaviour, but Mr. Ringdahl did go on to say that "my job is to fill the building, ... if the demand for a particular game is high then we would likely not offer many discounts for that game"¹³. This implies that NHL teams profit maximize, by responding to increases in demand by raising the price, albeit in an indirect fashion.

The interview did not end there. Glen Ringdahl went on to say that "we can't tick the public off; we have to look at our business with a long term strategy; these people come back and see other games as well" (where excess demand may not exist). This is almost the epitome of the fairness in pricing behaviour hypothesized by Thaler (1985). Further, Mr. Ringdahl went on to say that "fans view an NHL franchise as community property;

¹³ It is standard practice in the NHL to offer package deals to fans wishing to view only a few games. Another common practice is to sell large blocks of tickets at reduced prices to businesses which use the tickets for promotional reasons.

management is in a privileged position and must behave in a manner which the fans perceive to be in the best interest of the community." He made other statements about "community spirit" and the "recognition that the fan was the most important factor in the selling of hockey." All of this would seem to support the hypothesis that the fan's concept of fairness is the most important determinant in the pricing of tickets in the NHL.

The interview with Mr. Ringdahl clearly did little to solve the issue at hand. Do NHL teams price tickets to maximize profits, or are NHL teams constrained from doing this by the community standards of fairness in pricing?

1.5 Summary

This chapter has described two potential explanations of ticket pricing behaviour in the NHL. The first hypothesis, profit maximization, implies that prices are set on the principal of marginal revenue equalling marginal cost and a subsequent clearing of the market. However, within the NHL certain markets consistently do not clear.

The second hypothesis asserts that the price increases necessary to ensure market clearing would be judged unfair by fans. Teams may feel that fans will not attend future games under these circumstances so prices are not raised to exploit those situations of excess demand.

This chapter also demonstrated that the empirical support for these hypotheses, as explanations of actual ticket pricing behaviour in the NHL, has been rather weak.

The purpose of a hypothesis is to explain and to predict real world events. When a hypothesis is useful, it corresponds well to what actually happens. The abstract nature of economic hypotheses makes perfect parallelism between theory and reality unlikely. Empirical tests are often applied to establish a presumption in favor of a particular hypothesis. So far, only an indeterminate assessment of the most appropriate explanation of the pricing mechanism in the NHL can be delivered from the survey and heuristic evidence presented in this section. The need to empirically test the profit maximizing pricing and fairness in pricing hypotheses should be apparent.

Heretofore the greatest single obstacle to improved empirical analysis of these pricing hypotheses is the absence of a suitable theoretical framework. The next chapter develops a framework which allows for a more direct empirical analysis of these pricing hypotheses.

Chapter 2

A FRAMEWORK FOR ANALYZING THE PRICING HYPOTHESES

"The topic of firm objectives has received relatively slight empirical investigation in the professional team sports literature" (Jennet et al., 1986, p.8).

The lack of empirical studies is no doubt related to the absence of a framework for empirically analyzing firm objectives. In particular, it was evident in the previous chapter that sufficient empirical investigation of firm objectives in the NHL has not been carried out. This is particularly relevant to this study in the way firm objectives are reflected in pricing policies.

The intent of this chapter is to develop a framework which allows for the direct empirical testing of the pricing hypotheses outlined in Chapter 1¹. To this end, each section of this chapter adds a significant component to the specification of suitable models used in the empirical testing of the pricing hypotheses.

1. Although the framework is specifically employed to analyze the NHL in this study, it should be apparent that it is also readily applicable to other markets similar to the NHL.

Section 2.1 outlines the general theoretical framework of the models and the testing procedure. Section 2.2 describes in more detail the estimation technique, and statistical testing procedure. Section 2.3 then presents the data set to be used in the estimation, and section 2.4 provides a detailed exposition of the actual models.

2.1 Theoretical Framework for Testing the Hypotheses

Each model developed here consists of an attendance equation and a price equation. The imposition of a particular pricing hypothesis on the system leads to restrictions on the coefficients within and/or between the equations. These coefficient restrictions in turn form the basis of the hypothesis testing. When the restrictions do not significantly alter the system, in a statistical sense, then support for the pricing hypothesis can be asserted.

The following is a more formal general representation of the models and of the testing procedure. For this purpose the following notation will be employed:

g is an index of games

t is an index of teams

Attend_{gt} is the attendance at game (g) of team (t)

X_{gt} is a vector of game and city variables influencing attendance

p_t is the ticket price of team t

The general form of the attendance equation is:

$$\text{Attend}_{gt} = f(X_{gt}, p_t, \alpha) \quad (1)$$

where α is a vector of coefficients in the attendance equation. Seasonal attendance for team t ($S\text{attend}_t$) will then be:

$$S\text{attend}_t = \sum_{g=1}^N f(X_{gt}, p_t, \alpha)$$

where N is the number of games each team plays in a season. The general form of the price equation is:

$$p_t = f(Z_t, \beta) \quad (2)$$

where Z_t is a vector of variables which are pertinent for the particular pricing hypothesis, and β is a vector of coefficients for the price equation

It can be shown that each of the pricing hypotheses imposes particular restrictions on the coefficients (α and β) within and between equations (1) and (2). Each hypothesis will now be considered separately.

2.1.1 Profit Maximization

Previous research (Ferguson and Jones, 1988) has assumed that teams seek to maximize season profits. From

elementary economic theory this entails optimizing the difference between season revenues and costs. On the basis of the evidence in Noll (1974), costs are assumed to be primarily fixed for NHL teams. There is apparently little marginal cost associated with increased attendance.² Ostensibly therefore, the hypothesis of profit maximizing pricing is equivalent to revenue maximizing pricing. In particular it is assumed that teams price tickets to maximize season revenue ($SRevenue_t$). It follows that since

$$SRevenue_t = p_t * SAttend_t$$

the price equation must satisfy the first order condition

$$\frac{d SRevenue_t}{d p_t} = 0$$

This implicitly defines the price equation (2).

The variables (Z) must be derived from the variables (X) of the attendance equation. Further, by construction the coefficients (β) in the price equation must be derived from the coefficients (α) in the attendance equation. The particular form that these coefficient restrictions take depend upon the functional form of the attendance equation.

² Noll (1974, p.25) provides cost sheets which show that there is little difference between marginal costs (games) from one season to another. Ferguson and Jones (1988, p.445) just assume that there is no marginal costs associated with extra attendance from game to game.

The source of these restrictions is the hypothesis of revenue maximization. Therefore, a statistical test of whether or not these restrictions bind serves as a test of the pricing hypothesis. The nature of this test will be discussed later in this section.

2.1.2 Fairness in Pricing I

The hypothesis of fairness in pricing is not as firmly grounded in economic theory as the hypothesis of profit maximizing pricing. Consequently, models representing the fairness in pricing hypothesis might take several divergent forms. This should not, however, preclude the application of the above framework.

In particular the results in the Knetsch et al. (1986(b), p S296) study suggest that it was unfair for a firm to exploit an increase in its market power not associated with an increase in cost. Cost plus pricing is therefore, perceived as fair³. If teams set fair prices then this implies that the price equation is a function of only those variables which affect cost.

3. "Price increases that are based on cost increases are "fair", while those based on demand increases often are viewed as unfair." (Okun, 1981, p.153).

The price equation for the cost plus pricing model would be different from the price equation of the revenue maximizing model. In particular, there should be no cross equation restrictions, and variables which only affect demand should not be included in the price equation of a cost plus pricing model. Formally, this is equivalent to restricting the coefficients on these variables to being zero within the price equation. Again a statistical test of these restrictions can be applied to test the behavioral hypothesis.

2.1.3 Fairness in Pricing II

It has also been argued that people judge prices as fair or unfair on the basis of the change in price. A large change in price not accompanied with a proportionate change in cost is judged as unfair (Knetsch et al. 1986(b)). Firms must clearly use a reference price if they are to judge current prices as fair or unfair. It seems reasonable to assume that the previous price is the most appropriate reference price.

"Market prices, posted prices and the history of previous transactions between a firm and transactor can serve as reference transactions. When there is a history of similar transactions between firm and

transactor the most recent price ... will be adopted for reference." (Knetsch et al., 1986(a), p. 730)

It is also assumed that NHL teams are more likely to price fairly when the possibility of being punished for not doing so increases.

"community standards of fairness which deter firms from exploiting excess demand ... are most effective when these standards are backed up by a willingness on the part of the customers ... to pay some cost to avoid unfair transactions and unfair firms" (Knetsch et al., 1986(b), p. S287).

In theory, should fans perceive current prices to be unfair then this would be reflected in attendance. If this is the case, then we would expect a somewhat different form of the attendance equation.

$$S\text{Attend}_t = \sum_{g=1}^N f(X_{gt}; \alpha; P_{t,\tau-1}; P_{t,\tau} - P_{t,\tau-1}) \quad (1')$$

where τ is the time period so $P_{t,\tau-1}$ is last years price for team t , and $P_{t,\tau} - P_{t,\tau-1}$ (or ΔP) is the change in price from last season for team t .

Whether or not previous prices and changes in prices affect demand in different ways, can be tested by imposing specific restrictions on the coefficients of the variables $P_{t,\tau-1}$ and ΔP . A test of these restrictions can be used to determine whether fans employ a reference price ($P_{t,\tau-1}$) in judging current prices as fair or unfair. In other words when hockey fans judge prices to be unfair, does this in turn affect their attendance at hockey games? Strictly, this does not serve as a test of a particular pricing hypothesis, but it does indicate whether the perception of fairness affects attendance.

2.1.4 Fairness in Pricing III

Assuming that last year's price ($P_{t,\tau-1}$) affects perceived fairness, then presumably teams will take this into account when they determine current prices. Specifically, for revenue maximizing teams this entails choosing the optimal change in price (ΔP) to maximize.

$$S\text{Revenue}_t = P_t * (\sum_{g=1}^N f(X_{gt}, \alpha, P_{t,\tau-1}, \Delta P_t))$$

As before, the price equation can be derived from the first order conditions. However, in this instance the dependent variable will be ΔP_t rather than the price level P_t . This implies that change in price is on the

left hand side of the price equation while last years price is on the right.

$$\Delta P = f(Z, \beta, P_{t, t-1})$$

As in the case of the original revenue maximization model, the derivation of the price equation involves the formation of cross equation restrictions. The β 's and Z 's of the price equation (ΔP) are derived from the α 's and X 's of the attendance equation. Tests of the coefficient restrictions on the β 's can be used to determine whether revenue maximizing ticket pricing is constrained by the fans' perceptions of fairness.

All four of these theoretical models will be developed into explicit testable forms later in this chapter. Prior to this however, it is necessary to discuss two elements which have an impact on the models. The first element is the specific testing and estimating procedure used, and the second is the data set used in the estimation. Each of these will be examined before proceeding to the specification of the models.

2.2 The Testing Procedure

The combination of full information maximum likelihood estimation with the likelihood ratio test provides the appropriate vehicle for the analysis of the pricing hypotheses. Maximum likelihood estimation yields consistent estimators and allows for nonlinearity in the parameters.

Generally, iterative optimization of the maximum likelihood function of the nonlinear system follows a gradient search pattern (Hill et al., 1980, p. 145). Once the functional form has been specified, a vector of appropriate coefficient starting values is designated. The likelihood function is evaluated and an appropriate step size and direction, for the parameter values, is chosen. The step size is vital to finding the solution because too small a step would be inefficient, and too large a step might jump right over the peak and miss the maximum. After the new parameter values have been obtained, the likelihood function is again evaluated and the change in the parameter values is compared against some convergence criterion. If the convergence criterion is met then a maximum is assumed to have been achieved, but if not then the iterative search for a maximum continues.

The optimum likelihood function value is reported as the log of the likelihood function. This value is directly applicable to the likelihood ratio test. Formally:

$$V_{LR} = 2(LL_{ur} - LL_r)$$

is distributed⁴ as a χ^2_J where:

V_{LR} is the value of likelihood ratio test statistic

LL_{ur} is the log likelihood value of the unrestricted system

LL_r is the log likelihood value of the restricted system and

J is the number of restrictions resulting from the model specification.

The likelihood ratio test is specifically designed to test whether coefficient restrictions bind or not. An unrestricted system is compared to a restricted one with a significant difference in their log likelihood values indicating that the restrictions do not bind. It is apparent, however, that the likelihood ratio test requires the further estimation of an unrestricted system to compare with the restricted system. These unrestricted systems will be explicitly specified in the fourth section of this chapter. Before this, the next section

4. The likelihood ratio test statistic is distributed as a χ^2 distribution with degrees of freedom equal to the number of restrictions specified in the model. For proof see Amemiya, 1985, pp. 111-123.

will outline the data set that will be used for the empirical analysis of the pricing hypotheses.

2.3 The Data

The data set used here consists of three seasons (1981-1983) of game by game data for the NHL.⁵ The data contain information on price, attendance, team attributes, locational characteristics and the scheduling of games.⁶ More specifically, the following variables will be used⁷:

- attend_{gt} - the game attendance for home team (t)
- htrl_{gt} - the league ranking (1-21) of the home team before the game.
- vtrl_{gt} - the league ranking (1-21) of the visiting team before the game.
- pldq4_{gt} - a variable based upon the point spread between teams vying for a playoff spot in the fourth quarter of the season.
- starvt_{gt} - the number of stars on the visiting team
- starht_t - the number of stars on the home team

5. This data set is an extended data set from that which was used in Ferguson and Jones (1988).

6. The data set involves 2520 observation and hence its attachment is precluded, although a copy is available upon request.

7. See Jones (1984) or Jennet et al. (1986) for a discussion of why these particular variables are used.

- skatevt_{gt} - a dummy variable classifying the visiting team as a skating team
- fightvt_{gt} - a dummy variable differentiating a visiting team as a fighting team
- skateht_t - a dummy designating the home team as a skating team
- fightht_t - a dummy variable qualifying the home team as a fighting team.
- can_t - a dummy variable which is one if the home team is in a Canadian city and zero otherwise.
- day_{gt} - a dummy variable differentiating between weekend and weekday games, 1 if it's a weekend game.
- inc_t - the average per capita income of the inhabitants of the home team's city.
- pop_t - the population of the pertinent city.
- p_t - the average seasonal price of tickets for the home team

Those variables subscripted with a "gt" vary from game to game for home team (t), whereas the other variables are based on single observations for each season.

2.3.1 Data Considerations

There are certain aspects of this data set which may affect either the appropriate specification of the models, or the data used for estimation, or both. These will be discussed below.

Structural Changes

Over the time period of this data set there were three structural changes of note. In 1981 the Detroit Red Wings moved from the Olympia to the Joe Louis Arena. Also in 1981, the Colorado Rockies moved to New Jersey and became the Devils, and in 1982 the Calgary Flames moved from the Corral to the Saddledome. The impact of structural changes on a particular model estimation will be evaluated by breaking down the data set into subsamples corresponding with the structural changes. Significant changes in the estimations from one subsample to the next might indicate the importance of the structural change.

Outlying Observations

Some values of certain variables may be considerably outside the normal range of values for that variable. Although it is important to have data variation these outlying values may affect the estimation results disproportionately. Examples within this data set are the average season prices for the Calgary Flames which in the 1981 and 1982 seasons were \$1983 and \$2363 respectively. These prices are more than double the mean of the prices for all the other teams. The effect which these observations have on the estimation results will be

accorded due consideration in the estimation of the models.

Insufficient Data Variation

Should the estimation of a particular model produce a large negative log likelihood value, then this is a possible indication of insufficient variation in the data. For example, it can be shown that in the general multivariable single equation case that the computed value of the log likelihood function is as follows:

$$LL = - n/2 (\log(\pi) + 1 + \log(((Y-X\beta)'(Y-X\beta))/n))^8$$

In the polar case when all observations are replicated q times then:

$$LL = - qn/2 (\log(\pi) + 1 + \log(q((Y-X\beta)'(Y-X\beta))/qn))$$

which in turn equals:

$$= q(-n/2 (\log(\pi) + 1 + \log(((Y-X\beta)'(Y-X\beta))/n)))$$

It follows that when the estimated log likelihood value is negative without replication, that the estimated log likelihood value will be q times larger in absolute value when complete replication of the data exists. Therefore, in as much as replication is an extreme case of insufficient variation in the data, the large negative

8. The meaning of the notation used here can be found in any elementary econometric textbook (see for example Pindyck and Rubinfeld, 1981, p.101). Specifically, LL is the value of the log likelihood function and log represents the natural logarithm.

log likelihood values in Table III of Chapter 3 might be a result of insufficient variation in the data.

A closer examination of the team, season and game to game observations in the data reveals several potential sources of insufficient data variation. These possible variation problems can be divided into two separate categories. The first category involves an apparent lack of variability in certain key city variables from season to season. The second category involves the potential lack of variation among the game to game observations within a season. Each of these categories will be discussed separately.

It should be noted, however, that the large negative log likelihood values in Table III could also be a symptom of a misspecified model. Validation of model specification error would require the development of specification tests specific to the models in this study. These tests, however, are beyond the scope of a primarily methodological paper. In as much as the issue is how to best specify a model for a particular data set, then the issue is given some attention in Chapter 3⁹.

9. More specifically, some of the models are estimated using two different specifications using a variety of different subsamples of the data. This might be viewed as a preliminary investigation of the most appropriate model specification for each pricing hypothesis.

Season to Season Variation

The values of some variables like population and income do not vary much over the course of the three year data set (see Appendix Table A). This could lead to some serious estimation difficulties, such as the inability to achieve a global maximum of the likelihood function, or a lack of confidence in the likelihood ratio test statistics.

A possible method of evaluating this potential source of insufficient data variation is to break the data down into two season subsamples, and estimate each model with each of these subsamples. A substantial difference between the results of estimating a particular model using the full three season data set, and the results from estimating the same model with a two season subsample might indicate a lack of data variation between the seasons.

Game to Game Variation

There are two potential sources of insufficient variation in the game to game observations. First, certain important game to game exogenous variables like

home team rank do not necessarily change much over the course of a season. Second, and perhaps more importantly, the endogenous price variable does not vary from game to game at all. This is particularly significant as the estimation of the price and attendance equations, discussed in section I, implicitly requires that both equations have the same number of observations. Here, however, there are 2520 observations for the attendance variable and only sixty-three observations of the price variable.

One possible method of testing for the existence of insufficient game to game variation involves estimating an alternative form of the model based on single observations for each team in each season. A substantial difference in the estimation results between a particular model using game to game observations, and one using season observations, might indicate the presence of insufficient game to game variation in the data. The specific form of these alternative models will be discussed more thoroughly in the following section.

2.4 The Models

The remainder of this chapter is devoted to the formation of appropriate models of the profit maximization and fairness in pricing hypotheses. The models discussed here are particular implementations of the theoretical models outlined in section I of this chapter. Throughout this section each system of a particular attendance and price equation will be denoted with a letter.

As discussed in section II the likelihood ratio test requires estimating the models in both their restricted and unrestricted forms. As a result both models will be presented.

2.4.1 Revenue Maximization

Game by Game Attendance System

Throughout, it will be assumed that the attendance function is linear with:¹⁰

10. The particular model specifications chosen here are well supported in the literature (see for example Jennet et al., 1986)

$$\begin{aligned}
\text{attend}_{gt} = & \alpha_0 + \alpha_1 \cdot \text{htrl}_{gt} + \alpha_2 \cdot \text{vtrl}_{gt} + \alpha_3 \cdot \text{pldq4}_{gt} \\
& + \alpha_5 \cdot \text{starvt}_{gt} + \alpha_6 \cdot \text{starht}_t + \alpha_7 \cdot \text{skatevt}_{gt} \\
& + \alpha_8 \cdot \text{fightvt}_{gt} + \alpha_9 \cdot \text{skateht}_t + \\
& \alpha_{10} \cdot \text{fightht}_t + \alpha_{11} \cdot \text{day}_{gt} + \alpha_{12} \cdot \text{can}_t + \\
& \alpha_{13} \cdot \text{inc}_t + \alpha_{14} \cdot \text{pop}_t - \alpha_{15} \cdot p_t \quad (3)
\end{aligned}$$

Seasonal attendance is:

$$\begin{aligned}
S\text{Attend}_t = & \alpha_0 + \sum_{g=1}^N \alpha_1 \cdot \text{htrl}_{gt} + \sum_{g=1}^N \alpha_2 \cdot \text{vtrl}_{gt} \\
& + \sum_{g=1}^N \alpha_3 \cdot \text{pldq4}_{gt} + \sum_{g=1}^N \alpha_5 \cdot \text{starvt}_{gt} + \\
& \alpha_6 \cdot \text{starht}_t + \sum_{g=1}^N \alpha_7 \cdot \text{skatevt}_{gt} + \\
& \sum_{g=1}^N \alpha_8 \cdot \text{fightvt}_{gt} + \alpha_9 \cdot \text{skateht}_t + \\
& \alpha_{10} \cdot \text{fightht}_t + \sum_{g=1}^N \alpha_{11} \cdot \text{day}_{gt} + \alpha_{12} \cdot \text{can}_t + \\
& \alpha_{13} \cdot \text{inc}_t + \alpha_{14} \cdot \text{pop}_t - \alpha_{15} \cdot p_t
\end{aligned}$$

from which we obtain:

$$\text{Seasonal revenue}_t = p_t * S\text{attend}_t$$

The solution to the first order condition for a revenue maximum yields the revenue maximizing price equation:

$$\begin{aligned}
p_t = & (\alpha_0 + \alpha_1*ahtrl_t + \alpha_2*avtrl_t + \alpha_3*apldq4_t + \\
& \alpha_5*astarvt_t + \alpha_6*starht_t + \alpha_7*askatevt_t + \\
& \alpha_8*afightvt_t + \alpha_9*skateht_t + \alpha_{10}*fightht_t \\
& + \alpha_{11}*aday_t + \alpha_{12}*can_t + \alpha_{13}*inc_t + \\
& \alpha_{14}*pop_t)/2\alpha_{15}
\end{aligned}$$

The combination of this equation with equation (3) forms system (A) for estimation purposes. A comparison of the equations within system (A) quickly reveals the form of the cross equation restrictions implied by revenue maximization¹¹.

Our testing procedure, the likelihood ratio test, requires the estimation of an unrestricted system. This unrestricted system removes all of the restrictions present in system (A). Specifically this unrestricted system is:

$$\begin{aligned}
Attend_{gt} = & \alpha_0 + \alpha_1*htrl_{gt} + \alpha_2*vtrl_{gt} + \alpha_3*pldq4_{gt} + \\
& \alpha_5*starvt_{gt} + \alpha_6*starht_t + \alpha_7*skatevt_{gt} \\
& +\alpha_8*fightvt_{gt} + \alpha_9*skateht_t + \alpha_{10}*fightht_t \\
& +\alpha_{11}*day_{gt} + \alpha_{12}*can_t + \alpha_{13}*inc_t + \\
& \alpha_{14}*pop_t - \alpha_{15}*p_t
\end{aligned}$$

(B)

11. Throughout the specification of the models, the prefix "a" before a variable indicates the mean of that variable for a season.

$$\begin{aligned}
 p_t = & \beta_0 + \beta_1*ahtrl_t + \beta_2*avtrl_t + \beta_3*apldq4_t + \\
 & \beta_5*astarvt_t + \beta_6*starht_t + \beta_7*askatevt_t + \\
 & \beta_8*afightvt_t + \beta_9*skateht_t + \beta_{10}*fightht_t + \\
 & \beta_{11}*aday_t + \beta_{12}*can_t + \beta_{13}*inc_t + \beta_{14}*pop_t
 \end{aligned}$$

The null hypothesis is that the fourteen coefficient restrictions in system (A) hold. This implies that the log of the likelihood value from the revenue maximization system (A), will not differ significantly from the log of the likelihood value in the unrestricted system (B). The likelihood ratio test statistic will be the criterion for accepting or rejecting the null hypothesis.

The Average Attendance System

There are several interrelated reasons for estimating the revenue maximization system using season observations. Firstly the results in the next Chapter would seem to suggest that there is insufficient variation in the game to game observations. Secondly, it is difficult to discuss the meaning of the estimation results using game to game observations when prices do not vary over the course of a season. Ostensibly such an estimation involves replicating each price observation 40 times over the course of a season. Finally, there is an

intuitive appeal in forming a model, of a particular ticket pricing hypothesis for the NHL, which can be estimated with season observations. Ticket prices in the NHL are only set once a year. It is more likely the case that this one price per season is based on information from the whole season than on the information from individual game to game fluctuations over the course of a season.

One method of forming such a model is to reduce the attendance equation to 63 observations by using average attendance data. This implies that the those exogenous variables which vary from game to game would have to be averaged as well.¹² This altered model formation follows logically from the season attendance equation specified earlier.

The use of an average attendance equation not only reduces the number of observations for the attendance equation, but it also has an impact on the relevance of certain variables in that equation. In particular, variables which primarily influence game to game

¹² This does not violate an a priori restriction on functional form because a correct attendance equation specification does not exist. If anything, this functional form allows greater freedom by allowing simpler formation of systems with nonlinear attendance equations. Further, this adjustment has great potential for use in a reduced data set.

variations in attendance tend to balance out over an entire season. Appropriately, it is possible to omit all the variables from equation (3)¹³ which were subscripted with a "gt".

It follows that the appropriate form of the revenue maximization system using average attendance is:

$$a\text{Attend}_t = \alpha_0 + \alpha_1\text{ahtrl}_t + \alpha_2\text{inc}_t + \alpha_3\text{pop}_t + \\ \alpha_4\text{can}_t - \alpha_5p_t$$

(C)

$$p_t = (\alpha_0 + \alpha_1\text{ahtrl}_t + \alpha_2\text{inc}_t + \alpha_3\text{pop}_t + \\ \alpha_4\text{can}_t)/2\alpha_5$$

There are five coefficient restrictions in the above system. The unrestricted system for hypothesis testing is:

$$a\text{Attend}_t = \alpha_0 + \alpha_1\text{ahtrl}_t + \alpha_2\text{inc}_t + \alpha_3\text{pop}_t + \\ \alpha_4\text{can}_t - \alpha_5p_t$$

(D)

$$p_t = \beta_0 + \beta_1\text{ahtrl}_t + \beta_2\text{inc}_t + \beta_3\text{pop}_t + \beta_4\text{can}_t$$

13. The variable htrl was not omitted because it was seen as a vital proxy of home team quality. Further, the removal of skatevt and fightvt, effectively connotes the elimination of skateht and fightht as these variables work in combination to proxy the playing style of a particular game.

Comparison of the estimation results from (E) and (F) forms the basis of the likelihood ratio test statistic for these models.

2.4.2 Fairness in Pricing I

Proceeding from the theoretical framework of section I, a cost plus pricing model suggests that demand is immaterial in pricing decisions. Variables which influence attendance at hockey games, but which have no bearing on the home team's cost are not included in the price equation. The endogenous price variable in the system, therefore, is strictly a function of those variables which may have an effect on a team's cost. The following variables are included in the proposed cost plus pricing model:

Ahtrl - In discussion with Mr. Ringdahl he implied that a positive correlation existed between winning and player costs. Further, as Noll (1974 p27) points out, team salaries are likely to go up after a winning season. Increases in team member salaries could lead to rising ticket prices, in an effort to maintain the appropriate cost plus markup.

Skateht - It is assumed that if a team is considered more of a skating team the salaries for the players increase. Players more likely to accumulate penalty minutes and help designate their teams as fighting teams often do not command high salaries. Agents often market their players on the basis of their goal production and not on their penalty minutes.¹⁴

Starht - The more stars a team has the higher the salaries for these players.¹⁵

Pop - Bigger centres often have higher rent or more expensive real estate in the downtown areas where hockey arenas are typically located, thus increasing arena costs. Also the cost of living is higher and this might be expressed in salaries.

Can - Canadian hockey teams may have different outlays than American ones. There may be differences in taxes¹⁶ or just in weather (heating bills). As a reflection of cost this variable could prove to be significant.

14 An example is the free agent negotiations with Steve Thomas, then of the Toronto Maple Leafs. See "Talks Continue as Leafs Dicker with Thomas", Globe and Mail, June 9, 1987, p.D3.

15 See "Lemieux Given Huge Pay Raise", Globe and Mail, Nov. 30, 1988, p.A14.

16 See Kennedy and Williamson, 1979, p.319 for a discussion of the still lucrative tax havens for professional sports teams in the United States.

Inc - The per capita income is an important proxy for wage inflation.

The system formed with a game by game attendance equation and incorporating the above variables is:

$$\begin{aligned} \text{Attend}_t = & \alpha_0 + \alpha_1 \cdot \text{htrl}_t + \alpha_2 \cdot \text{vtrl}_t + \alpha_3 \cdot \text{pldq4}_t \\ & \alpha_5 \cdot \text{starvt}_t + \alpha_6 \cdot \text{starht}_t + \alpha_7 \cdot \text{skatevt}_t + \\ & \alpha_8 \cdot \text{fightvt}_t + \alpha_9 \cdot \text{skateht}_t + \alpha_{10} \cdot \text{fightht}_t + \\ & \alpha_{11} \cdot \text{day}_t + \alpha_{12} \cdot \text{can}_t + \alpha_{13} \cdot \text{inc}_t + \alpha_{14} \cdot \text{pop}_t \\ & - \alpha_{15} \cdot p_t \end{aligned}$$

(E)

$$\begin{aligned} p_t = & \beta_0 + \beta_1 \cdot \text{htrl}_t + \beta_2 \cdot \text{starht}_t + \beta_3 \cdot \text{skateht}_t \\ & + \beta_4 \cdot \text{can}_t + \beta_5 \cdot \text{inc}_t + \beta_6 \cdot \text{pop}_t \end{aligned}$$

The price equation incorporates those variables associated with the cost plus pricing assumption, while the use of the β coefficients indicates no relationship, within the system, between price and attendance. The unrestricted system for use in the likelihood ratio test is simply system (B) from the revenue maximization model. For the cost plus pricing model there are seven restrictions as the coefficients for vtrl, skatevt, fightvt, day, fightht, pldq4, and starvt have all been explicitly set to zero.

Analogously to the revenue maximization model the cost plus pricing model will also be estimated using season observations. Appropriately this entails forming a model with an average attendance equation.

$$\begin{aligned}
 a\text{Attend}_t = & \alpha_0 + \alpha_1 \cdot a\text{htrl}_t + \alpha_2 \cdot a\text{vtrl}_t + \alpha_3 \cdot a\text{pldq4}_t \\
 & \alpha_5 \cdot a\text{starvt}_t + \alpha_6 \cdot a\text{starht}_t + \alpha_7 \cdot a\text{skatevt}_t + \\
 & \alpha_8 \cdot a\text{fightvt}_t + \alpha_9 \cdot a\text{skateht}_t + \alpha_{10} \cdot a\text{fightht}_t \\
 & + \alpha_{11} \cdot a\text{day}_t + \alpha_{12} \cdot a\text{can}_t + \alpha_{13} \cdot a\text{inc}_t + \\
 & \alpha_{14} \cdot a\text{pop}_t - \alpha_{15} \cdot p_t
 \end{aligned}$$

(F)

$$\begin{aligned}
 p_t = & \beta_0 + \beta_1 \cdot h\text{trl}_t + \beta_2 \cdot s\text{tarht}_t + \beta_3 \cdot s\text{kateht}_t \\
 & + \beta_4 \cdot c\text{an}_t + \beta_5 \cdot i\text{nc}_t + \beta_6 \cdot p\text{op}_t
 \end{aligned}$$

The corresponding unrestricted system is:

$$\begin{aligned}
 a\text{Attend}_t = & \alpha_0 + \alpha_1 \cdot a\text{htrl}_t + \alpha_2 \cdot a\text{vtrl}_t + \alpha_3 \cdot a\text{pldq4}_t + \\
 & \alpha_5 \cdot a\text{starvt}_t + \alpha_6 \cdot a\text{starht}_t + \alpha_7 \cdot a\text{skatevt}_t \\
 & + \alpha_8 \cdot a\text{fightvt}_t + \alpha_9 \cdot a\text{skateht}_t + \alpha_{10} \cdot a\text{fightht}_t \\
 & + \alpha_{11} \cdot a\text{day}_t + \alpha_{12} \cdot a\text{can}_t + \alpha_{13} \cdot a\text{inc}_t + \\
 & \alpha_{14} \cdot a\text{pop}_t - \alpha_{15} \cdot p_t
 \end{aligned}$$

(G)

$$\begin{aligned}
 p_t = & \beta_0 + \beta_1 \text{ahtrl}_t + \beta_2 \text{avtrl}_t + \beta_3 \text{apldq4}_t + \\
 & \beta_5 \text{astarvt}_t + \beta_6 \text{starht}_t + \beta_7 \text{askatevt}_t + \\
 & \beta_8 \text{afightvt}_t + \beta_9 \text{skateht}_t + \beta_{10} \text{fightht}_t \\
 & + \beta_{11} \text{aday}_t + \beta_{12} \text{can}_t + \beta_{13} \text{inc}_t + \\
 & \beta_{14} \text{pop}_t
 \end{aligned}$$

It is evident, however, that this system based on an average attendance equation can not be estimated omitting those variables which might be superfluous to such a specification¹⁷. Potentially, therefore, this model might contain several redundant variables. The significance of this overspecification will be considered in the next chapter.

2.4.3 Fairness in Pricing II

The linear reduced form¹⁸ of the attendance equation corresponding to (1') is:

$$\begin{aligned}
 \text{aAttend}_t = & \alpha_0 + \alpha_1 \text{ahtrl}_t + \alpha_2 \text{inc}_t + \alpha_3 \text{pop}_t + \\
 & \alpha_4 \text{can}_t - \alpha_6 P_{t, \tau-1} - \alpha_7 \Delta P \quad (4)
 \end{aligned}$$

¹⁷ There would be no restrictions between the restricted and the unrestricted equations.

¹⁸ This form of the attendance equation was chosen because the results in Chapter 3 seem to suggest that this is the most appropriate specification.

The significance of past prices on attendance can be estimated by imposing restrictions on α_6 and α_7 . Specifically when $\alpha_6 = \alpha_7$ the attendance equation becomes:

$$a\text{Attend}_t = \alpha_0 + \alpha_1 \text{ahtrl}_t + \alpha_2 \text{inc}_t + \alpha_3 \text{pop}_t + \alpha_4 \text{can}_t - \alpha_7 p_t \quad (5)$$

This is identical to the average attendance equation in the revenue maximization system (C). This restriction eliminates the reference price $P_{t, \tau-1}$ as a determinant of demand. Using OLS techniques if equation (5) is not significantly different from (4) then past prices are a determinant of average seasonal attendance.

2.44 Fairness in Pricing III

Assuming α_6 is significantly different from α_7 then past prices have an impact on attendance. This section seeks to investigate to what extent this constrains revenue maximizing behaviour.

The season revenue equation is:

$$\begin{aligned} \text{Srevenue}_t = & p_{t,\tau} * (\alpha_0 + \alpha_1 \text{ahtrl}_t + \alpha_2 \text{inc}_t + \alpha_3 \text{pop}_t \\ & + \alpha_4 \text{can}_t - \alpha_6 P_{t,\tau-1} - \alpha_7 \Delta P_{t,\tau}) \end{aligned}$$

The first order condition for choosing $\Delta P_{t,\tau}$ to maximize season revenue yields the optimal price change equation and the following system:

$$\begin{aligned} \text{aAttend}_t = & \alpha_0 + \alpha_1 \text{ahtrl}_t + \alpha_2 \text{inc}_t + \alpha_3 \text{pop}_t + \\ & \alpha_4 \text{can}_t - \alpha_6 P_{t,\tau-1} - \alpha_7 \Delta P_{t,\tau} \end{aligned} \quad (\text{H})$$

$$\begin{aligned} \Delta P_{t,\tau} = & (\alpha_0 + \alpha_1 \text{ahtrl}_t + \alpha_2 \text{inc}_t + \alpha_3 \text{pop}_t + \\ & \alpha_4 \text{can}_t - (\alpha_6 + \alpha_7) P_{t,\tau-1}) / 2\alpha_7 \end{aligned}$$

The associated unrestricted system used in the likelihood ratio test statistic is:

$$\begin{aligned} \text{aAttend}_t = & \alpha_0 + \alpha_1 \text{ahtrl}_t + \alpha_2 \text{inc}_t + \alpha_3 \text{pop}_t + \\ & \alpha_4 \text{can}_t - \alpha_6 P_{t,\tau-1} - \alpha_7 \Delta P_{t,\tau} \end{aligned} \quad (\text{I})$$

$$\begin{aligned} \Delta P_{t,\tau} = & \beta_0 + \beta_1 \text{ahtrl}_t + \beta_2 \text{inc}_t + \beta_3 \text{pop}_t + \beta_4 \text{can}_t \\ & - \beta P_{t,\tau-1} \end{aligned}$$

If the estimated log likelihood value from system (H) is not significantly different from that of system (I), then this implies that past prices act as a constraint on revenue maximizing behaviour. Further, in as much as fair price pronouncements are largely determined by last

year's prices, it can be argued that an acceptance of this null hypothesis is validation of the fairness in pricing hypothesis.

2.5 Summary

" ... given a more sharply focused perspective, economists should be able to provide a more informed discussion of price setting" (Jennet et al., 1986, p.24)

The intent of this chapter was to provide a concrete framework for testing the ability of two different hypotheses to explain actual ticket pricing behaviour. Although the framework developed in this chapter is specifically applied to the NHL, the general methodology is equally valid for analyzing the pricing mechanism in other markets¹⁹.

The results of the empirical testing procedure, using data from the NHL, will be reported in the following chapter. For reference purposes Table I on the next page

19. For example simple demand systems, with the price equation formed on the basis of a particular pricing hypothesis, could be employed to analyze the pricing mechanism in other professional sports markets, or even the pricing mechanism for cabbage patch kids.

summarizes each model and the associated systems as specified in this chapter.

Table I
Summary of Models for the Pricing Hypotheses

Model	System	
	Restricted	Unrestricted
<u>Revenue Maximization</u>		
(i) Game by Game	A	B
(ii) Average Attend.	C	D
<u>Fairness I</u>		
(i) Game by Game	E	B
(ii) Average Attend.	F	G
Fairness II ²⁰	(4)	(5)
Fairness III	H	I

²⁰. The estimation of this model only involves equations, and not systems.

Chapter 3

THE STATISTICAL RESULTS

This chapter presents the empirical analysis of the pricing hypotheses utilizing the framework developed in the previous chapter. The models of the pricing hypotheses are statistically evaluated using the likelihood ratio test. These statistics are found in Tables II, IV and VII in this chapter. The log likelihood values obtained from estimating the restricted and unrestricted models, are the essential components of the likelihood ratio test statistics¹. The log likelihood values for some of the model estimations are also presented where relevant in this chapter. The order of presentation of the statistical results for each model coincides with the order of model presentation in the previous chapter.

1. The credibility of the likelihood ratio test statistics is, therefore, directly dependent upon the rigor imposed on the estimation of the models, which produce the log likelihood values. Standard practices, for assuring that a particular log likelihood value was a global maximum of the likelihood function, were followed throughout this study. See Hill et al., 1980, pp.743-745, for a general discussion of this approach.

3.1 Revenue Maximization

Table II contains the likelihood ratio test statistics for the systems representing the revenue maximization pricing hypothesis. The specific systems being tested here are associated with (A) - (D) in the previous chapter. At the bottom of Table II are the χ^2 critical values at the $\alpha = .01$ and $\alpha = .05$ level of significance. Table III contains the log likelihood value associated with each estimation.

Formally the null hypothesis to be tested for the systems using game by game attendance (gt) is:

$H_{0_{gt}}$ The fourteen coefficient restrictions in (A), resulting from the assumption of revenue maximizing ticket pricing, hold. This implies that the log of the likelihood value from estimating the system (A) is not significantly different from the log of the likelihood value from estimating system (B).

For the system formed using average attendance(a) the null hypothesis is:

H_{0a} : The five coefficient restrictions in system (C) hold. For the likelihood ratio test this implies that the log of the likelihood value from estimating a system (C) is not significantly different from the log of the likelihood value of the unrestricted system (D).

For both systems not rejecting the null hypothesis at the chosen χ^2 critical values would provide direct statistical support for the revenue maximizing pricing hypothesis. Asterisks in Table II represent situations where the null hypothesis is not rejected.

It is apparent, however, that Table II is devoid of any asterisks. This consistent rejection of the null hypotheses suggests the rejection of the revenue maximizing ticket pricing hypothesis for the 1981-1983 NHL seasons. However, a likelihood ratio statistic of 10704 for the full data set game by game attendance system compared to a critical value of 32.8, could be symptomatic of problems other than a failure of the hypothesis. More suspiciously, there is large difference between the likelihood ratio statistics for the game by game attendance system and the average attendance system. These differences seem to be further highlighted in Table

III containing the associated estimated log likelihood values for these systems.

Table II
Likelihood Ratio Test Statistics For the Revenue
Maximization Systems

System Type by 2 and 3 season combinations	Full data set	Without Calgary	Without Sellouts
<u>All 3 Seasons</u>			
Game by Game Attend. †	10704	11196	9014
Avg. Season Attend. ††	26	24	28
<u>Seasons 1 & 2</u>			
Game by Game Attend.	7204	7632	6594
Avg. Season Attend	20	16	22
<u>Seasons 2 & 3</u>			
Game by Game Attend.	6000	8336	6490
Avg. Season Attend.	18	20	40
<u>Seasons 1 & 3</u>			
Game by Game Attend.	7758	8196	6104
Avg. Season Attend.	20	18	28

- * - H_{0gt} is accepted at $\chi^2(14, .01) = 30.58$
 ** - H_{0gt} is accepted at $\chi^2(14, .05) = 24.99$
 *** - H_{0a} is accepted at $\chi^2(5, .01) = 15.09$
 **** - H_{0a} is accepted at $\chi^2(5, .05) = 11.07$

†. N = 2520 observations for all three seasons, and N = 1680 for any two season combination, these numbers are accordingly reduced as Calgary and those teams which regularly sell out are left out of some estimations.

††. N = 63 observations for all three seasons, and N = 42 for any two season combination of the data, these numbers are accordingly reduces as Calgary and those teams which regularly sell out are left out of some observations.

Table III
The Log Likelihood Values Associated With Table II

System Type by 2 and 3 season combinations [‡]	Full data set	Without Calgary	Without Sellouts
=====			
<u>All 3 Seasons</u>			
Game by Game Attend			
restricted (A)	-44769	-42419	-31858
unrestricted (B)	-39417	-36821	-27351
Avg. Season Attend			
restricted (C)	-993	-919	-693
unrestricted (D)	-980	-907	-679
=====			
<u>Seasons 1 & 2</u>			
Game by Game Attend			
restricted	-29719	-28149	-21347
unrestricted	-26117	-24333	-18050
Avg. Season Attend			
restricted	-664	-610	-455
unrestricted	-654	-602	-444
=====			
<u>Seasons 2 & 3</u>			
Game by Game Attend			
restricted	-29109	-29062	-21289
unrestricted	-26109	-24894	-18044
Avg. Season Attend			
restricted	-660	-612	-463
unrestricted	-651	-602	-443
=====			
<u>Seasons 1 & 3</u>			
Game by Game Attend			
restricted	-29854	-29029	-21260
unrestricted	-25975	-24931	-18208
Avg. Season Attend			
restricted	-659	-615	-463
unrestricted	-649	-606	-449

[‡] The particular system being estimated is specified in
() where relevant in this table.

Each particular model was estimated using a variety of different subsamples of the data in response to the data considerations raised in Chapter 2. The results here suggest that these may warrant closer examination.

It was suggested in Chapter 2 that observations involving Calgary as a home team might be viewed as outliers. These observations were left out of some estimations to help remove any disproportionate effect on the estimation results that these observations might present. The results in Tables II and III would suggest that including the Calgary observation does not disproportionately alter the results.

Teams which consistently verged on the attendance capacity constraint were left out of some estimations because the models do not adequately capture the capacity constraint². It is apparent in Table III that the omission of these teams from the estimations consistently raised the log of the likelihood values. This did not however, make any statistical difference for the pricing hypotheses, as the null hypothesis is rejected throughout Table II.

2. It could be argued that omitting these observations should favor the acceptance of the revenue maximization hypothesis as these are the teams most likely to be constrained by fairness considerations.

It was also suggested in Chapter 2 that the large negative log likelihood values of the game by game attendance system might be attributable to insufficient variation in the data³. The two most likely sources of any insufficient data variations are in the season to season observations over the three season data set, and in the game to game observations over a particular season.

The possibility of insufficient variation in the data from season to season was evaluated by estimating the models using two season subsamples of the data. The log likelihood values in Table III indicate that an inverse relationship exists between sample size and log likelihood value⁴. This offers some support for the suspicion of insufficient data variation from season to season. It might be the case that reducing the sample size increases the variation in the data, and hence raises the log likelihood value.

3. It was difficult to evaluate this assertion as no reference of similar log likelihood values was found in previous studies, see Cramer (1986), Hill et al. (1985) and Goldfield and Quandt (1976).

4. It is also possible that this relationship is a result of structural changes in the NHL, and as such an improvement in model specification. It is doubtful, however, that these results are just a coincidence of estimation.

A more obvious source of insufficient variation in the data would seem to be in the game to game observations. The existence of insufficient game to game variation in the data might account for the astounding differences between the estimation results of the average attendance system, and the game by game attendance system. It is probably no coincidence that the magnitude of the log likelihood values rose by about a factor of forty when the number of observations was reduced by a factor of forty (see discussion in Chapter 2).

Although this may mean that insufficient variation in the game to game observations exists, it is not necessarily the only explanation for the results in Tables II and III. It could also be the case that the average attendance model is a more appropriate specification, and hence produces higher log likelihood values. A more rigorous analysis is required before a more definite explanation of the results can be offered.

The statistical results here yield only a qualified rejection of the revenue maximizing pricing hypothesis for the NHL. Should future research corroborate these results using similar methodology and a larger data set⁵,

⁵ A larger data base might remove some of the suspected insufficient variation in the data. The lack of variation in the data is apparent in Appendix Table A.

then a stronger statement concerning the appropriateness of the revenue maximizing ticket pricing hypothesis for the NHL can be made.

3.2 Fairness in Pricing I

The likelihood ratio statistics of the models representing cost plus pricing form the contents of Table IV. The number of variables in the average attendance system precludes its estimation with any two season subsamples of the data. This is reflected in Table IV. The log likelihood values for these systems are contained in Table V. The specific null hypotheses being tested in Table IV are:

Game by Game Attendance system:

H_0 - The seven coefficient restrictions on the price equation of system (E) hold. For the likelihood ratio test statistic this implies that the log of the likelihood value from estimating system (E) is not significantly different from estimating the unrestricted system (B).

Average Attendance system:

H_0 - The seven coefficient restrictions in system (F) hold. This implies that the log of the likelihood value from estimating system (F) is not significantly different from that of system (G).

In many respects the estimation results for these models are similar to the results for the revenue maximization models⁶. Specifically these results would seem to further corroborate the suspicion of insufficient variation in the data. Firstly, there is an inverse relationship between the sample size and the log of the likelihood values in Table V. This could be indicative of insufficient variation in the data from season to season. Secondly, the log of the likelihood values in Table V, and the likelihood ratio test statistics in Table IV consistently illustrate a large difference in results between models estimated using game by game observations, and models estimated using season observations. It is difficult to judge, however, whether this arises from insufficient game to game variation in the data, or from an improvement in model specification.

6. This is not surprising since the unrestricted systems for the game by game attendance system is identical between the two models. It is therefore, a statistical inevitability that the log likelihood values for this cost plus pricing model be less than or equal to those values of the unrestricted model. This is easily confirmed by comparing the log likelihood values in Table V with those in Table III.

Table IV
Likelihood Ratio Test Statistics For the Cost Plus Pricing Model

System Type by 2 and 3 season combinations	Full data set	Without Calgary	Without Sellouts
<u>All 3 Seasons</u>			
Game by Game Attend. †	1588	7994	1310
Avg. Season Attend. ††	14**	14**	.3**
<u>Seasons 1 & 2</u>			
Game by Game Attend.	1710	1262	4542
<u>Seasons 2 & 3</u>			
Game by Game Attend.	1192	962	4090
<u>Seasons 1 & 3</u>			
Game by Game Attend.	1186	1140	3922

* - H_0 is accepted at $\chi^2(7, .01) = 18.48$

** - H_0 is accepted at $\chi^2(7, .05) = 14.07$

†. N = 2520 observations for all three seasons, and N = 1680 for any two season combination, these numbers are accordingly reduced as Calgary and those teams which regularly sell out are left out of some estimations.

††. N = 63 observations for all three seasons, this number is accordingly reduced as Calgary and those teams which regularly sell out are left out of some estimations.

Table V
Log Likelihood Values Associated With the Results of
Table II

System Type by 2 and 3 season combinations	Full data set	Without Calgary	Without Sellouts
<u>All 3 Seasons</u>			
Game by Game Attend			
restricted (A)	-40211	-40823	-28006
unrestricted (B)	-39417	-36826	-27351
Avg. Season Attend			
restricted (C)	-973	-899	-664.25
unrestricted (D)	-966	-892	-664.1
=====			
<u>Seasons 1 & 2</u>			
Game by Game Attend			
restricted	-26972	-24964	-20321
unrestricted	-26117	-24333	-18050
=====			
<u>Seasons 2 & 3</u>			
Game by Game Attend			
restricted	-26705	-25375	-20089
unrestricted	-26109	-24894	-18044
=====			
<u>Seasons 1 & 3</u>			
Game by Game Attend			
restricted	-26568	-25501	-20169
unrestricted	-25975	-24931	-18208

() - indicate the particular system being estimated

The main difference between the results in Tables II and those in Table IV is the presence of some asterisks in Table IV. In particular, the null hypothesis was not rejected for any of the estimations of the cost plus pricing model using average attendance.

There is however, an a priori belief that this form of the average attendance system is inappropriate. Several variables were omitted in the revenue maximization model because these variables were thought to primarily influence game to game attendance⁷. Coincidentally these are the same variables excluded from the cost plus pricing model as a result of the coefficient restrictions. If it can be shown that these variables are statistically superfluous to the model using an average attendance equation, then the importance of the failure to reject the null hypothesis in Table IV is ambiguous. The likelihood ratio test statistics in this case, could be as much a result of the misspecification of the model, as the test statistics are a result of the coefficient restrictions from the particular pricing hypothesis. As the central contribution to the literature of this study is the use of coefficient restrictions to verify particular pricing hypothesis, it is important to investigate this particular potential misspecification further.

It is possible to test the significance of these omitted variables using the likelihood ratio test

7. Over the course of a season the influence of these variables is thought to balance out. A good example of this is the average rank of the visiting team, which is probably about the same for all teams over the course of a season.

statistic as the evaluation criterion. It is simply a matter of comparing the estimation results of the unrestricted system for the cost plus pricing average attendance model (G), with the results of the unrestricted average attendance system for the revenue maximization model (D). For the likelihood ratio test statistic (D) is considered a restricted system with a number of coefficients restricted to be zero. Formally the null hypothesis to be tested is:

H_0 - The eighteen coefficients restricted to zero in system (D) hold. In terms of the likelihood ratio test statistic this implies that the log likelihood values from estimating system (D) are not significantly different from the log likelihood values from estimating system (G).

The test statistics in Table VI do not reject the null hypothesis. This supports the belief that these variable should be omitted from the average attendance system. These results suggest that the cost plus pricing average attendance system might be misspecified⁸.

8. It is impossible to re-estimate the cost plus pricing model with a more appropriate specification.

Table VI
Likelihood Ratio Test Statistics For The Most
Appropriate Specification of the System Based on the
Average Attendance Equation

System Type	Full data set	Without Calgary	Without Sellouts
<u>All 3 Seasons</u>			
Average Season Attend	28*	30**	30**

** - H_0 is accepted at $\chi^2(18, .01) = 34.81$

* - H_0 is accepted at $\chi^2(18, .05) = 28.87$

Not rejecting the null hypothesis in Table IV was likely a result of this misspecification and not of the particular pricing hypothesis. This does not mean, however, that the fairness in pricing hypothesis is rejected. Perhaps it is the case that the cost plus pricing model does not accurately represent the fairness in pricing hypothesis. If this were the case then it is the cost plus pricing model that is rejected and not the fairness in pricing hypothesis. Thaler (1985) and Knetsch et al. (1986b) would seem to agree with this assertion.

" a hypothesis that turned out to be wrong was that the community standard of fair pricing should be determined by adding a markup to the unit costs" (Knetsch et al., 1986(b), p S292).

This is one reason for forming alternative models of the fairness in pricing hypothesis.

3.3 Fairness in Pricing II

This is not a direct test of the fairness in pricing hypothesis. The result of the estimation here serves to test whether perceptions of fairness affect attendance. As such the estimation only involves the average attendance equations (4) and (5). The likelihood ratio test⁹ can still be used as the criterion for evaluation, but the estimation technique is ordinary least squares and not maximum likelihood.

The coefficient restriction of $\alpha_6 = \alpha_7$ yields the following null hypothesis.

H_0 - Since the restriction eliminates the P_{t-1} variable from equation (4) the null hypothesis is that P_{t-1} has no significant effect on attendance¹⁰. Statistically this implies that the log likelihood value of equation (4) is not

9 There are other methods for checking if the coefficient restrictions bind or not, but using this technique preserves the consistency of analysis in the study.

10. $n = 42$ observations as only the second and third observations are used in regression.

significantly different from that of equation (5).

A likelihood ratio statistic of .6¹¹ was derived from the estimation of equations (4) and (5). This is well below the critical value at $\chi^2(2, .05)$, which means the null hypothesis is not rejected.

This suggests that past prices did not significantly effect attendance in the 1982 and 1983 NHL seasons. This in no way however, denotes a rejection of the fairness in pricing hypothesis.

3.4 Fairness in Pricing III

Despite the results of the previous section, it is still feasible that NHL teams might be constrained by the concept of fairness in their current ticket pricing decisions¹². Table V contains the likelihood ratio test statistic values for evaluating whether or not fairness constrains revenue maximizing ticket pricing. The

11. The log of the likelihood value for the restricted equation was 374.3, and log of the likelihood value for the unrestricted equation was 374.

12. It may be, that fans do not necessarily have to back up their perceptions with actions. The mere threat of punishing teams which price unfairly may be sufficient to constrain the ticket pricing decisions of NHL teams.

associated log likelihood values can be found in Appendix Table B. The null hypothesis being tested is:

H_0 - The six coefficient restrictions in system (I) hold. This implies that the log of the likelihood values for the restricted system (I) is not significantly different from the estimated value of the unrestricted system (J).

Table VII
The Likelihood Ratio Test Statistics For the Fairness in Pricing III Model

System Type [‡]	Full data set	Without Calgary	Without Sellouts
<u>Seasons 2 & 3</u>			
Average Season Attend	16.5**	20	24

* - H_0 is accepted at $\chi^2(6, .01) = 12.59$

** - H_0 is accepted at $\chi^2(6, .05) = 16.81$

The null hypothesis is not rejected for the full data set at the .01 level of significance. In the other two cases the null hypothesis is rejected. These results would seem to agree with the hypothesis of fair pricing elucidated in Chapter 1. The teams whose revenue maximizing behaviour would be most constrained by

[‡] N = 42 and is reduced accordingly as Calgary and those teams which consistently sell out are left out of some estimations.

considerations of fairness are those teams that regularly sell out. Coincidentally, when these teams are included in the estimation sample the null hypothesis is not rejected.

On the basis of this rather limited data set it is difficult to assert however, that fairness prevents those teams which regularly sellout from setting ticket prices at their revenue maximizing levels. The results here suggest that continued research with a larger data base should be conducted. A data base which is large enough to test this pricing hypothesis on just those teams that sellout could prove to be a valuable contribution to determining the most appropriate pricing hypothesis in the NHL. It is possible that it is a combination of the two pricing hypotheses presented here.

3.5 Summary

The empirical test results of any econometric study are not cast in stone. It is virtually impossible to account for every distortion in the data, or to fully represent reality in a model. Are hockey ticket prices determined by motives of revenue maximization, do the

fans' perceptions of fair prices act as a pricing constraint, or is it a combination of both?

The empirical results in this study offer some support for the fairness in pricing hypothesis. These results are inconclusive, however, because two important questions have been left unanswered by the empirical analysis of this study. First, are the models in this study correctly specified? Second, was there sufficient variation in the data to obtain reliable estimates? Ultimately, therefore, the validity of the empirical results of this chapter rely on future research using a similar theoretical framework for testing pricing hypotheses.

Conclusion

This study has made two contributions to the study of pricing hypotheses. The first and most important is the development of a framework which allows for the evaluation of alternative pricing hypotheses. The general framework developed here, could be used to analyze the pricing behaviour in most markets. The specific analysis of ticket pricing behaviour in the NHL in this study, merely serves to illustrate the general applicability of the theoretical framework. The second contribution of this study to the literature might be termed as empirical legwork for future research. This section will discuss these two contributions by reviewing evidence presented in the paper.

Many economists, who have studied the economics of professional sports, are of the opinion that the primary objective of teams is to maximize profits. However, certain teams in the NHL consistently experience excess demand for their hockey games. The equilibrating mechanism, price, is not being used to balance supply with demand. This behaviour is inconsistent for a profit maximizing NHL franchise. Knetsch et al. (1986(a)) and Thaler (1985) contend that this apparent underpricing of

hockey tickets exists because fans might perceive revenue maximizing pricing as unfair.

Hitherto, neither pricing hypothesis has undergone substantial empirical evaluation. This is likely a result of not having a satisfactory methodology which could be used to empirically test these pricing hypotheses. The main contribution to the literature of this study is a theoretical framework which allows for the more direct evaluation of these two pricing hypotheses. In its general form this framework is applicable beyond the two pricing hypotheses discussed here.

Firstly, simple demand systems encompassing an attendance and a price equation were formed. The imposition of a particular pricing hypothesis created cross equational restrictions within and between the price and attendance equations. Testing whether these restrictions do or do not bind connotes a test of the particular pricing hypothesis. Suitable models were developed using this framework, and then these were empirically evaluated with three seasons of game by game data from the NHL.

The statistical results in this study suggest limited and qualified support for the fairness in pricing

hypothesis. The revenue maximization hypothesis received no empirical support in this study. Therefore, it could be concluded that NHL teams are constrained from setting ticket prices at revenue maximizing levels by considerations of fairness. This conclusion, however, is qualified because this was primarily a methodological study and not an empirical one. Specifically, there was some concern raised in this study about the correct model specification, and the existence of sufficient data variation to obtain reliable estimates. In this regard, this study may be making a contribution to future research on this subject. Should future research, using the analytical techniques described here, obtain similar statistical results, then a case can be made for the fairness in pricing hypothesis in those markets where the profit maximizing pricing hypothesis apparently fails.

It should be stressed however, that the chief contribution of this study should not be determined by the statistical test results of Chapter 3. The central contribution of this study is the provision of a framework which allows for these empirical tests to even occur.

Bibliography

- Amemiya, Takeshi, 1985, Advanced Econometrics, Harvard University Press, Cambridge, Mass.
- Bain, Joe S., 1968, Industrial Organization, John W. Wiley and Sons, Inc. New York.
- Barnes, John, 1983, Sports and the Law, Butterworths, Toronto.
- Barnes, John, 1988, Sports and the Law, Butterworths, Toronto.
- Beamish, Rob, 1982, "Sport and the Logic of Capitalism", in Sport, Culture, and the Modern State, ed by Cantelon Hart, and Richard Gruneau, University of Toronto Press, Toronto, pp. 141-197.
- Cramer, J.S., 1986, Econometric Applications of Maximum Likelihood Estimators, University Press, Cambridge.
- Eaton, B. Curtis, and David Donaldson, 1981, "Patience More than its own Reward: A Note on Price Discrimination", Canadian Journal of Economics, 14, pp. 93-105.
- Eitzen, D. Stanley, 1979, "The Business of Team Ownership", in Sport in Contemporary Society ed. by Stanley Eitzen, St. Martin's Press, New York, pp. 325-328.
- El Hodir, Mohammed, and James Quirk, 1974, "Economic Theory of Professional Sports Leagues", in Government and the Sport Business, ed by Roger Noll, Brookings Institute, Washington, pp. 33-80
- Elchin, Harvey, "Canadian fans take religion seriously", Globe and Mail, Feb. 27, 1989, p.A10.
- Ferguson, D.G., and J.C.H. Jones, 1988, "Hockey Puckes Rex, Location and Survival in the N.H.L.", Journal of Industrial Economics, 36:4, pp. 443-458.
- Goldfield, Stephen M., and R.E. Quandt, 1976, Studies in Nonlinear Estimation, Ballinger Publishing Co., Cambridge, Mass.,

- Gruneau, Richard, 1976, "Elite, Class and Corporate Power in Canadian Sport: Some Preliminary Findings", in Sociology of Sport, ed. by Ferdinand Landry and William Orban, Symposia Specialists Inc., Miami.
- Gruneau, Richard, 1980, "Power and Play in Canadian Society" in Power and Change in Canada, ed by Richard J. Ossenburg, McClelland and Stewart, Toronto
- Hall, B., R. Schnake, and C. Cummins, 1986, TSP Reference Manual, Version 4.1, TSP International.
- Henderson, James, and Richard Quandt, 1980, Microeconomic Theory: A Mathematical Approach, McGraw-Hill Book Company, New York.
- Hill, R., T. Lee, G. Judge, and W. Griffiths, 1980, The Theory and Practice of Econometrics, John Wiley and Sons, New York.
- Hill, R., T. Lee, G. Judge, and W. Griffiths, and H. Lutkepohl, 1985, The Theory and Practice of Econometrics, John Wiley and Sons, New York.
- Hsiao, Cheng, 1986, Analysis of Panel Data, Cambridge University Press, London.
- Jennet, N., J. Cairns, and P.J. Sloane, "The Economics of Professional Team Sports: A Survey of Theory and Evidence", Journal of Economic Studies, 13:1, 1986, pp. 3-80
- Johnson, Arthur, T. (ed.) , and James H. Frey (ed.), 1985, Government and Sport, Rowman and Allenheld, New Jersey.
- Jones, J.C.H., 1976, "Economics of the National Hockey League", in Canadian Sport, Sociological Perspectives, ed. by Richard Gruneau and John Albinson, Addison-Wesley, Don Mills.
- Jones, J.C.H., 1984, "Winners, Losers and Hosers: Demand and Survival in the N.H.L.", Atlantic Economic Journal, 12:3, pp.54-63.
- Jones, J.C.H., and W.D. Walsh, 1987, "The World Hockey Association and Player Exploitation in the N.H.L.", Quarterly Review of Economics and Business, 27:2. pp. 87-100.

- Kennedy, Ray and Nancy Williamson, 1979, "The Economic Benefits of Professional Team Ownership", in Sport in Contemporary Society, ed by Stanley Eitzen, St. Martin's Press, New York, pp. 312-324.
- Kenyon, Gerald S. (ed.), John W. Loy (ed.), and Barry D. McPherson (ed.), 1981, Sport, Culture, and Society, Lee and Feiberger, Philadelphia.
- Kleinbaum, D., and L. Kupper, 1978, Applied Regression Analysis and Other Multivariate Methods, Duxbury Press, Boston, Massachusetts.
- Knetsch, Jack, Daniel Kahneman, and Richard Thaler, 1986(a), "Fairness as a Constraint on Profit Seeking: Entitlements in the Market", American Economic Review, 76, pp. 728-741.
- Knetsch, Jack, Daniel Kahneman, and Richard Thaler, 1986(b), "Fairness and the Assumptions of Economics", Journal of Business, 59, pp. S285-S300.
- Knox-Levell, C.A., and Kenneth L. Wertz, 1985, "Third Degree Price Discrimination in Imperfectly Sealed Markets", Atlantic Economic Journal, 13:2, pp. 1-11.
- Koch, J, 1980, Industrial Organization, Prentice Hall, Englewood Cliffs, New Jersey.
- Lavoie, M., G. Grenier, and S. Coulombe, 1987, "Discrimination and Performance in the N.H.L." Canadian Public Policy, 13:4, pp. 407-422.
- Mason, Edward S., 1939, "Price and Production Policies of Large Scale Enterprise," American Economic Review, 29, (March Supplement), pp.61-74.
- Milner, Bruce, "Leafs mirror image of owner", Globe and Mail, Feb. 28, 1989, p.A14.
- Noll, Roger, 1974(a), "The U.S. Team Sports Industry: An Introduction", in Government and the Sport Business, ed. by Roger Noll, Brookings Institute, Washington, pp.1-32.
- Noll, Roger, 1974(b), "Attendance and Price Setting", in Government and the Sport Business, ed by Roger Noll, Brookings Institute, Washington, pp. 115-158
- Okun, Arthur, 1981, Prices and Quantities: A Macroeconomic Analysis, Brookings Institute, Washington.

- Pindyck, Robert S., and Daniel Rubinfeld, 1981, Econometric Models and Economic Forecasts, McGraw-Hill Book Company, New York.
- Russell R. Robert, and Maurice Wilkerson, 1979, Microeconomics: A Synthesis of Modern and Neoclassical Theory, John Wiley and Sons, New York.
- Strachen, Al, "Oilers profit from Pocklington's dealings", Globe and Mail, March 3, 1989, p.A14.
- Thaler, Richard, 1985, "Mental Accounting and Consumer Choice", Marketing Science, 4, Summer, pp.199-214
- Thaler, Richard, 1986, "The Psychology and Economics Handbook: Comments", Journal of Business, 59, pp. S279-S284.
- Tremblay, Jack, 1967, The Birth of Hockey, Brunswick Press, Fredericton.
- White, K., S. Haun, and N. Horsman, 1987, Shazam User's Reference Manual, Version 6.0, UBC Department of Economics
- York, Geoffry, "Enterprising Group Came to Aid of Jets", Globe and Mail, March 1, 1989, p.A11.

APPENDIX

TABLE A
THE REDUCED DATA SET[†]

TEAM	YEAR	AVG. †† PRICE	AVG. ATTEND	AVERAGE RANK IN LEAGUE	POPULATION ('000 's) †	INCOME (\$) ††
QUEBEC (15434)	'81	15181	1108	7.12	630	10148
	'82	15112	1200	9.95	580	11021
	'83	15110	1236	7	589	11732
NEW Y. RANGERS (17500)	'81	17398	1098	12.12	9120	11878
	'82	17397	1187	11.75	9120	12838
	'83	17383	1282	3.85	9120	13808
ST. L. BLUES (17666)	'81	14432	928	12.12	2356	11247
	'82	12621	934	14.32	2356	12020
	'83	12982	1104	12.12	2356	12710
WINN. JETS (15250)	'81	13435	1169	11.82	564	11489
	'82	12927	1263	11.92	517	12518
	'83	12398	1305	14.95	576	13686
VANC. CANUC. (16533)	'81	13273	1162	12.37	1268	13511
	'82	14674	1250	13.47	1285	14460
	'83	14278	1413	12.95	1309	15569
BUFF. SABRES (16433)	'81	15264	895	5.2	1243	10479
	'82	12855	937	9.82	1243	11009
	'83	14141	912	4.37	1243	11398
L.A. KINGS (16005)	'81	10751	1030	15.95	7478	12234
	'82	11542	1012	12.22	7478	12754
	'83	10663	1086	17.05	7478	13417
CHIC. BH's (17317)	'81	12410	822	12.05	7104	12338
	'82	17105	811	3.05	7104	12883
	'83	16821	1167	12.15	7104	13456
EDM. OILERS (17312)	'81	17488	1092	1.95	658	13610
	'82	17498	1416	5.97	680	14493
	'83	17498	1513	1.02	706	15659
BOSTON BRUINS (14451)	'81	12026	1038	4.35	2763	12046
	'82	13272	1113	3.4	2763	13120
	'83	13588	1238	3.62	2763	14297
MONT. CANS. (16074)	'81	16602	1071	3.95	2838	10707
	'82	16620	1189	4.32	2850	11611
	'83	16728	1164	11.85	2869	12496

TEAM	YEAR	AVG. ATTEND	AVG. PRICE	AVERAGE RANK IN LEAGUE	POPULATION ('000 's)	INCOME (\$)
PHIL. FLYERS (17211)	'81 '82 '83	17049 16843 16636	964 971 1042	6.77 3.75 3.87	4717 4717 4717	11137 11933 12700
MINN. N.S. (15499)	'81 '82 '83	15196 14482 14189	1062 1232 1267	6.52 4.3 10.75	2114 2114 2114	12201 12981 13781
HART. WHALE. (15126)	'81 '82 '83	11690 10692 11683	972 1188 1411	18.05 19.55 15.35	726 726 726	12531 13599 14522
PITTS. PENG. (16033)	'81 '82 '83	11299 8408 7091	842 905 895	11.6 18.6 20.05	2264 2264 2264	11094 11628 11920
COL./ N.J. (19040)	'81 '82 '83	8235 12490 11352	884 1437 1439	20.67 16.8 20.6	1621 * 1966 1966	12941 13818 14847
CALG. FLAMES (16833)	'81 '82 '83	7231 7242 16998	1983 2363 1675	13.85 12.72 11.3	594 622 655 **	15131 16047 17440
WASH. CAPS. (18130)	'81 '82 '83	11376 12376 11796	788 1098 1211	19.37 10.87 10.6	3061 3061 3061	13954 15063 16137
TOR. M.L.'s (16182)	'81 '82 '83	16337 16346 16357	849 1074 1172	16.12 18.12 14.7	3009 3084 3084	12683 13841 15018
NEW Y. ISLES. (16270)	'81 '82 '83	15048 15137 15500	1246 1348 1452	3.05 4.75 4.5	9120 9120 9120	11878 12838 13803
DET. R.W.'s (19275)	'81 '82 '83	12517 12927 16737	1072 1091 1159	16.62 18.1 15.67	4353 4353 4353 ***	11454 11766 12537

‡ - this data was extracted from an expansion of the data set which was used in Ferguson and Jones, 1988, and references to the sources of the data can be found there.

‡‡ - income and price data are in current dollars

‡ - population figures are 1981 SMSA's for U.S cities and census interpolations for Canadian cities

* - moved from Colorado to New Jersey

** - moved to Saddledome

*** - moved to Joe Louis Arena

() - present seating capacity

Table B
Log Likelihood Values of
Fairness in Pricing III

System Type †	Full data set	Without Calgary	Without Sellouts
<u>Seasons 2 & 3</u>			
Avg. Season Attend restricted (I)	-650.2	-601	-452
unrestricted (J)	-641.9	-591	-441

† The specific system being estimated is contained in ()

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Author



Andre Le Dressay

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ISBN 0-315-53752-3