TRANSACTION FEES IN BANKING MACHINE NETWORKS: A SPATIAL AND EMPIRICAL ANALYSIS

by

ELIZABETH W. CROFT

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

in

THE FACULTY OF GRADUATE STUDIES

Department of Commerce and Business Administration, Policy Programme

We accept this thesis as conforming to the required standard.

THE UNIVERSITY OF BRITISH COLUMBIA

April 1999

© Elizabeth W. Croft, 1999
In presenting this thesis in partial fulfilment of the requirements for an advanced degree at the University of British Columbia, I agree that the Library shall make it freely available for reference and study. I further agree that permission for extensive copying of this thesis for scholarly purposes may be granted by the head of my department or by his or her representatives. It is understood that copying or publication of this thesis for financial gain shall not be allowed without my written permission.

Department of Commerce & Business Admin.

The University of British Columbia
Vancouver, Canada

Date April 20/99
This thesis concerns the effects of network member features on the pricing of automated teller machine (ATM) transactions. The first chapter outlines the development of ATM networks and provides an institutional and public policy backdrop for the theoretical and empirical analysis in the thesis. ATM fees have recently received increased attention in North America due to the Interac abuse of dominance case in Canada and the widespread introduction of surcharge fees at ATMs in the United States.

In Chapter 2, a new circular spatial model of ATM networks is developed and used to analyze the pricing preferences of banks when choosing to link their proprietary ATM networks into a shared network. This model captures the consumer trade-off between the inconvenience of travelling to a machine of their own bank and the fee charged to use the machine of a rival bank. In this chapter, there are two banks, which differ only with respect to the size of their client bases. The results show that the smaller bank's preferred common transaction fee always exceeds that of its larger competitor. The bank with the larger client base will always choose to link networks provided that the common fee charged by both banks is non-negative. For both banks there is always a range of common fees for which there is mutual gain from linking the networks. When surcharges are allowed, both banks have an incentive to raise fees above the common fee that was charged previously.

In Chapter 3 the model is adapted to consider the effects of an asymmetry in the number of machines owned by each bank. For the same client base in each bank, the results show that the bank with the larger number of machines prefers a higher common fee than does its rival. When surcharges are allowed, the bank with the larger number of ATM machines will choose to price discriminate by location of machine. Such behaviour has been observed in the United States.
In the final chapter, the theory developed with respect to surcharging is examined empirically using an original data set of United States banks compiled from several public data sources. Probit, Tobit and OLS techniques are used to analyze the relationship between bank features and the surcharging decision. The results provide some support for the findings of the spatial model.
# TABLE OF CONTENTS

Abstract \hspace{150pt} ii  
Table of Contents \hspace{150pt} iv  
List of Tables \hspace{150pt} vi  
List of Figures \hspace{150pt} vii  

**CHAPTER I** Overview and Institutional Background \hspace{150pt} 1  
1.1 Thesis Overview \hspace{150pt} 1  
1.2 Introduction \hspace{150pt} 2  
1.3 Technological Innovation in Client Interface Systems \hspace{150pt} 4  
1.4 ATM’s in Canada \hspace{150pt} 7  
1.5 The Interac Case \hspace{150pt} 10  
1.6 US ATM Controversies \hspace{150pt} 13  
1.7 Policy Concerns and Theoretical Literature Review \hspace{150pt} 15  
1.8 Conclusion \hspace{150pt} 18  

**CHAPTER II** Equal Network Model \hspace{150pt} 19  
2.1 Introduction \hspace{150pt} 19  
2.2 Overview of Spatial Model of Bank \hspace{150pt} 23  
2.3 Proprietary Network \hspace{150pt} 26  
2.4 Consumer Choice With Linked Equal Networks \hspace{150pt} 29  
2.5 Profitability With Linked Equal Networks \hspace{150pt} 37  
2.6 Analysis of Acquirer Only Network Membership \hspace{150pt} 47  
2.7 Profitability With Surcharges \hspace{150pt} 49  
2.8 The Model in the North American Context \hspace{150pt} 52  
2.9 Conclusion \hspace{150pt} 55  

**CHAPTER III** Unequal Network Model \hspace{150pt} 57  
3.1 Introduction \hspace{150pt} 57  
3.2 Consumer Choice With Linked Unequal Networks \hspace{150pt} 58  
3.3 Consumer Choice Without Leapfrogging \hspace{150pt} 61  
3.4 Profitability With No Leapfrogging \hspace{150pt} 66  
3.5 Analysis on Issuer Only Network Membership \hspace{150pt} 73  
3.6 Profitability With Surcharges \hspace{150pt} 75  
3.7 The Model in the North American Context \hspace{150pt} 78  
3.8 Conclusion \hspace{150pt} 80  

**CHAPTER IV** Empirical Analysis of Surcharging in the US \hspace{150pt} 82
TABLE OF CONTENTS (continued)

CHAPTER IV (cont.)

<table>
<thead>
<tr>
<th></th>
<th>Introduction</th>
<th>82</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.2</td>
<td>Related Research</td>
<td>85</td>
</tr>
<tr>
<td>4.3</td>
<td>The Development of ATM Surcharges</td>
<td>87</td>
</tr>
<tr>
<td>4.4</td>
<td>Research Questions and the Model Specification</td>
<td>95</td>
</tr>
<tr>
<td>4.5</td>
<td>Data Description</td>
<td>101</td>
</tr>
<tr>
<td>4.6</td>
<td>Empirical Results</td>
<td>106</td>
</tr>
<tr>
<td>4.7</td>
<td>Conclusion</td>
<td>110</td>
</tr>
</tbody>
</table>

Bibliography | 113
---|---
Appendix 2.1 | Analysis of Transaction Fees in a Proprietary Network | 120
Appendix 2.2 | Derivation of Second Order Conditions | 123
Appendix 4.1 | Regional Status of Urban Centres in Data Set | 126
Appendix 4.2 | Sample of FDIC Data | 127
Appendix 4.3 | Institution Directory Definitions | 131
List of Tables

4.1 ATM Transaction Fees 89
4.2 Poll Results on Surcharging in U.S. 91
4.3 Variable Means, Standard Deviations, Maxima and Minima 105
4.4 Results of the Probit, Tobit and OLS Models 108
## List of Figures

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>Unit Circle Market with $M^A = M^B$ as Viewed by a Customer of Bank B Located at ($\bigcirc$)</td>
<td>31</td>
</tr>
<tr>
<td>3.1</td>
<td>Unit Circle Market with $M^A = 2M^B$ as Viewed by a Customer of Bank B Located at ($\bigcirc$)</td>
<td>59</td>
</tr>
</tbody>
</table>
CHAPTER I - OVERVIEW AND INSTITUTIONAL BACKGROUND

SECTION 1.1 THESIS OVERVIEW

This thesis is an investigation into the determinants of fees charged in shared ATM (automatic teller machine)\(^1\) networks. The first chapter outlines the development of ATM networks and provides an institutional and public policy backdrop for the theoretical and empirical analysis in the thesis.

In Chapter 2, a new circular spatial model of ATM networks is developed and used to analyze the pricing preferences of banks when choosing to link their proprietary ATM networks into a shared network. This model captures the consumer trade-off between the inconvenience of travelling to a machine of their own bank and the fee charged to use the machine of a rival bank. In this chapter, there are two banks, which differ only with respect to the size of their client bases. The results show that the smaller bank’s preferred common transaction fee always exceeds that of its larger competitor. The bank with the larger client base will always choose to link networks provided that the common fee charged by both banks is non-negative. For both banks there is always a range of common fees for which there is mutual gain from linking the networks. When surcharges are allowed, both banks have an incentive to raise fees above the common fee that was previously charged.

In Chapter 3 the model is adapted to consider the effects of an asymmetry in the number of machines owned by each bank. For the same client base in each bank, the results show that the bank with the larger number of machines prefers a higher common fee than does its rival. When surcharges are allowed, the bank with the larger number of ATM machines will choose to price

---
\(^1\) "ATM" is an unfortunate acronym for automatic teller machines as it coincides with the acronym for Asynchronous Transfer Mode - an important technological development in electronic networks. The term "automated banking machine" and the acronym "ABM" can be used to eliminate any potential confusion. Notwithstanding, "ATM" is used in this paper to remain consistent with the majority of previous studies.
discriminate by location of machine. Such behaviour has been observed in the United States.

In the final chapter, the theory developed with respect to surcharging is examined empirically using an original data set of United States banks compiled from several public data sources. Probit, Tobit and OLS techniques are used to analyze the relationship between bank features and the surcharging decision. The results provide some support for the findings of the spatial model.

The contribution of the thesis is two-fold: 1) a careful examination of pricing in shared ATM networks and ii) a preliminary analysis of the factors that explain observed surcharges in the US market. As the chapters are designed as stand-alone entities, the literature related to each topic is reviewed where appropriate in the course of the thesis.

SECTION 1.2 INTRODUCTION

In parallel with the expansion of the industrial economy, the financial services sector has experienced a series of transformations as a result of technological innovations. Bank systems, once considered to be the stable framework for economic growth and change, now themselves undergo rapid changes due to advances in technology.

While technological progress was accompanied by rapid growth of the banking industry in the early 1980's, technological progress is not, a priori, a motor of growth for the traditional participants in the financial services industry. Innovations can provide opportunities for new entrants into the industry, introduce substitutes for established products, and threaten a firm's competitive position within the industry. Restrictions on access to technological innovations jeopardise the prospects of individual firms and may foster market foreclosure. These positive and negative features of technological advances in the banking industry have strategic implications for both private and public policy makers.

---

2 Real (1992)
The rapid evolution of communications and information networks has been a principal impetus behind technological change in the banking industry. Network technology has transformed all aspects of major banking institutions, from the direct institutional interface with clients to the organizational planning structures. The purpose of this chapter is to provide background description of the evolution and effects of a network technology that has had a significant effect on banks' client interface systems - automatic teller machine networks. The final sections of the chapter will focus on the recent controversies regarding the Canadian national ATM network, "Interac", and the introduction of surcharges in United States networks. The motivating factors behind the focus of this chapter are as follows:

1) As the first self-serve client interface options, ATM networks established a precedent for other self-serve networks. Research into the formation, structure, and impact of these networks could inform the organization and regulation of new and upcoming technological innovations in banking.

2) In Canada, the dominance of a single ATM network (Interac) has raised questions regarding abuse of market control. Issues of financial market control are particularly sensitive in Canada, where the financial system has historically been dominated by a core of large institutions. (Shaffer, 1994) The Canadian financial system and payment system are currently under intense review, with final determinations scheduled for 2000.

3) In the United States the recent and wide-spread introduction of surcharges, or convenience charges, has raised questions regarding their impact on competition and consumer choice.

---

3 (1996) C.C.T.D. No. 12, Trib. Dec No. CT9502/93, Canada Competition Tribunal, Ottawa, Ontario

4 The staff of the Bank of Canada and the Department of Finance have published five discussion papers for the Payments System Advisory Committee (Feb., May, July, Dec 1997, and July 1998). These broad-ranging papers cover all aspects of the Canadian Payments System and all make specific reference to the role of ATM's within that system. They have been submitted to the Task Force on the Future of the Canadian Financial Services Sector to be incorporated into their industry-wide recommendations.
fees, on each ATM transaction has created concern among consumer advocates and public policy makers about disclosure and fairness in ATM fees.

The technology's impacts will first be discussed in general terms, followed by a more detailed description of the impacts of ATM technology in the Canadian context. Section 1.2 provides a structural overview of banking systems, and discusses the technology-driven evolution of the client interface systems. It specifically elaborates on the role of ATM network technology in this evolution. The history of ATM technology in Canada is outlined in Section 1.3. Section 1.4 describes the origins and results of the abuse of market dominance case against the major Canadian network, followed by a discussion of ATM network concerns in the United States in Section 1.5. Section 1.6 provides an overview of the literature related to networks and to the spatial model to be introduced in chapters 2 and 3. Brief concluding remarks lead into the following theory chapters.

SECTION 1.3 TECHNOLOGICAL INNOVATION IN CLIENT INTERFACE SYSTEMS

Systems analysts view banks as networks of inter-related subsystems with varying levels of impact on the day-to-day transactions made at the organization. Client interface systems form a part of the transactions systems of the organization. The original client interface systems of financial institutions were their branch systems. Clients could only conduct transactions directly with their financial institution, that is, without the intervention of the cheque clearing system or other payment systems, by visiting a branch and making a person-to-person transaction. The introduction of automatic teller machines in the early 1970's created a self-service alternative to the person-to-person client interface system. Although ATMs were initially automated interfaces to single branches, they were subsequently linked together in institution owned networks, commonly known as "proprietary networks". In many countries, proprietary ATM networks were largely abandoned in favour of

5 Walker (1993)
shared networks in the mid-1980’s. At the retail level, ATMs have augmented the availability of liquid funds, changed the role of branch systems, and increased the interdependency between banks via national and international networks. Further self-serve options have followed including home banking systems, debit cards, smart cards, and Internet based systems. These more recent innovations tend to build on the inter-institutional connections already in place to facilitate inter-institutional use of ATMs.

Before and during the period that the first self-serve interface options came into being, the branch systems themselves underwent enormous change. Manual processing of transactions was first automated, then removed from the branches and centralized via rapidly advancing information technology, allowing for increased specialization and efficiency. The combination of this processing rationalization and of the increasing availability of diverse self-serve options has allowed for a general shift in the organizational culture of the branch systems away from accounting and control and toward customer relations and marketing. It has also led to new efficiency-driven inter-institutional associations and communications networks.

As noted above, the introduction of ATMs contributed to significant changes in consumer behaviour and inter-bank relationships. The first ATM in North America was introduced by Philadelphia National Bank in 1969. Adoption and diffusion of the early versions of the technology were protracted, and only 4000 machines were in operation in the US by 1975. Elsewhere in the world the diffusion of the technology was more rapid, most notably in Japan and France.

A consumer’s use of an ATM is unlike their consumption of "normal" goods or services in

---

6 "Smart card" is a generic term used to describe credit-sized plastic cards that use embedded computer chip technology rather than magnetic stripe technology. These cards provide superior memory capacity and flexibility of applications for financial services and many other industries.

7 MacAndrews (1991)
that the ATM facilitates their consumption of their bank or financial institution's primary products, financial services. An ATM's value to the consumer is therefore as a transaction processor. Within some range of fees, machine accessibility, and transaction capabilities, customers would be expected to make most of their simple financial transactions through the ATM network rather than at an in-branch teller.

Initially the limitations of ATM technology and concerns about consumer privacy confined customers to using only machines that were owned by the institutions where they held accounts. As the technology evolved, it became possible for network access to be shared between two or more institutions, creating inter-institutional networks. As noted above, the majority of North American banks linked their proprietary ATM networks together by the mid-1980's to form shared systems. This serves as an example of firms forgoing a portion of their independence to take advantage of a positive network externality. Each ATM within the network potentially provides transactional convenience to the customers of all of the network members. Since the adoption stage, however, the automatic teller machine environment has evolved into a complex variety of inter-institutional networks. Also, a far greater number and proportion of "stand alone" machines have been installed than anticipated in the early adoption period, thus increasing the convenience of access to financial services away from the traditional branch systems. The membership of financial institutions in rapidly growing common automated teller machine networks has increased and complicated the nature of their interdependence. This has raised questions regarding market control, pricing and resource strategies and consumer protection, which have both private and public policy implications. In developed economies, the issues regarding adoption of the technology are less

---

8 Machines owned by financial institutions but not located at a branch of that institution.

9 See Hunter and Timme (1992) and Warf (1989) for a more complete discussion.
interesting than the issues regarding the inter-institutional network effects. For convenience these will be referred to as "inter-bank" networks, although technically nothing precludes non-bank or non-financial institutions from obtaining access to such networks.

Two general categories for members of shared networks are "acquirers" and "issuers." Acquirers deploy or own ATMs, while issuers have the capacity to issue cards usable at the machines. Of course, many network member institutions can assume either role. In a typical shared transaction, a consumer uses an acquirer’s ATM, and the acquirer transmits a request for authorization to the issuer. If the request is authorized, cash is dispensed or a transfer is made by the acquirer. If not, the transaction request is denied at the ATM.

A general description of inter-bank networks in the US by McAndrews (1991) explains that a "typical" network’s structure includes transaction fees that are determined jointly by the member institutions. These are "interchange" fees paid to the network by member institutions for each transaction made at another bank’s ATM by one of their customers. In addition, members of other networks or non-member institutions wishing to have access to a network may be required to pay a "switching" fee in order to use the network’s software technology. Some or all of the combined interchange and switching fees are debited to the customer’s account at month end. The hardware of the network, primarily the actual ATMs, is generally owned by the individual member institutions. The ownership and control of the networks communication and transaction technology can have a variety of structures. As will be discussed below, this ownership can also constitute network control.

SECTION 1.4 ATMS IN CANADA

10 These terms are consistent with the glossary listed in the Dec. 14,1995 Application of the Director of Investigations and Research to the Competition Tribunal in Canada with respect to Interac.
There is no official record of the initial pilot date of ATM technology in Canada, however conventional wisdom, based on discussions with Interac and with bank communications officers, is that the pioneer full-fledged adopter of ATM technology was the Toronto Dominion Bank in 1977. The ATM technology was readily available to the North American market in the late 1970's, and one can infer that the five major banks had equal opportunity to adopt the technology at any given time. It is interesting to note that the leader in introducing ATMs, the Toronto Dominion Bank, ranked as the smallest and least profitable of the five major banks at the date of adoption.\(^ {11}\) The three largest banks adopted the technology at virtually the same time, three years later than the market leader. The fourth largest bank, the Bank of Nova Scotia, lagged far behind, adopting ATMs a full six years later than the leader. The other large deposit taking institutions delayed adoption until the early 1980's. Each organization initially established a "proprietary" network, that is a network owned and operated by each institution for the exclusive use of their own customers. These proprietary networks were subsequently linked by sharing arrangements, which permitted card holders of one institution to access their accounts through ATMs owned by other institutions.

The foundation of the present Canadian national Interac network was an agreement between the five principal VISA-issuing institutions\(^ {12}\) in late 1984 to form a mutually accessible national network. Within a year they had been joined by the four principal Mastercard-issuing

\(^ {11}\) See the data appendices of Stewart (1982) for detailed information on the relative size and profitability of the major Canadian banks.

\(^ {12}\) The Bank of Nova Scotia, the Confederation des caisses populaires et d'économie Desjardins du Quebec, Canadian Imperial Bank of Commerce, Royal Bank of Canada and the Toronto-Dominion Bank.
These nine institutions came to be known as "charter members". Until 1996 these charter members had exclusive direct access to and joint ownership of Interac Inc., a private incorporated entity which in turn owned all the inter-bank transaction software. The separate, unincorporated Interac Association (Interac) of all the network participants was comprised of the same nine charter members, together with 18 "sponsored" members. The sponsored members, up until 1996 all deposit taking organizations, were required to pay a one time fee to join the organization and pay annual fees to maintain indirect access to the Interac Inc. inter-bank software via the charter members' communications software. As they were both private entities, the details of the operation of both Interac Inc. and Interac the association, were largely protected from significant public scrutiny.

By 1996, the Interac network was comprised of more than 17,000 banking machines and processed in excess of 90% of all shared transactions. The network's growth has been fuelled by enthusiastic consumer response. Canada trails only Japan as the world leader in ATMs per capita, and has the highest per capita ATM usage of any country in the world. With the advent of new technologies such as point of sale (POS) and smart cards, it is expected that the growth in the number of ATMs in Canada has or will soon level off. Also, it is anticipated that new imaging technology will render ATMs, POS, and other direct payment systems more reliable over the next five years. This should in turn lead to more sophisticated machines, suitable for increasingly complex transactions.

13 Bank of Montreal, Canada Trustco Mortgage Company, Credit Union Central of Canada and National Bank of Canada

14 The structure of these fees includes an initial membership fee of $10,000 and a minimum service access fee of $100,000.

These technological advances are already being used at ATMs in other parts of the world, however in Canada, prior to 1996, the agreements between the network members only extended to Shared Cash Dispensing (SCD), the main function of ATMs, and to Interac Direct Payment (IDP), the Canadian version of POS. Generally customers have a far greater range of services on the ATMs located at the branches of the institution they frequent than at machines owned by the other members of Interac. At their own institution’s ATMs they can normally make deposits, bill payments and account information inquiries in addition to the standard cash withdrawals. As will be discussed below, constraints on the number of services available through the shared network was one of the criticisms levelled against Interac during the Competition Bureau’s investigation.

**SECTION 1.5 THE INTERAC CASE**

The Interac network became a source of controversy in the early 1990’s when American Express of Canada Inc. (Amex), publicly complained of mistreatment by the charter members with respect to its efforts to join the network as a charter member. Charter members at the time controlled the pricing of the network and the communications system. Interac quoted an up-front access fee of over $11 mil. to Amex, far in excess of previous access fees for network membership. To Amex and to industry observers this appeared to be a concerted effort by Canada’s major banks to block US competition in the retail sector of the financial services industry. Amex eventually gained some Canadian ATM access for its customers by joining the smaller Circuit network operated by the Bank of Montreal. Subsequently, Interac’s charter members agreed to even higher membership fees of $15-20 mil for future new charter members.

Amex’s complaints, coupled with other less publicized complaints, led to an investigation of Interac conducted by the federal Competition Bureau from 1992 to 1996. The investigation

---

culminated in a controversial hearing before the quasi-judicial Canada Competition Tribunal. The respondents to the Director of Investigation of Research's application to the Tribunal were the nine charter members of Interac and Interac Inc. The respondents, interveners and commenters, made formal presentations before the tribunal, including small and large participants in the financial services and retail sectors of the Canadian economy.17 The summary results of the investigation and deliberations were published on June 20, 199618. The following descriptions of the Interac sharing arrangements and the recommendations are based on that publication, and on the Draft Consent Order of the Director, dated Dec. 14, 1995. The issues covered in the deliberations were complex and wide ranging. A large component of the deliberations regarded the IDP (or POS) network technology, also effectively controlled by Interac's charter members. Although the future of POS technology is linked to that of ATMs, only the issues specifically related to ATMs are discussed in detail below.

The Draft Consent Order maintained that Interac's bylaws had "exclusionary" purposes with respect to eligibility for membership, fees, and services. Furthermore, prior to the Tribunal only charter members of the association voted with respect to amendments to its bylaws. With respect to the ATM function of Interac, the key points of interest in the investigation preceding the Tribunal were that the bylaws resulted in:

1) Restricted and privileged access to charter membership

   a) exclusive direct connection to inter-bank software

   b) exclusive voting rights

   c) charter membership available only with investment of $15 mil to $20 mil, with full

17 Church and Ware (1998)

investment (less $1) subject to surrender on loss of charter status

e) open only to joint acquirer/issuers

f) open only to direct clearers with the Canadian Payments Association (CPA)\textsuperscript{19}

2) Restricted access to sponsored membership

a) acquirer only entities denied access, although issuer only entities were admitted

b) limited to "financial institutions" narrowly defined as deposit taking institutions which are CPA members, thereby limiting potential membership to 155 organizations.

3) Restrictive fees and services.

a) acquirer's (interchange) fee fixed by bylaws\textsuperscript{20}

b) excessive access fees\textsuperscript{21} and inappropriate distribution of fee revenues

c) lack of innovation in products and services

One of the major points stressed in the Director's presentation was that the charter members' effective collective control of the governance of Interac Inc., the Association, and other financial institutions in Canada such as the CPA had led to less price and service innovation competition from institutions both outside and inside the network. The Director's principal recommendations were that the existing barriers be eliminated, including all constraints on competitive pricing and all distinctions between issuers, acquirers, and acquirer/issuers, and that

\textsuperscript{19} The Canadian Payments Association is a federally mandated self-regulatory body that sets the standards and procedures for electronic payments in Canada. It is dominated by the charter members of Interac.

\textsuperscript{20} The maximum acquirer's fee has been fixed at $.75. Surcharges are prohibited on such fees while rebates are not, however the latter option is seldom taken by member organizations.

\textsuperscript{21} As discussed in paragraph 52 of the Tribunal's June 20, 1996, prior to the Tribunal fees were $7.50 per cardholder based on the applicant's best estimation of the number of cards issued over the following three years, with a minimum fee of $100,000. The minimum fee was seen to penalize smaller institutions. Also, financial penalties were assessed for underestimation of the number of card holders, creating a disadvantage to rapidly growing institutions.
Interac Inc. be run on a cost retrieval basis in the future. The recommendations make provision for the charter members to recover the costs of their original investment in the network switch technology over a ten year period, net of service access fees collected to date. The cost of switch technology stated to be a total of $16.8 mil. The Tribunal concurred with the spirit of the recommendations, while expressing concern that both the technical and regulatory aspects of the proposed changes would require extensive further review. This review is currently being conducted by the Task Force on the Future of the Canadian Financial Services Sector.

SECTION 1.6 US ATM CONTROVERSIES

Despite regulatory and market structure differences between the Canadian and US financial services industries, some of the same questions on market control have arisen with respect to US ATM networks. In the 1970’s, as the first ATM networks were being created, Congress established the National Commission on Electronic Funds Transfer (NCEFT) as a forum on the new technology. Arguments arose as to whether such networks were natural monopolies that should be accessible to any firm wishing to join them, or whether competing networks should be encouraged. Although some states did adopt a form of mandatory sharing regulations, the proponents of competition between smaller networks generally triumphed. During the 1980’s opinion shifted in favour of widespread sharing of ATM networks on the grounds that the "economies of ubiquity" would result in benefits to the consumer. Mergers of ATM networks proceeded unchallenged. In the late 1980’s, and 1990’s, however new questions are being raised concerning the exclusivity, rules and practices of large ATM networks and their implications with respect to market power. These concerns generally seem to be precipitated by


23 Balto (1995)
the interlinks between ATMs and new transaction alternatives such as POS, and by upward pressures on consumer fees.

The most high profile bank network issue in the US in the late 1990’s is surcharging. Surcharges are transaction fees charged directly to the consumer, above and beyond the network related fees. They are set and collected by the owner of the ATM, independent of the network. These fees are ostensibly charged to compensate the machine owners for providing superior convenience to consumers. The widespread imposition of surcharges began in 1996 when the national ATM networks, Cirrus and Plus, lifted the prohibition they had maintained on surcharges up to that point. The surcharges are collected at the time the transaction is made, so that if an individual makes a withdrawal of $20, an amount of $20 plus the surcharge is taken out of their account immediately. They will subsequently also be charged the network related fees for the same transaction at the end of the month. Surcharges are highly visible fees from the consumer’s perspective. Since constraints are not imposed on the amount of the surcharge by the network agreement, the ATM owner could conceivably charge whatever price the market will bear. Also, there is nothing to prevent ATM owners from price discriminating by charging more in areas sparsely served by ATMs. As will be discussed at greater length in Chapter 4 of this thesis, surcharges have elicited attention from consumer advocacy groups and regulatory bodies, and generated heated debate.

In addition to providing national bank access, ATMs allow customers to complete transactions across borders in the local currency. Network coverage of foreign markets may be a blanket, as in the case of the Hong Kong Bank network, or selective in countries or regions with high economic activity, as in the case of Citibank network. These national and international

---

networks are now being closely monitored for anti-competitive practices by the US Conference of State Attorneys General. The potential public policy concerns regarding bank networks include the following: discriminatory and exclusive membership practices, anti-competitive pricing and public placement policies, and the establishment of an appropriate regulatory agency.

SECTION 1.7 POLICY CONCERNS AND THEORETICAL LITERATURE REVIEW

The principal public policy concerns noted above stem largely from spillover or externality effects and market structure effects.

Economic theory suggests that positive network externalities exist if the value of a good or service increases as more organizations adopt related technology that is the same or compatible\(^\text{25}\) (Tirole, 1988). These network externalities have both supply and demand implications. From the demand perspective, network users create market inefficiencies by hesitating too long when choosing between competing network technologies, or by too hastily accepting inferior technology in an attempt to reap network benefits quickly. From the supply perspective, which is of particular interest for the purposes of this paper, firms may use network technologies as a strategic tool to maintain market control. Larger firms have less incentive than smaller firms to ensure that their network technology is compatible with other networks. Late adopting firms have an incentive to "free ride" on the established systems and expertise.

It might be argued that the high initial expense of a network's infrastructure and technology can create a natural monopoly scenario because of economies of scale. Under certain market conditions costs would be minimized by having a single network. This private gain might provide the initial developers of a network technology with an incentive to control network

\(^{25}\) As noted in Tirole (1988), p405, the benefits may be direct, since compatibility allows sharing of the network or indirect, due to returns to scale in production.
pricing, access, and other policies in order to stifle competition. As the volume of network transactions and of network compatible hardware increases, the value and market dominance of any network increases. Both these factors can prevent competing institutions or alternative networks from entering the market. It is unclear whether this type of market foreclosure will be in the public interest. Without regulatory intervention, this aspect of network technologies has and will shape the organizational structure of any ATM network.

Economists have used diverse models of ATM networks in order to analyze their behaviour in a formal, abstract manner. These models relate to the spatial model to be developed and discussed in Chapters 2 and 3 of this thesis. The relevant empirical literature is discussed in Chapter 4.

The initial models of ATM networks generally addressed adoption rates and network externalities. More recent models have focused on pricing, regulation, and welfare effects. Gilbert (1991) develops a model to analyze the incentives and welfare consequences of the pricing decisions and inter-member coordination with respect to each level of fees involved in the network.26 This model provides some support for delegating price setting to the firm level, rather than maintaining network-wide pricing, in order to allow the pursuit of economic profits. These profits result from superior local market and cost knowledge at the firm level. The model does not, however, indicate whether such delegation would be socially optimal or suggest how it should be regulated.

Economides (1991), Salop (1991) and Economides and Salop (1992) present a different

---

26 This model is motivated by First Texas vs Pulse, a significant US arbitration case in the late 1980's regarding the networks authority to set fees unilaterally. See Kauper (1988), Opinion of the arbitor, in the matter of the arbitration between First Texas Savings Association and Financial Interchange, Inc. (Reprinted in Antitrusta and Trade Reporter (BNA), 1988, August 25, 55, 340-373)
perspective on ATM networks. Their approach is to consider the use of an ATM at a specific location and the use of a particular bank card as complementary "elementary" goods. In combination they form a complete transaction, or "composite" good. When the two elementary goods are supplied by different sources the composite good is a "hybrid". Each ATM or each bank card is a potential substitute for any other. Economides (1991) analyzes the firms’ decisions to make their proprietary networks more or less technologically compatible under different market symmetry and decision sequence assumptions. The model indicates that differences between inter-network and intra-network demand will influence the compatibility decision, with high inter-network demand favouring high levels of inter-network compatibility. Salop (1991) uses a similar model to analyze social efficiency of the joint pricing decision in shared networks. In general he concludes that active competition between members of a network will approach social optimality more closely than self-regulation or government price regulation.

In the same vein, Economides and Salop (1992) examined the contrasts between independent and joint network ownership, with the finding that prices are higher under joint ownership only when the composite goods offered are close substitutes. Their examination of other market structures includes partial vertical integration and one-sided (or rule based) joint price setting.

More recently Matutes and Padilla (1994) develop a spatial model to focus on the trade-offs between different levels of network compatibility and interbank competitiveness for deposit business via interest rate differentiation. Their analysis incorporates both interchange fees and depositor switching costs and is particularly suited to the analysis of network compatibility, and the trade-offs that arises when consumers trade-off ATM transaction convenience and deposit interest rates.
The model developed in Chapters 2 and 3 of this thesis differs from the existing models because it allows for the examination of the role of bank characteristics in the ATM pricing decision. As discussed in this Chapter, price setting has become an important issue in the North American ATM market, and gaining a better understanding of bank's pricing incentives is a new contribution to the analysis of ATM networks.

SECTION 1.8 CONCLUSION

This chapter provides the reader with an overview of the role of ATMs in the development of the North American financial services industry and some insights into the public and private policy concerns related to ATM networks. In Canada, network access emerged as the predominant issue of the 1990's, due to the structure and governance of the powerful Interac network. In the more fragmented US market, transaction pricing has been the public and regulatory focus.

In the following chapters, features of ATM networks and the issues of recent interest will be discussed in the context of a new circular spatial model. The model places particular emphasis on consumer preferences and on per transaction costs.
CHAPTER II - EQUAL NETWORK MODEL

SECTION 2.1 INTRODUCTION

Early studies of automated teller machines such as Hannan & McDowell (1984) and Hunter & Timme (1991) focused on adoption patterns in the US as they related to individual bank characteristics and to variations in state regulations. In developed countries, however, as the technology matures, the structure, pricing and regulation of the resulting inter-bank networks has become a more interesting research area. Also, as discussed in the previous chapter, in Canada and the United States specific concerns regarding ATMs have recently attracted heightened public policy and regulatory attention. The Canada Competition Tribunal ruling on Interac, and the US controversy over surcharging are two specific examples of these concern.

The purpose of this chapter is to examine the incentives of non-affiliated banks with proprietary networks to forming an inter-bank network, and on their price setting incentives with respect to inter-bank network services. An important contribution of this chapter is the development of a simple spatial model of inter-bank networks. This captures the trade-off for consumers between the inconvenience of travelling to a their own bank’s machine and the fee charged to use the rival bank’s machine. The model is used to develop hypotheses about bank pricing preferences. The initial findings from the model outlined in this paper will be discussed in relation to features of the Canadian Interac case and of US surcharging practices.

The motivations behind this chapter are as follows:

a) to examine common pricing decisions in relation to the linking of two networks with similar numbers of machines but with divergent levels of transaction numbers (or its proxy measure,

---

27 Recall that "inter-bank" network is used for brevity, but that non-banks and non-financial services firms may also join such networks.
customer base). Will the bank with the larger or the smaller customer base prefer higher fees?
This question would be of particular interest in instances where consumer behaviour patterns or
numbers of cards issued differ greatly between two networks negotiating to link up. Over the
history of ATMs in Canada smaller networks appear to have failed because of restrictions on
their linking with the principal large network. In the United States there has been ongoing
concern about network mergers, market structure and competition since the creation of the
National Commission on Electronic Funds Transfer in the 1970's.

b) to examine if and when it might be in the interest of an existing network consisting of
acquirer/issuers to link up with the network of an acquirer only entity. In Canada, acquirer
only entities were specifically prohibited from Interac membership of any sort prior to
Competition Tribunal case. In the US, acquirer only entities are increasingly commonplace.

c) to use the model to analyze the surcharging decision over and above the common network fee.
Industry observers report that surcharges are causing shifts in consumer behaviour patterns and
influencing the placement and ownership of new bank machines.

To focus on these motivating issues, this chapter considers the incentives to form a
network for two banks with equal size networks of ATM's, but with different customer bases. A

---

28 Evidence to this effect was presented in paragraph 22 of the Dec. 14, 1995 Application by the Director
of Investigations and Research to the Competition Tribunal in the as part of the Interac case.

29 Balto (1995)

30 Recall from the previous chapter that "issuers" are entities that issue cards to consumers. "Acquirers"
are entities that are capable of receiving signals, such as withdrawal requests, and transmitting the message to
the issuer. They own ATM's, are members of the network, but do not bring any of their own customers to
the network.

31 Report to the Chairman, Committee on Banking, Housing, and Urban Affairs, U.S. Senate (1998) Automated
Teller Machines.

common fee is negotiated based on Nash bargaining between the two banks. In setting this fee, there are two central considerations. First, banks gain net revenue when their machines are used for transactions by customers of the other bank. We refer to this source of revenue as arising from cross-customer use of machines. Secondly, cost savings are achieved by shifting own customers from the use of the branch to the use of the other bank's machines. A main result is then to show that the profit-maximizing fee depends on the size of the customer base, with the larger bank preferring to set a lower common fee than would the smaller bank. This, perhaps surprising, result arises from the fact that with a larger customer base, there is a greater cost saving from switching a given proportion of own customers from use of the branch to the use of the other bank's machines. A lower common fee helps to promote this switch. With respect to the incentives to form a network, it is interesting that the bank with the larger customer base will want to link its network even at a zero fee for cross-customer use of machines, whereas the smaller bank may require a strictly positive fee, making at least some contribution towards ATM transaction costs. Nevertheless, under broad conditions there is a mutual gain from forming a network.

At the extreme of asymmetry in customer base, one of the banks could be an acquirer only with only machines and no customers. As before, the acquirer/issuer would gain from joining the network even at a zero common fee, but since the acquirer only bank is interested only in fee revenue, its preferred fee is strictly positive and always exceeds the fee desired by the acquirer/issuer. At least for the demand conditions arising from our model of consumer choice, it is also the case that the fee desired by the acquirer is independent of the customer base.

Consideration is also given to the joint profit maximizing common fee that could be maintained with lump sum payments between the banks. This fee is shown to lie between the
preferred fees of the small and large banks (determined by customer base) and to involve cross
customer use of machines.

To model surcharging, we assume that fees are set based on a Nash equilibrium in which
each bank maximizes own profits taking the fee set by the other bank as given. In this context,
the incentive of firms to maintain a lower fee in order to obtain cost saving by shifting
transactions away from the branch in favour of ATM use breaks down. Also, since customers do
not pay to use their own bank’s machines, the only remaining motive for surcharging is to
maximize own profits from cross-customer use of machines. In this situation, a main result is to
show that both banks charge the same fees, independently of the size of the customer base. This
applies whether the banks are both acquirer/issuers or one is an acquirer only. In fact, the
equilibrium price charged is the same as the common fee (mentioned above) that would be
preferred by an acquirer-only firm with no customers. If both banks are acquirer/issuers, the fee
strictly exceeds the common fee that each bank would prefer to charge in the absence of
surcharging. This result is driven by the removal of common cost considerations, and suggests
that allowing banks to surcharge can lead to a significant increase in fees charged across the
entire network.

Economists’ interest in the network competition and compatibility has increased as
interconnected technologies have increasingly shaped industries. The telecommunications industry
has been the catalyst for much of the economic analysis, from Katz and Shapiro (1985) to more
recent work by Laffont, Rey and Tirole (1998). ATM networks, although based on
telecommunications technology, are different from "pure" telecommunication networks in so far
as they serve as a direct substitute for the branch transactions service that banks already provide.
Existing models of ATM networks, including Economomides (1991), Gilbert (1991) and Matutes
and Padilla (1994) emphasize issues of compatibility between networks, rather than the effects on costs of shifting consumers away from branch transactions. Although Saloner and Shepard (1991) address cost issues in their analysis of adoption of ATM technology, these issues and their implications have not been specifically addressed in the literature on interactions between networks.

The fact that costs drive the model developed in this chapter differentiates it from other studies of ATM networks. The emphasis on the cost implications of the consumers choice between the branch, their own bank’s ATM and a rival bank’s ATM facilitates the examination of the effect of differences in the sizes of bank’s customer bases on pricing incentives. These incentives are examined using the model both with and without the imposition of a common network usage fee.

Section 2.2 provides an overview of the model, including an introduction to the relationship between machine numbers and consumer convenience. The base case scenario of a single bank operating a proprietary ATM network is developed in Section 2.3. Section 2.4 outlines consumer choice with linked equal networks, leading into an analysis of separate and joint profitability in such a scenario in Section 2.5. Section 2.6 describes the specific case of the acquirer only network member. Section 2.7 examines the surcharge issue. The findings of the model are related to the Canadian and United States examples in Section 2.8. Concluding remarks and areas for future study are discussed in Section 2.9.

**SECTION 2.2 OVERVIEW OF A SPATIAL MODEL OF BANK NETWORKS**

This section outlines the fundamental assumptions and justifications of the model with respect to consumer choice and firm profitability, and introduces the model’s parameters.

The initial representation of the model shares with Salop’s 1979 model the assumptions
that consumers and firms (or in this case ATMs) are positioned uniformly around a unit circle, that firms are positioned symmetrically. In this application, the economy is comprised of a single industry with two banks 33 offering in-branch teller services and automated bank services. The services of the two banks are assumed to be identical in all aspects except location. In order to isolate the choice of transaction-mode from the choice of bank, consumers are assumed to hold accounts at a single bank. They are also assumed to move around the "city", as represented by the circular network of ATMs.

All banks offer a variety of services, including deposits, withdrawals, bill payments, and sundry services such as traveller’s cheques and safekeeping. As research in the North American context confirms that the majority of transactions made at ATMs are cash withdrawals34, the transactions referred to in this model are assumed to be withdrawals. For the purposes of the model, it is also assumed that consumers are not charged for withdrawals made at a branch. Apart from some very limited exceptions35, this fits with the institutional reality. One possible explanation (not captured by the model) is that banks fear they will lose their customer base if they charge fees for cash deposits or withdrawals. To focus on the issues arising from banking machine networks, in-branch fees are not included in the model and these transactions enter the model only in terms of their costs. As the automation of the financial services industry progresses it may become more common for banks to impose fees for branch services to encourage use of

33 Bank is used as a generic term for financial institution, although increasingly non-financial institutions are becoming interested in network membership.

34 Humphrey (1994), Canadian Banker’s Association (1994)

35 For example, an article in the June 1995 edition of the Retail Banking Journal discussed at length the justification for and consumer response to First Chicago Corporation’s imposition of an unusual $3 charge to use a "live" teller for certain types of transactions.
ATMs. That possibility is not addressed in this model.

Everything is exogenous with the exception of where transactions are made. The numbers of machines and the size of each bank's customer base are assumed to be fixed, and are public knowledge. Based on this knowledge, each bank determines whether or not it is in their interest to agree to form an inter-bank (or linked) network. The decision to form a network is assumed to be long term. The justification for this assumption is that the decision requires standardization and coordination of ATM software and hardware, and of security provisions. Furthermore, the decision would be difficult to reverse, due to its impact on consumer habits and attitudes. Each bank i = A, B has N_i customers who each make an identical "average" number of transactions per period. Since the model is static, only one "typical" period is considered.

The number of customers can therefore serve as a proxy for the number of transactions. The consumers' propensity to use in-branch or automated teller services is assumed to be fixed over the period. One could think of it as being a function of consumer sophistication or of a tendency to combine withdrawal transactions with other types of in-branch transactions. It is assumed that the number of customers in the marketplace remains constant. As a consequence of the assumptions, fee changes result in customers changing their transaction mode, rather than changing the bank where they hold their account.

As noted earlier, each bank has the options of operating a proprietary ATM network

---

36 Security considerations regarding ATM machines relate to both the protection of the associated physical assets (including the machines and the currency they contain) and the information assets (including the protection of customer privacy and the protection of individual institutions' proprietary client information). The introduction of interbank networks tends to complicate effective control of the security of both categories of assets.

37 Recent research suggests that the increasing convenience of ATM's has progressively prompted consumers to make more frequent, smaller withdrawals in a given time period (Humphrey, 1994). In contrast to that result, anecdotal reports provide some evidence that withdrawal amounts rise and withdrawal frequency falls as fees rise. While these issues are not specifically addressed in this paper, they suggest a possible extension of the model addressing the relationship between fees, machine numbers and transaction numbers for future work.
exclusive to its own customers or of linking into an interbank network. When and if an inter-bank network is formed, for each transaction made at the "foreign" bank's ATM consumers are charged an interchange fee f which is common within the network.

There are two stages of decision. In stage 1, two banks each own existing proprietary networks, and consider the option of linking the networks. The two proprietary networks may be of equal or unequal size in terms of the number of ATMs they contain. It is important to note here that the optimal choice of numbers of machines is not the focus of this thesis. The issue of linking networks with different numbers of ATMs is modelled in Chapter 3, with the number of machines in each network assumed to have been determined prior to the pricing negotiation. The two banks may differ with respect to the size of their customer bases. This aspect of the pricing decision is addressed in the present chapter. In making the decision whether or not to link their networks, each bank takes into account that there will be a subsequent negotiation to determine an interchange fee based on Nash Bargaining. If both banks decide that linking the networks is in their interest, in stage 2 they negotiate to set a common interchange fee. In fact, some costs would be associated with developing the infrastructure to link the networks, but these costs are not addressed in the model. The fee preferences of each institution will be predicated on their common knowledge of consumer behaviour and on the anticipated impact of this behaviour on their profitability.

SECTION 2.3 PROPRIETARY NETWORK

In the base case each bank maintains a branch system and a proprietary ATM network. As noted above, in this model we assume that no fees are charged for use of the branch tellers. Despite the existence of no fees for the use of tellers, banks face a relatively high marginal cost for these transactions, denoted by c. The marginal transaction cost associated with the use of a
machine is lower (δc with δ < 1), giving banks an incentive to install machines so as to shift customer transactions from tellers to the machines. One question is then whether banks should charge their own customers for use of their own machines within a proprietary network. We consider this possibility by introducing a fee f for each transaction at a machine, and by exploring the fee setting decision of bank A. The establishment of a network is seen as a two step process, where the bank first sets the optimal number of machines and then adjusts fees to maximize profits.

For convenience, symmetry is maintained around the unit circle by assuming that the number of machines owned by bank A, \( M^A \), is even; i.e. \( M^A = 2, 4, 6, 8 \). At any given point on the circle, the utility from use of machines varies with the distance d from the closest machine. Representing this utility by \( U^A \), we assume that the utility of a customer of bank A at distance d from A's machine is given by \( U^A = x - d - f \). If there are no machines (\( M^A = 0 \)), then customers have no choice but to use the branch. Units of measurement are chosen so that a one dollar increase in the fee has the same effect on utility as a one unit increase in the distance d of travel. Although customer use of machines will vary with their particular position on the circle, the assumption that the customers move has the advantage that on average around the circle, customers can be treated as identical.

Assuming \( M^A > 0 \), the distance between any two adjacent machines of bank A is \( \ell^A = 1/M^A \). Since the furthest a consumer can be from either of the machines is at the midpoint of the distance between the machines, their maximum distance from the closest machine = \( \ell^A/2 = 1/(2M^A) \). Assuming customers move around the circle, on average each identical customer is at distance \( d = \ell^A/4 = 1/(4M^A) \) from the closest machine, which implies an average utility from the use of machines of \( \bar{U}^A = x - 1/(4M^A) - f = x - \ell^A/4 - f \). If \( \bar{U}^A > 0 \), then there is some
use of machines, but we assume that there is also some positive probability that each customer will use his/her branch. If \( \bar{U}_{AP} \leq 0 \), then utility is not sufficiently high for consumers to use the machines and all transactions take place at the branch teller\(^{38}\). The index of convenience of machine use, \( I = \bar{U}_{AP} \) for \( \bar{U}_{AP} > 0 \) and \( I = 0 \) otherwise, we assume that the probability of use of the branch is given by:

\[
\rho^0 = e^{-\beta I}
\]  

(3.1)

where \( \beta > 0 \) is a positive constant. This implies that \( \rho^0 = e^0 = 1 \) if \( I = 0 \) and that \( \rho^0=1 \) for \( I = x - \frac{f^A}{4} - t^o > 0 \). Also, since \( d\rho^0/dI = -\beta \rho^0 \), the probability that each customer will use his/her branch rather than a machine declines as the utility from machine use increases. This implies:

\[
\frac{d\rho^0}{df^o} = \beta e^{-\beta I} = \beta \rho^0 > 0 \text{ and } \frac{d\rho^0}{dM^A} = -\beta e^{-\beta I}/(4(M^A)^2) < 0.
\]

(3.2)

The corresponding probability of a customer using one of the bank’s machines, \( \rho^p \), is \( 1-\rho^0 \), and \( \frac{d\rho^p}{df^o} = -(\frac{d\rho^0}{df^o}) \).

The bank’s profit function can be expressed as follows:

\[
\pi^A = \phi^A(N^A) + N^A \rho^p(f^p - \delta c) - N^A \rho^0 c - KM^A
= \phi^A(N^A) + N^A(f^p - c - \rho^0 f^p + c(1 - \delta)) - KM^A
\]

(3.3)

where \( K \) represents the cost of a machine and \( \phi^A \) represents revenues prior to the deduction of customer transaction related costs for the period as a function of the number of bank clients, \( N^A \). Other factors affecting bank earnings such as interest rate spreads and asset size are assumed to

\(^{38}\) Conceptually one could think of the branch being located at the centre of the unit circle of machines, and equidistant from each potential customer.
be constant and are omitted for convenience.

The fee setting incentives within the proprietary network are analyzed in detail in Appendix 2.1. and it is shown that the bank’s profit maximizing fee would be a subsidy. Due to the moral hazard problem this would engender, it makes sense that a proprietary bank network would set \( f^p = 0 \) if condition (3.8) is satisfied and \( f^p > 0 \) otherwise. For the subsequent analysis examining the incentive to link networks, we restrict attention to the former case in which banks would choose not to charge fees for own customer transactions using own bank machines.

**SECTION 2.4 CONSUMER CHOICE WITH LINKED EQUAL NETWORKS**

We now build on the proprietary network to analyze an interbank network established to link the proprietary networks of two banks, A and B. As noted earlier, the network decision takes place in two stages: the banks first decide whether or not to form such a network, and then negotiate a common interchange fee for the resulting network. To analyze this two stage firm decision it is first useful to determine how the interchange fee will affect the consumers’ choices between A and B’s machines located around the network. The assumption here is that the entire interchange fee is passed on to the consumer\(^{39}\). Initially only the competition between the banks with respect to the consumers’ choices of automated teller services is modelled. The third consumer option of using in-branch teller services will be incorporated below.

When the two banks’ networks are linked the consumer located at any point on the circle decides to transact at one firm’s ATM or another. The decision is based on the relative utility of travelling to the closest of his/her own bank’s machines to make the transaction or travelling to

\[^{39}\text{Strictly speaking the interchange fee is exchanged between the banks. The consumer’s own bank collects the cross-use fee from the consumer’s account which includes the interchange fee which they pass on to the bank owning the ATM used, a relatively small switch fee for network expenses which they pass on to the network organization and a mark up to cover their own collection costs. Although there are some exceptions in the US this mark-up is usually not high relative to the interchange fee.}\]
the closest of the competing bank's machines and paying a standard and common interchange fee to the competing bank for cross bank use of machines. Consumers gain from the size of the combined network of machines, which is captured by assuming that consumers move around the unit circle.

In the simplest two bank scenario, banks A and B own equal numbers of ATMs positioned symmetrically around the circular market. Such symmetry would prevail if each bank were restricted to establishing ATMs in pairs on opposite sides of the unit circle. Symmetry is maintained by assuming that at any point in time the proportion of customers at any one location on the circle is constant. The numbers of machines owned by each bank, $M_A$ and $M_B$, are assumed to have been set by the banks as a profit maximizing strategy after they decided to enter the inter-bank network. In this base case $M_A = M_B$, and the total number of machines in the network equals $M_A + M_B$ which, where appropriate, will be denoted as $M_T$. The distance between adjacent A and B machines is $\ell = 1/M_T = 1/(2M_A)$, and the distance between adjacent A machines is $\ell^A = 1/M_A$.

With machines placed evenly around the circle, the automated teller services market will be divided according to Figure 2.1, with A's and B's machines alternating around the circle.

Although each bank is assumed to have the same number of machines in this section, the size of the customer base, denoted by $N_A$ or $N_B$ for bank's A and B respectively, can differ across banks. The total number of bank customers is denoted by $N_T = N_A + N_B$. Each bank's customer base is uniformly distributed around the unit circle or market. Each of the individual customers of banks A and B makes a fixed average number of transactions per period. As in the

---

40 This assumption is obviously artificial, but it simplifies the analysis.
previous section, the number of transactions is assumed to be constant for all consumers and the numbers of clients are used as proxies for total transactions per period. Automated banking transactions are assumed to be an homogenous commodity from which each customer receives an identical benefit or utility of $x$ per transaction. Every banking customer can be described by the distance $d$ around the circumference of the circle at the transaction time from their location to the nearest ATM owned by their own bank. This is used as a measure of their disutility per transaction due to the cost or inconvenience of travelling to the nearest machine, and therefore deducted from $x$ to calculate the net utility from the transaction. Where an interchange fee applies due to a consumer’s decision to use the competing bank’s machine, this fee together with the cost or inconvenience of travelling to the nearest competing bank’s machine are both deducted from
the utility per transaction to find the net utility. Both the interchange fee and the disutility "cost" of the transaction are assumed to be measured in the same units as the per transaction costs to the bank.

If the two equal networks are linked each individual customer of bank A or bank B is located between an A and a B machine and now has the option of using either of the machines or their branch to make their transactions. For ease of presentation bank A's customers serve as the focus of the following analysis, although as shown later the resulting expressions are symmetric for bank B's customers. The linkage to the other network potentially increases the convenience of making transactions at a machine rather than at the branch for bank A's customers, but they will offset this added convenience against the disutility of paying the interchange fee. Rational, utility maximizing individuals will use the machine associated with the higher net utility for each one of their transactions, or will continue to use the branch if the combined convenience of the ATM network is still insufficient to convince them to use either sort of machine. If the utility from A or B's machine is equal it is reasonable to expect that loyalty, familiarity or some other intangible factor would lead bank A's customers to choose bank A's machine over bank B's machine.

For a customer of bank A at distance \( d \) from A's machine, the utility of using their own bank's machine is \( U_{AP} = x - d \) and the utility from using the other bank's machine (where the superscript AS indicates a customer of bank A using a "shared" machine) is \( U_{AS} = x - [\ell - d] - f \). Setting \( U_{AP} = U_{AS} \), defines

\[
\hat{d} = (\ell + f)/2 \quad \text{for} \quad f < \ell = 1/MT \quad \text{and} \quad \hat{d} = \ell \quad \text{for} \quad f \geq \ell, \tag{4.1}
\]

where A's customers will use A's machine (or their branch) for \( d \leq \hat{d} \) and will use B's machine (or their branch) for \( d > \hat{d} \). Note that the expression for the critical distance \( \hat{d} \) depends only on the total number of machines and the fee \( f \), so it is the same for both bank A and bank B's
customers. If \( f > \ell \) then \( \hat{d} = \ell = 1/M_T \), which implies that there is no cross customer use of machines. All customers use their own bank's machines or their own branch. If \( f < \ell \), the proportion of customers for whom \( d \leq \hat{d} \) is given by \( \hat{d}/\ell = (\ell + f)/2\ell \). The proportion of customers for whom \( d > \hat{d} \) is given by \( (\ell - \hat{d})/\ell = (\ell - f)/2\ell \).

For the subset \( \hat{d}/\ell \) of customers located within \( \hat{d} \) of their own machine, bank B's machines offer no extra convenience. They will make the decision between their branch and their own bank's machine as if no network linkage had occurred. On average these customers are \( \hat{d}/2 \) away from their own bank's machine. Hence, the average utility from use of machines for customers within \( \hat{d} \) of their own bank's machine is \( \bar{U}_{AP(d)} = x - (\hat{d}/2) \).

For the subset \( (\ell - \hat{d})/\ell \) customers located between \( \hat{d} \) and \( \ell \) away from their own bank's machine, the average customer is located \( (\ell - \hat{d})/2 \) from the other bank's machine and hence the average utility from use of those machines is

\[
\bar{U}_{AS} = x - [\ell - \hat{d}]/2 - f = x - \ell/2 + \hat{d}/2 - f. \tag{4.2}
\]

By contrast, with a proprietary network (and no access to B's machines), the average of these customers had utility:

\[
\bar{U}_{AP(\hat{d})} = x - \hat{d} - (1/(2M^A) - \hat{d})/2 = x - 1/(4M^A) - \hat{d}/2. \tag{4.3}
\]

This formula reflects the greater distance to travel to A's machine than to B's machine for these customers. Since \( M^A = M^T /2 \), it follows that linking the networks increases the utility of these customers from use of machines by

\[
\bar{U}_{AS} - \bar{U}_{AP(\hat{d})} = \hat{d} - f = (\ell - f)/2 \geq 0 \text{ for } f \leq \ell. \tag{4.4}
\]

If \( f \geq \ell \), then \( \hat{d} = \ell \) and no customers would use the other banks' machines.

Weighting by the proportion of customers located in each region at any one time, as customers move around the circle, their index of convenience from use of machines in the linked
network, (L for linked) is given by

\[ U^\text{AL} = (\hat{d}/f)U^\text{AP} + ((\ell - \hat{d})/\ell)U^\text{AS}, \]

\[ = (\hat{d}/\ell)(x - (\hat{d}/2)) + ((\ell - \hat{d})/\ell)(x - \ell/2 + \hat{d}/2 - f), \] (4.5)

which is the average utility from use of machines around the circle. This implies that with linked equal networks, the probability that a customer will use the branch is \( p^0L = \exp{-\beta U^\text{AL}}. \)

To relate \( p^0L \) to \( p^0 = \exp{-\beta U^\text{AP}} \), we express \( U^\text{AL} \) in terms of \( U^\text{AP} = x - 1/(4M^\Lambda) \). Since \( U^\text{AP} = (\hat{d}/f)U^\text{AP}(\hat{d}) + ((\ell - \hat{d})/\ell)U^\text{AP}(\ell - \hat{d}) \), we have from (3.1) and (4.5) that

\[ \bar{U}^\text{AL} = \bar{U}^\text{AP} + [(\ell - \hat{d})/\ell](\bar{U}^\text{AS} - \bar{U}^\text{AP}(\ell - \hat{d})) \] for \( \bar{U}^\text{AP} = x - 1/(4M^\Lambda) = x - \ell/2. \) (4.6)

If \( f \leq \ell \), from \((\ell - \hat{d})/\ell = (\ell - f)/2\ell \), (4.4), (4.6) and \( M^\Lambda = M^T/2 \), we then obtain:

\[ \bar{U}^\text{AL} = \bar{U}^\text{AP} + (\ell - f)^2/4\ell = x - \ell/2 + (\ell - f)^2/4\ell. \] (4.7)

Hence, it follows that

\[ \rho^0L = \exp{-\beta \bar{U}^\text{AL}} = \rho^0 \exp{-\beta((\ell - f)^2/4\ell)} \] for \( f \leq \ell. \) (4.8)

If \( f \geq \ell \), then \( \hat{d} = \ell \) and it follows using (4.6) that \( \rho^0L = \rho^0 \). At \( f = 0 \), then \( \rho^0L = \rho^0 \exp{-\beta/8M^\Lambda} = \exp{-\beta(x - 1/8M^\Lambda)} \), which is appropriate since it corresponds to a proprietary network with twice as many machines.

The effect of an increase in the fee \( f \) on the proportion using the branch is given by

\[ \partial \rho^0L/\partial f = \rho^0L\beta(1-M^T)/2 = \rho^0L\beta(\ell - f)/2\ell, \] (4.9)

which is positive for \( f < \ell \) and zero for \( f \geq \ell \). If \( f \geq \ell \), A’s customers do not use B’s machines, so use of the branch is at a maximum. However, a small reduction in \( f \) below \( \ell \) would reduce \( \rho^0L \). Using (4.9), we also obtain

\[ \partial^2 \rho^0L/(\partial f)^2 = -\beta[\rho^0L - (\ell - f)(\partial \rho^0L/\partial f)]/2\ell, \] (4.10)

which can be either positive or negative depending on the value of \( f \).

Assuming \( f \leq \ell \), the proportion of A’s customers using A’s machine and the proportion
of A’s customers using the other bank’s machine are respectively given by:

\[ \rho_{PL} = (d/\ell)(1-\rho^{0L}) = (\ell + f)(1-\rho^{0L})/2\ell \quad \text{and} \]

\[ \rho_{SL} = [(\ell - d)/\ell](1-\rho^{0L}) = (\ell - f)(1-\rho^{0L})/2\ell \quad (4.11) \]

If \( f \geq \ell \), then \( \rho_{PL} = 1 - \rho^{0L} \) and \( \rho_{SL} = 0 \). We also obtain

\[ \partial \rho_{PL}/\partial f = [1 - \rho^{0L} - (\ell + f)(\partial \rho^{0L}/\partial f)]/2\ell. \quad (4.12) \]

Since \( \partial \rho^{0L}/\partial f = 0 \) at \( f = \ell \), (4.12) implies that \( \partial \rho_{PL}/\partial f > 0 \) at \( f = \ell \), indicating that use of own machines will fall as \( f \) is reduced when no customers use the other bank’s machine. However, our assumptions so far do not prevent \( \partial \rho_{PL}/\partial f \leq 0 \) for fees below \( f = \ell \). Since higher fees at the other bank’s machine should move people to their own bank’s machines as well as to the branch, we assume \( \partial \rho_{PL}/\partial f > 0 \), which holds if the parameter \( \beta \) determining the rate at which people switch to their branch is not too large. From (4.9) and (4.12), we require

\[ \beta < 2(1-\rho^{0L})/\rho^{0L}(\ell + f)(\ell - f) = 2(1-\rho^{0L})/\rho^{0L}(\ell^2 - f^2) \quad \text{for} \quad f < \ell. \quad (4.13) \]

For example, (4.13) holds at \( f = 0 \) if \( \beta < 2(1-\rho^{0L})/\rho^{0L}(\ell^2) \).

It is always the case that increasing the fee reduces the use of the other bank’s machine: i.e.

\[ \partial \rho_{SL}/\partial f = -(1-\rho^{0L})/2\ell - (\ell - f)(\partial \rho^{0L}/\partial f)]/2\ell < 0. \quad (4.14) \]

Since \( \rho_{SL} = 1 - \rho_{PL} - \rho^{0L} \), the assumption \( \partial \rho^{0L}/\partial f > 0 \) implies that the reduction in \( \rho_{SL} \) exceeds the proportion of customers who move to the branch.

Each bank earns \( \rho_{SL} \) from its proportion of foreign customers \( \rho^{SL} \), giving rise (using (4.14)), to an expression for marginal revenue,

\[ \partial (\rho_{SL})/\partial f = \rho_{SL} + \ell(\partial \rho_{SL}/\partial f) = [(1-\rho^{0L})(\ell - 2f) - f(\ell - f)(\partial \rho^{0L}/\partial f)]/2\ell. \quad (4.15) \]

As can be seen from (4.15), an increase in the fee would reduce the revenue from cross-customer banking, making marginal revenue with respect to the fee negative, if \( f \geq 1/2M^T = \ell/2 \). The
sign of marginal revenue proves important for the subsequent analysis.

In this simple scenario of two banks with equivalent networks, the proportion of customers using their own or the other bank’s machine is identical in every AB arc segment around the circular market. Hence, letting \( \omega^{AL} = N^A \rho^{PL} + N^B \rho^{SL} \) and \( \omega^{BL} = N^B \rho^{PL} + N^A \rho^{SL} \) respectively denote the usage of bank A’s and bank B’s machines over the entire circle of ‘shared’ AB segments, it follows using \( \rho^{PL} = 1 - \rho^{OL} - \rho^{SL} \), that

\[
\omega^{AL} = N^A \rho^{PL} + N^B \rho^{SL} = N^A(1 - \rho^{OL}) - (N^A - N^B)\rho^{SL} > 0.
\]

\[
\omega^{BL} = N^B \rho^{PL} + N^A \rho^{SL} = N^B(1 - \rho^{OL}) + (N^A - N^B)\rho^{SL} > 0.
\] (4.16)

From (4.16), the interchange fee affects the usage of A’s and B’s machines on the basis of

\[
\frac{\partial \omega^{AL}}{\partial f} = -(N^A - N^B)(\partial \rho^{SL}/\partial f) - N^A(\partial \rho^{OL}/\partial f)
\]

\[
\frac{\partial \omega^{BL}}{\partial f} = (N^A - N^B)(\partial \rho^{SL}/\partial f) - N^B(\partial \rho^{OL}/\partial f)
\] (4.17)

Although the banks have equal numbers of machines, it can be seen from (4.17) that differences in the size of each bank’s customer base, as reflected in the magnitudes of \( N^A \) and \( N^B \), affect the usage of each bank’s machines. Supposing bank A has the larger customer base making \( N^A - N^B > 0 \), a decrease in the proportion \( \rho^{SL} \) of customers using the other bank’s machine can increase or decrease the usage of bank A’s machines. An increase in the interchange fee \( f \) lowers \( \rho^{SL} \). However, the increase in the interchange fee also increases the proportion of in-branch banking. Since some of the customers that previously used the other bank’s machines will shift to in-branch banking, it is possible that the use of A’s machines by B’s customers will fall by more than the increase in the use of A’s machines by A’s customers, causing an overall fall in the usage of A’s machines. This makes the sign of \( \partial \omega^{AL}/\partial f \) as given by (4.17) ambiguous. By contrast, since the shift to in-branch banking reinforces the tendency for the usage of B’s machines to fall, \( \partial \omega^{BL}/\partial f \) as given by (4.17) is always negative. Nevertheless, we are able to
show that if $\omega^A$ falls, it always falls by less than $\omega^B$: i.e. from (4.16),

$$
\frac{\partial \omega^A}{\partial f} - \frac{\partial \omega^B}{\partial f} = (N^A - N^B)[(\frac{\partial \rho}{\partial f}) + 2(\frac{\partial \rho}{\partial f})] > 0.
$$

(4.18)

Overall, since, $\omega^A + \omega^B = N^T(1-p^0)$, the total usage of machines is reduced by an increase in the fee $f$.

**SECTION 2.5 PROFITABILITY WITH LINKED EQUAL NETWORKS**

This section discusses the profit incentives of banks with respect to linking networks and choosing an interchange fee. In order to understand the effect of a difference in the customer base across the two banks, the analysis is carried out holding the number of each bank's machines fixed at $M^A = M^B$. Taking account of the costs of own machine usage as well as the revenue earned from interchange fees, the profits of banks A and B respectively can be expressed as:

$$
\Pi^A = \phi^A(N^A) - N^A \rho^0 c - \omega^A \delta c + N^B \rho^S f - K^A
$$

$$
\Pi^B = \phi^B(N^B) - N^B \rho^0 c - \omega^B \delta c + N^A \rho^S f - K^A
$$

(5.1)

where the superscript $L$ in $\Pi^A$ and $\Pi^B$ stands for linked networks.

From (3.3) with $t^0 = 0$ and (5.1), the effect of linking the networks on the profit of bank A is

$$
\Pi^A - \pi^A = N^A c(\rho^0 - \rho^0) + \delta c(N^A \rho^P - \omega^A) + N^B \rho^S f.
$$

(5.2)

Carrying out a similar analysis for bank B and using $\rho^P = 1 - \rho^0$ and $\omega^A$ from (4.16) in (5.2), it is useful to express the difference in profits from linking the networks as:

$$
\Pi^A - \pi^A = N^A c(1-\delta)(\rho^0 - \rho^0) + \rho^S(N^B f + \delta c(N^A - N^B))
$$

$$
\Pi^B - \pi^B = N^B c(1-\delta)(\rho^0 - \rho^0) + \rho^S(N^A f - \delta c(N^A - N^B)),
$$

(5.3)

where $\rho^0 - \rho^0 = \rho^0 (1 - \exp\{-\beta(\ell - f)/4f\}) > 0$ from (4.8).

For $f \geq \ell$, since $\rho^S = 0$ and $\rho^0 = \rho^0$, it follows from (5.3) that $\Pi^A - \pi^A = \Pi^B - \pi^B = 0$, and hence that there is no gain from linking the networks. An interchange fee of $\ell$ or above
destroys the incentive for cross customer use of machines, making the linked networks and profits no different than if there were two separate proprietary networks. Since a fee \( f > \ell \) is equivalent to a fee \( f = \ell \), without loss of generality, we restrict attention to values of \( f \) satisfying \( f < \ell \) for the subsequent analysis.

For \( f < \ell \), there is a potential gain from the network, since the increase in consumer access to ATMs arising from cross customer use of machines \( (\rho^{SL} > 0) \) reduces the use of the branch. Also the banks can potentially gain from fee income. However, at some sufficiently low fee (which may be negative, and therefore a subsidy), denoted by \( f^A \) for bank A and by \( f^B \) for bank B, the banks would again earn zero profits from linking the networks. For banks A and B, respectively setting \( \Pi^{AL} - \pi^A = 0 \) and \( \Pi^{BL} - \pi^B = 0 \) in (5.3), and using \( \rho^{SL} > 0 \) from \( f^A < \ell \) and \( f^B < \ell \), we obtain:

\[
N^B f^A = -N^B c(1-\delta)(\rho^0 - \rho^{SL})/\rho^{SL} - \delta c(N^A - N^B) \\
N^A f^B = -N^A c(1-\delta)(\rho^0 - \rho^{SL})/\rho^{SL} + \delta c(N^A - N^B). \tag{5.4}
\]

Having defined \( f^A \) and \( f^B \), an important assumption for tractability of the analysis is that the profit function \( \Pi^{AL} \) is strictly concave in \( f \) for \( f^A < f < \ell \) and \( \Pi^{BL} \) is strictly concave in \( f \) for \( f^B < f < \ell \). The conditions required for concavity are explored in the Appendix 2.1.

At least for bank A with its larger customer base, (5.3) and (5.4) show that it is possible for the bank to gain from the network even if this involves a subsidy to cross customer use of ATM machines. From (5.4), the fee \( f^A \) is negative and (using the strict concavity of the profit function), bank A gains from linking the network (i.e. \( \Pi^{AL} - \pi^A > 0 \)) when the fee is a subsidy (i.e. for \( f^A < f < 0 \)) as well as for \( 0 \leq f < \ell \). Payment of the subsidy to bank B’s customers using bank A’s ATM machines would lower bank A’s profit, but this may be more than made up for by the fact that the corresponding subsidy paid by bank B to the larger number of A’s customers would reduce bank A’s costs by further shifting A’s customers away from the branch. However, for bank B, with its
smaller customer base, \( f^B \) may be positive or negative from (5.4), indicating that a positive fee may be required. As we discussed when considering a subsidy for ATM transactions in a proprietary network, perverse incentive problems make an actual subsidy as a common fee undesirable. Hence if the fee determined by Nash bargaining is negative (a subsidy), this would translate to an outcome in which no fee would be charged.

As shown in Proposition 1, despite the disparity in the size of the customer base, there is a potential for mutual gain to both banks from forming a network.

**Proposition 1:** Assume \( M^A = M^B \). If \( N^A > N^B \) then \( f^A < f^B < \ell \). For any \( f \in [f^B, \ell] \), bank A strictly gains and bank B weakly gains from forming a network.

**Proof:** To see the potential for mutual gain, we need to determine the range of values of \( f \) for which \( \Pi^{AL} - \pi^A \geq 0 \) and \( \Pi^{BL} - \pi^B \geq 0 \). From (5.3) we obtain:

\[
\Pi^{BL} - \pi^B = \Pi^{AL} - \pi^A - (N^A - N^B)[c(1-\delta)(\rho^0, \rho^{0L}) + \rho^{SL}(2c - f)]
\]  

(5.5)

At \( f = \ell \), since \( \rho^{SL} = 0 \) and \( \rho^{0L} = \rho^0 \), it follows from (5.5) that \( \Pi^{AL} - \pi^A = \Pi^{BL} - \pi^B = 0 \). Since \( f^A < 0 \) from (5.4), setting \( \Pi^{AL} - \pi^A = 0 \) in (5.5) it follows that at \( f = f^A \), \( \Pi^{BL} - \pi^B < 0 \) for \( N^A > N^B \).

For \( f = f^B \), we have \( f^A < \delta c(N^A - N^B)/N^A \) from (5.4) and hence, \( 2\delta c - f^B > \delta c(1 - N^B/N^A) \geq 0 \). Thus, setting \( \Pi^{BL} - \pi^B = 0 \) in (5.5), it follows that at \( f = f^B \), \( \Pi^{AL} - \pi^A > 0 \) for \( N^A > N^B \). Since \( \Pi^{AL} - \pi^A = 0 \) at \( f = f^A \) and at \( f = \ell \), strict concavity of the profit function then implies \( f^A < f^B < \ell \) for \( N^A > N^B \).

Since \( \Pi^{AL} - \pi^A > 0 \) and \( \Pi^{BL} - \pi^B \geq 0 \) for any fee \( f \in [f^B, \ell] \), at least one bank is made better off and the other no worse off by forming the network. Since there is room for mutual gain, this proves the result. ***

In the scenario where there are interbank differences in the size of the customer base, the
individually optimal network-wide fee, denoted by \( f^A \) and \( f^B \) for bank A and B respectively, will differ across banks. The conflict between the desired value of the fee is assumed to be resolved on the basis of a non-cooperative Nash Bargaining game. As shown by Binmore, Rubinstein and Wolinsky (1986), the generalized Nash bargaining solution is the limiting case of non-cooperative bargaining as the period between offers goes to zero. Recalling that \( f \leq \ell \) (values of \( f \) above \( \ell \) have no effect since there is no sharing within AB segments) the bargaining problem is then to choose \( f \) to maximize \( z = (\Pi^{AL} - \pi^A)^{\alpha}(\Pi^{BL} - \pi^B)^{1-\alpha} \) subject to \( f^B \leq f \leq \ell \) where we have \( \Pi^{AL} - \pi^A \geq 0 \) and \( \Pi^{BL} - \pi^B \geq 0 \) for values of \( f \) in this range. Letting \( x = f - f^B \), the problem can be re-expressed in the standard Kuhn-Tucker format: choose \( x \geq 0 \) to maximize \( z \) subject to \( x \leq \ell - f^B \). Also, since \( \Pi^{AL} \) and \( \Pi^{BL} \) are assumed to be strictly concave for \( f^B \leq f \leq \ell \), this implies \( z \) is strictly concave for \( f^B \leq f \leq \ell \) ensuring that the maximum exists and is unique.\(^{41}\)

This revised problem gives rise to a Lagrangian \( L^L = \ln z + \lambda(\ell - f^B - x) \), where \( \lambda \geq 0 \) is the Lagrange multiplier and \( \ln z \) is used for convenience. Maximizing the Lagrangian with respect to \( x \) recognizing \( \partial \ln z / \partial x = (\partial \ln z / \partial f) (df/dx) = \partial \ln z / \partial f \), it follows that the bargained fee satisfies the following first order Kuhn-Tucker conditions:

\[
\begin{align*}
\partial L^L / \partial x &= \partial ln z / \partial x - \lambda \leq 0 \text{ and } (\partial ln z / \partial x - \lambda)(x) = 0; \\
\partial L^L / \partial \lambda &= \ell - f^B - x \geq 0 \text{ and } \lambda(\ell - f^B - x) = 0 \text{ or, substituting } x = \ell - f^B
\end{align*}
\]

\( \partial L^L / \partial \lambda = \ell - f \geq 0 \) and \( \lambda(\ell - f) = 0 \).

(5.6)

If \( \alpha = 1 \) (bank A has all the bargaining power), if \( \alpha = 0 \) (bank B has all the bargaining power) and

\(^{41}\) To show that \( z \) is strictly concave under the stated assumptions we use the fact that \( \ln z \) is concave iff \( z \) is concave:

\[
\ln z = \alpha \ln(\Pi^{AL} - \pi^A) + (1-\alpha)\ln(\Pi^{BL} - \pi^B)
\]

\[
\frac{\partial \ln z}{\partial f} = \alpha \frac{\partial(\Pi^{AL} - \pi^A)}{\partial f} + (1-\alpha)\frac{\partial(\Pi^{BL} - \pi^B)}{\partial f}
\]

\[
\frac{\partial^2 \ln z}{\partial f^2} = \alpha \left[ (\Pi^{AL} - \pi^A)(\partial^2 \Pi^{AL} / \partial f^2) - (\partial \Pi^{AL} / \partial f)(\Pi^{AL} - \pi^A) \right] + (1-\alpha)\left[ (\Pi^{BL} - \pi^B)(\partial^2 \Pi^{BL} / \partial f^2) - (\partial \Pi^{BL} / \partial f)(\Pi^{BL} - \pi^B) \right]
\]

Given the assumptions that \( \partial^2 \Pi^{AL} / (\partial f)^2 < 0 \) and \( \partial^2 \Pi^{BL} / (\partial f)^2 < 0 \), it follows that \( \partial^2 \ln z / (\partial f)^2 < 0 \) and that \( z \) is concave.
if $0 < \alpha < 1$, and recognizing $\partial \ln z / \partial x = (\partial \ln z / \partial f)(df / dx) \equiv \partial \ln z / \partial f$, then $\partial \ln z / \partial f$ takes the respective values:

$$
\frac{\partial \ln z}{\partial f} = \frac{\partial \Pi^A}{\partial f} / (\Pi^A - \pi^A) \text{ for } \alpha = 1, \quad \frac{\partial \ln z}{\partial f} = \frac{\partial \Pi^A}{\partial f} / (\Pi^B - \pi^B) \text{ for } \alpha = 0 \text{ and } \frac{\partial \ln z}{\partial f} = \alpha \frac{\partial \Pi^A}{\partial f} / (\Pi^A - \pi^A) + (1-\alpha) \frac{\partial \Pi^B}{\partial f} / (\Pi^B - \pi^B) \text{ for } 0 < \alpha < 1.
$$

(5.7)

From (5.1) and $\partial \omega^A / \partial f$ as in (4.17), we obtain:

$$
\frac{\partial \Pi^A}{\partial f} = -N^A c(\partial \rho^0L / \partial f) - \delta c(\partial \omega^A / \partial f) + N^B(\rho^{SL} + f(\partial \rho^{SL} / \partial f))
= -N^A c(1-\delta)(\partial \rho^0L / \partial f) + N^B(\rho^{SL} + f(\partial \rho^{SL} / \partial f)) + \delta c(N^A - N^B)(\partial \rho^{SL} / \partial f).
$$

(5.8)

Similarly for bank B, from (5.1) and (4.17) we obtain:

$$
\frac{\partial \Pi^B}{\partial f} = -N^B c(\partial \rho^0L / \partial f) - \delta c(\partial \omega^B / \partial f) + N^A(\rho^{SL} + f(\partial \rho^{SL} / \partial f))
= -N^B c(1-\delta)(\partial \rho^0L / \partial f) + N^A(\rho^{SL} + f(\partial \rho^{SL} / \partial f)) - \delta c(N^A - N^B)(\partial \rho^{SL} / \partial f).
$$

(5.9)

Proposition 2 concerns the extreme case in which bank A has all the bargaining power ($\alpha = 1$). The case where bank B has all the bargaining power ($\alpha = 0$) forms the other extreme. These extreme cases are interesting since they magnify the effects of the incentives arising from the size of the customer base. As can be seen from (5.6) and (5.7), for intermediate cases (i.e. $0 < \alpha < 1$), the bargained fee will fall between these two extremes.

**Proposition 2:** Assume $N^A \geq N^B > 0$, $M^A = M^B$ and $\alpha = 1$.

(i) Bank A’s optimal interchange fee $f^A$, chosen when $\alpha = 1$, is strictly less than $\ell$, which implies cross-customer use of machines. If $f^A > f_B$, then $f^A < \ell / 2$.

(ii) For $N^A > N^B$, the fee is a subsidy if $f^A > f_B$ for $f_B < 0$ and if the tendency to switch to machine use is sufficiently large that $\beta > N^B(1-\rho^0L)/N^A c(1-\delta)\rho^0L$. For $N^A = N^B$, the fee is a subsidy if $\beta > (1-\rho^0L)/c(1-\delta)\rho^0L$.

(iii) If $f^A > f_B$, marginal revenue is always positive at $f^A$.

---

If $0 < \alpha < 1$, then $\Pi^A - \pi^A > 0$ and $\Pi^B - \pi^B > 0$ making the expression in (5.7) well defined.
Proof:

(i) Letting \( v^A = N^B f + \delta c(N^A - N^B) \) and expanding (5.8), using \( \partial \rho^0 / \partial f = \rho^0 \beta (\ell - f) / 2 \ell \) and \( \rho^S = (\ell - f)(1 - \rho^0) / 2 \ell \) from (4.9) and (4.11), we obtain

\[
\partial \Pi^{AL} / \partial f = (\ell - f)[N^B(1 - \rho^0) - N^A c(1 - \delta) \rho^0 \beta] / 2 \ell + v^A (\rho^S / \partial f).
\]  (5.10)

Supposing \( f^A = \ell \), we have from \( \alpha = 1, \ell - f^B > 0, (5.6) \) and (5.7), that \( \partial \xi^L / \partial x = (\partial \Pi^{AL} / \partial f)(\Pi^{AL} - \pi^A) - \lambda = 0. \) However, at \( f = \ell \), using (4.11) and \( v^A > 0 \) at \( f = \ell \), (5.10) implies that \( \partial \Pi^{AL} / \partial f = v^A (\rho^S / \partial f) < 0 \) and hence that \( \lambda < 0 \), which is a contradiction. Hence \( f^A < \ell \) and \( \lambda = 0. \)

Next, expanding (5.10) using (4.14), we obtain

\[
\partial \Pi^{AL} / \partial f = \xi^A (1 - \rho^0) / 2 - Y^A (\rho^S / \partial f) \text{ where,}
\]

\[
\xi^A = N^B(\ell - f) / \ell - v^A / \ell \quad \text{and} \quad Y^A = N^A c(1 - \delta) + v^A (\ell - f) / 2 \ell.
\]  (5.11)

for \( v^A = N^B f + \delta c(N^A - N^B). \) From (5.3), using \( \rho^S = (\ell - f)(1 - \rho^0) / 2 \ell \) and (5.11), we obtain

\[
\Pi^{AL} - \pi^A = Y^A (1 - \rho^0) - N^A c(1 - \delta)(1 - \rho^0) \geq 0 \text{ for } f \in [f^A, \ell],
\]  (5.12)

which implies \( Y^A > 0. \) Also, since \( \rho^S > 0 \) for \( f < \ell \), (5.3) implies that \( v^A = -N^A c(1 - \delta)(\rho^0 - \rho^L) / \rho^S \) for \( f^A \leq f < \ell. \)

If \( \partial \Pi^{AL} / \partial f > 0 \) at \( f = f^B \), then from (5.6) and (5.7), \( \lambda = 0 \) (since \( f^A < \ell \)) and \( f^A > f^B \) satisfies \( \partial \Pi^{AL} / \partial f = 0. \) Setting \( \partial \Pi^{AL} / \partial f = 0 \) in (5.11), we obtain \( \xi^A (1 - \rho^0) / 2 = Y^A (\rho^S / \partial f) > 0 \) and hence \( \xi^A > 0. \) Rearrangement of \( \xi^A > 0 \) using (5.11) then yields:

\[
f^A < [N^B \ell - \delta c(N^A - N^B)] / 2 N^B = (\ell / 2) - \delta c(N^A - N^B) / 2 N^B.
\]  (5.13)

showing the \( f^A < \ell / 2. \)

(ii) From (5.4), \( f^B < 0 \) if \( N^A - N^B < -N^B(1 - \delta)(\rho^0 - \rho^L) / \delta \rho^S. \) From (5.10), we have that \( \partial \Pi^{AL} / \partial f < 0 \) at \( f = -\delta c(N^A - N^B) / N^B \) if and only if \( \beta > (N^B / N^A)((1 - \rho^0) / c(1 - \delta) \rho^0). \) Hence, using the strict concavity of \( \Pi^{AL} \) and \( \partial \Pi^{AL} / \partial f = 0 \) assuming \( f^A > f^B \) and \( f^B < 0, \) we obtain

\[
f^A < -\delta c(N^A - N^B) / N^B < 0 \text{ for } \beta > (N^B / N^A)((1 - \rho^0) / c(1 - \delta) \rho^0). \]  (5.14)
If $N_A = N_B$, then $\partial II^A/\partial f = 0$ at $f^A$ (since $f^A > f^B = f^A$), proving the result for $\beta > (1-\rho^O)/(1-\delta)\rho^O$.

(iii) If $f^A > f^B$, then from (5.6) and (5.7) at $\alpha = 1$, we obtain $\partial II^A/\partial f = 0$, and setting $\partial II^A/\partial f = 0$ it follows from the second line of (5.8) and $\partial \rho^S/\partial f < 0$, that marginal revenue is positive: i.e.
\[
\partial(\rho^S)/\partial f = \rho^S + f^A(\partial \rho^S/\partial f) = \left[\frac{N^A c(1-\delta)(\rho^O) - (N^A - N^B)\delta c(\rho^S)}{N^B}\right] > 0. \tag{5.15}
\]

**Proposition 2** above and the expression for the critical distance at which consumers are indifferent between their own or the other bank’s machine (4.1) imply that, provided the smaller bank will receive some benefit and so can be convinced to join a shared network, the larger bank would like to set a fee sufficiently low to encourage more than one quarter of its machine using customers to use the smaller banks machines. From Proposition 2(ii), in the absence of free rider problems, if customers had a sufficiently high preference for banking at the machine rather than at a branch and if bank B could be convinced that they would benefit financially from joining the network, the larger bank would prefer to have cross-use of machines subsidized by the network members. Finally, the result Proposition 2(iii) is useful in the proof of Proposition 3 which follows.

Proposition 3 concerns the extreme case where the bank with the smaller customer base has all the bargaining power.

**Proposition 3**: Assume $N^A \geq N^B > 0$, $M^A = M^B$ and $\alpha = 0$.

(i) If $N^A > N^B$, bank B’s optimal interchange fee $f^B$, chosen when $\alpha = 0$, strictly exceeds $f^A$.

(ii) Bank B’s optimal interchange fee $f^B$ strictly exceeds $f^A$ and if $\ell > \delta c(N^A - N^B)/N^A$, then $f^B < f^A$, which implies an internal equilibrium with cross-customer use of machines. If, in addition, $\beta \leq N^A(1-\rho^O)/N^B c(1-\delta)\rho^O$, then $f^B$ is positive.

**Proof**. (i) From (5.8) and (5.9),

43
\[ \frac{\partial \Pi^{BL}}{\partial f} = \frac{\partial \Pi^{AL}}{\partial f} + (N^A - N^B)(c(1-\delta)(\partial \rho^{0L}/\partial f) + (\rho^{SL} + f(\partial \rho^{SL}/\partial f)) - 2\delta c(\partial \rho^{SL}/\partial f) \] (5.16)

Evaluating (5.16) at \( f = f^A \), since \( \frac{\partial \Pi^{AL}}{\partial f} = 0 \) (from \( f^A < \ell \)) and \( \frac{\partial (f \rho^{SL})}{\partial f} = \rho^{SL} + f^A(\rho^{SL}/\partial f) \) > 0 from Proposition 2, this implies \( \frac{\partial \Pi^{BL}}{\partial f} > 0 \) at \( f^A \) and hence that \( f^B > f^A \).

(ii) Letting \( \rho^B = N^A f - \delta c(N^A - N^B) \) and expanding (5.9), using \( \partial \rho^{0L}/\partial f = \rho^{0L}(\ell - f)/2\ell \) and \( \rho^{SL} = (\ell - f)(1-\rho^{0L})/2\ell \) from (4.9) and (4.11), we obtain:

\[ \frac{\partial \Pi^{BL}}{\partial f} = (\ell - f)[N^A(1-\rho^{0L}) - N^B(1-\delta\rho^{0L})]/2\ell + \rho^B(\partial \rho^{SL}/\partial f) \] (5.17)

Since \( \frac{\partial \rho^{SL}/\partial f = -(1-\rho^{0L})/2\ell < 0 } \) from (4.14), setting \( f = \ell \) in (5.17) implies \( \frac{\partial \Pi^{BL}}{\partial f} < 0 \) for \( \ell > \delta c(N^A - N^B)/N^A \). Supposing \( f^B = \ell \), it then follows from \( \ell - f^B > 0 \), (5.6) and (5.7), that \( \frac{\partial \Pi^{BL}}{\partial \lambda} = (\partial \Pi^{BL}/\partial f)/(\Pi^{BL} - \pi^B) - \lambda = 0 \), and hence that \( \lambda < 0 \), which is a contradiction. Hence if \( \ell > \delta c(N^A - N^B)/N^A \), then \( f^B < \ell \) and \( \lambda = 0 \).

Next, setting \( f = \delta c(N^A - N^B)/N^A \) in (5.17), the second term vanishes and we obtain \( \frac{\partial \Pi^{BL}}{\partial f} > 0 \) and hence \( f^B > \delta c(N^A - N^B)/N^A \geq 0 \) for \( \ell > \delta c(N^A - N^B)/N^A \) and \( \beta \leq N^A(1-\rho^{0L})/N^Bc(1-\delta)\rho^{0L} \).

(iii) From Proposition 1, a sufficient condition for \( f^B < \ell \) is \( \ell > \delta c(N^A - N^B)/N^A \).

The concavity of profit, implies \( \Pi^{BL} - \pi^B > 0 \) for \( f^B < f^B < \ell \). ***

As shown in the Appendix 2.1, the condition \( \ell \geq \delta c(N^A - N^B)/N^B \) is required to ensure that \( \Pi^{BL} \) is strictly concave at \( f = f^B \). To understand this condition, it is useful to point out that for \( N^A = N^B \), it simply implies \( \ell > 0 \), which always holds since \( \ell = 1/M^T > 0 \). However, if \( N^A \) is large relative to \( N^B \) then the increase in costs to bank B from serving A’s customers exceeds the increase in costs to bank A from serving B’s customers by \( \delta c(N^A - N^B) \), raising the fee that B would need in order to break even from linking the networks.

To better understand these results, recall that ATMs are offered as a service to a bank’s own customers. Each bank is limited in its ability to recoup the costs of machine transactions made by its own customers if they are simultaneously trying to encourage the use of machines over in-branch
transactions. Hence the banks have an incentive to encourage their own customers to use the machines of other banks. In addition each bank would like to receive fee paying customers from the other bank provided that the interchange fee exceeds the per transaction cost $\delta c$. A reduction in the interchange fee causes more of A’s customers to use B’s machines than vice versa due to the different sizes of their customer bases. Lower fees decrease bank B’s profit margin on what has now become an increasing portion of Bank B’s overall business, while bank A will have succeeded in decreasing its customers use of its own facilities of either sort and the related costs. Thus bank B would like a higher interchange fee than would bank A.

**Joint Profit Maximization:** If lump sum payments were possible between the bargaining parties, their mutual incentive would be to choose a fee to maximize their joint profits and apportion them according to a prior agreement. The total (joint) profit maximizing interchange fee, denoted $f^J$ ($J$ for joint), provides an important benchmark for comparison. Using $\omega^AL + \omega^BL = N^T(1-\rho^OL)$ from (4.19), the joint profitability of the network is:

$$\Pi^J = \phi^A + \phi^B - N^T\rho^OLc - \delta cN^T(1-\rho^OL) + N^T\rho^SLf - KM^T. \quad (5.18)$$

To maximize $\Pi^J$ with respect to $f$ for $f \in [0, \ell)$ we form the Lagrangian $\mathcal{L}^J = \Pi^J + \lambda^J (\ell - f)$ where $\lambda^J \geq 0$ represents the Lagrange multiplier, the total profit maximizing fee $f^J$ satisfies the following Kuhn-Tucker conditions:

$$\frac{\partial \mathcal{L}^J}{\partial f} = \frac{\partial \Pi^J}{\partial f} - \lambda^J = 0; \quad \frac{\partial \mathcal{L}^J}{\partial \lambda} = \ell - f \geq 0 \text{ and } \lambda^J(\ell - f) = 0. \quad (5.19)$$

From (5.18) the partial effect of the fee $f$ on joint profits is given by,

$$\frac{\partial \Pi^J}{\partial f} = N^T\rho^SL + f(\partial \rho^SL/\partial f) - c(1-\delta)(\partial \rho^OL/\partial f) \quad (5.20)$$

Since $\Pi^AL$ and $\Pi^BL$ are assumed to be strictly concave, it follows that $\Pi^J$ is also strictly concave.

**Proposition 4:**

Assume $N^A \geq N^B > 0$ and $M^A = M^B$ is fixed. At the joint profit-maximizing fee $f^J$:
(i) there is always cross customer use of machines, marginal revenue from the fee is positive and \( f^* < \ell/2 \).

(ii) \( f^A < f^I < f^B \) for \( N^A > N^B \).

Proof:

(i) At \( f = \ell = 1/M^T \), it follows from (4.15), using \( \partial \rho^{0L}/\partial f = 0 \), that
\[
\rho^{SL} + \ell(\partial \rho^{SL}/\partial f) = -(1-\rho^{0L})/2
\]
and hence from (5.20) that \( \partial \Pi^L/\partial f < 0 \). Supposing \( f^I = \ell \), it then follows that (5.19) can be satisfied only if \( \lambda^J < 0 \), which is a contradiction. Hence \( f^I < \ell \), proving that there is cross customer use of machines. From (5.19), \( f^I < \ell \) implies \( \lambda^J = 0 \) and \( \partial \Pi^L/\partial f = 0 \) and it then follows from (5.20) that \( \partial(\rho^{SL}/\partial f) = c(1-\delta)(\partial \rho^{0L}/\partial f) > 0 \). From (4.15), this last condition holds only if \( f^I < 1/2M^T = \ell/2 \).

(ii) To show \( f^A < f^I \) for \( N^A > N^B \), first compare (5.20) with (5.8) to obtain
\[
\partial \Pi^L/\partial f = \partial \Pi^L/\partial f - N^Bc(1-\delta)(\partial \rho^{0L}/\partial f) + N^A(\rho^{SL} + f(\partial \rho^{SL}/\partial f)) - \delta c(N^A - N^B)(\partial \rho^{SL}/\partial f). \tag{5.21}
\]
Next, evaluating (5.21) at \( f = f^A \) and using \( \partial \Pi^L/\partial f = 0 \) and (5.15), we obtain:
\[
\partial \Pi^L/\partial f = ((N^A)^2 - (N^B)^2) [c(1-\delta)(\partial \rho^{0L}/\partial f) - \delta c(\partial \rho^{SL}/\partial f)]/N^B > 0 \text{ for } N^A > N^B, \tag{5.22}
\]
and the result follows.

To show \( f^I < f^B \) for \( N^A > N^B \), first compare (5.20) with (5.9) to obtain
\[
\partial \Pi^L/\partial f = \partial \Pi^L/\partial f - N^Ac(1-\delta)(\partial \rho^{0L}/\partial f) + N^B(\rho^{SL} + f(\partial \rho^{SL}/\partial f)) + \delta c(N^A - N^B)(\partial \rho^{SL}/\partial f). \tag{5.23}
\]
Next, to obtain marginal revenue evaluated at \( f = f^B \), we set \( \partial \Pi^L/\partial f = 0 \) and use the second line of (5.9) to obtain:
\[
\rho^{SL} + f^B(\partial \rho^{SL}/\partial f) = [N^Bc(1-\delta)(\partial \rho^{0L}/\partial f) + (N^A-N^B)\delta c(\partial \rho^{SL}/\partial f)]/N^A > 0. \tag{5.24}
\]
Finally, setting \( \partial \Pi^L/\partial f = 0 \) in (5.23) and using (5.24), we obtain:
\[
\partial \Pi^L/\partial f = -(N^A)^2 - (N^B)^2 [c(1-\delta)(\partial \rho^{0L}/\partial f) - \delta c(\partial \rho^{SL}/\partial f)]/N^A < 0 \text{ for } N^A > N^B, \tag{5.25}
\]
which implies that \( f^I < f^B \). ***
Interpreting these results, the difference between size of the customer bases of the two banks determines how far each bank's optimal fee diverges from the joint optimal fee. The value of the joint maximizing fee itself, that is, the solution for $f$ when $\partial \Pi^I/\partial f = 0$, is independent of the number of customers of each bank. This would suggest that (all other things being equal) the banks' private knowledge about anticipated trends in the size of their own or their competitor's customer base might affect the amount of effort they expended in the fee bargaining process.\textsuperscript{43} For example, a bank with a small customer base negotiating with a bank with a large and rapidly growing customer base with respect to a lump sum payment agreement might be inclined to push for a longer term agreement for fixed payment exchanges, in anticipation of a greater divergence of pricing incentives in the future.

The extreme case where $N^A > N^B = 0$, i.e. where bank B is purely a transaction acquirer (or a machine deployer) while bank A is an acquirer/issuer, is analyzed in the following section. It is easy to recognize that the conflicting incentives in a negotiation would rise as $N^B$ approaches zero, and agreement would become increasingly difficult.

\textbf{SECTION 2.6 ANALYSIS OF ACQUIRER ONLY NETWORK MEMBERSHIP}

Where bank A is an acquirer/issuer (i.e. has both ATM machines and card-holding ATM customers) and the other institution attempting to join the network is strictly an acquirer or deployer of machines ($N^B = 0$), and not necessarily involved in the financial services business in any other capacity, the two companies' profit incentives diverge completely. The acquirer-only entity is referred to as a "firm" to distinguish it as a non-financial institution. Bank A has no possibility of earning profits from ATM fees, but would be interested in linking with B's network if doing so

\textsuperscript{43} In the special case where have both identical numbers of machines and identical numbers of customers, The partial effect of the fee on each bank's individual profits is given by:

$$\delta \Pi^A/\delta f = \delta \Pi^B/\delta f = \frac{N^A}{2} \left[ \rho^A + f(\rho^A/\delta f) - c (1-\delta)(\delta^0/\delta f) \right]$$

Comparing this to (5.20) we can see that the profit maximizing fee in this case will be equal to the joint profit maximizing fee in the more general case.
would induce a shift of customers from using their own machines to using those of firm B. Firm B is purely interested in maximizing fee income. In terms of the model, using (4.16), total machine usage for each of the banks would be expressed as follows:

\[
\begin{align*}
\omega^{AL} &= N^A \rho^{PL} = N^A (1 - \rho^{OL} - \rho^{SL}) \\
\omega^{BL} &= N^A (1 - \rho^{OL} - \rho^{PL}) = N^A \rho^{SL}
\end{align*}
\]

(6.1)

Using the above and (5.1), the profit functions of each of the banks would be

\[
\begin{align*}
\Pi^{AL} &= \phi^A - N^A c [\rho^{OL} + \delta (1 - \rho^{OL} - \rho^{SL})] - KM^A \\
\Pi^{BL} &= \phi^B + N^A \rho^{SL} (f - c) - KM^B
\end{align*}
\]

(6.2)

If we assume that both firms owned bank machines before joining the network, comparing each of the above profit functions to profits before the networks were linked yields

\[
\begin{align*}
\Pi^{AL} - \pi^A &= N^A c [(1 - \delta)(\rho^{OL} - \rho^{SL}) + \rho^{OL} \delta] > 0 \\
\Pi^{BL} - \pi^B &= N^A \rho^{SL} (f - c) \geq 0 \text{ for } f \geq c
\end{align*}
\]

(6.3)

As expected, the bank with both customers and machines is always better off if the networks are linked, because that draws some customer use away from both the transaction media that represent costs to them. If Firm A owned its machines before linking networks it will be better off after linking the networks provided marginal costs are covered.

The effects of fee changes on the profits of each firm diverge sharply. For bank A

\[
\frac{\partial \Pi^{AL}}{\partial f} = - N^A c [(1 - \delta)(\partial \rho^{OL}/\partial f) - \delta (\partial \rho^{SL}/\partial f)] < 0
\]

(6.4)

As bank A makes no fee revenues, any increase in fees can only serve to increase the costs of serving their own customers, both at the branch and at their machines. Without solving explicitly for \( f^A \), it is clear that bank A would be willing to subsidize its customers' use of the other bank's machines up to the point where the subsidy amount was equal to A's cost savings from providing less branch and machine service to its clients. If individual customers were being subsidized to do
their transactions at the other bank’s branch perverse incentive problems, leading to excessive numbers of transactions as described in Section 2.3, would once more arise. As before, we assume that bank A’s profit maximizing and preferred fee would therefore be $f^A = 0$. Bank A’s customers choice between A’s and B’s machines purely by how far they are from each machine. For the acquirer B:

$$\frac{\partial \Pi^B}{\partial f} = N^A[(\frac{\partial \rho^S}{\partial f})(f-\delta c)+\rho^S]$$  \hspace{1cm} (6.5)

Setting $\frac{\partial \Pi^B}{\partial f} = 0$, we find that B’s profit maximizing fee is:

$$f^B = \delta c-\frac{\rho^S}{\frac{\partial \rho^S}{\partial f}} > \delta c$$  \hspace{1cm} (6.6)

and $f^B > f^A = 0$ as expected.

This simple result clearly shows that the acquirer only firm B would want to charge a common fee that exceeds marginal cost. Their preferred fee will depend on the elasticity of demand for use of their machines. As the common fee rises, this reduces customer cross-use of machines. At some point this will reduce the profits of the acquirer only firm, which has only machines. From proposition 4, we know that $f^A = 0 \leq f^B$. This acquirer only case will be discussed further in the Canadian context below.

**SECTION 2.7 PROFITABILITY WITH SURCHARGES**

As discussed in Chapter 1, the most recent ATM fee trend in the US has been the introduction of surcharges. These per transaction cross-use fees are set and charged by ATM owning institutions for non-customer use of machines. This section explores what would be the impact of such fees in the equal network model described thus far.

Consider the case of two banks with networks that are already linked, with $M^A = M^B$ and $N^A > N^B$. They operate the linked network with a common fee $f^C \in [f^B, f^A]$, where $f^B < f^A$.\]
and where the fee charged depends on the relative bargaining powers of the two banks as indicated by the value of $\alpha$ in the model. When banks are free to surcharge (charge an additional amount above the common fee for each cross-use of their ATMs) or subsidize (pay some amount out for each cross-use of their ATMs) their profit incentives and pricing strategies are no longer constrained by the common interchange fee, $f^C$. We model them as choosing the total fee they will charge, $f^A$ or $f^B$, to maximize their own profits, taking the total fee charged by the other bank as given. This gives rise to a Nash equilibrium in total fees with the equilibrium values represented by $f^*_A$ and $f^*_B$ for banks A and B respectively. The surcharge (or subsidy) is measured by the amount that each bank’s chosen total fee varies from the common fee, as $f^*_A - f^C$ and $f^*_B - f^C$. The proportion of each banks customer’s using the branch will now be a function both of their distance from the respective machines and of a fee set by the other bank. Using bank A as the example, and adapting (4.8) and (4.11), the expressions for use by bank A’s customers of the branch, their own machines and the other bank’s machines respectively are as follows:

$$p_{OL}(A) = \rho^0 \exp \left\{ -\beta (\ell - f^B)^2 / 4 \ell \right\}$$  \hspace{1cm} (7.1)

$$p_{PL}(A) = (f + f_B) \left( 1 - p_{OL}(A) \right) / 2 \ell$$ \hspace{1cm} (7.2)

$$p_{SL}(A) = (\ell - f^B) \left( 1 - \rho_{OL}(A) \right) / 2 \ell$$ \hspace{1cm} (7.3)

The expressions for bank B’s customers are the mirrors of the above, with the B’s and A’s interchanged. The profit for bank A assuming $f^B$ to be exogenous can therefore be expressed as:

$$\Pi^A(f^B) = \phi^A(N^A) - N^A\rho_{OL}^A(c) - \left( N^A\rho_{PL}^A + N^B\rho_{SL}^B \right) \delta c + N^B\rho_{SL}^B f^A - KM^A$$ \hspace{1cm} (7.4)

and the effect of bank A’s own fee changes on its profit is:

$$\partial \Pi^A(f^B) / \partial f^A = N^B \left[ (\partial \rho_{SL}^B / \partial f) (f - \delta c) + \rho_{SL}^B \right]$$ \hspace{1cm} (7.5)

The expression for bank B will be again be the mirror of the above:

$$\partial \Pi^B(f^A) / \partial f^B = N^A \left[ (\partial \rho_{SL}^A / \partial f) (f - \delta c) + \rho_{SL}^A \right]$$ \hspace{1cm} (7.6)
Note that if (7.5) and (7.6) above are set equal to zero to solve for the Nash equilibrium fee, the variables $N^A$ and $N^B$ are eliminated. Thus despite the difference in the size of the bank’s customer bases, at the Nash equilibrium, both banks will charge an identical fee, given by $f^A^* = f^B^* = f^N$, the Nash equilibrium fee.

The following proposition concerns the sign of $f^N - f^C$ under different assumptions about the bargaining power of each bank.

**Proposition 5:** Assume $N^A > N^B > 0$, and $M^A = M^B$. At the Nash equilibrium (under surcharging) both banks will charge the same fee, $f^N$, which strictly exceeds the common fee $f^C$ they would charge either at $\alpha=1$ or $\alpha=0$.

**Proof** That $f^A^* = f^B^* = f^N$ is proved in the text.

i) If bank A with the larger customer base has all the bargaining power ($\alpha=1$) before surcharging or subsidies are allowed, then $f^C = f^A$ and the network’s common fee is bank A’s optimal common fee. From (5.8) and (7.5),

$$\frac{\partial \Pi^A^L(f^*)}{\partial f} = \frac{\partial \Pi^A^L}{\partial f} + N^A \left[c(1-\delta)(\partial \rho^0L/\partial f) - \delta c(\partial \rho^S L/\partial f)\right]$$

(7.7)

Evaluating (7.7) at $f=f^A$, since $\partial \Pi^A^L/\partial f=0$ and $\partial \rho^S L/\partial f<0$, this implies $\partial \Pi^A^L(f^*)/\partial f^B > 0$ at $f^A$ and hence that $f^A^* = f^N > f^B$.

ii) If bank B with the smaller customer base has all the bargaining power ($\alpha=0$) before surcharging or subsidies were allowed, then $f^C = f^B$ and the network’s common fee is bank B’s common fee. From (5.9) and (7.6),

$$\frac{\partial \Pi^B^L(f^*)}{\partial f} = \frac{\partial \Pi^B^L}{\partial f} + N^B \left[c(1-\delta)(\partial \rho^0L/\partial f) - \delta c(\partial \rho^S L/\partial f)\right]$$

(7.8)

Evaluating (7.6) at $f=f^A$, since $\partial \Pi^B^L/\partial f=0$ and $\partial \rho^S L/\partial f<0$, this implies $\partial \Pi^B^L(f^*)/\partial f^B > 0$ at $f^B$ and hence that $f^B^* = f^N > f^B$.

***
The expression for the Nash equilibrium fee, (7.5) and (7.6), are the same as the expression for the optimal price for an acquirer only (or non-bank) negotiating with an acquirer/issuer to set a common fee, as seen in (6.6). However, in the acquirer only case, for any $\alpha > 0$ bank A, the acquirer/issuer, would be able to negotiate a lesser fee in order to obtain more transactions cost savings, and consumers would benefit from paying a lower common interchange fee. In the Nash equilibrium case, both banks will charge the higher price. Each will enjoy some transactions cost savings, provided that $f^N < f$, and will charge more per transaction than they would have at their optimal common fee.

The model described in this chapter is static and limited to two banks. In a dynamic marketplace with banks linked into networks it would be unlikely for the member banks to arrive at $f^N$ simultaneously. When a common fee has been negotiated, for any value of $\alpha > 0$, the bank with a smaller customer base is at a fee below its profit maximizing fee before surcharging is permitted, while the bank with a larger customer base is above its optimal common fee. After surcharges became permissible, one would expect the smaller bank to have a higher incentive to impose surcharges quickly. Their imposition of a surcharge would subsequently deplete the network benefits that the larger bank had enjoyed due to the cost savings from shifting its customers away from its own branches and machines. The larger bank would then have an incentive to impose surcharges of their own. In a multi-bank network the model then suggests that in the short term banks with smaller customer bases would impose surcharges prior to banks with larger customer bases. In the long term, however, one would expect the per transaction price of cross-use to stabilize at $f^N$, provided that each bank had identical numbers of ATMs in their networks.

SECTION 2.8 THE MODEL IN THE NORTH AMERICAN CONTEXT

The model described and analyzed above can provide some insights into the Canadian and
The first motivating question behind this chapter was how the pricing incentives of banks linking networks would vary with the size of the customer base of the bank. In Sections 2.4 and 2.5, the initially counter-intuitive indication of the model was that, all other things being equal, banks with larger customer bases would prefer to set lower common fees. The expressions derived showed that this was because they benefited less from fee revenue than from cost savings after the networks were linked. One would expect a lower common fee to prevail if the larger bank held more bargaining power, than if the smaller bank had more bargaining power. The more disparate in size the customer bases of the two banks are, the more difficult it will be for them to reach agreement upon a common fee.

Relating this to the Canadian experience discussed in Chapter 1, Interac’s exclusivity of membership and voting rights to the large institutions coincides with the model’s finding that establishing and maintaining a shared network with a common fee will be easier if the customer bases of the institutions are comparable in size. Also, the Competition Tribunal found that Interac’s interchange fees were established collusively, and that members were prohibited from adding surcharges, but not from offering discounts. For most goods and services collusive behaviour would be expected to result in excessive prices, with incentives or coercion used to prevent participants in the collusion from undercutting. The Interac actions seem to be directly opposite to this expectation. In keeping with the model, the larger charter members maintained downward pressure on the fees because of the network benefits they enjoyed. In addition, the $0.75 interchange fee remained unchanged for over 10 years, despite rising charges in other areas. The model suggests that given a mixture of large and small customer based sub-networks, all parties can have incentives to maintain "reasonable" fees, provided costs are covered, in order to prevent or to minimize more expensive
in-branch activities. The Competition Tribunal lifted the prohibition on surcharging, which should allow prices to be driven by market forces rather than by the edict of large network members.

The second motivating question behind the chapter was to examine the market entry of an acquirer only firm. The model shows that the incentives of acquirer/issuers and acquirer only entities diverge sharply when setting common prices, since the acquirer/issuer will receive no fee revenue once the networks are linked. The acquirer only firms do provide some cost savings to acquirer/issuers, and should be welcomed in a two-firm network. This result seems to go against Interac’s exclusion of acquirer only members. However, this issue needs to be viewed in the context of a multi-member network. Following from the discussion of Section 2.6, acquirer only members would be expected to place upward pressure on fee levels, and would have directly affected the fee revenues of the acquirer/issuers. The impact acquirer only entities would have had on the revenues of the acquirer-issuers might have been particularly detrimental when the Interac network was in its formative stages. At that time the charter members had not yet established widespread ATM locations, and consumers had not adjusted to using the new transaction medium. Operating machines profitably in the first years of operation would already have been a challenge, without the addition of any new competition from acquirer only firms. Once the network infra-structure was in place, the large financial institutions had shouldered the costs and risks that accompany the introduction of new technology on a national scale in a country the size of Canada. It is not surprising that Interac was reluctant to allow acquirer only firms, with profits from fees alone as their incentive to join the network, to free ride on the investment made by the charter members. One of the stipulations of the Tribunal’s ruling was that the charter members would recoup this investment. This should, in part, offset the reluctance of Interac to admit acquirer only members. A further issue remains, however, since acquirer only entities are not necessarily subject to the same regulations and privacy constraints
as are financial institutions. Questions of protection of proprietary financial information and regulatory control still need to be addressed.

Turning to the final issue of surcharging, the model leads to the expectation that, in the long term, all firms will arrive at a common surcharge fee that would be higher than the optimal common fee of either of the banks. The subsequent discussion using the results of Sections 2.4 and 2.5, suggests that in the short term, banks with smaller customer bases would be expected to surcharge more frequently and higher amounts. This hypothesis remains to be empirically tested in Chapter 4, keeping in mind that the model does not account for many other possible factors in the surcharging decision.

SECTION 2.9 CONCLUSION

The preceding paper describes a relatively simple model of consumer behaviour when using ATMs in a two-bank world, which allows some insights into the pricing activities of institutions with different sized consumer bases. The Interac case and surcharging controversy primarily motivated the research and provided an opportunity to relate the propositions to well documented facts.

While the model facilitates the exploration of the issue of the size of customer base, it does not allow for examination several other features of the ATM market. Firstly, the number of transactions per customer is held constant in the model. As transaction fees rise one would expect consumers to reduce the number of transactions per period. Secondly, with the customer bases of the two banks assumed to be held constant it is not possible to use this model to examine the strategic impacts of changing transaction fees on the banks' competition for customers. If banks can successfully use higher fees to create an incentive for their rival's customers to move their deposit accounts this could lead to even higher fees than predicted by the model once surcharging is allowed.

The model is designed as a basis for future empirical research on ATM networks. In
addition, a testable set of theories on the pricing practices of ATM networks could be adaptable to other types of banking network technologies. These include point-of-sale units, telephone banking, and smart cards. Important extensions of the present chapter would be to explore further strategic price setting in a dynamic model and to test empirically whether the propositions are borne out by actual price-setting, networking, and consumer behaviour. The static model developed in this chapter adapted to analyze conditions for linking networks with unequal numbers of machines in the following chapter.
CHAPTER III - UNEQUAL NETWORK MODEL

SECTION 3.1 INTRODUCTION

This chapter uses the simple spatial model of ATMs developed in Chapter 2 to explore market interactions in scenarios where the banks have unequal numbers of machines prior to linking up networks. The motivation behind this paper is to investigate:

1) how the joint pricing decision would be influenced by disparity in the numbers of machines owned by the two banks proposing to link networks. A possible scenario of this would be the linkage of two equally large banks (in terms of customer base/transactions), where one has chosen to provide machine convenience (high machine # per capita) and the other has chosen locations more strategically. The potential for this kind of disparity is evident in the US, where there are many financial institutions and networks with different regional and regulatory mandates. Also, in the US there is a trend toward inter-bank mergers which may cause changes to the pricing incentives of network participants, since post-merger the numbers of machines in a bank’s proprietary network may be greatly altered.

2) if and when an existing network would be prepared to grant access to an issuer only party. This is closely parallel to the Canadian case of Amex’s attempt to gain charter membership to Interac in 1989. As noted in Chapter 1, Interac’s request of a substantial lump sum membership fee from Amex was one of the principal driving forces behind the eventual Competition Tribunal hearing.

3) how permitting surcharges set by individual banks, effectively undermining the notion of a common interchange fee, will affect the pricing decisions of two banks when they own different numbers of ATMs

In order to investigate these questions, the next section will explore consumer behaviour given unequal numbers of machines in general terms, requiring some reformulation of the original
spatial model. Sections 3.3 and 3.4 rework the issues of consumer choice and profitability under the conditions of unequal numbers of ATMs, and the assumption that consumers use ATMs at either end of their market segment or their branch, and provide preliminary results. Section 3.5 explores the specific extreme condition suggested by motivation 2) above. Section 3.6 discusses the issue of surcharges in the context of banks owning different numbers of ATMs. The final section summarizes the results in view of the recent industry experience and suggests fruitful areas for further exploration of this model.

Note that to avoid unnecessary repetition of material this chapter contains a number of references to basic equations derived in Chapter 2. In order to minimize the confusion this could cause, the equation numbers specific to Chapter 2 are marked with asterisks (*).

SECTION 3.2 CONSUMER CHOICE WITH LINKED UNEQUAL NETWORKS

The following section examines how consumers' behaviour changes when the stipulation that $M^A = M^B$ is relaxed so that $M^B < M^A$. To facilitate the analysis, we assume that $M^A = tM^B$ where $t$ is an integer greater than one. In considering this scenario the assumptions of the previous section about symmetrical placement, equidistance, and market coverage are maintained for each of the proprietary networks prior to them being linked. To focus on the effects arising from the difference in the numbers of machines it is assumed that each bank has the same number of customers, i.e. that $N^A = N^B = N/2$.

Before the networks are linked both A's machines and B's machines are equally spaced around the circle in proprietary networks. When the unequal networks are linked we assume that both A's and B's machines remain equally spaced around the circle, but that B's machines become interleaved with A's machines in such a way that each of B's machines is placed at the mid-point of the distant between two of A's machines. Provided $t \geq 2$, there are fewer of B's machines, which
implies that there are both AA segments, i.e., segments with an A machines at each end, and AB segments\textsuperscript{44}. The simplest case of \( t=2 \) is illustrated in Fig. 3.1.

Since Bank B's machines are located equidistant between two of A's machines, the inter-

machine distance is no longer constant around the circle. In AA segments, the distance between machines is \( \ell^A = 1/M^A \), just as in A's proprietary network. In AB segments, the distance between machines is \( \ell^{AB} = 1/(2M^A) \), the same distance as occurs when the networks are of equal size. As the number of machines owned by bank B is increased, the spaces between A's machines become filled, until the networks are of equal sizes.

\textsuperscript{44} If \( M^A < M^B \) the circle market would consist of a mixture of AB and BB segments and the expressions for \( \gamma \) and \( 1-\gamma \) in the following analysis would be adjusted accordingly.
The existence of $M^A$ machines gives rise to $M^A$ segments of length $\ell^A = 1/M^A$ around the circle. The positioning of each $B$ machine in one of these segments creates two $AB$ segments, bisecting the original $AA$ segment. The proportion of the circle covered by $AB$ segments is:

$$\gamma = 1/t = M^B/M^A.$$  

(2.1)

e.g. When $M^A = 4$ and $t = 2$, then $M^B = 2$, and half the circle consists of $AB$ segments. When $M^A = 6$ and $t = 3$, then $M^B = 2$ and one third of the circle consists of $AB$ segments.

A customer from bank $B$ in an $AA$ segment faces the options of using the branch, using the closest of $A$'s bank machines and paying a fee, or opting to travel the extra distance to their own bank’s machine in order to avoid paying a fee. For the remainder of this chapter the term "leap frogging" will refer to the latter consumer option of travelling past one or more of the other bank’s machines to use the nearest of their own bank’s machines.

Using the superscripts /AA to denote consumers located in segments between two of bank $A$’s machines, and BS to identify that the expression refers to bank $B$’s customer using the shared network, the utility to bank $B$’s customers from use of the closest of $A$’s machines is $U_{BS/AA} = x - d^A - f$ where $d^A$ represents the distance to the closest $A$ machine. With the superscripts BP used to identify that the expression refers to a bank $B$’s customer using their own bank’s proprietary network, the utility from the use of the closest of $B$’s machines is $U_{BP/AA} = x - d^B$ where $d^B$ is the distance to the closest of $B$’s machines. Since the distance between a bank $B$ machine and the closest of bank $A$’s machines is $\ell^{AB} = 1/(2M^A)$, for $B$’s customers in an $AA$ segment contiguous with the $AB$ segment, $d^B = 1/(2M^A) + d^A$ and hence $U_{BS/AA} - U_{BP/AA} = (1/(2M^A)) - f = \ell^{AB} - f$. However if the customer has to pass two of $A$’s machines before reaching the $B$ machine, then $d^B = \ell^A + \ell^{AB} + d^A$ and $U_{BS/AA} - U_{BP/AA} = 3/(2M^A) - f = \ell^A + \ell^{AB} - f$. As a consequence, the conditions under which $B$’s customers will leap frog to their own machines depends on their particular location within
contiguous AA segments. For customers in an AA segment that is next to an AB segment, leapfrogging occurs if and only if \( f \geq f_{AB} = 1/(2M^A) \), but in "inner" AA segments, where the customer has to pass through at least one AA segment in addition to the AB segment, the conditions for leapfrogging become more difficult to satisfy. This means that a B customer may use an A machine for some values of \( f \) above \( f_{AB} \). For the moment, we analyze only consumer behaviour and profitability under the assumption that \( f < f_{AB} \), in which case leapfrogging will not occur. This limitation would prevail if government policy or regulation prevented banks from setting ATM fees so high that consumers located in shared segments would only use their own bank’s machine, even if they found themselves only steps away from the other bank’s machine. Such a policy might be motivated by concerns for consumer protection.

The utility from use of machines and hence the propensity for any one customer at any one point on the circle to use the branch will vary. However, since customers of each bank are assumed to move uniformly around the circle, they are identical. This means that to determine the propensity of the customers of each bank to use the branch, we only need the average utility from the use of machines around the circle. We do this by first examining the average utility of customers of banks A and B respectively within AA segments, before combining this with the average utility of customers within AB segments of the type analyzed in the Chapter 2.

**SECTION 3.3 CONSUMER CHOICE WITHOUT LEAPFROGGING**

**AA Segment**

Under the assumption of no leapfrogging, A’s customers in AA segments all use A’s machines. Since the distance between adjacent machines is \( l^A = 1/M^A \) in the AA segment, the maximum distance from an A machine is \( l^A/2 = 1/(2M^A) \) and the average distance is \( l^A/4 = 1/(4M^A) \). Hence the average utility from use of machines by customers of bank A in the AA segment
(for both a linked and proprietary network, using the superscript U to denote an unequal network) is

\[ \bar{U}^{AU/AA} = \bar{U}^{AP/AA} = x - \ell^A/4 = x - 1/(4M^A). \]  \hspace{1cm} (3.1)

Taking into account the fee \( f \) paid per transaction on cross-customer use of machines, bank B’s customers in AA segments have an average utility from use of A machines of:

\[ \bar{U}^{BS/AA} = x - 1/(4M^A) - f. \]  \hspace{1cm} (3.2)

If leapfrogging is ruled out, then B’s customers use either A’s machines or B’s branch in AA segments and using (3.2) and (3.3), the effect of linking the networks is

\[ \bar{U}^{BU/AA} = \bar{U}^{BS/AA} = \bar{U}^{AU/AA} - f \text{ for } f < \ell^AB. \] \hspace{1cm} (3.3)

**AB Segment**

Analogous with the superscript notation /AA, the notation /AB indicates that the expressions in question pertain to AB segments. The analysis is essentially the same as in Chapter 2, but the interpretation is slightly different. The utility from using machines in the linked network is unchanged, except for replacing \( \ell = 1/M^T \) with \( \ell^AB = 1/2M^A \). However, the utility from use of the proprietary network for B’s customers is \( \bar{U}^{BP/AB} = x - \ell^AB/2 = x - 1/(4M^A) \). This is NOT the same as \( x - 1/(4M^B) \), which is the utility to B’s customers from use of the proprietary network before the networks are linked. The utility \( x - \ell^AB/2 \) captures the fact that on average B’s customers in AB segments are \( \ell^AB/2 \) away from the nearest B machine. Therefore, using (4.7*) and the above

\[ \bar{U}^{BU/AB} = \bar{U}^{BP/AB} + (\ell^AB - f)^2/4\ell^AB \text{ for } f < \ell^AB \]

where

\[ \bar{U}^{BP/AB} = \bar{U}^{AP/AB} = x - 1/(4M^A) = x - 1/(4M^B) = \bar{U}^{BP} + (t-1)/(4M^A) \] \hspace{1cm} (3.4)

The average utility when bank B operates only a proprietary network is \( \bar{U}^{BP} = x - 1/4M^B \). The higher utility shown for B’s customers in AB segments when the networks are unequal arises from the fact that these customers are closer to a B machine than those in AA segments. For A’s
customers, \( \bar{U}^{AP/AB} = x - \ell^{AB}/2 = x - 1/4M^A \) (as in the proprietary network). Hence, 
\[
\bar{U}^{AU/AB} = \bar{U}^{AP} + M^T(\ell-f)^2/4 \text{ and, using } M^A = tM^T/(t+1) \text{ and } \ell = 1/M^T \text{ we obtain}
\]
\[
\bar{U}^{AU/AB} = \bar{U}^{AP} + (\ell^{AB} - f)^2/4\ell^{AB} \text{ for } f \leq \ell^{AB}.
\tag{3.5}
\]

**Full Circle Market**

Combining the two segments, we see that the average utility from the use of machines in the proprietary network is unchanged from chapter 2: from (2.1), (3.1) and (3.4), we obtain:
\[
\bar{U}^{BP} = \gamma \bar{U}^{BP/AB} + (1-\gamma) \bar{U}^{BP/AA}
\]
\[
= \{x - 1/(4M^B) + (t-1)/(4M^A) + (t-1)[x - 1/(4M^B) - 1/(4M^A)]\}/t
\]
\[
= x - 1/4M^B \tag{3.6}
\]
This implies \( \rho^{B0} = \exp\{-\beta[x - 1/(4M^B)]\} \) as before.

Now considering the linked networks, the average utility \( \bar{U}^{BU} \) from the use of machines by B’s customers around the circle can be expressed in terms of the relative utility of the other bank’s customers and as a function of \( t \), representing the degree to which the networks are unequal: from (2.1), (3.3) and (3.4), for \( f < \ell^{AB} \):
\[
\bar{U}^{BU}(t) = \gamma \bar{U}^{BU/AB} + (1-\gamma) \bar{U}^{BU/AA}
\]
\[
= (\bar{U}^{AP/AB} + (\ell^{AB} - f)^2/4\ell^{AB} + (t-1)[\bar{U}^{AP/AA} - f])/t
\]
\[
= \bar{U}^{AP} + [(\ell^{AB} - f)^2/4\ell^{AB} - (t-1)/f]/t. \tag{3.7}
\]
In AB segments \( \bar{U}^{AP/AB}=\bar{U}^{BP/AB}=\bar{U}^{AP} \), and defining \( \rho^0 = \exp\{-\beta(x - \bar{U}^{AP})\} = \exp\{-\beta(x-1/4M^A)\} = \exp\{-\beta(x-\ell^{AB}/2)\} \), the propensity of B’s customers around the circle market to use the branch when the networks are linked is:
\[
\rho^{B0}(t) = \rho^0\exp\{-\beta[(\ell^{AB} - f)^2/2\ell^{AB}-(t-1)f]/t \text{ for } f < \ell^{AB} \tag{3.8}
\]
Similarly for bank A’s customers, for \( f < \ell^{AB} \) from (2.1) and (3.5),
\[
\bar{U}^{AU}(t) = \gamma \bar{U}^{AU/AB} + (1-\gamma) \bar{U}^{AU/AA}
\]

\[ = \bar{U}_{AP} + (\ell_{AB} - f)^2/4t_{AB}. \] (3.9)

Hence, the propensity to use the branch for customers of A when the networks are linked is

\[ \rho^{A0}(t) = \rho^0 \exp\{-\beta(\ell_{AB} - f)^2/4t_{AB}\} \text{ for } f < \ell_{AB} \] (3.10)

Note that at \( t = 1 \), which implies that the two banks have equal numbers of machines in their proprietary networks, \( \rho^{0B}(1) \) and \( \rho^{0A}(1) \) reduce to the previous condition \( \rho^{0L} \) as in Chapter 2.

For \( f < \ell_{AB} \), in AB segments, the expressions for the proportions of each bank’s customers using the branch, their own bank’s ATM or the other bank’s ATM are identical for the two banks. Thus \( \rho^{AO/AB} = \rho^{BO/AB} = \rho^{O/AB} \), where

\[ \rho^{O/AB} = \rho^0 \exp\{-\beta(\ell_{AB} - f)^2/4t_{AB}\} < \rho^0 \text{ for } f < \ell_{AB} \] (3.11)

and

\[ \partial \rho^{O/AB}/\partial f = \rho^{O/AB} \beta(\ell_{AB} - f)^2/2t_{AB} > 0 \text{ for } f < \ell_{AB} \] (3.12)

Analogous to the (4.11*), (4.12*) and (4.13*) in the previous chapter,

\[ \rho^{PA/AB} = (\ell_{AB} + f)/(1 - \rho^{O/AB}) \]

\[ \rho^{SA/AB} = (\ell_{AB} - f)/(1 - \rho^{O/AB}) \] (3.13)

where:

\[ \partial \rho^{PA/AB}/\partial f = -[\rho^{O/AB} - (\ell_{AB} + f)(\partial \rho^{O/AB}/\partial f)]/2t_{AB} \] (3.14)

and

\[ \partial \rho^{SA/AB}/\partial f = -[(1 - \rho^{O/AB}) + (\ell_{AB} - f)(\partial \rho^{O/AB}/\partial f)]/2t_{AB}. \] (3.15)

Using \( \rho^{O/AB} + \rho^{PA/AB} + \rho^{SA/AB} = 1 \), and recalling that \( N^A = N^B = N^T/2 \), it is now possible to construct an expression for total use of each bank’s machines in AB sections, denoted be \( \omega^{A/AB} = \omega^{B/AB} = \omega^{O/AB} \) is:

\[ \omega^{O/AB} = (N^T/2)(1 - \rho^{O/AB}) \] (3.16)

where:

\[ \partial \omega^{O/AB}/\partial f = -N^T/(\partial \rho^{O/AB}/\partial f) < 0. \] (3.17)

64
The above implies that in AB segments, as the fee rises, use of both banks’ ATMs (located at opposite ends of the segment) falls.

For \( f < \ell^{AB} \), no customers in AA segments will use bank B’s machines. From (3.1*) and (3.1) for bank A’s customers in AA segments

\[
\rho^{A0/AA} = \rho^0
\]
\[
\rho^{AP/AA} = 1 - \rho^0
\]
\[
\rho^{AS/AA} = 0
\]

and

\[
\partial \rho^0 / \partial f = \partial \rho^0 / \partial f = \partial \rho^0 / \partial f = 0
\]

For bank B’s customers in AA segments, from (3.8),

\[
\rho^{BO/AA} = \rho^{AO/AA} \exp\{-\beta(-f)\} > \rho^{AO/AA} = \rho^0 \text{ for } \ell^{AB} < f
\]
\[
\rho^{BS/AA} = 1 - \rho^{BO/AA}
\]

where

\[
\partial \rho^{BO/AA} / \partial f = \beta \rho^{BO/AA} > 0
\]
\[
\partial \rho^{BS/AA} / \partial f = - (\partial \rho^{BO/AA} / \partial f) < 0
\]

It follows from (3.11) and (3.20) that \( \rho^{BO/AA} > \rho^0 > \rho^{AB} \). This makes intuitive sense, since in the unshared segments if leapfrogging is not allowed B’s customers have only the choice between using the branch or paying to use the other bank’s machine. Thus branch use would be more attractive to them in unshared than in shared segments.

With no leapfrogging only bank A’s machines will be used in AA segments, therefore \( \omega^{B/AA} = 0 \). Using (3.18) and (3.20) and \( N^A = N^B = N^T / 2 \) to construct an expression for total bank A’s machines in AA sections, denoted by \( \omega^{A/AA} \), yields:

\[
\omega^{A/AA} = (N^T / 2)(\rho^{AP/AA} + \rho^{BS/AA}) = N^T / 2(2 - \rho^{BO/AA} - \rho^0)
\]
where

\[ \frac{\partial \omega^{AA}}{\partial f} = (-N_T/2)(\partial \rho^{\text{BO/AA}}/\partial f) < 0 \quad (3.23) \]

This implies that any increase in fees will lead to a decline in the use of A's machines in AA segments because bank B's customers have a greater incentive to use their branch rather than the other bank's ATM.

**SECTION 3.4 PROFITABILITY WITH NO LEAPFROGGING**

Adjusting for the relative proportions of AA and AB segments in the market, and using the letter U to denote unequal networks, the total profits for banks A and B, \( \Pi^{AU} \) and \( \Pi^{BU} \) respectively, can be expressed as follow:

\[ \Pi^{AU} = \left( N_T/2 \right) \left[ (1-\gamma)\Pi^{AA} + \gamma \Pi^{AB} \right] + \phi(N_T/2) - KM^A \]

\[ \Pi^{BU} = \left( N_T/2 \right) \left[ (1-\gamma)\Pi^{BA} + \gamma \Pi^{AB} \right] + \phi(N_T/2) - KM^B \quad (4.1) \]

where \( \Pi^{i\text{AA}} \) (i=A,B) represents each bank's per customer profit from transactions in AA segments and \( \Pi^{i\text{AB}} \) represents each bank's per customer profit from transactions in AB segments. Note that in the above expressions, when \( N^A = N^B = N_T/2 \) it follows that the expression for \( \phi' \) (representing each bank's total profits from all other activities except customer transactions) as defined in Chapter 2 reduces to \( \phi(N^i) = \phi(N_T/2) \). Using (5.1*), (3.11) & (3.13), the expression for the per customer profit earned by both banks in AB segments in an unequal network is as follows:

\[ \Pi^{\text{AB}} = (f-\delta\rho)\rho^{\text{IS/AB}} - cp^{\text{IO/AB}} - \delta\rho^{\text{IP/AB}}. \quad (4.2) \]

The form of \( \Pi^{AA} \) differs from that of \( \Pi^{BA} \) for \( f < \ell^{AB} \), since in AA segments bank A's customers never use B's machines and hence never pay any interchange fees. The per transaction profit for bank A in AA segments can be expressed as

\[ \Pi^{\text{AA}} = (f-\delta\rho)\rho^{\text{BS/AA}} - cp^{\text{AO/AA}} - \delta\rho^{\text{AP/AA}}. \quad (4.3) \]

while per transaction profit of bank B in AA segments is
First we explore the incentives of the two banks to link networks rather than maintain proprietary networks under the condition of no leapfrogging \((f < \ell^{AB})\). It is necessary to adapt the expression for profitability with a proprietary network from Chapter 2 in order to compare it to the section by section per customer profitability analyzed at this point. The earlier expression \((3.3^*)\) modelled profitability, assuming no fee is charged to own customers for ATM use, in the form \(\pi^j = \phi(N^j) + N^j[-\delta c \rho^{IP}-\rho^{O}] - KM^j\). Given \(N^A = N^B = N^T/2\), the expression for per customer profitability strictly from transactions for each bank using only a proprietary network derived from \((3.3^*)\) is:

\[
\Pi^I = [-\delta c \rho^{IP}-\rho^{O}]
\]

where \(\rho^{O} = \exp\{-\beta[x-1/(4M^j)]\}\) and \(\rho^{IP} = 1-\rho^{O}\). From \((4.2)\) and \((4.5)\), in AB segments the difference between transaction related profits per customer with and without linked networks for bank A is,

\[
\Pi^{A/AB_{-}A} = (f-\delta c)\rho^{S/AB_{-}A} + c(\rho^{AO_{-}AB_{-}A}) + \delta c(\rho^{AP_{-}AB_{-}A}) \geq 0 \text{ for all } \ell^{AB} > f \geq 0
\]

and for bank B is

\[
\Pi^{B/AB_{-}B} = (f-\delta c)\rho^{S/AB_{-}B} + c(\rho^{BO_{-}AB_{-}B}) + \delta c(\rho^{BP_{-}AB_{-}B}) \geq 0 \text{ for all } \ell^{AB} > f \geq 0.
\]

Although similar in form, \((4.6)\) and \((4.7)\) are not equal, since for \(M^A > M^B\), \(\rho^{AO} < \rho^{BO}\), and \(\rho^{AP} > \rho^{BP}\). The above expressions reveal that in AB segments the benefit that each bank derives from joining the network is the sum of the net revenue from machine use by the other bank’s customers and the savings from shifting some of their own customers away from using either their own bank’s branch or their own bank’s ATMs. Since \(c > \delta c\) by definition, it follows that \(\Pi^{B/AB_{-}B} > \Pi^{A/AB_{-}A}\). Thus at every positive \(f < \ell^{AB}\) the bank with less machines will made better off by joining the network than will the other bank with respect to transactions made in AB segments.

Next, from \((4.3)\) and \((4.5)\), in AA segments the difference between transaction related per customer profits with and without linked networks for bank A is,
The above shows that in the AA segments bank A’s benefit from joining the network is entirely from
the net revenues earned from use of their machines by their competitor’s customers. Then from
(4.4), (4.5), the difference in transaction related per customer profits for bank B with and without
linked networks is

\[ \Pi^{B/AA} - \Pi^B = c(\rho^{BO} - \rho^{BO/AA}) + \delta c(\rho^{BP}) > 0 \text{ for all } f \geq 0 \] (4.9)

since from (3.4) and (3.20), \( \rho^{BO} = \rho^{AO} \exp \{ \beta(t-1)/4M^A \} > \rho^{BO/AA} \) for \( f < \ell^{AB} \) and \( t \geq 2 \). This shows that
in the AA segments bank B derives benefit from joining the network due to savings resulting from
reduced usage of both their branches and their ATM machines by their own customers.

Next we explore the respective minimum fees acceptable to each bank, which we will define
as \( f^{AU} \) and \( f^{BU} \). From (3.3*),(4.1),(4.7),(4.8), and (4.9) the total differences in profits with and
without linked networks around the circle market for each bank are,

\[ \Pi^{AU} - \Pi^A = \frac{N^T}{2} \{ (f - \delta c)(\rho^{BS/AA}) + (1 - \gamma)(\rho^{BO/AA}) + \gamma [c(\rho^{AO} - \rho^{O/AB}) + \delta c(\rho^{AP} - \rho^{P/AB})] \} \] (4.10)

\[ \Pi^{BU} - \Pi^B = \frac{N^T}{2} \{ \gamma (f - \delta c)(\rho^{BS/AB}) + \gamma [c(\rho^{AO} - \rho^{O/AB}) + \delta c(\rho^{AP} - \rho^{P/AB})] + (1 - \gamma) [c(\rho^{BO} - \rho^{BO/AA}) + \delta c(\rho^{BP})] \} \]

setting \( \Pi^{AU} - \Pi^A = 0 \) and \( \Pi^{BU} - \Pi^B = 0 \) in the above:

\[ f^{AU} = \delta c - \theta^A / \psi^A \text{ and } f^{BU} = \delta c - \theta^B / \psi^B \text{ where} \]

\[ \theta^A = \gamma [c(\rho^{AO} - \rho^{O/AB}) + \delta c(\rho^{AP} - \rho^{P/AB})], \]

\[ \theta^B = \gamma [c(\rho^{BO} - \rho^{O/AB}) + \delta c(\rho^{BP} - \rho^{P/AB})] + (1 - \gamma) [c(\rho^{BO} - \rho^{BO/AA}) + \delta c(\rho^{BP})], \]

\[ \psi^A = \gamma (\rho^{BS/AB}) + (1 - \gamma)(\rho^{BS/AA}) \text{ and} \]

\[ \psi^B = \gamma (\rho^{BS/AB}). \] (4.11)

The above expressions lead to the following proposition regarding the fee interval over which both

\[ ^{45} \text{The expression for the total profit with a profitability } \pi' \text{ is used here as it is appropriate for comparison with } \Pi^U. \]

68
Proposition 1: Assume $N^A = N^B$.

i) For $M^A > M^B$, it holds that $f^B < f^A$.

ii) For any $f \in [f^A, f^B]$, bank B strictly gains and bank A weakly gains from forming a network.

Proof:

i) Using (4.11), from (3.20) and $\rho^{BO} > \rho^{AO}$

$$\theta^B - \theta^A = \gamma [c(\rho^{BO} - \rho^{AO}) + \delta c(\rho^{BP} - \rho^{AP})] + (1-\gamma) [c(\rho^{BO} - \rho^{BO/AA}) + \delta c(\rho^{BP})] > 0 \text{ for } M^A > M^B,$$ (4.12)

therefore $\theta^B > \theta^A$. Next,

$$\psi^A - \psi^B = (1-\gamma) (\rho^{BS/AA}) > 0 \text{ for } M^A > M^B,$$ (4.13)

therefore $\psi^A > \psi^B$ and $1/\psi^A < 1/\psi^B$. It follows from (4.12) and (4.13) that $f^A > f^B$.

ii) At $f^AB$, $\rho^{S/AB} = \rho^{BS/AA} = \rho^{AO} - \rho^{O/AB} = \rho^{AP} - \rho^{P/AB} = 0$, therefore $\Pi^{AU} - \pi^A = 0$

Likewise, at $f^AB$, $\rho^{S/AB} = \rho^{BO} - \rho^{O/AB} = \rho^{BP} - \rho^{P/AB} = \rho^{BP} - \rho^{P/AB} = 0$ and $\rho^{BP} > 0$, therefore

$\Pi^{BU} - \pi^B > 0$. Given the concavity of $\Pi^{AU} - \pi^A$ and $\Pi^{BU} - \pi^B$, this proves that $\Pi^{AU} - \pi^A \geq 0$ for $f \geq f^A$ and $\Pi^{BU} - \pi^B \geq 0$ for $f \geq f^B$.

Combining the above results and the assumed restriction on fee levels, for $M^A > M^B$,

$f^B < f^A < f^AB$. ***

The above establishes the range of fees for which mutual gain can occur from linking the two proprietary networks. As in Chapter 2, the fee setting problem can now be seen as a non-cooperative Nash Bargaining game. $\alpha$ and $1-\alpha$ are defined as constants in the range $0 \leq \alpha \leq 1$, representing the respective bargaining power of the two banks. The bargaining problem is then to choose $f$ to maximize

$$z = (\Pi^{AU} - \pi^A)(\Pi^{BU} - \pi^B)^{1-\alpha} \text{ subject to } f^A \leq f \leq f^B \text{ where we have } \Pi^{AU} - \pi^A \geq 0 \text{ and } \Pi^{BU} - \pi^B \geq 0 \text{ for values of } f \text{ in this range. Letting } x = f - f^A, \text{ and expressing the problem in the Kuhn-Tucker format: choose } x \geq 0 \text{ to maximize } z \text{ subject to } x \leq f^B - f^A. \text{ Under the assumption}$$
that \( f^A \leq f \leq f^{AB} \) this implies that \( z \) is strictly concave in that range and that the maximum exists and is unique.

This revised problem gives rise to a Lagrangian \( L^U = \ln z + \lambda (f^{AB} - f^A - x) \), where \( \lambda \geq 0 \) is the Lagrange multiplier and \( \ln z \) is used for convenience. Maximizing the Lagrangian, recognizing \( \partial \ln z/\partial x = (\partial \ln z/\partial f )(df/dx) = \partial \ln z/\partial f \), it follows that the bargained fee satisfies the following first order Kuhn-Tucker conditions:

\[
\frac{\partial L^U}{\partial x} = \frac{\partial \ln z}{\partial x} - \lambda \leq 0 \text{ and } (\frac{\partial \ln z}{\partial x} - \lambda)(x) = 0;
\]

\[
\frac{\partial L^U}{\partial \lambda} = f^{AB} - f^A - x \geq 0 \text{ and } \lambda(f^{AB} - f^A - x) = 0 \text{ or substituting } x = f - f^A \]

\[
\frac{\partial L^U}{\partial \lambda} = f^{AB} - f \geq 0 \text{ and } \lambda(f^{AB} - f) = 0
\]

(4.14)

and if \( 0 < \alpha < 1 \), and recognizing \( \partial \ln z/\partial x = (\partial \ln z/\partial f )(df/dx) = \partial \ln z/\partial f \), then \( \partial \ln z/\partial f \) takes the respective values:

\[
\frac{\partial \ln z}{\partial f} = \alpha(\frac{\partial \Pi^A}{\partial f})/(f^{AB} - \pi^A) + (1-\alpha)(\frac{\partial \Pi^B}{\partial f})/(f^{AB} - \pi^B) \text{ for } 0 < \alpha < 1. \quad (4.15)
\]

If \( \alpha = 1 \), this implies \( \partial \ln z/\partial f = (\partial \Pi^A/\partial f)/(\Pi^A - \pi^A) \). If \( \alpha = 0 \), this implies \( (\partial \Pi^B/\partial f)/(\Pi^B - \pi^B) \).

In order to understand effects arising from the Nash Bargaining equilibrium it is useful to first explore the pricing incentives of the two banks in the two different types of market segments. With the same number of customers and machines, both banks would prefer and agree to the same common fee throughout the unequal market, which can be denoted as \( f^U = f^{AB} \). The question is how the existence of \( AA \) segments will move each bank away from this mutually preferred price. To answer this, expressions are formed for the relationship between per customer profit from transactions in \( AA \) segments and in \( AB \) segments for each bank. For bank A, (4.2) and (4.4)

\[
\Pi^{AA} = \Pi^{AB} + (I - \delta)(\rho^{AA} - \rho^{AB}) - \delta(\rho^{AA} - \rho^{AB}) - c(\rho^{AA} - \rho^{AB}).
\]

(4.16)

Thus for bank A, there are two different effects on profits in \( AA \) segments compared to \( AB \) segments. First, more of bank B’s customers use bank A’s machines, increasing bank A’s net profit.
revenues from cross-machine use. Second, bank A’s customer’s use both bank A’s branch and ATMs more in AA segments, increasing bank A’s transaction costs.

For bank B, from (4.2) and (4.5),

\[ \Pi^{B/AA} = \Pi^{B/AB} - (f-5c)p^{S/AA}c(\rho^{BO/AA} - \rho^{0/AB}) + 5c(p^{B/AB}) \]  \hspace{1cm} (4.17)

For bank B also there are two different effects on profits in AA segments compared to AB profits. First, there is no use of B’s ATMs in AA segments, leading to lower net revenues from cross use and lower transactions costs due to own customer use. Second, more of bank B’s customers use the branch, increasing transactions costs. These results are used in the following proposition which sets out the conditions under which bank A’s desired common fee will exceed bank B’s desired common fee.

To establish fee notation for the scenario where banks could price discriminate between customers in different segment types,

Let:

- \( f^{B/AB} \) = fee that would be chosen by both banks in AB segments
- \( f^{A/AA} \) = fee that would be chosen by bank A in AA segments
- \( f^{B/AA} \) = fee that would be chosen by bank B in AA segments
- \( f^A \) = bank A’s preferred common fee in entire market
- \( f^B \) = bank B’s preferred common fee in entire market

**Proposition 2:** Assume \( N^A = N^B = N^T/2 \) and \( f < f^{AB} \)

i) The existence of an unequal network with \( M^A > M^B \) will raise the common fee \( f \) at the Nash Bargaining solution if bank A has all the bargaining power (\( \alpha = 1 \)) and \( \partial[(f-5c)\rho^{SA/AA}/\partial f] > 0 \) at \( f = f^{AB} \), which holds if the customers’ tendency to switch from branch use to machine use is sufficiently high, and

ii) will lower the common fee if bank B has all the bargaining power (\( \alpha = 0 \)).
Proof

i) From (4.16)

\[ \partial \Pi^{A/AA}/\partial f = \partial \Pi^{A/AB}/\partial f + \partial [(f-\delta c)(\rho^{BS/AA}-\rho^{S/AB})]/\partial f + \partial c(\partial \rho^{P/AB}/\partial f) + c(\partial \rho^{O/AB}/\partial f) \]  

(4.18)

From (4.2)

\[ \partial \Pi^{AB}/\partial f = \partial [(f-\delta c)\rho^{S/AB}]/\partial f - c(\partial \rho^{O/AB}/\partial f) - \partial c(\partial \rho^{P/AB}/\partial f) = 0 \text{ at } f=f^{i/AB} \]  

(4.19)

Therefore at \( f=f^{i/AB} \)

\[ \partial [(f-\delta c)\rho^{S/AB}]/\partial f = c(\partial \rho^{O/AB}/\partial f) + \partial c(\partial \rho^{P/AB}/\partial f) > 0. \]  

(4.20)

Also, from (4.20), using (4.18) and (4.19), at \( f=f^{i/AB} \)

\[ \partial \Pi^{A/AA}/\partial f = \partial [(f-\delta c)(\rho^{BS/AA}-\rho^{S/AB})]/\partial f + \partial \Pi^{A/AB}/\partial f \]

\[ = \rho^{BS/AA}-\rho^{S/AB} + (f-\delta c)(\partial \rho^{BS/AA}/\partial f - \partial \rho^{S/AB}/\partial f) + (f-\delta c)\partial \rho^{S/AB}/\partial f \]

\[ = \rho^{BS/AA} + (f-\delta c)\partial \rho^{BS/AA}/\partial f \]

\[ = \rho^{BS/AA} - (f-\delta c)(1-\rho^{BS/AA}) \]

\[ = \partial [(f-\delta c)\rho^{BS/AA}]/\partial f \]  

(4.21)

If the above is positive then bank A would prefer to raise the common fee.

Bank A prefers to set \( f^{A} > f^{i/AB} \) iff \( \partial [(f-\delta c)\rho^{BS/AA}]/\partial f > 0. \)

Using (4.21), at \( f=f^{i/AB} \)

\[ \partial^{2} \Pi^{A/AA}/\partial f \partial \beta = (f-\delta c)[\beta(\partial \rho^{BS/AA}/\partial \beta) - (1-\rho^{BS/AA})] + \partial \rho^{BS/AA}/\partial \beta \]  

(4.22)

where \( \partial \rho^{BS/AA}/\partial \beta = - \partial \rho^{BO/AA}/\partial \beta = (x-1/4M^{A}-f)\rho^{BO/AA} > 0. \)

Using \( (1-\rho^{BS/AA})=\rho^{BO/AA} \), and \( (x-1/(4M^{A})-f) > 0 \) by definition, and substituting into (4.22), we see that

\[ \partial^{2} \Pi^{A/AA}/\partial f \partial \beta > 0 \]  

for all \( \beta > 1/(x-1/(4M^{A})-f). \)  

(4.23)

ii) Turning now to bank B, from (4.17)

\[ \partial \Pi^{B/AA}/\partial f = \partial \Pi^{B/AB}/\partial f - \partial [(f-\delta c)\rho^{S/AB}]/\partial f + c(\partial \rho^{O/AB}/\partial f - \partial \rho^{BO/AA}/\partial f) + \partial c(\partial \rho^{P/AB}/\partial f) \]

(4.24)
At \( f = f^{A/B} \), using (4.19) and (4.20)
\[
\frac{\partial I^{B/A}}{\partial f} = -c(\partial \rho^{B/A}/\partial f) < 0
\]
therefore bank B would prefer lower the common fee to set \( f^B < f^{A/B} \). \( (4.25) \)

***

Interpreting the result of Proposition 2(i), bank A, with more machines, would like to take advantage of the fact that the customers of bank B in the AA segments are "captive", because they are only able to choose between using the branch or the other bank's machine. If required to charge a common fee in the entire market, bank A prefers to charge more than it would want to charge in AB segments. This is because bank A can maximize its network profits (generally) by increasing the fee profits they enjoy in the AA segment. As shown by the condition that \( f^A > f^{A/B} \) when that \( \partial[(f-\delta c)\rho^{B/A}] / \partial f > 0 \), this result holds provided that consumer preference for using machines rather than branches is sufficiently high.

Proposition 2(ii) shows that when the same common fee prevails in the entire market, bank B would prefer to charge a lower fee than the fee they would want to charge in AB segments. This will maximize network profits, because the lower fee saves costs by shifting customers from B's branches to A's machines in AA segments.

These results will be discussed in the Canadian context in Section 3.7. As the portion of the market occupied by AA segments increases, and the incentives of the banks diverge further, one would expect agreement on a common fee (with some exogenous shared bargaining power, \( 1 > \alpha > 0 \)) to become more difficult to reach. The extreme case of an issuer only member is explored below.

**SECTION 3.5 ANALYSIS OF ISSUER ONLY NETWORK MEMBERSHIP**

Where bank A is an acquirer/issuer and the other institution attempting to join the network
is strictly an issuer of ATM cards ($M^B=0$) without any proprietary ATM network, the two banks' profit incentives with respect to fees diverge more than if they were both ATM owners. Bank B has no possibility of earning profits from fees, but it is servicing all of its own customers' transactions at the branch ($\rho^{BO}=1$). This scenario is akin to a small credit union choosing to join the network of a larger bank rather than to incur the expense of establishing a proprietary network. Bank B will be interested in allowing its customers to access their accounts through A's network provided it will shift some portion of branch transactions to A's machines. In contrast, bank A's only incentive to allow bank B's customers to use its network, in terms of the model outlined here, is to gain fee revenues in excess of marginal costs. If a network agreement is reached, the circle market is serviced by equally spaced bank A machines, and customers of either bank located anywhere around the market now choose only between their branch or the nearest A machine.

In this case, if the assumption of $N^A=N^B=N^T/2$ is maintained, the profit functions of each of the banks would be

$$\Pi^A_U = \phi^A - N^T/2[c\rho^AO - \delta c \rho^AP + (f - \delta)(\rho^{BS/AA})] - KM^A$$

$$\Pi^B_U = \phi^B - N^T/2(c\rho^{BO/AA})$$ (5.1)

where $\rho^{BS/AA} = 1 - \rho^{BO/AA}$ and $\partial \rho^{BS/AA}/\partial f = -\partial \rho^{BO/AA}/\partial f < 0$ as in (3.20) and (3.21).

Comparing each of the above to profits before the network agreement was reached yields

$$\Pi^A_U - \pi^A = N^T/2[(f - \delta)(\rho^{BS/AA})] \geq 0 \text{ for } \ell^{AB} > f \geq \delta c \quad (5.2)$$

$$\Pi^B_U - \pi^B = N^T/2c(\rho^{BO} - \rho^{BO/AA}) = N^T/2c(\rho^{BS/AA}) \geq 0 \text{ for } f < \ell^{AB}$$

This shows that both banks would be better off signing a network agreement provided that the fee charged for cross customer use exceeds the marginal costs of machine use. Bank B, the issuer only bank) will be better off at any fee provided some customers would opt to use the machines rather than their branches, and would be prepared to subsidize its customers to use the machines provided
that the cost of the subsidy did not exceed the cost savings from reduced use of branches. The preferred fee of Bank A would be at the point where \( \partial \Pi^{AU}/\partial f = 0 \), or where

\[
f^A = \delta c - (\rho^{BS/AA})/(\partial \rho^{BS/AA}/\partial f) > \delta c \text{ for all } f_{AB} > f^A.
\]  

(5.3)

This shows that the bank that has both machines and customers will want to charge a fee that is greater than marginal costs.

As in the acquirer only case described for equal networks in Section 6 of Chapter 2, it is the bank with more machines that would place upward pressure on the common fee in a negotiating session. However, there are two clear differences between the issuer only case described here and the acquirer only case described in chapter 2. Although they are not specifically addressed by the model, they would have implications for actual common fee negotiations. In the issuer only case, the bank with no machines benefits only in so far that its customers are shifted from using its branch to using bank A's machines, whereas in the acquirer only case the acquirer/issuer benefited from cost savings from both branch use and use of their own machines. Also, in the issuer only case, the bank with no machines did not have to make any capital investment in bank machines while in the acquirer only case, the acquirer/issuer saw the use of their existing ATMs decline. These issues will be discussed in the context of the US and Canadian examples below.

**SECTION 3.6 PROFITABILITY WITH SURCHARGES**

Further to the discussion in both Chapters 1 and 2, it is now possible to analyze the impact of an unequal network on the decision to surcharge or subsidize. Recall that surcharges are per transaction cross-use fees set and charged by ATM owning institutions for non-customer use of machines in addition to the common network fees.

Two possibilities can be discussed in the non-equal network context. First, without the constraint of a common fee around the entire market, in the absence of preventative regulation, banks
A could instigate price discrimination by machine location. This possibility is of interest because, as will be discussed in Chapter 4, there is prima facie evidence of price discrimination by location in the US market. In this case each bank would choose a total fee (common fee + surcharge or subsidy) to maximize its profits or minimize its losses in that type of segment, taking the total fee charged by the other bank in the segment as given. This gives rise to a Nash equilibrium in total fees, where the preferred total fees would be \( f^{A/A}_* \), \( f^{B/A}_* \), and \( f^{i/AB}_* \). This is explored in Proposition 3. The second possibility is that price discrimination by location is ruled out, and that the two banks choose the total fee that they will charge, \( f^{A/U}_* \) or \( f^{U/AB}_* \) to maximize their own profits or minimize their costs, taking the total fee charged by the other bank around the entire network as given. This scenario is analyzed in Proposition 4.

First, however, expressions need to be established for the revised first order conditions for profit maximization in each type of segment. As in Proposition 2, we continue to work with the per customer profits from transactions. In the AB segments, analogous to the two banks responses are mirrors of one another,

\[
\frac{\partial \Pi^{A/AB}(f^{B/AB}_*)}{\partial f} = (f-\delta c)(\partial \rho^{BS/AB}/\partial f) + \rho^{BS/AB}
\]

\[
\frac{\partial \Pi^{B/AB}(f^{A/AB}_*)}{\partial f} = (f-\delta c)(\partial \rho^{AS/AB}/\partial f) + \rho^{AS/AB}
\]  

(6.1)

In the AA segments

\[
\frac{\partial \Pi^{A/AA}(f^{B/AA}_*)}{\partial f} = (f-\delta c)(\partial \rho^{BS/AA}/\partial f) + \rho^{BS/AA}
\]  

(6.2)

and

\[
\frac{\partial \Pi^{B/AA}(f^{A/AA}_*)}{\partial f} = - (c \rho^{BO/AA}/\partial f)
\]  

(6.3)

**Proposition 3:** Assume \( N^A = N^B = N^T/2 \), and that price discrimination by location is possible

i) In AB segments, both banks would surcharge an equal amount above their preferred common fee in AB segments, where the surcharge amount \( f^{i/AB}_* - f^{i/AB} > 0 \)
ii) In AA segments, bank A will surcharge up to the point where the total fee charged is equivalent to the fee they would charge if they had all the bargaining power, and if there were only bank A’s ATMs in the network.

iii) Bank A will surcharge more in AA segments than both bank A and B surcharge in AB segments provided that consumer preference for using machines is sufficiently high.

**Proof:**

i) Referring to each of the profit functions in (6.1) with the generic functions \( \partial \Pi^{i/AB}(d^{i/AB^*})/\partial f \), from (4.2) and (6.1)

\[
\partial \Pi^{i/AB}(d^{i/AB^*})/\partial f = \partial \Pi^{i/AB}/\partial f + c(\partial p^{i/AB}/\partial f) + \delta c(\partial \rho^{i/AB}/\partial f). 
\]  

(6.4)

Evaluated at \( f^{i/AB} \), \( \partial \Pi^{i/AB}/\partial f = 0 \), and \( \partial \Pi^{i/AB}(d^{i/AB^*})/\partial f > 0 \)

Therefore at \( f^{i/AB} \), and \( f^{i/AB^*} - f^{i/AB} > 0 \) and both banks would subsidize above their preferred common fee if they could price discriminate in AB segments.

ii) From (4.3) and (6.2), \( \partial \Pi^{i/AA}(d^{i/AA^*})/\partial f = \partial \Pi^{i/AA}/\partial f \) when \( \alpha = 1 \).

iii) It follows from proposition 4 (i), (6.1) and (6.2) that \( f^{i/AA^*} > f^{i/AB^*} \) iff \( \partial((f-\delta c)\rho^{i/AA})/\partial f > 0 \) at \( f^{i/AB^*} \) and \( f^{i/AB^*} < \rho^{i/AA} \).

This result demonstrates that the more customers prefer using ATMs rather than branches for simple transactions, the greater the incentive of banks with larger networks to price discriminate by location. Although we will not specifically model it here, consider the scenario where the circle market is dominated by AA segments. With surcharges and price discrimination allowed and unregulated, under extreme assumptions regarding demand for machines over branches, the bank with more machines could conceivably also carry price discrimination by location to extremes. One condition that could give rise to such potentially monopolistic (in AA segments) levels of surcharging might include a reduction in the number of branches. If the option of using the branch rather than
an ATM were to become progressively less attractive to consumers they would become increasingly reliant on ATMs.

The second possibility mentioned at the outset of the section is that banks be forced by regulation or law to abstain from price discrimination by location, and to surcharge at the same rate around the entire market. While this is difficult to model specifically for the unequal market case, the results from Proposition 3 and the subsequent discussion lead to the expectation that, given the presence of AA segments in the marketplace, bank A would charge a higher surcharge around the entire network once the constraint of negotiating a common fee were relaxed. This expectation would increase as the ratio of bank A machines to bank B machines, t, increased. Consumers' price sensitivity in their choice between branch and ATM banking would mitigate against bank A's incentive to impose a high network wide surcharge.

SECTION 3.7 THE MODEL IN THE NORTH AMERICAN CONTEXT

As in Chapter 2, the results of this analysis can provide some new insights into the development of ATM networks.

The first motivating question for the chapter was to see how the existence of unequal networks influenced the common pricing decision. The assumption that the banks in the network had equal customer bases was maintained in order to simplify the analysis and to focus on the effects of machine numbers. Banks with larger numbers of machines relative to their competitors would be expected to want a higher common fee, all other things being equal. This finding can be related to the concerns of the US regulating bodies that competing networks with large numbers of machines could lead to market foreclosure. It provides some insight into more recent US anti-trust concerns about the flurry of mergers of regional ATM networks in the US. Small banks or co-ops attempting to join a network may be powerless in the process of negotiating a common interchange fee. They
may have no choice but to accept a fee level that is far from optimal to maintain their customer base, since ATM service and accessibility has become a consumer expectation rather than a service bonus.

The second motivating question was how the special case of an issuer only member influenced the pricing process. This was of particular interest because of the parallels to the Canadian Amex case. Amex was the subsidiary of a very large issuer of cards with essentially no branch system for retail level cash transactions in Canada. They made an attempt to "bootstrap" a broad based entry into the Canadian retail financial industry by joining the Interac network in the capacity of a negotiating charter member. The model shows that issuer only banks would want to keep prices low. Also, although not a direct finding of the model, it is evident that issuer only banks would be able to free ride on the investment of early network members. Of course, Interac's resistance to Amex's charter membership may have been motivated by many factors, including the members' desire to protect the dominance of bank-issued Visa and Mastercard products. However, at some level the divergence of pricing incentives of the parties and the potential negotiating power of Amex may also have been factors in Interac's stance. Certainly the high lump sum upfront membership fee seems to have been an attempt to offset the "free rider" problem associated with entry of an issuer only entity into an established network.

The final motivating question of the chapter was to see how the unequal network affected the surcharging decision. The model indicated that unregulated surcharging could lead to price discrimination by location by the network member with more machines. Even if such price discrimination were not allowed, the dominant machine owner would have incentives to surcharge more than their competitor if consumer demand were not highly sensitive to price increases. The US experience appears to support this finding, as much of the discussion in recent US government reviews of surcharging policy has focused on the issue of the anti-trust implications of the
combination of large (by machine numbers) banks, surcharges, and the need for consumer protection.

**SECTION 3.8 CONCLUSION**

The simple model developed in this and the preceding chapter is intended as a first step toward a better understanding of network pricing policies. Many extensions to the model can be suggested. Among the most interesting would be the following:

1) to consider the model in a dynamic setting, viewing the pricing decision as a multi-stage process. This would be particularly valuable in analyzing surcharges, since they are essentially a second-stage add-on to the negotiated common fee.

2) to incorporate the consumers' choice of banks into the model, with the each bank's market coverage with ATMs serving as part of the portfolio of financial services they provide relative to their competitors.

3) to address issues of efficiency within the model, both from the perspective of consumer welfare and from the perspective of operating efficiency.

4) to relax the assumption that machine numbers remain fixed as fees change. Given the advantage that the bank with more machines has in most market conditions, it seems likely that this would provide banks with an incentive to attempt to dominate the market as a profit making strategy.

Unfortunately all of the extensions suggested above would add to the mathematical complexity of the model as it is currently specified.

While pricing is the focus of this thesis, changes in numbers and physical locations of machines, and numbers of transactions could also be approached using adaptations of this theoretical framework to develop hypotheses, either under static or dynamic assumptions.

Although this model was motivated by bank behaviour with respect to ATM networks, it has the potential to be applied to other banking networks, such as POS and home banking. Furthermore,
with appropriate adaptations, some aspects of the model could contribute to studies of the structure, pricing policies and other features of non-banking networks.

This concludes the theory portion of the thesis. The fourth and final chapter of the thesis is structured as a stand alone empirical paper. Some references are made to both the institutional discussion in Chapter 1, and to hypotheses developed in Chapters 2 and 3. The chapter describes and tests specific research questions directly related to the ATM surcharge issue in the United States.
CHAPTER IV-EMPIRICAL STUDY OF SURCHARGING IN THE US

"Consumers pay extra for the convenience of using a pay telephone, buying tickets by phone instead of going to the box office or buying milk at a convenience store. The ATM has brought Americans exceptional convenience. Let’s let consumers - not lawmakers - decide whether to pay a fee”

Walter A. Dodds Jr, president, American Bankers Association

"The case can be made that surcharges are one step worse than predatory pricing. It’s the anti-competitive equivalent of having your cake and eating it too. Surcharges allow the bank to increase its profits while creating incentives for non-customers to switch to the bank."

John L Bley, director, State of Washington Dept.of Financial Institutions

"There are three things wrong with ATM surcharges. They are deceptive, anti-competitive, and unconscionable."

ATM Surcharge, consumer information Internet site.

SECTION 4.1 - INTRODUCTION

Since 1996 many US banks owning and operating ATMs have begun to charge a new kind of per transaction fee known as a surcharge. This fee applies to non-customers taking advantage of the convenience of using another firm’s machine to make transactions on their account at their own bank. The surcharge is collected from the ATM user’s account by the ATM owner at the time that the transaction is made and does not vary with the size of the transaction. The surcharge amount on a machine is set by the ATM owner and is additional to the network fees already agreed upon by the network’s member-firms to compensate them for cross-customer use of their machines.

In the US, the widespread introduction of ATM transaction surcharges, or "convenience fees", since 1996 has engendered an ongoing debate amongst financial institutions, regulators and consumer groups. A similar debate can be anticipated in Canada, where surcharges have been

---

46 This chapter will focus on the machines owned by financial institutions. As noted in the earlier chapters, an increasing number of machines are owned and operated by firms not otherwise involved in the financial services industry. Also, as in previous chapters "bank" is used as a generic term for all types of financial institutions.

47 As will be described later in the paper, the network fees are collected by the consumer’s own bank and then transferred to the appropriate machine owner and the network organization.
permitted since 1996 but where they have been introduced more gradually than in the US. Preliminary evidence suggests that surcharges have changed consumer behaviour patterns\textsuperscript{48} and the structure of ATM networks\textsuperscript{49}. Some regulators and industry analysts believe that surcharges may have further reaching impacts on the structure of the financial services industry.

The introduction of surcharges and its impacts on the industry have been closely monitored by state and federal regulatory agencies\textsuperscript{50} and by financial services industry publications such as \textit{Bank Network News} and the Internet information service, \textit{Bank Rate Monitor}. A proprietary study sponsored by the American Bankers' Association (ABA) examining the consumer response to the new fees provides further evidence of the interest in this issue. Little attention has been devoted to how the features of individual banks might influence their decisions to introduce surcharges on the ATMs that they own, or whether banks' features have influenced the relative size of the surcharge. A better understanding of the influences driving this new pricing trend is required in order to guide public policy responses, particularly with respect to issues of abuse of market power and consumer protection. Are large banks more likely to surcharge than small banks, or are banks in certain regions more likely to surcharge than others? Are regional, size, or market coverage factors related to variations in the amount of the service charge levied by different banks? Answers to these questions could provide some insights into whether banks are competing on a level playing field and

\textsuperscript{48} Numerous reports in the Bank Network News confirm that surcharges have led to a decline in the number of transactions switched through the networks. Although estimates range between 15\% and 30\%, the precise magnitude of the decline attributable to surcharges is difficult to determine, because as surcharges were being introduced, a series of major bank mergers also took place. This caused some transactions that would have been switched in the past to be handled within the larger proprietary network of the merged bank.

\textsuperscript{49} McAndrews (1998) provides evidence that surcharges have led to an increase in the number of ATM's deployed per capita.

\textsuperscript{50} Bley (1997) describes the concerns of regulatory bodies and consumer groups. Further evidence of these concerns is provided by the proceedings records of the July 15, 1998 "Hearing on the Practice of Automated Teller Machine Surcharging" held before the US Senate Banking, Housing and Urban Affairs Committee.
whether government intervention is required to ensure that ATM markets function competitively.

This chapter tests research questions about the surcharge decisions made by US financial institutions\(^{51}\) using a new cross-sectional data set based on the combination of two sets of publicly available information. The analysis begins by examining the data broken down by key variables. Then regression analysis is used to assess a number of hypothesized relationships. A discrete choice probit model is used to examine the firm’s decision on whether or not to levy a surcharge. This question is of interest because the industry effectively regulated itself by self-imposing a ban on ATM surcharges until 1996, when member pressure caused the national networks to lift the ban. A bank’s introduction of a surcharge of any amount since the ban was lifted represents a fundamental change in strategy\(^{52}\) with respect to their ATM operations, while a bank’s resistance to introducing surcharges in markets where others are collecting them indicates a different strategic approach to the marketplace. The probit model treats those who charge different surcharge fees equally, and focuses on explaining the underlying "surcharge or not" decision. Then Tobit and ordinary least squares (OLS) regression methodologies are used to examine the amount of surcharge being levied by those who opt to surcharge. The corresponding public policy question of interest here is whether or not undue competitive advantage exists with respect to ATM pricing in some segments of the US ATM market.

Section 4.2 describes related previous research theory with respect to ATM networks. Section 4.3 reviews the emergence of ATM surcharges in the US and of the related concerns that have resulted in public debate. This review and the spatial model described in Chapters 2 and 3 of this thesis.

\(^{51}\) The focus of this paper is on ATM’s owned by financial institutions, rather than by third party deployers who do not have the capacity to issue bank cards, i.e. the "acquirer only" firms as discussed in Chapters 1-3 of this thesis.

\(^{52}\) Nixon (1996) explores the diversity of bank attitudes toward the introduction of surcharges, and their impact on the competitive position of different types of institutions.
thesis serve as a basis for forming a model of surcharging behaviour to be used to examine research questions about the relationships between firm features and surcharges in Section 4.4. Section 4.5 describes the data and its sources. The empirical results are discussed in Section 4.6. Section 4.7 concludes the chapter by relating the results to the original hypotheses and suggesting directions for future research.

**SECTION 4.2 - RELATED RESEARCH**

The model discussed in Chapters 2 and 3 of this thesis is the principal theoretical foundation for the research questions in this chapter. Specifically, the discussion in Section 2.7 shows that, all other things being equal, banks with relatively small customer bases would be expected to surcharge more than those with large customer bases in the short run. Also, Section 3.6 shows that, controlling for all other factors, banks with large networks would be expected to surcharge more than would banks with small networks. Several other models address related questions regarding ATM networks.

A circular spatial model is used by Matutes and Padilla (1994) to examine bank incentives to sign ATM compatibility agreements when banks are competing for depositors by varying interest rates. This model examines offsetting effects of differing ATM network sizes and withdrawal fees, and common interchange fees and switching costs, on the desirability of full or partial network compatibility to the banks. The results are then used to motivate a discussion of public regulation with respect to both regulation of levels of access fees charged to banks to join compatible networks and imposition of deposit rate ceilings. The discussion of the banks’ trade off between ATM fee revenue and interest rate based deposit revenue suggests a possible extension for the present paper.

McAndrews and Rob (1996) analyze the impact of the structure of the ownership of the network switch, essentially the information routing mechanism of the network, in the ATM adoption and pricing decisions. The issue of the monopoly power associated with jointly owned switches is
key to their analysis. One of the conclusions from the model is that the trend in favour of joint ownership of fewer, larger networks should be of public policy concern with respect to anti-trust legislation because of the upward pressure that is placed on retail level prices. This concern should be maintained despite the positive network externalities enjoyed by consumers who find it convenient to have more ATMs that accept their card in larger networks. As will be discussed below, this tradeoff between price and convenience is also at the heart of the surcharge debate.

Considering the scope of the theoretical research, both on networks in general and on ATM networks specifically as noted in Chapter 1, and the high level of public interest in the trend toward increasing retail bank fees, it is surprising to find little empirical research in this area. One possible explanation is that, until recently, bank fees were of relatively less importance to policy makers and consumers than other features of financial services, such as interest rates and new product developments. Another is that reliable detailed information on bank fees was not available previously, either from regulatory offices or from other public and private sources. The lack of interest and information regarding bank fees are both now changing as more regulatory and industry attention is being focused on fee fluctuations and their impacts on consumers and on industry structure. In part, the new found attention paid to bank fees has been stimulated by the transparency and controversial nature of ATM fees, and of the surcharge in particular.

Empirical models that introduce bank fees in their analysis include Barry (1998), which models the performance of Australian banks, and Saunders and Udell (1989) and Heggestad and Mingo (1976), both of which incorporate fees into the traditional structure-conduct-performance analysis of the financial services industry. With respect to ATMs, Heffernan (1992) and (1993) use the number of ATMs as a key non-price feature in studies of competition between British banks, while Humphrey (1994) uses ATM costs per transaction in a comparative study of service delivery.
systems. McAndrews (1996) develops a model that specifically tests the relationship between ATM fees and network size, and finds evidence of network effects on demand and of economies of scale.

While industry sponsored studies of ATM fees and of consumer response to these fees exist, many are considered proprietary and given minimal circulation or publication outside the industry, or are only available at substantial cost to outside researchers. Regulatory studies tend to be limited to presentation and discussion of stylized facts, with restrictions on public access to the complete survey results. Questions remain to be explored by neutral parties with respect to the role of retail fees in the financial services industry.

Section 4.3 - The Development of ATM Surcharges

The earliest ATMs could be accessed exclusively by customers of the specific branch at which the machine was located. The potential benefits to be derived from linking the machines into networks were recognized from the outset, and technology was quickly developed to allow bank customers access to funds from their accounts via any of the machines owned by their bank. Initially the ATMs were located at or outside branch locations. They allowed banks to provide 24 hour fund access to their customers. Also, as the marginal costs of ATM use to the banks rapidly declined to below the marginal costs of branch use, cost savings accrued to the banks themselves. Fees were rarely charged for simple transactions made at the customer’s own bank’s ATM, and that generally remains true to this day53. As with not charging for simple services provided by tellers in the branch, the competitive consideration of retaining the customer’s deposit business appears to dictate this policy.

53 The 1998 Annual Report to the Congress on Retail Services of Depository Institutions presented to the Board of Governors of the Federal Reserve System indicates that 7.4%, 3.3% and 6.7% of banks and 6.2%, 4.6% and 5.9% of savings associations charge their own customers for ATM withdrawals, deposits and balance inquiries (respectively).
Positive response to the convenience of ATMs changed consumer’s banking patterns and led to escalating demand for more machines. New technology allowed banks to locate "stand alone" ATMs at highly convenient locations such as shopping malls or gas stations. It soon became evident that having many banks install and maintain stand alone machines at the same popular locations represented hefty investments to the individual institutions and a costly duplication of effort to the banking system as a whole. Also, regulatory restrictions in the US prevented many of the institutions from providing ATM service to their customers at locations outside their state or region. The potential benefits of allowing customers to access funds through machines owned by other financial institutions were clear, however the development of a secure technology to support the required infrastructure was protracted. Delays were caused by concerns about protecting customer information from competitors and safeguarding the network against systemic failure or security violations by external parties. Once secure technology became available, organizations had to reach agreements with respect to the ownership of network infrastructure, the sharing of costs and the pricing of such services at the state, regional or national level. Furthermore, government policy had to be coordinated at the state and national levels to ensure that anti-trust legislations and other regulations could adequately control the new multi-bank ATM networks.

In the US, ATMs are linked according to three types of networks: proprietary, shared regional and shared national. Proprietary networks are owned by individual banks or firms. According to McAndrews (1998), shared regional networks generally take the form of a joint venture.

---


owned by a central group of network members\textsuperscript{56}. As discussed by McAndrews (1991), the combination of network externalities, cost economies of scale and relaxed barriers to interstate banking has led to increasing market concentration as the industry matures, and fewer regional networks with fewer owners now operate that portion of ATM transactions. The national networks are operated by the two major credit card companies, Visa and Mastercard, on a for profit basis. When transactions cannot be accommodated by the proprietary or regional networks they are switched to the national network.

\begin{table}[h]
\centering
\begin{tabular}{|l|l|l|l|}
\hline
Fee & Paid by & Set by & Description & Fee per Transaction \\
\hline
ATM surcharge & ATM cardholder & ATM owner & Per transaction fee paid by cardholder to ATM owner for the convenience of using that machine rather than travelling to one of their own bank’s ATM’s & $0.50$ to $5.00$ \\
\hline
Foreign or User fee & ATM cardholder & Cardholder’s bank & Per transaction fee paid by cardholder to their own bank to cover the interchange fee, the switch fee, and collection costs & $0.25$ to $2.50$ \\
\hline
Switch fee & Cardholder’s bank & ATM network & Network-wide per transaction fee paid to network organization by card issuing network members to compensate for the cost of routing transaction information & $0.02$ to $0.15$ \\
\hline
Interchange fee & Cardholder’s bank & ATM network & Network-wide per transaction fee paid to compensate ATM owners for cross-customer use of their machines & $0.30$ to $0.60$ \\
\hline
\end{tabular}
\caption{ATM Transaction Fees}
\end{table}

At present, a variety of retail and wholesale fees, described in Table 4.1, support these networks. A common per transaction interchange fee determined by the network for use of a machine

\textsuperscript{56} McAndrews notes that a small minority of the networks are owned by either all the network members or by a non-bank data processing firm.
by a customer of another network member bank is a feature of most inter-bank network agreements. This fee is designed to compensate the ATM-owning bank for the costs involved with the transaction, plus some agreed upon mark-up. All or part of the interchange fee is passed on to the consumer by way of the user (or "foreign") fee. 1998 survey results from the US Congressional Budget Office indicate that, while interchange fees have increased since 1985, there may be some price "stickiness" with respect to adjusting interchange fees. An additional lower "switch" fee, is charged by the network owners to cover the communications and transmission costs involved with ATM transactions, and may or may not be included in the user fee charged to the client. Not all the ATMs within the networks are owned and operated by financial institutions. The establishment of shared networks and the profit potential of the fees involved also attracted non-financial institutions to enter the networks as deployers of ATM machines with no deposit taking capacity\textsuperscript{57}. The data set used for the present paper includes only ATMs owned by financial institutions.

Over the first 20 years of their existence the two national networks, Plus and Cirrus, specifically prohibited surcharging by their members. Surcharges are defined as separate per transaction fees charged directly and independently by the ATM owner to compensate for the convenience of their machine. This fee is in additional to the interchange fee, and is charged to the consumer's account as the withdrawal is made from their account. Unlike the two national networks, the smaller, southern US based, eight state Pulse network was forced by law, as a result of a 1987 ruling on a dispute with one of its members, to permit its members to levy surcharges in addition

\textsuperscript{57} As noted in the \textit{Competition in ATM Markets} study published by the US General Accounting Office in July 1998, non-bank ATM deployers have a greater incentive to impose surcharges than do bank ATM deployers. This is supported by the models presented in Chapters 2 and 3 of this paper. From a policy standpoint, bank ATM deployers must be concerned about the implications of surcharges on the underlying competition between banks for deposit business, while non-bank deployers are strictly concerned with the per transaction profit potential of ATM's.
to collecting the interchange fee for transactions made by non-customers using their ATMs.\textsuperscript{58}

On April 1 1996 Plus and Cirrus simultaneously lifted their restrictions on surcharging. The decision to lift the ban appears to have been a response both to mounting member pressure and to pressure from the US Department of Justice, which at the time was considering whether or not the ban was anti-competitive\textsuperscript{59}, since it limited intra-network competition. The Department of Justice may also have been influenced by state level legislation against the ban on surcharges. In some cases, state legislation in favour of surcharges was designed to allow banks located in tourist destinations to profit from out-of-state cardholder use of their ATM networks. Financial institutions implemented surcharges on a wide scale soon after the ban was lifted. The fees are frequently identified to the consumers as "convenience fees". The banks owning the surcharging ATMs are generally required to clearly post notice of the fee and its amount at the machine so that consumers can opt to travel to another machine or to forego the transaction altogether to avoid paying the surcharge.

<table>
<thead>
<tr>
<th></th>
<th>Banks</th>
<th>Savings Associations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent of Firms Surcharging</td>
<td>44.8</td>
<td>60.1</td>
</tr>
<tr>
<td>Average Surcharge ($)</td>
<td>1.19</td>
<td>1.14</td>
</tr>
</tbody>
</table>

Source: Board of Governors of the Federal Reserve System, 1998 Annual Report to the Congress on Retail Fees and Services of Depository Institutions

Table 4.2: Poll Results on Surcharging in U.S.

\textsuperscript{*} Significant at the 90\% confidence level
\textsuperscript{**} Significant at the 95\% confidence level

For the first time in the 10 year history of the report, the 1998 Annual Report to Congress

\textsuperscript{58} See discussion of First Texas vs Pulse case in Balto (1995)

\textsuperscript{59} See Balto, D., "Payments Systems Face more Antitrust Scrutiny," American Banker, June 14, 1994, p12
on Fees and Services of Depository Institutions provides surcharge information. Their findings, based on their survey of 1050 financial institutions are summarized in Table 4.2. The new fees have been a subject of heated debate both within and between the financial institutions, their regulators and consumer groups.

Financial institutions can be roughly divided into the group that considers surcharging crucial to the maintenance and improvement of existing ATM service and the group that actively campaigns against surcharges. The arguments of the first group are well articulated in industry publications such as *American Banker* and include the following:

i) controlling ATM prices will limit the deployment and development of existing ATM networks

ii) consumers can avoid surcharges by using their own bank’s ATMs or by using point of sale cards at retail outlets

iii) low volume ATMs cannot be operated profitably without surcharges

iv) over half of surcharge revenues is earned by non-bank ATM operators.  

The above are just a few of the many parries made by the banks and their supporters in defense of surcharges. Their arguments are generally supported by statistics selected from research conducted by or on behalf of the financial institutions. In a recent briefing paper responding to threats of government restrictions on surcharge, an interesting further argument made is that such restrictions represent a "time tax" on consumers since they would deny consumers convenient access to ATMs.

---

60 Research by the Pulse network as reported by the Consumer Banker’s Association.

Although financial institutions in favour of surcharging outnumber those against, there are firms that are employing not surcharging as a marketing strategy. For example, the Community Bank League of New England engaged a marketing agency to promote a "transparent" no surcharge image for its community bank network.\(^{62}\) Likewise, Bank Network News has published reports of banks in Kentucky and Massechusetts banding together to advertise the fact that they were not surcharging. Aside from the marketing aspect, there are additional possible explanations for taking such a position, as discussed in Section 4.4 below. In April of 1998, an unusual stance was taken by the Louisiana based LBA Savings Bank when it both eliminated the surcharge of $1 on its own ATMs and committed to paying $1.50 per transaction to its customers to use another bank’s ATM.\(^{63}\) In addition to improving public relations, the bank cites potential cost and risk savings on expenditures on new branches and ATMs as justifications for its new policy.\(^{64}\) It is difficult to determine in that case if not surcharging indicates an anti-surcharge philosophy or a strategic plan to shift the costs associated with a retail banking network on to their competitors.

Despite the fact that regulators played a part in causing the national networks’ ban on surcharges to be lifted, neither regulators or politicians have allowed the subsequent controversy to pass without critical comment. John Bley, Director of the Washington State Department of Financial Institutions, has been a particularly vocal regulator on the subject of surcharges. His principal objection is that surcharges may be a threat to the deposit base of smaller-sized depository


\(^{63}\) " Bank Pays customers to use competing ATM’s", Bank Rate Monitor Online. The bank limits the number of $1.50 payment to 4 per month.

\(^{64}\) Bank Rate Monitor, July 30, 1998. "What some bankers and consumers see as radical, Reaux (chief executive of LBA) views as a sound business decision - one that’s less risky than shelling out money for new branches and ATM’s in the hopes of attracting enough customers to offset the costs. Reaux finds that "Field of Dreams" style of bank management too risky".
institutions. He states that the current network configurations evolved from the self-imposed price constraint of the earlier ban on surcharges, which encouraged smaller institutions to take advantage of the greater network investments of large institutions. Since ATMs in highly accessible locations, such as convenience stores, tend to be controlled by large institutions through long term contracts, consumers of institutions with small proprietary networks will have incentives to move their accounts in order to avoid paying the surcharge.\textsuperscript{65} He also cites evidence that surcharges are being applied in a discriminatory fashion, using the example of Seafirst, which in 1997 surcharged at only 348 of the 880 ATMs that it owned in Washington state. Although he maintains that he is not anti-surcharge, Bley is concerned that surcharge amounts are not being set in an efficient market. On the national political front, chairman of the Senate Banking Committee, Sen. Alfonse D’Amato and others have introduced unsuccessful bills to ban surcharges, with the aim of protecting consumers.

The catch phrase of consumer groups with respect to surcharges is that they constitute "double dipping", since the ATM owner receives both the interchange fee and the surcharge for the same transaction. A number of regional and state Internet sites have been established by consumer groups that provide information to consumers on the location and ownership of non-surcharging ATMs. Further surcharge related consumer criticisms are that the legally required notification at the ATMs is often inadequate or confusing, that banks are using the fees to wield local or regional market power, that the fees are regressive since the represent an unduly high proportion of poorer people’s incomes, and that surcharges encourage people to withdraw larger amounts of cash at each transaction, which could lead to a higher incidence of ATM-related crime. At least one consumer group, the New York based Inner City Press/Community on the Move, is attempting to mount

\textsuperscript{65} \textit{Issue Brief regarding ATM Surcharges from the Washington State Department of Financial Institutions}, Feb. 13, 1997
support for a class-action suit against surcharges.

The variety of the arguments for and against surcharges demonstrates that more research is needed on the many factors influencing the surcharging decision. From the perspective of the banks and the networks, a better understanding of the underlying influences will lead to improved anticipation of competitive trends. For consumers and regulators, it could lead to better designed public policies toward the ATM pricing and more efficient market competition.

SECTION 4.4 - RESEARCH QUESTIONS AND THE MODEL SPECIFICATION

This section will draw on the models discussed in Section 4.2 and on existing descriptive analysis of the financial services industry in the US to discuss research questions about the relationships between firm specific features and surcharges. The basic purpose is to arrive at a regression model with the form:

\[ Y(\text{SURCHARGE}) = f(x_i) \]

where \(Y\) either equals 1 or zero if a bank surcharges or not, or the amount of the surcharge of the bank, and \(x_i\) is a vector of variables describing bank features and control variables.

Firstly, as summarized in Section 4.2, the theoretical spatial model in this thesis leads us to expect that, all other things being equal, network member banks with relatively small customer bases would prefer to charge a higher surcharge non-customer use of their ATMs than would banks with relatively large customer bases, since they will benefit more from revenues earned from cross-use by their larger competitor’s customers than from savings due to their own customers making their transactions elsewhere. Without network restrictions on surcharges, smaller based banks would have a more pressing incentive to introduce a surcharge than larger based banks, and in the short term tend to charge higher surcharges than their competitors. In the model outlined below, total domestic deposits serve as a proxy measure of the size of a bank’s customer base (SIZE), and this variable
is used to test the hypothesis that banks with fewer customers will be likely to both have surcharges and to have higher surcharges (SURCH). Under this hypothesis, the coefficient of the SIZE variable would be expected to be negative.

Secondly, the spatial model indicates that banks owning and operating relatively more machines, would prefer to have a higher common interchange fee than would banks that own fewer machines. Again, without a network restriction on surcharges they would yield to the short term incentive to price non-customer transactions higher than would their competitors. Thus banks with more machines would be likely to both have surcharges and to have higher surcharges. As the data does not contain information on the number of bank machines owned by each banks, the total number of branches (BRANCH) is used as a proxy measure for the number of machines owned by a bank, on the basis that the number of in-branch machines owned by a firm can be expected to be proportional to the number of branches operated. Also banks operating a higher number of branches display a greater commitment to using consumer convenience as part of their marketing strategy, and could be expected to operate more ATMs. Under these assumptions, the coefficient of BRANCH would be expected to be positive.

Thirdly, a relationship might be expected to exist between the user or foreign fee already being charged by a bank and the tendency to surcharge others' customers. Recall that the user fee, although collected by a bank from its own customers for use of another bank's ATM, is largely passed on to the machine owning bank in the form of an interchange fee. The relationship between the user fee and the surcharges could be subject to a variety of competitive forces, and expectations

---

66 One might expect branch numbers to be negatively correlated with machine numbers. This does not appear to be the case. Based on US government statistics on the top 50 bank ATM acquirer/issuers, a positive correlation of .91 exists between branch and machine numbers. This counter-intuitive result suggests an area for further research.
for the sign of the co-efficient of the user fee (FEE) in the proposed model are therefore ambiguous. Several hypotheses are explored below.

i) Banks charging high user fees to their own customers and in effect discouraging them from using other bank’s machines may also be inclined to institute a surcharge to non-customers to entice them to open accounts with them in order to avoid the surcharge and benefit from other service features. This justification of a surcharge would be particularly convincing, for example, for banks offering preferential interest rates or owning ATMs in high traffic locations such as airports or malls. Under this hypothesis one would expect a positive sign on the relationship between the user fee and the surcharge.

ii) Alternatively, banks charging high user fees may be in networks charging high interchange and switch fees. If consumers are sensitive to high transaction fees, surcharges could have a particularly negative impact on the number of transactions numbers made by other bank’s customers at their machines, even if the machines were at high traffic locations. This could leave them vulnerable to having machines operating at a loss. In order to offset the effects of the already high network fees, banks might be less inclined to introduce surcharges in this situation. Under this hypothesis, a negative relationship would be expected between user fees and surcharges.

iii) Members of networks charging low interchange and switch fees, and and tending to pass on low user fees to consumers, are benefitting from the added convenience that membership affords to their customers. These banks might be reluctant to introduce surcharges. Their action could result in their competitors retaliating by introducing their own surcharges, leading to the eventual elimination of the benefits they had all previously enjoyed. As discussed in Chapter 1, this was one of the principal arguments against surcharges in the Interac case in Canada.
would be expected to have a positive relationship.

Clearly independence is an issue in setting the interchange and surcharge fees. This would be an interesting area for future research if detailed information on network interchange fees becomes available.

The above are some of the factors that could drive a possible relationship between existing user fees and surcharges, even though user fees are charged to a bank’s own customers and surcharges to their competitors’ customers. User fees are included as an explanatory variable in the probit and Tobit analysis of the whole sample and the OLS analysis of the surcharging banks alone. It should be noted that as surcharges become more established the causality between network fees and surcharges will become ambiguous, since network fees will be adjusted to reflect the practice of surcharging.

Fourthly, market structure might be a determinant of if and how much is surcharged in a particular area. As will be discussed further below, the banks in the dataset are considered to hold dominant positions in their respective markets. The expectation is that higher market concentration would allow the dominant banks both to surcharge and to surcharge more than banks located in less concentrated markets (CONC). The measure of market concentration is defined further below. The coefficient of CONC would be expected to be positive.

The control variables in this model are as follows:

i) the existence of a highly complex regulatory system for the financial services industry in the United States must be taken into account, therefore a variable is defined to indicate the FDIC classification code of the institutions (CLASS). Descriptive analysis of the data indicates that banks with a national mandate are more likely to surcharge than those with a regional mandate, however no cause for this relationship is introduced in this paper.
ii) the earlier introduction of surcharges in the southern states of the US leads to expectations that more firms will have surcharges in that region, thus a variable is introduced to indicate that firms are situated in the South (SOUTH). The effects of early introduction on the amount of the surcharge are more difficult to analyze. As will be discussed below, preliminary data analysis shows that for the sample used there is a higher frequency of surcharging in the southern states, however the average surcharge is lower. There are several possible explanations of why this might be true of the bank population. First, it is conceivably the early adopters of surcharges in non-southern areas, where surcharges have been allowed more recently, may also be those with a tendency to charge higher surcharges. In the south, where more firms would be expected to surcharge, this early adopter effect would have diminished over time. Secondly, in the south, where the practice of surcharging has a longer history, price patterns may have adjusted in response to competitive pressures over time. In the long term, in a purely competitive market the network benefits derived from maintaining a low common fee would be dissipated by firms surcharging in an uncoordinated fashion. Firms maybe inclined to adjust their surcharges downward in a tacitly coordinated fashion in order to regain some of the network benefits lost when firms surcharge whatever amount the market will bear. Either of these explanations could lead us to expect SOUTH to have a positive relationship to the number of firms surcharging and a negative relationship to the amount of the surcharge. The respective values of the control variables will therefore be as follows:

\[ \text{SOUTH} = \begin{cases} 1 & \text{for areas SE and SW} \\ 0 & \text{otherwise} \end{cases} \]

\[ \text{CLASS} = \begin{cases} 1 & \text{for charter classes N and SM} \\ 0 & \text{otherwise} \end{cases} \]

In summary, the following features hold potential interest in relation to a firm’s short term
incentives to introduce surcharge and to the amount of the surcharge if they opt to charge one: relative size of customer base (SIZE), number of branches (BRANCH), the level of user fees (FEE), market concentration (CONC). Due to the range of the data set natural logs were taken of the SIZE and BRANCH variables to convert them to a scalar measures LSIZE and LBRANCH with the sign of the coefficients in the models of LSIZE expected to be negative and of LBRANCH expected to be positive.

The empirical work estimates the regression in three different functional forms: probit, Tobit, and OLS, with the latter functional form used only for the subset of surcharging banks. The probit and Tobit models are used to take into consideration the large proportion of non-surcharging firms in the full sample. The explanatory variables are assumed to relate linearly to the surcharge amount. The standard assumptions are made in each model with respect to the error terms as outlined by Maddala (1988) and Greene (1990).

Probit Model: The first model estimates whether or not an institution will surcharge. The amount of the surcharge is not an issue at this stage. The probit is used to test the effects of the explanatory variables on the probability that a firm surcharges.

In particular we examine the model:

\[ Y_i^* = b_{10} + b_{11} \text{FEE} + b_{12} \text{LSIZE} + b_{13} \text{LBRANCH} + b_{14} \text{CONC} + b_{15} \text{SOUTH} + b_{16} \text{CLASS} + \epsilon_i \]

In each of the models the coefficient on each of the explanatory variables is denoted by bij, where the first subscript, i, refers to the number of the equation and the second subscript, j, refers to the number of the coefficient on its respective equation.

---

68 The assumption of normally distributed error terms underlies the probit model. A logit model would be more appropriate if the error term were distributed logistically. As noted in Maddala (1988), the results of the two types of models or not likely to vary greatly unless the sample size is very large. In this case, the coefficients of the logit model proved to have the same sign and level of significance as did those of the probit model. The probit results are presented here as, unlike the results of a logit model, they can be interpreted without further transformations.
In the above expression $Y_i^*$ is, as discussed in Maddala (1988), a latent or unobserved variable. In this instance, $Y_i^*$ could be described as the propensity to surcharge. The observed outcome is a dichotomous result, where $Y_i = 1$ if $Y_i^* > 0$ and $Y_i = 0$ otherwise. The discrete choice variable $Y_i$ is defined as follows:

$$Y_i = \begin{cases} 
1 & \text{if the firm surcharges} \\
0 & \text{if the firm does not surcharge}
\end{cases}$$

**Tobit Model:** The Tobit model is used to test the effect of the explanatory variables on the amount of the surcharge, taking into account the large number of non-surcharging firms in the total sample, and thus the truncated distribution of the dependent variable.

The model for the amount of the surcharge can be defined as follows:

$$\text{SURCH}^* = b_{20} + b_{21}FEE + b_{22}\text{LSIZE} + b_{23}\text{LBRANCH} + b_{24}\text{CONC} + b_{25}\text{SOUTH} + b_{26}\text{CLASS} + \epsilon_2$$

Similarly to the probit model, $\text{SURCH}_i^*$ is a latent or unobserved variable. The observed outcome is $\text{SURCH}_i = 0$ if $\text{SURCH}_i^* \leq 0$ and $\text{SURCH}_i = \text{SURCH}_i^*$ if $\text{SURCH}_i^* > 0$.

**OLS model:** The ordinary least squares regression model is used to analyze only the observations for which there is a positive surcharge. As will be described below, this consists of approximately 50% of the original sample. Given the assumption of linearity, the model is therefore:

$$\text{SURCH} = b_{30} + b_{31}FEE + b_{32}\text{LSIZE} + b_{33}\text{LBRANCH} + b_{34}\text{CONC} + b_{35}\text{SOUTH} + b_{36}\text{CLASS} + \epsilon_3$$

**SECTION 4.5 DATA DESCRIPTION**

The data set used for the empirical work was derived from two separate sources: a 1997 Bank Rate Monitor Survey, and US Federal Deposit Insurance Corporation (FDIC) call report data.

**Bank Rate Monitor Data:** This data source consists of the publicly available results of an October 1997 telephone survey of banks and thrifts conducted by Bank Rate Monitor with respect to
transactions fees. Bank Rate Monitor’s origins is a 20 year old Florida-based firm. Its origins were as a publisher of newsletters for the banking industry. For the last three years the firm has specialized in tracking and publishing online information on consumer bank rates and fees. This information is published free of charge, and is distributed both by the company’s own website and 30 online partners, including Microsoft Money Insider and America Online. In addition, the firm’s research department produces custom national surveys for major players in the financial services industry and creates new finance-related online products. The survey data used for this chapter is a compilation of the ATM data reported on their website on an ongoing basis. The data set consists of information on 237 institutions spread across the 25 largest urban US markets, with each bank identified by name and city of location. Appendix 4.1 provides a listing of the urban areas included in the study. Data are furnished for either 9 or 10 of the banks and thrifts with the largest market share in each area.

The resulting complete data set includes information on per transaction surcharge fees levied by the banks and trusts polled as at October, 1997. In a number of cases, banks with inter-state banking capabilities were surveyed in different marketplaces. Fourteen banks report charging different surcharges in different urban centres, providing anecdotal evidence that banks are being regionally discriminatory when setting surcharge levels. Other information provided on a bank by bank basis included the following: a) user fees b) fees charged to use own bank’s machines c) ATM

---

69 Bank Rate Monitor also provided a copy of its March 1997 telephone survey of most of the same banks in the same areas. Although this survey did not include information on surcharges it did include the telephone numbers of the individual banks, which proved to be invaluable in identifying the correct bank charter number in some cases where that information could not be determined unambiguously from the name and location of the bank in the October 1997 information.

70 A hard copy of the data was provided by Bank Rate Monitor free of charge for educational research purposes.
availability (Y/N) d) card replacement fees e) monthly fees (where applicable) and other sundry fees. The survey contains no descriptive statistics about the financial status of banks, their relative sizes, or the number or distribution of the ATMs owned by the bank. Unfortunately, no further information is provided in the notes to the survey with respect to the basis on which the markets were selected or on how firms' respective market shares were determined. Of the 237 observations in the data, 17 (7.1%) were reported to have no ATM availability, and would therefore not be in a position to levy a surcharge for ATM use by non-customers. Since surcharges are the focus of this discussion and analysis these were omitted from the remainder of the analysis. Also, as noted below, descriptive data could not be obtained for 2 of the remaining 220 observations. Thus the final data set consists of 218 observations. As will be discussed at greater length below, in some cases the same firms were surveyed in different markets. Of the 218 observations, 110 levy surcharges for cross use of their ATMs and 108 do not.

FDIC Reports and Other Data: Information on the size, profitability, and other features of the individual banks included in the Bank Rate Monitor data set was obtained from the Summary Financial Reports attached to the Institution List of the US Federal Deposit Insurance Corporation (FDIC). These reports provide regulatory information and financial data on each FDIC-insured financial institution. The regulatory information is compiled from public sources and the financial information is based on mandatory reports provided by institutions to a variety of regulatory agencies. The information is updated quarterly, and each quarterly iteration is retained in the FDIC's Research Information System (RIS) data base. The Dec 31, 1997 reports were used for this analysis. Appendix 4.2 is a sample report for one of the firms in the data set, and a more detailed description of the data selected from these reports is provided below. Each report is identified by the specific bank charter number of the institution in question and banks can generally be linked to a report by
their name and location. In a number of cases, due to the similarity of the names of financial institutions with different charter numbers, considerable effort and cross-checking of information was required to ensure that the appropriate bank charter number and financial report were matched with each bank. Based on the information in the Bank Rate Monitor survey it was possible to clearly identify a Summary Report for 218 of the 220 institutions shown to operate ATMs in the survey. The 2 institutions with missing information were omitted from the analysis, leaving a total of 218 institutions.

The Summary Reports provide 109 lines of financial and other information. Table 4.3 below provides a summary of the key statistics for the 218 institutions in question. As noted in the previous section, FDIC data on domestic deposits serve as a proxy for the size of customer base (LSIZE) and numbers of branches serves as a proxy for the number of ATMs owned by a firm, or market coverage (LBRANCH). In addition, the qualitative information provided in the reports includes each firm's geographic regulatory area, used to construct the SOUTH variable in the model, and its institutional charter classification, used to construct the CLASS variable. In addition to a breakdown of the urban centres by area, Appendix 4.1 provides a distribution of the banks in the sample by area according to the specifications of the FDIC. Appendix 4.3 defines the Bank Charter Classes and provides a breakdown of the data set by class. Fees for use of own ATMs occurred in less than 10% of the cases, which is consistent with the expectations discussed earlier.

The information on market concentration was taken from the report published in July 1998 by the US Congressional Budget Office (CBO), *Competition in ATM Markets: Are ATMs Money Machines?* It consists of the CBO's 4-firm concentration ratios of deposits which denotes the fraction

---

71 This process was complicated by the fact that telephone numbers rather than addresses were provided in the Bank Rate Monitor data, and by the incompleteness of the bank name information in some cases, which made it necessary to use the telephone numbers to properly identify the firm in question.
of deposits held by the four largest FDIC insured institutions reported by state as at June 30, 1997. It is important to note that this is not a measure of the market concentration of ATM ownership, but of customer base concentration. Unfortunately, it proved impossible to locate a measure of ATM ownership concentration, which one might expect to play a greater role in the surcharging decision.

**Preliminary Descriptive Analysis:** This stage of the analysis was guided by the research questions discussed in Section 4.4, and consisted of descriptive statistics, correlation analysis, scatter plots, and other graphing methods. The possibility of additional financial information having a bearing on the surcharge decision were also explored at this time, however no apparent relationships emerged.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Std.Dev.</th>
<th>Maximum</th>
<th>Minimum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dependent variable</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surcharge (US$)(SURCH)</td>
<td>0.592</td>
<td>0.043</td>
<td>3.000</td>
<td>0.000</td>
</tr>
<tr>
<td>Explanatory variables</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>User fee (US$)(FEE)</td>
<td>1.147</td>
<td>0.033</td>
<td>2.000</td>
<td>0.000</td>
</tr>
<tr>
<td>Ln (deposits, US$) (LSIZE)</td>
<td>15.576</td>
<td>0.142</td>
<td>18.945</td>
<td>9.854</td>
</tr>
<tr>
<td>Ln (# of branches) (LBRANCH)</td>
<td>4.62</td>
<td>0.127</td>
<td>7.646</td>
<td>0.000</td>
</tr>
<tr>
<td>Concentration Ratio (CONC)</td>
<td>47.71</td>
<td>0.693</td>
<td>82.17</td>
<td>33.79</td>
</tr>
</tbody>
</table>

**Table 4.3: Variables Means, Standard Deviations, Maxima and Minima (N=218)**

The initial analysis of the "with surcharge" portion of the data set indicated a negative correlation between SURCH and LSIZE and a positive correlations between SURCH and both LBRANCH and FEE. The signs of these relationships are consistent with the expectations discussed in Section 4.4.

As noted earlier, the depository institutions are categorized by the FDIC by their regulatory area and by their charter class. Considering first the distinctions between surcharging and non-surcharging institutions, Appendix 4.4 depicts frequency distribution by area and by charter class for the total sample and for 110 surcharging banks in the sample. As anticipated, a larger proportion of the institutions surcharge in the southern areas than elsewhere. With respect to the charter class, the
N and SM classes have a higher proportion of surcharging institutions. These charter classes share the distinctions of being commercial banks and members of the Federal Reserve, although their jurisdictions of operation differ and they report to different supervisory bodies.

**SECTION 4.6 EMPIRICAL RESULTS**

The results of the three models are shown in Table 4.4.

In the probit model, the dependent variable is one if the firm surcharges and zero if it does not. The reported coefficients are the effects of a unit change in the explanatory variable (from the mean) on the probability of a firm surcharging. The results largely support the theories discussed in section 4-4 of this paper and in Chapters 2 and 3 of this thesis. The coefficients of LSIZE, LBRANCH, and SOUTH all prove to be highly significant in the model. The negative coefficient of LSIZE for the sample supports the hypothesis that (all other things being equal) firms with smaller customer bases have a higher likelihood of surcharging, while the positive coefficient of LBRANCH, which serves as a proxy for ATM network size, supports the hypothesis that firms with larger networks tend to favour additional fees for non-customer use of their machines over and above the mutually set network fees. The significance of the positive SOUTH variable supports the expectation that more firms will surcharge in the southern states, due to the earlier introduction of surcharges in that region of the US. The results also weakly support a negative relationship between user fees charged to own customers and surcharges charged to non-customers. Thus, for the sample, firms passing on higher fees to their own customers are less likely to require non-customer subsidization of machines. Interestingly, the results for the sample do not indicate a significant effect of market concentration on the likelihood of surcharging.

The results of the Tobit analysis, which focuses on factors affecting the amount of the surcharge, indicate that the same elements with high significance in predicting whether or not a firm
surcharges are also significant in predicting how high the surcharge will be. The highly significant
Table 4.4: Results of the Probit, Tobit, and OLS Models

<table>
<thead>
<tr>
<th>Variable</th>
<th>Probit Model (n=218)</th>
<th></th>
<th>Tobit Model (n=218)</th>
<th></th>
<th>OLS Model (n=110)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coefficient</td>
<td>t-stat</td>
<td>Coefficient</td>
<td>t-stat</td>
<td>Coefficient</td>
</tr>
<tr>
<td>CONSTANT</td>
<td>2.8242*</td>
<td>1.7260</td>
<td>3.0615</td>
<td>1.4035</td>
<td>1.5948**</td>
</tr>
<tr>
<td>FEE</td>
<td>-0.3756*</td>
<td>-1.7198</td>
<td>-0.2042</td>
<td>-1.1089</td>
<td>0.18633**</td>
</tr>
<tr>
<td>LSIZE</td>
<td>-0.3973***</td>
<td>-2.8499</td>
<td>-0.4032***</td>
<td>-3.3115</td>
<td>-0.0960</td>
</tr>
<tr>
<td>LBRANCH</td>
<td>0.6248***</td>
<td>3.8630</td>
<td>0.5971***</td>
<td>4.2693</td>
<td>0.1228*</td>
</tr>
<tr>
<td>CONC</td>
<td>0.0120</td>
<td>1.2761</td>
<td>0.1141</td>
<td>1.5198</td>
<td>0.0038</td>
</tr>
<tr>
<td>SOUTH</td>
<td>0.7330***</td>
<td>3.1154</td>
<td>0.5615***</td>
<td>3.1081</td>
<td>0.0362</td>
</tr>
<tr>
<td>CLASS</td>
<td>0.3704*</td>
<td>1.7217</td>
<td>0.3898**</td>
<td>2.1813</td>
<td>0.0974</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Probit Model (n=218)</th>
<th>Tobit Model (n=218)</th>
<th>OLS Model (n=110)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correct Predictions</td>
<td>69.71%</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Adjusted R²</td>
<td>0.2601</td>
<td>N/A</td>
<td>0.1048</td>
</tr>
<tr>
<td>Log likelihood</td>
<td>-151.10</td>
<td>-225.26</td>
<td>-39.36</td>
</tr>
</tbody>
</table>

* Significant at the 90% level
** Significant at the 95% level
*** Significant at the 99% level
and positive coefficient of LBRANCH is not difficult to interpret, since one would expect firms with more machines to place more emphasis on the fees earned from those machines. The direction of the relationship between surcharge amount and size of customer base is less intuitively clear. One possible explanation for the highly significant and negative sign of LSIZE can be developed by envisioning two banks with identical numbers of ATMs and alike in all respects, except that one has a larger customer base than the other. Assuming that some identical share of the customers of one bank find it more convenient to use the other bank’s machines, that share will represent a larger absolute number for the larger bank. This will provide the bank with the smaller customer base a greater opportunity to make revenue by surcharging its competitor’s customers, and could encourage them to charge more for the service. Even if their high surcharge eventually discourages some of the larger bank’s customers from using their ATMs, the smaller bank may still be able to make more money on its ATMs than its competitor by charging more to the remaining non-customer users.72

The highly significant positive relationship between SOUTH and the surcharge amount suggests that consumers, banks, or both adjust their expectations of the price to be paid for convenience upward over time. The evidence of a positive relationship between bank classification and surcharge has the anticipated sign. As noted earlier, the full regulatory significance of this relationship is not clear, however it does suggest that banks classified as "commercial" are likely to have higher surcharges. As in the probit analysis, there is not strong evidence of market concentration playing a significant role in the surcharging decision, however the limitations of the concentration measure used must be kept in mind when interpreting this result. In the future, it would be preferable to use a measure of the market concentration of ATMs if it were to become available. Although the level of the user fee is not a significant explanatory variable for the level of the surcharge, the sign of the coefficient

---

72This explanation is consistent with the theoretical discussion in Chapter 2 of this thesis.
is negative, and consistent with the probit result.

Turning to the results of the OLS analysis of the subset of the sample that surcharges we find the significance of the results declines sharply, although in general the signs of the coefficients are consistent with the Tobit model. Of course, sample bias has been created by selecting only the surcharging banks. For this reason they are not discussed here in great detail. The reversed sign and significance of the coefficient of the FEE variable, however, is confounding and suggests that further analysis of the relationship between the fees bank’s charge to their own customers and surcharge levels may be warranted.

SECTION 4.7 CONCLUSION

This discussion and preliminary empirical exploration of the relationship between surcharges and firm features have some implications for the three sets of players in the surcharge debate: bankers, consumers and regulators. From the banks’ perspective, for example, the results provide evidence that consumer resistance to paying for ATM convenience will subside over time. From the consumer’s perspective, they suggest that "bigger" banks in terms of customer base are not necessarily more inclined to take advantage of non-customer ATM users than are their smaller competitors, which contradicts popular perceptions about large banks. Finally, from the regulators perspective, the results suggest that the future of surcharges will depend on trade-offs made by banks between generating higher profits from their ATM networks and maintaining the benefits of ATM convenience for their clients.

There are many aspects of ATM pricing that could not be addressed due to the limitations

73 Residual tests were conducted to identify any unusual data points. Although several of the residual values were appeared to identified outliers re-estimation the model without these data points did not substantially effect the results. Since there was no evidence that the points represented "bad" data the results of the original model estimation are reported in Table 4.4.
of the data set. Specifically, it would have been useful to have regional data on the numbers of
machines owned by each bank and the numbers and size of transactions made. Such information
could reveal if either machine numbers or consumers’ transaction behaviour are different in the
Southern states where surcharges have a longer history. A further issue not addressed here are
implications of surcharges as part of a bank’s competitive strategy. If it were possible to consider
ATM services as part of the portfolio of services priced by a bank it might be possible to identify
distinct pricing patterns indicative of differentiation or cost leadership strategies.

In Canada, where the ATM marketplace is dominated by the Interac network, surcharges
have not yet become commonplace. Although the 1996 ruling of the Competition Tribunal eliminated
Interac’s effective ban on surcharging by its members there was no immediate widespread
introduction of surcharges by the major banks. Since Canadians are acknowledged to be the world’s
heaviest users of ATM’s\textsuperscript{74} it seems likely that ATM operators will attempt to generate higher profits
by charging more for the convenience of their machines. With the ATM market in Canada currently
dominated by the major banks, the cost savings enjoyed by shifting customers away from branch use
may be reducing the incentive to surcharge. Also, the negative effects that the appearance of “double-
dipping” could have on the reputation and competitive position of a major bank may be influencing
Canadian banks’ ATM pricing policies. As non-bank ATM operators are beginning to emerge in the
market the attitude toward convenience fees may change, particularly since ATMs are expected to
become useful for an increasing array of transactions, thereby increasing their value to
consumers.

Given the level of interest in ATM fees and profitability from all sides of the issue, it is
likely that public disclosure of fees will increase in the near future and that more complete data will

\textsuperscript{74} \textit{Financial Post}, Jan. 21, 1999, pC10
become available for empirical analysis. Possible areas for future research as the data improves could include the relationship between network-determined interchange fees (not currently publicly available) and surcharge levels, the changes in surcharge levels with changes in the concentration of ATM ownership, bank size, machine numbers and transaction numbers over time and the nature and sources of international differences in ATM pricing and use. It will be particularly interesting to follow the evolution of ATM networks as technology advances and consumer attitudes toward cash, and their willingness to pay for convenient access to it, change.
BIBLIOGRAPHY

ABA. *The Journal of the American Bankers Association* (various issues)


*Bank of Canada Review* (various issues)

*The Banker* (various issues)


Competition *Economic Inquiry* 31:1, 139-165

*Canadian Banker* (various issues)

Church, J., and R. Ware (1998) Abuse of Dominance under the 1986 Canadian Competition Act *Review of Industrial Organization* 13 (1-2), 85-129

Coleman, W.D. (1992). Financial Services Reform in Canada: The Evolution of Policy Dissension *Canadian Public Policy* 18, 139-152


*The Economist* (staff) International Banking Survey March 25, 1989 & April 10, 1993

*Euromoney* (various issues)


Review of Economic Studies LII, 383-401


Heggestad, A.A. and J.J. Mingo (1976) Prices, Nonprices, and Concentration in Commercial Banking Journal of Money, Credit, and Banking 107-117


Merris, R.C. (1985) Explicit Interest and Demand Deposit Service Charges - A Note Journal of Money, Credit, and Banking 17:4, 528-533


Salant, D.J. (1986) Equilibrium in a spatial model of imperfect competition with sequential choice of locations and quantities *Canadian Journal of Economics* 19, 685-715


Smirlock, M. (1985) Evidence on the (Non) Relationship between Concentration and Profitability in Banking *Journal of Money, Credit, and Banking* 17:1, 69-83


Tabuchi, T. (1994) Two-stage two-dimensional spatial competition between firms *Regional Science and


Appendix 2.1: Analysis of Transaction Fees in a Proprietary Network

In order to explore the effects of a fee in a proprietary network it is useful to relax the assumption of the model that the size of a bank’s customer base remains constant with changes in fees. For a given number of machines, the effect of a fee $f^p$ charged to a bank’s own customers for each ATM transaction is two-fold. First it will shift transactions from machines to in-branch tellers. In addition, because of competition from other banks, a high fee relative to other banks is also likely to have the effect of reducing the customer base. The effect of a fee in reducing the customer base can be incorporated by assuming that $\partial N^A/\partial f^p < 0$. Following the standard wisdom that larger banks are more profitable, we also assume that profit is increasing in the size of the customer base, but at a decreasing rate: i.e.

$$d\pi^A/dN^A = d\phi^A/dN^A + (1 - \rho^0)(f^p - \delta c) - \rho^0 c > 0 \text{ and } d^2\pi^A/(dN^A)^2 = d^2\phi^A/(dN^A)^2 < 0.$$

From (3.3), using (3.2), maximization of profit with respect to the fee $f^p$ gives rise to the first order condition:

$$\frac{\partial \pi^A}{\partial f^p} = N^A[1 - \rho^0 - \beta \rho^0 c(1 - \delta)] + (d\pi^A/dN^A)(\partial N^A/\partial f^p) = 0, \quad (A2.1.2)$$

which implies that:

$$f^p = \{ N^A[1 - \rho^0 - \beta \rho^0 c(1 - \delta)] + (d\pi^A/dN^A)(\partial N^A/\partial f^p) \}/N^A \beta \rho^0. \quad (A2.1.3)$$

If we make the additional assumption that an increase in $f^p$ reduces the customer base at a decreasing rate, so that $\partial^2 N^A/(\partial f^p)^2 < 0$, then the second order condition is satisfied: i.e. from (A2.1.1) and (A2.1.2),

$$\frac{\partial^2 \pi^A}{(\partial f^p)^2} = -N^A \beta \rho^0 [2 + \beta (c(1 - \delta) + f^p)]$$

$$+ (d\pi^A/dN^A)(\partial^2 N^A/(\partial f^p)^2) + (d^2\pi^A/(dN^A)^2)(\partial^2 N^A/\partial f^p)^2 < 0. \quad (A2.1.4)$$

An examination of the sign of (A2.1.3) reveals that the optimal fee may be negative, corresponding to a subsidy to machine transactions. A positive fee raises revenue for the bank, but
it also tends to reduce profits by reducing the customer base. In addition, a positive fee raises transaction costs by exacerbating the tendency for customers to use tellers in the branch. A subsidy is called for whenever these last two effects dominate. It follows from (A2.1.3) that \( f^p \leq 0 \) if and only if

\[
-(d^A/dN^A)(\partial N^A/\partial f^p) \geq N^A[1-\rho^0 - \beta\rho^0c(1-\delta)] \quad \text{at} \quad f^p = 0. \tag{A2.1.5}
\]

Since \(-(d^A/dN^A)(\partial N^A/\partial f^p) > 0\), this condition holds if \( \beta \), representing the rate at which customers shift to the branch (see (3.2)), is sufficiently large to make \( 1-\rho^0 - \beta\rho^0c(1-\delta) \leq 0 \). Nevertheless (A2.1.5) can also be satisfied for \( 1-\rho^0 - \beta\rho^0c(1-\delta) > 0 \) provided the advantage from an increase in the customer base due to the subsidy is sufficiently large.

However, a subsidy to ATM machine transactions would have obvious moral hazard problems, not captured by the model. If the subsidy is based on the number of transactions, this would give a strong incentive for customers to increase the number of their transactions, perhaps by withdrawing smaller amounts with each transaction, to obtain the subsidy. Other forms of a subsidy such as a subsidy based on the value of withdrawals or deposits, would give an incentive to withdraw money and then redeposit it. Thus one would not expect to see subsidies in practice. If banks want to encourage use of their own machines rather than tellers, the second best policy would be to set the fee at zero. This might help explain why most banks do not charge fees on machine transactions by their own customers.\(^75\)

Although the exact conditions under which the optimal fee would be zero is affected by access to

\(^75\) A survey of US banks in major markets conducted in March 1997 by Bank Rate Monitor showed that 95.73% of the banks included in the study charged no transaction fee for customer use of their own bank’s machines.
machines from other banks\textsuperscript{76}, the fundamental point remains that the fee should be zero if the effect of the fee in reducing the customer base is sufficiently large.

Due to the moral hazard problem this would engender, it makes sense that a proprietary bank network would set \( f^o = 0 \) if condition (A2.1.5) is satisfied and \( f^o > 0 \) otherwise. For the analysis in Chapters 2 and 3, we restrict attention to the former case in which banks would choose not to charge fees for own customer transactions using own bank machines. Although the exact conditions under which the optimal fee would be zero is affected by access to machines from other banks\textsuperscript{77}, the fundamental point remains that the fee should be zero if the effect of the fee in reducing the customer base is sufficiently large.

\textsuperscript{76} When customers of bank A can choose between using bank A’s machines or bank B’s machines without other associated fees, a fee \( f^o \) charged by bank A would cause a shift of A’s customers towards use of B’s machines as well as an increased use of the branch.

\textsuperscript{77} When customers of bank A can choose between using bank A’s machines or bank B’s machines without other associated fees, a fee \( f^o \) charged by bank A would cause a shift of A’s customers towards use of B’s machines as well as an increased use of the branch.
Appendix 2.2: Derivation of Second Order Conditions

In the analysis of the text, we have assumed that \( \Pi^A \) is strictly concave for \( f \in [f^A, \ell] \) and that \( \Pi^B \) is strictly concave for \( f \in [f^B, \ell] \). This Appendix sets out the conditions required for these assumptions and explores the circumstances under which the conditions would be satisfied.

From (5.10) and (5.17),
\[
\frac{\partial \Pi^A}{\partial f} = (\ell - f) [N^B (1 - \rho^B) - N^A c (1 - \delta \rho^B)] / 2 \ell + \nu^A (\partial \rho^B \cdot \rho^A) / \partial f.
\]
\[
\frac{\partial \Pi^B}{\partial f} = (\ell - f) [N^A (1 - \rho^A) - N^B c (1 - \delta \rho^A)] / 2 \ell + \nu^B (\partial \rho^A \cdot \rho^B) / \partial f
\]
(A2.2.1)

where \( \nu^A = N^B f + \delta c (N^A - N^B) \) and \( \nu^B = N^A f - \delta c (N^A - N^B) \). We first consider the conditions under which the profit function is concave for bank A.

**Proposition A1:** The profit function \( \Pi^A \) is strictly concave:

(i) at \( f = \ell \) and at \( f = f^A \) if \( N^B (1 - \rho^B) - \beta N^A c (1 - \delta \rho^B) / 2 < 0 \),

(ii) at \( f = f^A \) chosen when \( \alpha = 1 \), if \( f^A > f^B \).

**Proof:** From (A2.2.1) and (4.14), we obtain (as in (5.11) of the text):
\[
\frac{\partial \Pi^A}{\partial f} = \xi^A (1 - \rho^B) / 2 - Y^A (\partial \rho^B / \partial f)
\]
where,
\[
\xi^A = [N^B (\ell - f) - \nu^A] / \ell, \quad Y^A = N^A c (1 - \delta) + \nu^A (\ell - f) / 2 \ell
\]
for \( \nu^A = N^B f + \delta c (N^A - N^B) \). (A2.2.2)

Useful relationships are: from (A2.2.2):
\[
\frac{\partial Y^A}{\partial f} = N^B (\ell - f) / 2 \ell - \nu^A / 2 \ell = \xi^A / 2 \]
where \( \partial \xi^A / \partial f = -2 N^B / \ell \) (A2.2.3)

From (4.9) and (4.10), we also have:
\[
\frac{\partial \rho^B / \partial f} = \rho^B (\ell - f) / 2 \ell;
\]
\[
\frac{\partial \rho^A / (\partial f)^2} = - \beta [\rho^B - (\ell - f) (\partial \rho^B / \partial f)] / 2 \ell
\]
(A2.2.4)

Differentiating \( \partial \Pi^A / \partial f \) as in (A2.2.2) and using (A2.2.3) and (A2.2.4), it then follows that
\[
\frac{\partial^2 \Pi^A / (\partial f)^2} = - N^B (1 - \rho^B) / \ell - \xi^A (\partial \rho^B / \partial f) / 2 - (\partial \rho^B / \partial f) (\partial Y^A / \partial f) - Y^A (\partial^2 \rho^B / (\partial f)^2)
\]
\[
= - N^B (1 - \rho^B) / \ell - \xi^A (\partial \rho^B / \partial f) + \beta Y^A (\rho^B - (\ell - f) (\partial \rho^B / \partial f)) / 2 \ell
\]
\[
= - N^B (1 - \rho^B) / \ell + \beta Y^A (\rho^B - (\ell - f) (\partial \rho^B / \partial f)) / 2 \ell
\]
(A2.2.5)

(i) Expanding \( Y^A \) from (A2.2.2) and using (4.9), (A2.2.5) can be expressed as:
\[
\frac{\partial^2 \Pi^A / (\partial f)^2} = - [N^B (1 - \rho^B) - \beta N^A c (1 - \delta) \rho^B / \ell]
\]
\[
[\xi^A - \nu^A / 2 \ell + \beta Y^A (\ell - f) / 2 \ell]] (\partial \rho^B / \partial f)
\]
(A2.2.6)

At \( f = \ell \), we have \( \partial \rho^B / \partial f = 0 \) from (4.9) and the result follows from (A2.2.6) since \( \partial^2 \Pi^A / (\partial f)^2 < \).
0 for \(N^B(1-\rho^0L) - \beta N^A c(1-\delta)\rho^{0L}2 > 0\). At \(f = f^A\), we have \(\nu^A = N^B f^A + \delta c(N^A-N^B) < 0\) from (5.4), and hence \(x^A > 0\) from (A2.2.2). Since \(Y^A > 0\) from (5.12), (A2.2.6) then implies that \(\partial^2 \Pi^{AL}/(\partial f)^2 < 0\) for \(N^B(1-\rho^0L) - \beta N^A c(1-\delta)\rho^{0L}/2 > 0\).

(ii) If \(f^A > f^B\), then bank A\'s preferred fee \(f^A\) satisfies \(\partial \Pi^{AL}/\partial f = 0\) (from Proposition 2) and from (A2.2.2), we obtain \(Y^A (\partial \rho^{0L}/\partial f) = \xi^A(1-\rho^0L)/2\) or equivalently \(\beta Y^A = \xi^A(1-\rho^0L)/\rho^{0L}(\ell-f^A)\) at \(f = f^A\). Hence for \(f = f^A > f^B\), substituting for \(Y^A\) in (A2.2.5) and using \(2N^B(\ell-f^A)/\ell = -\xi^A = [N^B \ell + \delta c(N^A-N^B)]/\ell\), it follows that:

\[
\frac{\partial^2 \Pi^{AL}/(\partial f)^2}{\partial \Pi^{AL}/(\partial f)^2} = -(1-\rho^0L)[N^B/\ell - \xi^A/2(\ell-f^A)] - \xi^A (\partial \rho^{0L}/\partial f) [1 + (1-\rho^0L)/2\rho^{0L}]
\]

\[
= -(1-\rho^0L)[N^B/\ell + \delta c(N^A-N^B)]/2\ell(\ell-f^A) - \xi^A (\partial \rho^{0L}/\partial f)(\ell^0L+1)/2\rho^{0L}. \quad (A2.2.7)
\]

Since \(x^A > 0\) at \(f^A\) (from \(Y^A > 0\) and \(Y^A (\partial \rho^{0L}/\partial f) = x^A(1-\rho^0L)/2\)), it follows from (A2.2.7) that \(\partial^2 \Pi^{AL}/(\partial f)^2 < 0\) at \(f^A\) and hence that \(\Pi^{AL}\) is strictly concave at \(f^A\) for \(f^A > f^B\).

**Proposition A2:** The profit function \(\Pi^{BL}\) is strictly concave:

(i) at \(f = \ell\) and at \(f = f^B\) if \(N^A(1-\rho^0L) - \beta N^B c(1-\delta)\rho^{0L}/2 < 0\).

(ii) at \(f = f^B\) chosen when \(\alpha = 0\), if \(\ell \geq \delta c(N^A-N^B)/N^B\).

**Proof:** From (A2.2.1) and (4.14), we obtain (as in (5.11) of the text)

\[
\partial \Pi^{BL}/\partial f = \xi^B(1-\rho^0L)/2 - Y^B (\partial \rho^{0L}/\partial f) \quad \text{where,}
\]

\[
\xi^B = [N^A(\ell-f) - \nu^B]/\ell; \quad Y^B = N^B c(1-\delta) + \nu^B(\ell-f)/2\ell \quad \text{for} \quad \nu^B = N^A f - \delta c(N^A-N^B) \quad (A2.2.8)
\]

From (5.3) using \(\rho^{SL} = (\ell-f)(1-\rho^0L)/2\ell\) and (A2.2.8), it follows that for \(f \in [f^B, \ell]\):

\[
\Pi^{BL} - \Pi^B = Y^B (1-\rho^0L) - N^B c(1-\delta)(1-\rho^0) \geq 0, \quad (A2.2.9)
\]

and hence that \(Y^B > 0\) for \(f \in [f^B, \ell]\).

We also have from (A2.2.8):

\[
\partial Y^B/\partial f = N^A(\ell-f)/2\ell - \nu^B(\ell-f)/2\ell = \xi^B/2 \quad \text{where} \quad \partial \xi^B/\partial f = -2N^A/\ell, \quad (A2.2.10)
\]

Differentiating \(\partial \Pi^{BL}/\partial f\) as in (A2.2.8) and using (A2.2.10) and (A2.2.4), it then follows (analogously to (A2.2.5)) that:

\[
\partial^2 \Pi^{BL}/(\partial f)^2 = -N^A(1-\rho^0L)/\ell + \beta Y^B \rho^{0L}/2\ell - \{\xi^B + \beta Y^B(\ell-f)/2\ell\}(\partial \rho^{0L}/\partial f). \quad (A2.2.11)
\]

(i) Expanding \(Y^B\) from (A2.2.8) and using (4.9), (A2.2.11) can be expressed as:

\[
\partial^2 \Pi^{BL}/(\partial f)^2 = -[N^A(1-\rho^0L) - \beta N^B c(1-\delta)\rho^{0L}/2]/\ell -
\]

\[
\{\xi^B - \nu^B/2\ell + \beta Y^B(\ell-f)/2\ell\}(\partial \rho^{0L}/\partial f). \quad (A2.2.12)
\]

At \(f = \ell\), we have \(\partial \rho^{0L}/\partial f = 0\) from (4.9) and the result follows from (A2.2.12) since \(\partial^2 \Pi^{BL}/(\partial f)^2\)
< 0 for $N^A(1-\rho^{0L}) - \beta N^B c(1-\delta)\rho^{0L}/2 > 0$. At $f = f^B$, we have $\nu^B = N^B f^B - \delta c(N^A-N^B) < 0$ from (5.4), and hence $\xi^B > 0$ from (A2.2.8). Since $Y^B > 0$ from (A2.2.9), (A2.2.12) then implies that 
\[ \frac{\partial^2 \Pi^{BL}}{\partial \ell^2} < 0 \text{ for } N^A(1-\rho^{0L}) - \beta N^B c(1-\delta)\rho^{0L}/2 > 0. \]

(ii) If $\ell > \delta c(N^A - N^B)/N^A$, bank B's preferred fee $f^B$ satisfies $\partial \Pi^{BL}/\partial f = 0$ (from Proposition 3), and hence, from (A2.2.8), $f^B$ also satisfies $Y^B (\partial \rho^{0L}/\partial f) = \xi^B (1-\rho^{0L})/2$, or equivalently, $\beta Y^B = \xi^B (1-\rho^{0L})\ell/\rho^{0L}(\ell-f^B)$. Hence substituting for $Y^B$ in (A2.2.11) and using $2N^A(\ell-f^B)/\ell - \xi^B = [N^A\ell - \delta c(N^A-N^B)]/\ell$ it follows that at $f = f^B$:

\[ \frac{\partial^2 \Pi^{BL}}{\partial \ell^2} = -(1-\rho^{0L}) [N^A/\ell - \xi^B/2(\ell-f^B)] - \xi^B (\partial \rho^{0L}/\partial f)[1 + (1-\rho^{0L})/2\rho^{0L}] \]
\[ = - (1-\rho^{0L})[N^A\ell - \delta c(N^A-N^B)]/2\ell(\ell-f^B) - \xi^B (\partial \rho^{0L}/\partial f)(\rho^{0L}+1)/2\rho^{0L}. \quad (A2.2.13) \]

Since $\xi^B > 0$ at $f = f^B$ (from $Y^B > 0$ and $Y^B (\partial \rho^{0L}/\partial f) = \xi^B (1-\rho^{0L})/2$), it follows from (A2.2.13) that $\frac{\partial^2 \Pi^{BL}}{\partial \ell^2} < 0$, and hence that the second order conditions for a local maximum are satisfied at $f^B$ provided $\ell \geq \delta c(N^A-N^B)/N^B$. ***

Since $\Pi^{AL}$ and $\Pi^{BL}$ are strictly concave at $f^A$ and $f^B$ respectively for $\ell \geq \delta c(N^A-N^B)/N^B$, this ensures that $f^A$ and $f^B$ indeed give rise to local maximums of profit. However, the analysis assumes that $\Pi^{AL}$ is strictly concave for $f \in [f^A, \ell]$ and $\Pi^{BL}$ is strictly concave for $f \in [f^B, \ell]$, so as to ensure that the local maximums at $f^A$, $f^B$ and $\ell$ represent global maximums and that the Kuhn Tucker conditions for the choice of $f$ subject to constraint apply. We are able to show conditions under which $\Pi^{AL}$ is strictly concave at $f = f^A$ and at $f = \ell$ and similarly for $\Pi^{BL}$. However, the conditions for global concavity are quite complex in general.
## Appendix 4.1 Regional Status of Urban Centres in Data Set

<table>
<thead>
<tr>
<th>Area</th>
<th>Central</th>
<th>Midwest</th>
<th>Northeast</th>
<th>Southeast</th>
<th>Southwest</th>
<th>West</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban Centre</td>
<td>Chicago Cincinnati Cleveland Detroit Milwaukee</td>
<td>Kansas City Minneapolis St. Louis</td>
<td>Baltimore Boston New York Philadelphia Pittsburgh Washington</td>
<td>Atlanta Miami Tampa</td>
<td>Dallas Houston</td>
<td>Denver Los Angeles Phoenix San Diego San Francisco Seattle</td>
</tr>
<tr>
<td># of Banks in Sample</td>
<td>44</td>
<td>26</td>
<td>52</td>
<td>27</td>
<td>17</td>
<td>52</td>
</tr>
</tbody>
</table>
Appendix 4.2 Sample of FDIC Data

### Summary Financial Report
**Acacia Federal Savings Bank**

7600-B Leesburg Pike, Suite 200
Falls Church, VA 22043

CLASS: SA  REGULATOR: OTS  U.S. OFFICES: 1

The most recent demographic change for this institution was on March 24, 1995
Click on the row number for definition.

<table>
<thead>
<tr>
<th>Definition</th>
<th>(dollar figures in thousands)</th>
<th>Acacia Federal Savings Bank</th>
<th>Acacia Federal Savings Bank</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>December 31, 1997</td>
<td>December 31, 1996</td>
</tr>
<tr>
<td><strong>Assets and liabilities</strong></td>
<td></td>
<td>Acacia Federal Savings Bank</td>
<td>Acacia Federal Savings Bank</td>
</tr>
<tr>
<td>1.</td>
<td>Number of institutions reporting</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2.</td>
<td>Total employees (full-time equivalent)</td>
<td>51</td>
<td>48</td>
</tr>
<tr>
<td>3.</td>
<td>Total assets</td>
<td>562,003</td>
<td>554,461</td>
</tr>
<tr>
<td>4.</td>
<td>Cash and due from depositary institutions</td>
<td>8,659</td>
<td>4,562</td>
</tr>
<tr>
<td>5.</td>
<td>Interest-bearing</td>
<td>7,775</td>
<td>3,041</td>
</tr>
<tr>
<td>6.</td>
<td>Securities</td>
<td>45,113</td>
<td>55,115</td>
</tr>
<tr>
<td>7.</td>
<td>Federal funds sold &amp; reverse repurchase agreements</td>
<td>10,624</td>
<td>10,897</td>
</tr>
<tr>
<td>8.</td>
<td>Net loans &amp; leases</td>
<td>479,160</td>
<td>468,707</td>
</tr>
<tr>
<td>9.</td>
<td>Loan loss allowance</td>
<td>2,082</td>
<td>1,452</td>
</tr>
<tr>
<td>10.</td>
<td>Trading account assets</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>11.</td>
<td>Bank premises and fixed assets</td>
<td>1,325</td>
<td>1,299</td>
</tr>
<tr>
<td>12.</td>
<td>Other real estate owned</td>
<td>414</td>
<td>332</td>
</tr>
<tr>
<td>13.</td>
<td>Goodwill and other intangibles</td>
<td>170</td>
<td>71</td>
</tr>
<tr>
<td>14.</td>
<td>Mortgage servicing assets</td>
<td>170</td>
<td>71</td>
</tr>
<tr>
<td>15.</td>
<td>All other assets</td>
<td>16,538</td>
<td>13,478</td>
</tr>
<tr>
<td>16.</td>
<td>Total liabilities and capital</td>
<td>562,003</td>
<td>554,461</td>
</tr>
<tr>
<td>17.</td>
<td>Total liabilities</td>
<td>535,842</td>
<td>530,958</td>
</tr>
<tr>
<td>18.</td>
<td>Total deposits</td>
<td>296,335</td>
<td>299,846</td>
</tr>
<tr>
<td>19.</td>
<td>Interest-bearing deposits</td>
<td>289,501</td>
<td>294,368</td>
</tr>
<tr>
<td>20.</td>
<td>Domestic deposits</td>
<td>296,335</td>
<td>299,846</td>
</tr>
<tr>
<td>21.</td>
<td>% insured (estimated)</td>
<td>97.69</td>
<td>98.10</td>
</tr>
<tr>
<td>22.</td>
<td>Federal funds purchased &amp; repurchase agreements</td>
<td>19,097</td>
<td>36,659</td>
</tr>
<tr>
<td>23.</td>
<td>Demand notes issued to U.S. Treasury</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>24.</td>
<td>Trading liabilities</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>25.</td>
<td>Other borrowed funds</td>
<td>215,520</td>
<td>192,560</td>
</tr>
<tr>
<td>26.</td>
<td>Subordinated debt</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
### Memoranda

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>27</td>
<td>All other liabilities</td>
<td>4,890</td>
</tr>
<tr>
<td>28</td>
<td>Equity capital</td>
<td>26,161</td>
</tr>
<tr>
<td>29</td>
<td>Perpetual preferred stock</td>
<td>2,000</td>
</tr>
<tr>
<td>30</td>
<td>Common stock</td>
<td>3,000</td>
</tr>
<tr>
<td>31</td>
<td>Surplus</td>
<td>15,000</td>
</tr>
<tr>
<td>32</td>
<td>Undivided profits</td>
<td>6,161</td>
</tr>
</tbody>
</table>

### Income and Expense

<table>
<thead>
<tr>
<th></th>
<th>(Year-to-date)</th>
<th>(Year-to-date)</th>
</tr>
</thead>
<tbody>
<tr>
<td>43</td>
<td>Total interest income</td>
<td>40,334</td>
</tr>
<tr>
<td>44</td>
<td>Total interest expense</td>
<td>30,748</td>
</tr>
<tr>
<td>45</td>
<td>Net interest income</td>
<td>9,586</td>
</tr>
<tr>
<td>46</td>
<td>Provision for loan losses</td>
<td>1,080</td>
</tr>
<tr>
<td>47</td>
<td>Total noninterest income</td>
<td>1,717</td>
</tr>
<tr>
<td>48</td>
<td>Service charges on deposit accounts</td>
<td>N/A</td>
</tr>
<tr>
<td>49</td>
<td>Total noninterest expense</td>
<td>5,974</td>
</tr>
<tr>
<td>50</td>
<td>Salaries and employee benefits</td>
<td>3,412</td>
</tr>
<tr>
<td>51</td>
<td>Premises and equipment expense</td>
<td>1,273</td>
</tr>
<tr>
<td>52</td>
<td>Pre-tax net operating income</td>
<td>4,249</td>
</tr>
<tr>
<td>53</td>
<td>Securities gains (losses)</td>
<td>576</td>
</tr>
<tr>
<td>54</td>
<td>Applicable income taxes</td>
<td>1,930</td>
</tr>
<tr>
<td>55</td>
<td>Extraordinary gains - net</td>
<td>0</td>
</tr>
<tr>
<td>56</td>
<td>Net income</td>
<td>2,895</td>
</tr>
<tr>
<td>57</td>
<td>Net charge-offs</td>
<td>370</td>
</tr>
<tr>
<td>58</td>
<td>Cash dividends</td>
<td>240</td>
</tr>
<tr>
<td>59</td>
<td>Net operating income</td>
<td>2,526</td>
</tr>
<tr>
<td>60</td>
<td>% of unprofitable institutions</td>
<td>N/A</td>
</tr>
<tr>
<td>61</td>
<td>% of institutions with earnings gains</td>
<td>N/A</td>
</tr>
</tbody>
</table>

### Performance Ratios (%)

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>62</td>
<td>Yield on earning assets</td>
</tr>
</tbody>
</table>
Appendix 4.2 cont.

<table>
<thead>
<tr>
<th></th>
<th>Cost of funding earning assets</th>
<th>5.72</th>
<th>5.83</th>
</tr>
</thead>
<tbody>
<tr>
<td>64</td>
<td>Net interest margin</td>
<td>1.78</td>
<td>1.61</td>
</tr>
<tr>
<td>65</td>
<td>Noninterest income to earning assets</td>
<td>.32</td>
<td>.29</td>
</tr>
<tr>
<td>66</td>
<td>Noninterest expense to earning assets</td>
<td>1.11</td>
<td>1.44</td>
</tr>
<tr>
<td>67</td>
<td>Net operating income to assets</td>
<td>.45</td>
<td>.19</td>
</tr>
<tr>
<td>68</td>
<td>Return on assets</td>
<td>.52</td>
<td>.23</td>
</tr>
<tr>
<td>69</td>
<td>Return on equity</td>
<td>11.67</td>
<td>5.58</td>
</tr>
<tr>
<td>70</td>
<td>Retained earnings to average equity (ytd only)</td>
<td>10.70</td>
<td>4.49</td>
</tr>
<tr>
<td>71</td>
<td>Net charge-offs to loans</td>
<td>.08</td>
<td>.05</td>
</tr>
<tr>
<td>72</td>
<td>Loan loss provision to net charge-offs</td>
<td>291.89</td>
<td>324.32</td>
</tr>
<tr>
<td>73</td>
<td>Earnings coverage of net charge-offs</td>
<td>14.40</td>
<td>10.62</td>
</tr>
<tr>
<td>74</td>
<td>Efficiency ratio</td>
<td>52.85</td>
<td>76.00</td>
</tr>
<tr>
<td>75</td>
<td>Average assets per employee ($mill)</td>
<td>11.00</td>
<td>12.00</td>
</tr>
<tr>
<td>76</td>
<td>Market to book value of securities held to maturity</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>77</td>
<td>Cash dividends to net income</td>
<td>8.29</td>
<td>19.57</td>
</tr>
</tbody>
</table>

**Condition Ratios (%)**

<table>
<thead>
<tr>
<th></th>
<th>Loss allowance to loans</th>
<th>.43</th>
<th>.31</th>
</tr>
</thead>
<tbody>
<tr>
<td>78</td>
<td>Loss allowance to noncurrent loans</td>
<td>65.29</td>
<td>61.57</td>
</tr>
<tr>
<td>79</td>
<td>Noncurrent assets plus other real estate owned to assets</td>
<td>.64</td>
<td>.47</td>
</tr>
<tr>
<td>80</td>
<td>Noncurrent loans to loans</td>
<td>.66</td>
<td>.48</td>
</tr>
<tr>
<td>81</td>
<td>Net loans and leases to deposits</td>
<td>161.70</td>
<td>156.32</td>
</tr>
<tr>
<td>82</td>
<td>Net loans and leases to core deposits</td>
<td>177.85</td>
<td>170.77</td>
</tr>
<tr>
<td>83</td>
<td>Net non core funding to long term assets</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>84</td>
<td>Equity capital to assets</td>
<td>4.65</td>
<td>4.24</td>
</tr>
<tr>
<td>85</td>
<td>Core capital (leverage) ratio</td>
<td>4.65</td>
<td>4.24</td>
</tr>
<tr>
<td>86</td>
<td>Tier 1 risk-based capital ratio</td>
<td>9.44</td>
<td>9.01</td>
</tr>
<tr>
<td>87</td>
<td>Total risk-based capital ratio</td>
<td>10.20</td>
<td>9.54</td>
</tr>
</tbody>
</table>

**Demographic Information (from RIS end-of-quarter data)**

<table>
<thead>
<tr>
<th></th>
<th>Certificate #</th>
<th>32266</th>
<th>32266</th>
</tr>
</thead>
<tbody>
<tr>
<td>89</td>
<td>Institution Name</td>
<td>Acacia Federal Savings Bank</td>
<td>Acacia Federal Savings Bank</td>
</tr>
<tr>
<td>90</td>
<td>City, State, Zip</td>
<td>Falls Church, VA 22043</td>
<td>Falls Church, VA 22043</td>
</tr>
<tr>
<td>91</td>
<td>County</td>
<td>Fairfax</td>
<td>Fairfax</td>
</tr>
<tr>
<td>92</td>
<td>Bank Charter Class</td>
<td>SA</td>
<td>SA</td>
</tr>
<tr>
<td>93</td>
<td>Subchapter S Corporation</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>94</td>
<td>Ownership Type</td>
<td>Stock</td>
<td>Stock</td>
</tr>
<tr>
<td>95</td>
<td>Interstate Branches</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

129
## Appendix 4.2 cont.

<table>
<thead>
<tr>
<th>Regulator</th>
<th>OTS</th>
<th>OTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insurance fund membership</td>
<td>SAIF</td>
<td>SAIF</td>
</tr>
<tr>
<td>Number of Domestic Offices</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Number of Foreign Offices</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total Offices, Foreign and Domestic</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>FDIC Region</td>
<td>Atlanta</td>
<td>Richmond</td>
</tr>
<tr>
<td>FDIC Field Office</td>
<td>Richmond</td>
<td>Richmond</td>
</tr>
<tr>
<td>Federal Reserve District</td>
<td>Southeast</td>
<td>Southeast</td>
</tr>
<tr>
<td>Office of the Comptroller of the Currency District</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Office of Thrift Supervision Region</td>
<td>Southeast</td>
<td>Southeast</td>
</tr>
<tr>
<td>Quarterly Banking Profile Commercial Bank Region</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consolidated Metropolitan Statistical Area</td>
<td>Washington-Baltimore, DC-MD-VA-WV</td>
<td>Washington-Baltimore, DC-MD-VA-WV</td>
</tr>
<tr>
<td>Metropolitan Statistical Area</td>
<td>Washington, DC-MD-VA</td>
<td>Washington, DC-MD-VA</td>
</tr>
</tbody>
</table>

Bank demographic information is taken from FDIC's RIS Quarterly database, last March 3, 1998 downloaded on: March 3, 1998

Download Help (If using MS Internet Explorer, save the file with the *.csv extension)

Last updated: December 2, 1997
Prepared by: FDIC DRS/DIRM

Unless otherwise specified the source of data is Research Information System (RIS)
Appendix 4.3

Institution Directory Definitions

Bank Charter Class

A classification codes assigned by the FDIC based on the institution’s charter type (commercial bank or savings institution), charter agent (state or federal), and federal reserve membership status (fed member).

N = commercial bank, national charter, and Fed member, supervised by the Office of the Comptroller of the Currency

SM = commercial bank, state charter, and Fed member, supervised by the Federal Reserve (FRB)

NM = commercial bank, state charter and not Fed member, supervised by the FDIC

SB = savings banks, state charter, supervised by the FDIC

SA = savings associations, state or federal charter, supervised by the Office of Thrift Supervision

OI = insured U.S. branch of a foreign chartered institution

<table>
<thead>
<tr>
<th>Classification</th>
<th>N</th>
<th>SM</th>
<th>NM</th>
<th>SB</th>
<th>SA</th>
<th>OI</th>
</tr>
</thead>
<tbody>
<tr>
<td># in Sample</td>
<td>101</td>
<td>17</td>
<td>19</td>
<td>13</td>
<td>68</td>
<td>0</td>
</tr>
</tbody>
</table>

Source: US FDIC Website