A PROFIT FRONTIER ESTIMATION OF BANK EFFICIENCY AFTER
FINANCIAL REFORM IN THE DOMINICAN REPUBLIC

Dissertation
Presented in Partial Fulfillment of the Requirements for
the Degree Doctor of Philosophy in the Graduate
School of The Ohio State University

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* * *

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This dissertation assesses the profit efficiency of commercial banks in the Dominican Republic after a 1991 financial reform that liberalized interest rates and introduced a universal bank (multibanco) charter. A restricted profit efficiency frontier is fitted to panel data for 1991-1994. Technical and allocative inefficiency are evaluated from the assumption of maximization of profits restricted by regulatory constraints, on the basis of shadow prices that differ from actual prices. The distortion coefficients from the parametric estimation of allocative inefficiency capture the net effects of regulation, managerial behavior, and market power. A cost frontier is also estimated, and a financial ratio analysis add robustness to the results.

Using a fixed-effect model, technical inefficiency is estimated as bank-specific, and allocative inefficiency is estimated as netput-specific. Banks are ranked using the technical inefficiency estimates relative to the best-practice bank. Profit-frontier, cost-frontier, and financial-ratio rankings are compared, and a high Spearman correlation coefficient is found among the rankings.

Group means are compared and, when two outliers at the most efficient end are excluded, multibancos are found to be less technically inefficient than non-multibancos. Because economies of scope could not be estimated, technical inefficiency rankings do not provide sufficient information that multibancos are more efficient than non-multibancos.

Due to allocative inefficiency, banks were found to produce more investments and less loans than is optimum. On the input side, banks hold too many deposits per employee. Since the parameters are measured relative to labor, fitted shadow shares were evaluated at the geometric means to estimate the difference between optimal shares and shadow shares. Estimated shadow shares are
larger than optimal for investments and labor and smaller than optimal for loans and deposits. Large shares for labor reflect the discretionary power of managers, while large shares for investments reflect a monetary policy of forced placement of bonds with the banks. Small loan shares are the net result of tighter prudential regulation, learning processes for more strict lending, and the possibility of market power. Shadow profits were found to be 3 percent larger than optimal profits, suggesting some degree of market power.
TO MY MOTHER

for her unconditional love and support
ACKNOWLEDGMENTS

My deepest gratitude is to my mother. She has been the strength behind my perseverance during my years of study at Ohio State and throughout my life. Her understanding and encouragement at all times are priceless to me. I dedicate this dissertation to her, my long-distance loving helper.

I am also very grateful to my advisor Professor Claudio Gonzalez-Vega, who motivated me to think deeper. His valuable recommendations and challenging comments enhanced the quality of this dissertation in terms both of depth of analysis and clarity of my writing. My gratitude goes to him because when I needed him the most, he responded.

I am greatly indebted to Professor Patty Byrnes. As a member of my committee and as a friend, she was always willing to listen and her comments and guidelines were of great help. She believed in me even at the most difficult times of my research. Many thanks to Ian Sheldon for his insightful comments as a member of my committee and for his support in the final stages of this effort.

My appreciation to Mayada Baydas and Koro Ouattara, my friends and workmates who have dried my tears more than once since the beginning and who read the earliest versions of my dissertation and made helpful comments. Their friendship is a great asset to me. I am deeply thankful to God who blessed me with great support from my family and many friends. Their presence helped me realize that no matter how hard the times were, I was never alone. Thanks to
my brother José Miguel and his wife Karen, my sister, for their understanding and great concern for my success. Even from afar, they have given me all their love and care.

Among my friends, special thanks to Rita Mena, and Silvestre Aybar for their help with last minute information for my research, they, together with Claudia Ruiz, Eva Hentschel, Edna Camacho, and Vielka Arias, followed my journey step by step despite the distance. Their phone calls were of great help. In Columbus, Saroj Rai and Sylvia Schwarz have been like my closest family, and Ubaldo Soto a great friend. Also, thanks to many friends at Ohio State and in Columbus who have expressed their concern on the final part of my research. Among them, Verónica and Hans Dellien, Mónica de Castro, Verónica de Allende, Janina León, Harriet Nannyonga, Sergio Navajas, Genevieve Nguyen, Dan Salazar, and specially Hender Avila, who had his best wishes for me and provided me comfort in difficult times trying hard to keep my spirit up.

My gratitude to Susana Sanchez for her dear friendship and for helpful discussions about my research in the final stages, specially during the long night-hours of work that she dedicated to me in her visits to Columbus. In dealing with what seemed unsurmountable data problems, my many thanks to Professor Cosslett for his clarifications, and to Miguel Sanchez for his invaluable help with the convergence problems encountered with my model. My gratitude to Gary Schnitkey as well, who offered helpful insights about my research and reminded me of the limitations that I was not expected to overcome in my empirical model.

My studies were funded by the Rural Financial Services Program in the Dominican Republic and by the Financial Resources Management Cooperative Agreement between the Rural Finance Program at The Ohio State University and the United States Agency for International Development (USAID). Additional assistance was provided by the Central Bank of the Dominican Republic.

My sincere appreciation goes to the personnel at the Central Bank of the Dominican Republic. The of Vice-Governor Luis Manuel Piantini to approve and enforce the data collection,
and of my friend José Alfredo Guerrero with his great help since the beginning were essential to this research. I also thank Ana B. Rodriguez, Melba Cruz, Gladys Caraballo, César Pimentel, and Oscar Padilla. My special gratitude to Felicia Alcántara, for without whose dedication I would have never obtained the data for my dissertation despite the support of the administration.

Also, thanks to the personnel at Ohio State University for their kindness. In particular, to Barbara Lee, Juddy Petticord, and Joan Weber. Finally, many thanks to my professor and mentor Andrés Dauhajre, for providing me with the opportunity to come to Ohio State and for following my career with care since the beginning.
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CHAPTER 1
INTRODUCTION

After years of neglect, the role of finance in developing economies now occupies a prominent place in economic theory. Financial markets became a popular topic of study after the seminal work of McKinnon (1973) and Shaw (1973) highlighted the contributions of finance to economic development and growth. These authors showed, in particular, that the provision of financial services improves the efficiency of resource allocation in developing economies.

1.1 Objectives

Financial markets influence the overall performance of the economy. Regulation and efficiency are among the most important elements to consider in analyzing the impact of financial markets on economic performance. Financial regulation is an important determinant of differences in efficiency and in financial structures in otherwise similar countries (Vittas, 1992). For this reason, it is important to evaluate the regulatory framework and the efficiency of financial systems as indicators of their contribution to growth and development.

There is considerable interest in the role of economic policy and financial regulation in the Dominican Republic. This interest is due to the program of structural reform that this country started in 1991. Among major policy reforms, the liberalization of interest rates has replaced a system of rate ceilings and subsidized credit. A Código Monetario y Financiero (Monetary and Financial Code) was enacted by the authorities in early 1997 to regulate the financial system.
Previously, there was no specific legislation for the financial sector. Instead, this sector was regulated by a series of Monetary Board resolutions and by the general commercial legislation, also applicable to the banking sector.

Before the new Code was enacted, the Junta Monetaria (Monetary Board) issued resolutions in line with the directives of the proposed legislation. The purpose was to speed up the process of implementation of the new rules.¹ While awaiting for the Code to be enacted, the authorities adopted new prudential rules through the Superintendency of Banks and the Central Bank.

The Monetary and Financial Code includes as an option a universal bank charter. Universal banks had been promoted since 1992. This led to a mixed structure of the Dominican banking system. Two types of commercial banks coexist: universal/commercial banks or multibancos and the traditional commercial banks (non-multibancos).

This dissertation assesses the profit efficiency of Dominican commercial banks after financial reform. The period of analysis starts in January 1991, the year when financial reform began. After this date, banks became multibancos by following one of two paths. The first path consisted of a few commercial and other types of banks merging into multibancos. The second path resulted from the increase in the capital of a single intermediary to become a multibanco. This second path was not followed until after December, 1994. This is one of the reasons why the analysis of this dissertation is carried out for the period between January, 1991 and December, 1994, and why the dissertation focuses only on the transformations of banks that followed the first path. Transformations following the second path are still an ongoing process.

¹ This dissertation discusses the Code as if it has already been enacted. On March 4, 1997 the Senate approved the Code and sent it to the Executive for enactment. The regulations of the Code have been effectively in place through resolutions, and no major disagreement about the Code is now expected.
A comparative analysis of the technical and allocative efficiency of *multibancos* and *non-multibancos* may prove useful for policymakers in the adoption of regulations to improve the overall efficiency of the financial system. Moreover, the estimation of scope economies may provide private entrepreneurs with information that enhances their decision making. A bank may realize, for example, that becoming a *multibanco* is not optimal in its particular case, although it may be optimal for other banks.

Efficiency can mean different things depending on the setting. In this dissertation, efficiency will be identified with functional efficiency, which deals with the traditional economic functions of the financial system (Tobin, 1984). Other forms of efficiency are information-arbitrage efficiency, which is attained when no further profits can be obtained given generally available information. Fundamental-valuation efficiency reflects the accuracy with which the valuation of financial assets reflects the stream of future payments that they promise. Full-insurance efficiency occurs if a market allows agents to insure themselves for the delivery of goods and services, whatever the contingency that prevails.

1.2 Roles of finance

This dissertation focuses on financial intermediation. Intermediation allows the mobilization of funds from those with relatively abundant resources and poor marginal investment opportunities (surplus units) to those with better investment opportunities but relatively few resources (deficit units). Indirect finance, by transforming the deposits of surplus units into loans for deficit units, improves the efficiency of the allocation of resources and raises output (Shaw, 1973).

Besides intermediation, the financial system provides monetary, risk management, and fiscal functions (Long, 1983; González-Vega, 1992; McKinnon, 1989). The monetary function is
exercised through the provision of a means of payments and a stable unit of account. Monetization lowers transaction costs and furthers the integration of goods, services, and factor markets. Financial services facilitate risk management through the availability of stores of value and opportunities for portfolio diversification.

The fiscal function of finance is achieved by funding fiscal deficits through bank credit. When this function prevails, there is a crowding out of the private sector in credit portfolios, as loanable funds are used primarily for fiscal purposes (González-Vega, 1992). This crowding out together with targeted and subsidized credit policies lead to a financially repressed economy a la McKinnon-Shaw. Under repression, price distortions restrict the real flows of loanable funds and reduce the quantity and quality of productive investment (McKinnon, 1989).

1.3 From financial repression to prudential regulation

Government intervention in financial markets has shifted away from repressive regulation towards a prudential regulatory framework. Many developing countries, particularly in Latin America, have started processes of financial reform by moving toward liberalized markets. This is true for the Dominican Republic as well.

Policymakers have learned, however, that a robust regulatory scheme is needed under which agents can act more efficiently while system stability is preserved. Prudential regulation, as a set of rules for a safe and sound financial system, has taken over as the main concern of the authorities. Indeed, the role of the state is more evident in the field of prudential regulation than as an issuer of economic (allocative) directives (Long and Vittas, 1992). Prudential supervision serves as the mechanism to ensure compliance with prudential regulation.
1.4 Hypotheses

The set of hypotheses to be tested in this dissertation include:²

Ho1: Regulation constrains the optimization decisions of banks in the Dominican Republic and lowers their profits.³ Banks are assumed to maximize restricted profits because regulation distorts prices, limits business opportunities, and levies explicit and implicit taxes on bank transactions.

Ho2: Multibancos are more efficient than non-multibanco commercial banks. This hypothesis is intended to evaluate whether banks should become multibancos.

Ho3: The asset choices of Dominican banks reflect allocative inefficiency in inputs and outputs attributable to regulation.

An evaluation of the overall efficiency of banks and of its sources is carried out through the estimation of a bank profit frontier. Profit frontiers belong to a new generation of studies of efficiency as deviations from an optimal frontier. They represent state-of-the-art tools for the analysis of efficiency in financial markets.

The first hypothesis deals with the importance of regulation in determining the profit efficiency of the system in general.

The second hypothesis deals with universal versus specialized banking. Tests of this hypothesis attempt to evaluate the efficiency implications of the new entry rules. Because

² Originally, an additional hypothesis was intended to evaluate if there are optimal economies of scope in the Dominican banking system to be exploited by universal banking. The existence of these economies makes a fragmented framework of specialized banking less efficient than a market structure that allows for both specialized and universal banks. As explained in Chapter 6, however, this hypothesis could not be tested because of lack of disaggregated output data.

³ The objective of this dissertation is to identify the impact of regulation and inefficiency on private profits, not on social welfare. The authorities are concerned, however, with social objectives.
government intervention may artificially sustain inefficient institutions through incentives and protection, it has been argued that regulatory frameworks should only allow for the healthier and more efficient institutions to stay in the market. If the new rules induce all banks to become multibancos through regulatory incentives, but some of these banks will not become more efficient, the overall efficiency of the system may be compromised.

The third hypothesis evaluates the portfolio implications of input and output prices and other allocative distortions discussed in the theoretical and empirical models presented in this dissertation.

1.5 Organization

What follows is organized in seven additional chapters, including a final chapter with concluding remarks. An overview of the Dominican financial system describes the setting in Chapter 2. Chapter 3 reviews the literature on repressive regulation and describes its consequences in the Dominican case. This review provides an explanation for the demand for reform and for liberalized financial markets.

A model of the financial firm and a discussion of the literature on bank profit maximization are the topics of Chapter 4. Production economies as economies of scale and economies of scope are also discussed in Chapter 4, and the Berger et al. (1993) concept of optimal scope economies is introduced and later illustrated graphically in a frontier context. Chapter 5 reviews methods for frontier analysis. These methods are used for the empirical estimation of bank efficiency in the Dominican Republic.

The process of modeling, the selection of variables, and a discussion of the data belong to Chapter 6. Chapter 6 also includes a financial ratio analysis as a preliminary evaluation of the system after the reform. Chapter 7 reports the results of the estimation of the profit frontier. Efficiency is classified into technical and allocative, with technical efficiency being measured as
bank-specific and allocative efficiency being measured as input/output specific. Estimation of allocative inefficiency involves a distortion parameter for each input and output. The extent to which allocative inefficiency affects profits is calculated as a loss in potential profits compared to an unrestricted maximization process, i.e., without regulation affecting prices.

The estimation of technical inefficiency allows a determination of which banks are more efficient than others. Efficiency scores for multibancos and non-multibancos are then compared with bank rankings resulting from the financial ratio analysis. Chapter 8 presents concluding remarks and recommendations.
CHAPTER 2
THE DOMINICAN FINANCIAL SYSTEM: INSTITUTIONAL STRUCTURE

This chapter describes the Dominican financial system. As a result of the process of reform started in December of 1991, the structure of the financial sector has undergone numerous changes over the past few years. Examination of the evolution of this structure is critical for the analysis of the effects of regulation on efficiency. The evaluation of different types of institutions and the comparisons of their efficiency undertaken in Chapter 6 rely on the scenario described below.

Figure 1 is a representation of the financial sector, which is composed of regulatory entities as well as monetary and non-monetary institutions. The former comprise the Monetary Board (Junta Monetaria) and the Superintendency of Banks (Superintendencia de Bancos). The Board dictates policies and regulations; the Superintendency is in charge of prudential supervision. The Central Bank, created in 1947, implements monetary, financial, and exchange rate policies issued by the Junta Monetaria.

The purpose of Central Bank policies is to promote macroeconomic stability and to provide sufficient liquidity to the financial system. In addition, the Central Bank offers implicit deposit insurance --in its role as lender of last resort for the banks-- and it attempts to channel credit to priority sectors. The Superintendency was created in 1965 to collaborate with the Central Bank in implementing prudential standards. It supervises financial institutions, focusing primarily on monitoring early signals of solvency problems.
The Central Bank’s main policy instruments include rediscount facilities and targeted lines of credit, through the *Fondo de Inversión para el Desarrollo Económico* (FIDE) and *Fondo para el Fomento de la Infraestructura Turística* (INFRATUR). Only certain types of financial institutions have access to these funds. By offering special rediscount windows, the state provides incentives for the development of some financial institutions, while it discriminates against other types of intermediaries. These policies are in line with a regime of financial repression.

Banks operating in the formal and regulated sector are divided into monetary (commercial banks) and non-monetary institutions (development and mortgage banks). Savings and loan associations are additional non-monetary institutions. For the period January 1991-December 1994, there were 72 bank charters in the financial system of the Dominican Republic. These charters authorized the operation of 21 commercial banks, 36 development banks, and 15 mortgage banks. During this period some banks were under suspension by the Superintendency or in process of
revoked. In addition, some banks merged and others failed. Most banks that merged became multibancos, holding a charter similar to that of universal banks. Multibancos are a special type of commercial banks.

As in most developing countries, the major participants in the Dominican financial system are the commercial banks. They are the focus of this dissertation. These banks held at least 82 percent of the total assets of the formal financial system during 1991-1994.\(^4\) A description of development and mortgage banks is included here because some of the universal commercial banks resulted from mergers of development, mortgage, and commercial banks.\(^5\)

2.1 Commercial banks

Commercial banks are the only type of intermediary authorized to mobilize funds through checking accounts. As of December of 1994, only 14 commercial banks were under compliance with the prudential rules of the Superintendency, although 21 charters had been issued. Table 1 shows a list of these banks, including the 14 active banks plus the banks that failed or merged. Of the active banks, seven are multibancos. All banks are privately owned, with the exception of one state-owned bank (Banco de Reservas), which is the largest intermediary in the system.

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\(^4\) Calculated from the data set.

\(^5\) Originally this dissertation attempted to assess the efficiency of commercial, development, and mortgage banks. This purpose was not feasible because the data required were not available.
<table>
<thead>
<tr>
<th>COMMERCIAL BANKS</th>
<th>ESTABLISHED ON</th>
<th>OWNERSHIP</th>
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</thead>
<tbody>
<tr>
<td>The Bank of Nova Scotia</td>
<td>July 1, 1920</td>
<td>Foreign</td>
</tr>
<tr>
<td>Banco de Reservas</td>
<td>October 24, 1941</td>
<td>State</td>
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<tr>
<td>Citibank, N.A.</td>
<td>May 3, 1962</td>
<td>Foreign</td>
</tr>
<tr>
<td>Banco Popular Dominicano</td>
<td>August 23, 1963</td>
<td>Private: Domestic/ foreign</td>
</tr>
<tr>
<td>Banco de los Trabajadores(^a)</td>
<td>October 27, 1972</td>
<td>Mixed: state/ private</td>
</tr>
<tr>
<td>Banco Metropolitano</td>
<td>May 23, 1974</td>
<td>Private: Domestic/ foreign</td>
</tr>
<tr>
<td>Banco Dominicano del Progreso</td>
<td>September 19, 1974</td>
<td>Private: Domestic/ foreign</td>
</tr>
<tr>
<td>Banco del Comercio Dominicano(^b)</td>
<td>August 11, 1979</td>
<td>Private: Domestic</td>
</tr>
<tr>
<td>Banco Nacional de Crédito(^b)</td>
<td>November 28, 1980</td>
<td>Private: Domestic</td>
</tr>
<tr>
<td>Banco Regional Dominicano(^b)</td>
<td>October 28, 1982</td>
<td>Private: Domestic</td>
</tr>
<tr>
<td>Banco Universal(^b)</td>
<td>December 16, 1982</td>
<td>Private: Domestic</td>
</tr>
<tr>
<td>Banco Gerencial y Fiduciario(^b)</td>
<td>October 20, 1983</td>
<td>Private: Domestic</td>
</tr>
<tr>
<td>Banco del Exterior</td>
<td>November 1, 1984</td>
<td>Private: Domestic</td>
</tr>
<tr>
<td>Banco Mercantil(^b)</td>
<td>December 12, 1984</td>
<td>Private: Domestic</td>
</tr>
<tr>
<td>Banco Dominicano-Hispano(^b)</td>
<td>December 12, 1984</td>
<td>Private: Domestic</td>
</tr>
<tr>
<td>Banco Corporativo(^b)</td>
<td>May 23, 1985</td>
<td>Private: Domestic</td>
</tr>
<tr>
<td>Banco B.H.D.(^b)</td>
<td>October 18, 1985</td>
<td>Private: Domestic</td>
</tr>
<tr>
<td>Banco Latinoamericano(^d)</td>
<td>June 17, 1986</td>
<td>Private: Domestic</td>
</tr>
<tr>
<td>Banco Intercontinental(^b)</td>
<td>June 17, 1986</td>
<td>Private: Domestic</td>
</tr>
<tr>
<td>Banco Panamericano(^b)</td>
<td>June 17, 1986</td>
<td>Private: Domestic</td>
</tr>
<tr>
<td>Unibanco(^e)</td>
<td>1990</td>
<td>Private: Domestic</td>
</tr>
</tbody>
</table>

\(^a\): Banks that failed during the period of analysis.  
\(^b\): Multibancos.  
\(^c\): Originally Banco Antillano.  
\(^d\): Originally Banco del Caribe.  
\(^e\): This bank license was issued for the merge of Banco Regional Dominicano, Banco Antillano, and Banco Panamericano in 1990. No record exist of Unibanco as such, however. These banks were kept separate because for practical matters the merge never became effective.

Source: *Boletín Trimestral del Banco Central de la República Dominicana.*

**Table 1** Dominican Republic: Commercial bank charters as of December 1991
Among private commercial banks, *The Bank of Nova Scotia* and *Citibank* are subsidiaries of foreign banks. Until recently, these banks were allowed to leverage against the equity of their foreign offices, and no independent equity standards were required for the subsidiary. This preferential treatment was canceled in 1994, as both domestic and foreign banks were subjected to the same equity requirements.

A glance at Table 1 indicates that the majority of Dominican private commercial banks were created during the 1980s, in response to the regulatory framework (see Section 2.3). Seven banks in the list failed within the period between January, 1991 and August, 1996. Fifty percent of the twelve banks created during the boom of the 1980s failed. The only failed bank that was not created then was the *Banco de los Trabajadores*, a state-owned bank. One explanation is that regulatory incentives and not a competitive opportunity motivated the creation of these banks. They did not survive after the incentives were withdrawn.

Among financial institutions, commercial banks are subject to the most restrictive legal reserve requirements and minimum capital requirements, but they can deal with all kinds of deposits as well as loans and other financial services, while other intermediaries cannot. On the liability side, the wide variety of services they provide include checking accounts, time deposits, and certificates of deposit. Commercial banks can use their funds for purposes as diverse as individual and business loans, lines of credit, and credit card operations.

Although there are no restrictions on the terms to maturity of their loans, the evidence shows that they are mainly short-term lenders, primarily to commercial firms. Their longest terms to maturity are three years (Veloz, 1990). The fact that commercial banks chose to lend mostly to commercial firms is theoretically plausible since the high transaction costs of individual lending induce intermediaries to direct credit to commercial firms, which can signal creditworthiness at low cost to the banks. Because individual loans involve higher screening and monitoring costs than
commercial loans, the later dominate the credit supply of commercial banks (Stiglitz and Weiss, 1981). In addition, it has been argued that a plausible reason explaining shorter terms to maturity in the Dominican Republic were expectations of high inflation that induced intermediaries to reduce terms to maturity to avoid capital losses from loans at longer terms and fixed nominal interest rates (Guilliani and Aristy, 1991; González-Vega, 1992).

2.2 Development and mortgage banks

Besides commercial banks, development and mortgage banks belong to the formal financial sector. Development banks (bancos de desarrollo) --originally called development financial institutions-- were created in 1966 to specialize in medium- and long-term lending. These non-monetary intermediaries have been restricted to a narrow set of authorized activities as it is also the case for mortgage banks. The major source of funds for development banks is the rediscount window of the Central Bank, in addition to subsidized funds from FIDE (Fondo de Inversiones para el Desarrollo Económico) and INFRATUR (Fondo Especial para el Desarrollo de la Infraestructura Política). Development banks mobilize funds from the public in the form of certificates of deposit and term bonds.

Development banks enjoyed preferential treatment regarding income taxes, which together with other incentives motivated the creation of many of these intermediaries. In 1970 there were only two development banks, but their number reached 29 by 1986 and 36 by 1990. As of the end of 1994, when most of those incentives had been eliminated, the number of active development banks had declined to 19, despite the fact that 36 institutions had charters to operate as development banks.

Mortgage banks (bancos hipotecarios) were created in 1972 to address the demand for credit by the construction sector. They have access to subsidized funds through FIDE and INFRATUR,
but not to the rediscount window of the Central Bank. Mortgage banks issue certificates of deposit and bonds, primarily to finance medium- and long-term loans and recently to finance construction firms for working capital purposes. Of 15 mortgage banks that existed in 1986, only five remained active as of late 1994.

2.3 Number and diversity of institutions

The large number and variety of institutions that emerged in the Dominican financial system during the 1980s might be mistaken for a sign of deeper intermediation (González-Vega and Zinser, 1987). Indeed, the 23 commercial banks, 29 development banks, and 15 mortgage banks that existed in 1986 were numerous for a small country with 6.5 million people. The configuration of the Dominican financial system for the 1989-1994 period is shown in Table 2.

The rapid growth in the number of institutions that took place during the 1980s was actually motivated by the regulatory framework, including subsidies that promoted the creation of many development and mortgage banks. Veloz (1990) explains that since 1986 the extraordinary growth of the Dominican financial system resulted from a combination of different factors. These factors included the levying of further reserve requirements on the commercial banks as a means to control money growth, the growing demand for credit due to increased economic activity, and changes in the public’s preferences, due to inflationary and unstable foreign exchange conditions.

The market became more fragmented as agents moved to the unregulated sector. A large informal financial sector emerged, reducing the degree of monetary control by the authorities. The Junta Monetaria tried to face this problem by regulating part of the informal sector by levying reserve requirements on the financieras in 1987. The large number of financieras (409 were

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6 In contrast, in 1960 there were only four commercial banks.
registered as of December 31, 1987) was reduced to 165 as of December, 1994, and it is still declining. The number of commercial banks declined from 21 to 14. A market screening process took place, with the more successful firms surviving, regardless of the incentives provided through repressive regulation. The shift to prudential regulation thus sets the new rules of the game for those institutions that survived the financial crisis of the late 1980s.

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</thead>
<tbody>
<tr>
<td>Commercial banks(^a)</td>
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<td>18</td>
<td>21</td>
<td>20</td>
<td>14</td>
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<tr>
<td>Development banks</td>
<td>34</td>
<td>36</td>
<td>36</td>
<td>36</td>
<td>25</td>
<td>19</td>
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<tr>
<td>Mortgage banks</td>
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<td>16</td>
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<td>5</td>
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<tr>
<td>Financieras(^b)</td>
<td>429</td>
<td>360</td>
<td>314</td>
<td>233</td>
<td>165</td>
<td>165</td>
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<td>Credit card companies(^c)</td>
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<tr>
<td>Casas de menor cuantía</td>
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<td>68</td>
<td>66</td>
<td>55</td>
<td>42</td>
<td>42</td>
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<td>10</td>
<td>6</td>
<td>6</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Credit unions</td>
<td>7</td>
<td>10</td>
<td>13</td>
<td>19</td>
<td>19</td>
<td>19</td>
</tr>
</tbody>
</table>

Source: Central Bank of the Dominican Republic.
\(a\): Including only banks that were effectively under operations.
\(b\): Not including 45 that are not operating.
\(c\): Not including card representatives that belong to commercial banks (13).

Table 2 Dominican Republic: Number of Financial Institutions, 1989-1994

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\(^7\) See Chapter 3 for a discussion of the financial crisis that led to a reduced financial sector.
As the inflation rate increased during the 1980s, the public shifted their assets from financial markets toward inflation hedges (González-Vega, 1992). Holdings of tangible assets and foreign currency increased while holdings of bank liabilities decreased. In addition, the resulting process of financial disintermediation took place very rapidly in the Dominican setting. Agents proved that the elasticity of substitution among financial assets is high (Guilliani and Aristy, 1991). This contrasted with the unwillingness to adjust shown by the authorities in not reviewing the highly restrictive regulatory regime.

The variety of specialized institutions characteristic of the Dominican financial sector increased transaction costs through a duplication of transactions. Also, financial repression biased bank credit allocation toward the financing of the fiscal deficit. Credit rationing occurred both because as deposits were reduced banks, had less funds available to lend, and because banks had to finance the public sector at the expense of the private sector.

To increase the available of loanable funds, banks had to offer more attractive effective deposit rates through implicit returns in addition to the explicit (restricted) deposit rate, which increased the banks’ transaction costs. Banks, in turn, increased their effective interest rates through implicit prices such as compensatory deposits and surcharges and fees additional to explicit loan interest rates, thus increasing borrower transaction costs. At the same time, some of the banks’ traditional customers had to be rationed out because banks did not have enough loanable funds. The alternative for customers who were crowded out of the regulated financial sector was the informal sector, where information was scarce and risks were high (González-Vega, 1992). Indeed, the high

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8 Bank had clients have to apply for short-term working capital loans at a commercial bank, for long-term investment loans at a development bank, and for a construction loan at a mortgage bank. Had banks been allowed to offer all types of loans to borrowers, the same client would have made only one loan application, thereby incurring less transaction costs.
risks involved were reflected in the failure of many of these institutions, leading to a financial crisis by the early 1980s.

2.4 Financial holding companies

When restricted interest rates and targeted credit requirements were enforced, Dominican entrepreneurs created multibank holding companies (grupos) to circumvent the obstacles raised by the regulatory framework, as predicted by the regulatory dialectic views (Kane, 1986). These holding companies are conglomerates of banks with a common corporate ownership, which share a common management and operational strategy (Kane, 1996).

Conglomerates generally emerge to help member firms to diversify their risks as a group as well as to share information about their costumers. In the Dominican Republic, joining a grupo was mostly a response to the regulatory framework, needed to sustain the competitiveness of the financial sector. The regulatory framework allowed different types of banks to engage only in restricted asset and liability transactions. These barriers on activity entry were reinforced by targeted credit policies and cost incentives. Thus, grupos emerged to allow for a diversified portfolio and to satisfy all customer demands through different banks of the group and thereby circumvent regulatory constraints.

Financial holding companies were authorized in the Dominican Republic by the Commerce Code (Código de Comercio) and were recognized by the Junta Monetaria in 1987. The grupos owned monetary and non-monetary intermediaries and operated as something more than mere holding companies, as they were allowed to undertake some activities directly. Commercial, mortgage, and development banks --and sometimes also financieras-- were related through the
holding company, which made global decisions for all the institutions in the group. The holding company directed its clientele towards its most adequate supplier, i.e., that which maximized profits of the grupo. This was usually a commercial bank.

After the liberalization of interest rates in December, 1991 and the reduction of access to funds from the Central Bank, development and mortgage banks became less profitable as they had to increasingly compete for resources at market interest rates instead of relying on soft credit from the Central Bank. As a result, most of these institutions ceased to operate and only the commercial bank of the holding company continued doing business. Duration gap issues are relevant in explaining the reduction of the number of banks. Mortgage banks, in particular, had short-term deposits at high interest rates mismatched with long-term loans at low (fixed) rates. Among the 14 active commercial banks, seven belong to grupos and another one belongs to a grupo económico or de facto grupo, created without the legal formality of a holding company.

2.5 Financial intermediation: comparison among types of banks

Commercial banks possess the majority of the total assets of the system. Comparing the level of total assets for each type of bank for the 1991-1994 period, commercial banks are almost ten times as large as either mortgage or development banks (Table 3). Indeed, between 1991 and 1994, the commercial banks’ participation in the total assets of the system steadily increased from 82 to 89 percent.

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9 In the Dominican Republic, financieras are part of the so-called informal sector, because it was originally unregulated, and they offer mostly short-term contracts, paying and charging higher interest rates than the commercial banks, but at the expense of higher risks.
<table>
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<tbody>
<tr>
<td>Commercial</td>
<td>81.9</td>
<td>85.3</td>
<td>87.6</td>
<td>89.0</td>
</tr>
<tr>
<td>Development</td>
<td>9.0</td>
<td>8.7</td>
<td>8.7</td>
<td>7.9</td>
</tr>
<tr>
<td>Mortgage</td>
<td>9.1</td>
<td>6.0</td>
<td>3.7</td>
<td>3.1</td>
</tr>
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</table>

Source: Data set provided by the Central Bank of the Dominican Republic.

Table 3 Total assets of banks as a percentage of the total assets of the formal system

Mortgage banks were the smallest component of the system, except in 1991. A dramatic decrease in the total asset participation of the mortgage banks is revealed in Table 3, which shows the composition of total assets by type of bank for the 1991 to 1994 period. Mortgage banks went from being as important as development banks to account for less than half the market share of development banks in 1994. The asset share of development banks has also declined but at a lower pace, except in 1994.

The pattern described above is a result of mergers and failures. Figure 2 includes all commercial, development, and mortgage banks as of the end of each year. Mergers of commercial, development, and mortgage banks to become multibancos are included among commercial banks in Figure 2. Earlier regulations that favored the operation of development and mortgage banks for other than market reasons, such as use of the rediscount window of the Central bank, have been substantially revised. As the incentives that kept some banks running were eliminated, these development and mortgage banks ceased to exist.

For commercial banks, total assets in constant RD$ of 1984 increased from RD$32.6 million in 1991 to RD$46.6 million in 1994, for the largest percentage increase among the three types of banks. Yearly average total assets for development banks increased from RD$3.6 million in 1991
to RD$4.1 million in 1994. Mortgage banks had RD$3.6 million in total assets in 1991 but this figure declined to RD$1.6 million in 1994.

![Graph showing total assets of the Dominican financial system by type of bank from 1991 to 1994.](image)

**Figure 2**  
Total assets of the Dominican financial system, by type of bank  
(Constant million RD$ of 1984)

In 1994, financial deepening measured by the total assets of each group of banks as a proportion of GDP was 30 percent for commercial banks, after rising from 25 percent in 1990 (Table 4). Taking the corresponding figures for the 1984-1987 period from Veloz (1990), the comparison shows a change in the ratio of commercial bank total assets to GDP. This increase in financial deepening, despite the smaller number of active intermediaries, resulted from macroeconomic stabilization and financial reform.
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<tr>
<td>Commercial</td>
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<td>16.6</td>
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<td>19.9</td>
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<td>23.4</td>
<td>27.8</td>
<td>29.8</td>
<td>29.9</td>
</tr>
<tr>
<td>Development</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>2.6</td>
<td>2.9</td>
<td>3.1</td>
<td>2.7</td>
</tr>
<tr>
<td>Mortgage</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>2.7</td>
<td>2.0</td>
<td>1.3</td>
<td>1.0</td>
</tr>
<tr>
<td>Total</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>29.1</td>
<td>33.8</td>
<td>35.2</td>
<td>34.0</td>
</tr>
</tbody>
</table>


Table 4    Financial Deepening as total bank assets to GDP: 1984-1994

In 1994, development bank assets represented 2.7 percent of GDP and this ratio had not changed significantly, although it increased through 1993 and then declined. Mortgage banks have become insignificant compared to other banks. There were 15 mortgage banks in 1991 and only five were active banks in 1994, whose assets accounted for only 1 percent of GDP.

2.6 Summary of findings

This chapter described the structure of the Dominican financial system as of early 1992, because after the financial reform new types of intermediaries were created. These intermediaries resulted from the merging of some of the institutions described above. Because these mergers, called multibancos, occurred after the process of financial reform discussed in Chapter 3, they are described below. Chapter 3 deals with aspects related to the process of financial reform exclusively. Reform in the Dominican Republic included the introduction of multibancos. These multibancos are crucial to the evaluation of efficiency among intermediaries that is carried out in the empirical model of this dissertation.
CHAPTER 3

FINANCIAL REFORM: FROM FINANCIAL REPRESION TO PRUDENTIAL REGULATION

Financial regulation in developing countries has been typically repressive. The recognition of the implications of this repression in terms of limited growth and development has led most of these countries to undertake financial reforms. As illustrated in Chapter 2, this has been the case in the Dominican Republic as well. A discussion of the importance of financial reform follows. Financial reform should optimize the contributions of the financial sector to economic development (González-Vega, 1992). With this intention, recent reforms in developing countries can best be described as attempts to move from financial repression to prudential regulation.10

This chapter starts with a brief review of the literature on market failure as the rationale for regulation. Rather than the interesting issue of market failure as a justification for regulation, however, the purpose of this dissertation is to evaluate the efficiency of the banking system after a financial reform that revises the regulatory framework. Next, the chapter continues with a discussion of the main regulatory changes in the Dominican Republic and their expected impact on microeconomic efficiency. The chapter concludes with a review of issues regarding the multibanco

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10 Financial reform that seeks an alternative to financially repressed systems, however, does not bring about a perfect market (Schiantarelli et al., 1996). After the reform, the market will still be characterized by agency problems arising from informational asymmetries and less than complete contract enforceability (explained below). Nevertheless, it is expected that these shortcommings will exist to a lesser extent.
rule and its implications for the analysis of productive efficiency.\textsuperscript{11} Efficiency involves an optimal use of scarce resources. Microeconomic (productive) efficiency entails the comparison between observed and optimal values for the inputs and outputs of a firm for given production technologies and production environments (Lovell, 1993).

3.1 \textbf{Optimal intervention theory}

The vast majority of countries have attempted to regulate financial markets, but this inclination is not sufficient to ensure regulation to be optimal. Sometimes policies are not stated correctly, or correct policies are not wisely enforced. In other cases the required regulation is not even adopted. Considerations about the institutional framework and about the nature and degrees of imperfection and of asymmetric information in a market must shape the regulation adopted.

In processes of policy formulation, a wrong diagnosis of the problem or an inaccurate medicine or dosage can reduce the effectiveness of the intervention. The rationale for regulation must be market failure, which has to be identified first, followed by the choice of the appropriate instrument to match the nature of the distortion (González-Vega, 1994).\textsuperscript{12} Indeed, market failure is not a sufficient condition for regulation (Vittas, 1992). It is further required that regulation can correct for the market failure effectively and efficiently.

\textsuperscript{11} This dissertation deals with the measurement of productive efficiency at the firm level. For further discussion see Chapter 5.

\textsuperscript{12} Market failure is the failure of a market economy to achieve a Pareto optimum given its available resources and technology (Gravelle and Rees, 1984). Pareto optimality is achieved when there is no other outcome that will be preferred by all agents, \textit{i.e.}, when no different allocation of resources will make someone better off without making someone else worse off (Varian, 1984). Since the real world has transaction costs and imperfect information, a more realistic benchmark is a constrained Pareto optimum that considers the best attainable outcome taking into consideration transaction costs. Then, market failure in financial markets is the inability of a free market to yield a constrained Pareto efficient allocation of credit.
Optimal intervention theory claims that the outcome achieved may be worse than the initial conditions if instruments are not matched to the nature of the distortion (Bhagwati, 1971). The first-best outcome that could have been achieved through regulation may be replaced by a third-best outcome if medicine and dosage do not match the diagnosed problem. This explains the failure of many financial repression measures that used the regulation of financial instruments to achieve fiscal or social objectives (González-Vega, 1992).

The efficiency of banks in the Dominican Republic is evaluated in this dissertation for the case when inappropriate repressive regulation was partially replaced by market-oriented regulation. Different objectives of the new regulation are considered, such as how the multibanco charter was introduced to reduce the number of banks in the system.

Chuppe and Atkin (1992) recognize two main reasons for inefficient outcomes to result from trade in unrestricted or inappropriately regulated financial markets. These reasons are information asymmetries and the risk of financial collapse (instability). These authors document the abundance of information asymmetries that lead to market failure in financial markets. Information asymmetries occur because agents have access to different information sets. Stiglitz (1993) argued that information in financial markets is a public good, which results in externalities that lead to market failure.

Carlton and Perloff (1990) define an externality as a situation when the cost or benefit of certain activity is borne by someone other than the person undertaking the activity. Externalities arise when property rights are not clearly defined. Externalities can be positive or negative.

---

13 The theory of the second best examines the best alternative policy scenario that is attainable when the first-best or Pareto efficient allocation is not attainable.

14 North (1990) defines property rights as the exclusive rights for individuals to appropriate over their own labor and the goods and services they possess.
Positive externalities occur when someone undertakes an action that benefits others who do not pay for these benefits. The externality is negative if agents do not bear the full cost of their damaging actions.

Banking instability is a serious concern because it can impair the payments system, reduce the savings rate of the economy, slow down the financial intermediation process, and harm small savers (Talley and Mas, 1990). Prudential regulation is intended to ensure the solvency and financial soundness of all the intermediaries to reduce the risk of financial collapse.\textsuperscript{15} A financial collapse may occur when there is a run on deposits.

The risk of bank runs creates a negative externality that springs from the fact that failing banks may be interpreted as signals about the stability of the market, inducing agents to withdraw their deposits from otherwise healthy banks. A domino effect takes place, where failing banks fall first and others follow. It is a negative externality because the bank that goes bankrupt does not bear the full costs of the harm it causes others. During the 1980s, such events took place in the Dominican Republic, which led to the financial crisis discussed below.

Another externality besides the risk of systemic failure is the infection effect. The infection effect is the negative effect over standards and prices due to excessive competition from opportunistic behavior and that affects all banks (Vittas, 1992).

Network effects of grouping competing institutions under a common network allow the exploitation of production economies. Nevertheless, these network effects can only be exploited by

\textsuperscript{15} A bank is insolvent if after the liquidation of its assets earnings are not enough to pay its debtors and the bank goes bankrupt. The bank will then be insolvent when it has negative equity. Solvency is related but not equivalent to liquidity. Liquidity risks are related to the fact that banks may not be able to meet payment obligations in a timely, cost-effective manner. Contrary to an insolvent bank, an illiquid bank has the assets to fulfill payments. If the assets cannot be transformed into cash fast enough, however, the bank will not be able to meet its customer demands on time. This leads to a run on deposits.
banks that generate production economies and increases in efficiency resulting from merging. Forcing all banks to merge without evaluating the potential gains may be detrimental.

Besley (1994) stated that market failure in financial markets results from the effects of imperfect information in the form of moral hazard—which involves a hidden action that might be taken by an agent—and adverse selection—which involves a hidden characteristic of an agent. Moral hazard arises because lenders are unable to determine ex ante what risks the borrower will take ex post. If the borrower engages in riskier activities than those disclosed when negotiating the loan contract, the probability of default rises.

Adverse selection exists in credit markets because lenders cannot distinguish between good and bad borrowers much like buyers of used cars cannot distinguish between good cars and lemons in the traditional Akerlof sense. Since lenders have to include a risk premium above their opportunity costs to cover for the risks from bad borrowers, the quality of their loan portfolio is affected because good borrowers are not willing to pay for an expected risk that does not match their actual risk. Moreover, high enforcement costs are likely in credit markets when borrowers are unable or unwilling to repay. If these costs are too high, the lender may choose not to lend (Besley, 1994). These high costs, however, are not a market imperfection per se.

3.2 Neoinstitutional economics and the role of the state

Two major strands of the literature deal with regulation: neoclassical and institutional economics. The synthesis of these strands is known as Neoinstitutional Economics (NIE), which introduces transaction costs and information asymmetries in the traditional neoclassical framework.

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16 Akerlof (1970) showed that market failure occurs when the quality of used cars is not known by buyers. The price of the car will be independent of quality so that the lower-quality car will set the purchasing price and only low-quality used cars will be in the market. This is the origin of the adverse-selection or lemons problem.
(Eggerston, 1992). The NIE claims that there can be a role for the state—under certain circumstances—to provide the appropriate incentives for economic agents to operate closer to their “technical and structural production frontier.”

The technical production frontier is bounded by the availability of knowledge and resource endowments of the economy, which determine the technical limits for productivity and output (Eggerston, 1992). A different structural production frontier exists for each structure of property rights set by the state. This structural production frontier is reached by selecting, from the set of feasible organizations, the structures of property rights that minimize costs and maximize output. The maximum frontier will be that closest to the technical production frontier. The set of feasible organizations is determined by the system of property rights, which in turn depends on the government.

The choice of the structure of property rights includes a provision of clearly defined rules of the financial game that moves agents closer to the technical production frontier, as expected with the enactment of the Financial Code in the Dominican Republic. Eggerston (1992) provides a list of factors that affect the structural production frontier. Such factors must be taken into account when formulating appropriate financial regulation.

First, decisionmakers must bear the full costs of their actions. Efficiency is enhanced when the system of property rights forces economic agents to pay for the full costs and allows them to appropriate the full benefits of their actions. If agents do not bear the full cost and benefits of their actions, there is a risk of bank runs, resulting in a negative externality. The financial crisis of the

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17 The analysis in Eggerston (1992) draws heavily on the work of Douglas North on property rights. This dissertation abstracts from his “political pressures,” which may affect the structural production frontier.
1980s in the Dominican Republic resulted from the effects of bank failures spilling over healthy banks (domino effect).

The lack of a financial code in the Dominican Republic to rule the financial system may have undermined the power of regulation in making a system more transparent. A financial reform was needed to bring about a clearer set of rules of the game whereby transaction costs are reduced. This reform should provide the institutional framework for the banks to act more efficiently. Since excessive regulation characterized the system (González-Vega, 1992), the new set of rules of the game needs to be clearer but not more intrusive. Indeed, the system was already overregulated and additional regulation was not feasible unless it implied rules that reduced transaction costs.

3.3 Objectives of regulation

Economic growth and innovation spring not from markets designed and controlled by regulators, but from the efforts of private entrepreneurs freely competing with each other (Chuppe and Atkin, 1992). For regulators to promote efficiency, having an accurate understanding of the institutions in the market and the prevailing competition among them as well as of the levels and sources of bank inefficiency is essential. Beyond efficiency, regulation can be aimed at promoting stability and the protection of third parties. Depending upon the relevance of each objective for government policy, the regulatory framework will be designed to favor the preferred objective.

There is a trade-off between controls that stimulate competition, efficiency, and innovation, and those that promote stability, safety, and fairness (Vittas, 1992). Regulation has to establish a balance between enhancing public trust and promoting efficiency. These objectives may not be complements but substitutes so that the regulatory entity has to choose and evaluate the priorities to be addressed under a given setting. Chaves and González-Vega (1994) discussed the three main goals of efficiency, promoting stability, and the protection of third parties and illustrated the difficult
task of developing a system that allows the market mechanism to work while keeping the system safe. Banks, for example must be allowed to fail to enhance the efficiency of the system, but this failure may affect the stability of the system.\textsuperscript{18} Hence, the objectives of efficiency and stability must be balanced.

3.4 Monetary and financial policies

Regardless of the objectives of financial regulation, policymakers use mainly six types of direct controls (Vittas, 1992). First, macroeconomic controls, such as reserve requirements and restrictions on interest rates, aim at achieving the stability of the financial system and at controlling the aggregate level of economic activity.

Second, targeted credit programs and compulsory investment policies favor priority activities, in attempts to influence the allocation of resources through allocative financial controls. Third, structural controls, such as entry barriers, shape the structure of the financial system. Fourth, prudential controls are employed for safety and soundness. Fifth, organizational controls, such as disclosure of information, and sixth, protective controls used to protect consumers of financial services complete the list of instruments adopted as direct controls.

The last three types of controls are more in line with prudential regulation while the first two types are clearly instruments of financial repression. The third type of control, in the form of entry restrictions, may not be a repressive measure \textit{per se}. Entry restrictions may be intended to ensure the stability of the system. For this purpose, entry restrictions are established to ensure the competence and moral standing of bankers, not to reduce competition (Chaves and González-Vega, 1994). Nevertheless, bank licensing affects the market structure of the financial sector, allowing for

\textsuperscript{18} For the Dominican case, as illustrated below, the lack of an exit mechanism made the crisis worse.
monopoly power to exist because it prevents entrants to compete with incumbents. If it is intended --as it became evident in many developing countries-- to target credit or to provide preferential treatment to certain types of institutions and to reduce competition, it is a typical repressive measure. This type of regulation will be explicitly considered in evaluating the efficiency of the Dominican commercial banks.

Instruments of financial repression such as interest rate ceilings, compulsory credit allocations, high reserve requirements, distorted financial prices and the like have been among the most widely-used financial policies in developing countries. Reserve requirements associated with portfolio quotas were among the most widely-used methods to control credit in the Dominican Republic.

Use of these instruments presumably improves the allocation of resources, as they are supposed to direct credit toward key sectors of economic activity through special funds such as FIDE and INFRATUR. Nevertheless, there was a mismatch between the social objectives sought through regulation and the financially repressive measures implemented. The evidence on the consequences of financial repression shows that these objectives were not achieved while other negative results were induced. Indeed, Adams et al. (1990) documented that default rates were typically very high in government-backed credit programs and that their benefits did not improve the welfare of the poor but the wealth of the wealthier. In the Dominican Republic, negative real rates of interest discouraged deposit mobilization (González-Vega and Zinser, 1987).

Restrictions on interest rates were easy to deal with in the 1960s and most of the 1970s given low rates of inflation and of devaluation and other favorable conditions in the economy. This was no longer the case when the macroeconomic situation changed. Increased financial repression made the reform imminent.
3.5 The demand for financial reform

In the Dominican Republic, inflation accelerated to over 19 percent per year in the first half of the 1980s, in contrast to the single-digit inflation rates that prevailed during the previous two decades. In such a scenario, the regulatory scheme of fixed nominal interest rates had to be adapted to the new macroeconomic circumstances. Favorable international terms of trade, large capital inflows, low fiscal deficits, and high rates of public investment had characterized the earlier two decades. The legal and institutional framework created under these favorable circumstances proved inadequate when the crisis arrived (Veloz, 1990).

Since the changes in regulation required by this change in circumstances did not take place, financial institutions no longer offered attractive products to their consumers. Indeed, facing regulation that kept nominal interest rates on loans fixed, financial institutions were unable to offer higher interest rates on their deposits. This led the public to move toward informal or unregulated markets (financieras), which offered higher interest rates to depositors, although at higher risks.

The informal sector was an important component of the system. Based on a 1984 survey of 95 informal financial institutions, Zinser et al. (1987) estimated deposits in the informal financial sector to represent 36 percent of the deposits of formal financial institutions. Investors not attracted by informal finance purchased real estate or foreign exchange as inflation hedges. By providing for alternative domestic uses of funds, the informal sector reduced capital flight. Indeed, the flow of capital was sometimes reversed because Dominicans in New York started to bring their funds to the Dominican informal sector to earn higher returns than in the United States.

The asset side of financial institutions was also constrained. Unable to charge higher interest rates on loans, financial institutions rationed out small and medium-size costumers, who
moved to the informal sector.\textsuperscript{19} As a result, the informal sector reduced the effect of financial repression by providing credit for customers that otherwise would have been left out (Zinser \textit{et al.}, 1987). Veloz (1990) showed that by 1987 the informal sector was equivalent to one-third of the total loans in the formal sector.

No unchanging pattern of financial contracting or regulation can remain optimal over time (Kane, 1986). A regulatory change was needed to allow for less-risky financial institutions to prevail. Still, neither regulation nor deregulation is an exogenous process; rather, they are typically motivated by financial system changes or crises (Long and Vittas, 1992). By the late 1980s, a financial crisis damaged the credibility of the Dominican banking system. Motivated by such crisis, an endogenous response in the form of financial reform emerged.

3.6 The financial crisis

The fragility of the financial system resulted in a crisis that became more evident at the beginning of 1989.\textsuperscript{20} The trigger was the failure of numerous \textit{financieras}, which followed the failure of a \textit{financiera} in July 1988. After the first failure, the domino effect spilled over to 122 other unregulated financial institutions, two development banks, three mortgage banks, and one savings and loans association (Guilliani and Aristy, 1991).

Commercial banks also failed. Two commercial banks were known to have large reserve requirement problems, which is evidence of liquidity problems, but were not liquidated. Liquidity problems arise when banks cannot fulfill payment obligations in a timely, cost-effective manner.

\textsuperscript{19} Informal loans are mainly short-term of less than a year, utilized for working capital or personal consumption.

\textsuperscript{20} Guilliani and Aristy (1991) noted that a study prior to 1989 reported serious solvency problems in the system that were likely to result in a crisis. Ill-managed institutions, however, continued to operate by using the funds FIDE and INFRATUR from the Central Bank.
Although the authorities tried to avoid panic by providing assistance to problem banks, there were too many to cover. Indeed, at least seven banks faced problems during the period. These banks were even allowed to open additional offices while other banks were allowed to merge. The lack of regulation dealing with the exit of banks became an additional problem, because charters could not be easily terminated and, thus, problem banks continued to operate. The authorities came up with a status for problem banks called feriado bancario (bank holiday), whereby these banks stayed legally open but had not transactions. As a result, depositors could not withdraw their funds for a long time until the feriado was no longer in effect.

Guilliani and Aristy (1991) and De Castro-Noboa Muñoz (1994) studied the Dominican financial crisis empirically. Both studies found that large liquidity problems characterized failing banks. Guilliani and Aristy (1991) estimated the probability of failure for all banks and the major determinants affecting that probability. The analysis was carried out for the period between September 1989 and September 1990, when eight private banks failed. They used solvency, liquidity, and profit financial ratios and found that liquidity ratios were related the most with the probability of failure.

Solvency ratios were not significant determinants of the probability of failure of banks. The data on capital, however, may be misleading because they refer to is accounting capital, which does not account for risk. Further, since grupos increased the effective capital of the commercial bank

\[\text{\textsuperscript{21}}\] The banks that faced major liquidity problems were Cibao, Domínico-Hispano, Panamericano, Antillano, Banregión, Universal y Banco del Caribe (Latinoamericano), which were all created between 1982 and 1986 (see Chapter 2). Moreover, in 1990, Antillano, Banregión and Universal were allowed to merge into Unibanco, which also failed.

\[\text{\textsuperscript{22}}\] This situation has major effects in the empirical analysis because the data reported for the seven banks that had problems were not reliable and reflected large inconsistencies. Chapter 6 illustrates the nature of the data problems faced. As a result, the analysis is carried out for the remaining banks only.
of the holding, the data on accounting capital may indicate that a ratio is higher than it actually is. For instance, some of the failed banks had reported capital to asset ratios above 10 percent and still failed (Guilliani and Aristy, 1991).

De Castro-Noboa Muñoz (1994) found similar evidence when estimating the deviations of liquidity and solvency financial ratios from the market average. The results on solvency, however, were not robust because of data problems. She estimated individual functions for each failed bank, relating five financial ratios to the industry average, and found that both the liquidity and solvency of the failed banks were below the industry average.

Typical bank problems reported by the Guilliani and Aristy (1991) study included the high concentration of the loan portfolio of commercial banks in the construction and tourism sectors, which increased exposure to systemic risk. Also, no regulation was in place to control for the excessive risk involved in lending to insiders that turned out to be a common practice in the Dominican system. There were no evaluations of creditworthiness and instead loans were based on company reputation and on a superficial review of financial statements. This increased credit risk.

Moreover, after 1985 the Dominican Republic established an agreement with the International Monetary Fund (IMF) that boosted the economy. The overshooting of the economy, however, led to an inflationary process that affected the decision process of financial institutions. Many banks invested in fixed assets instead of lending, or lent to customers that then invested in fixed assets as inflation hedges. This strategy is rewarding while the economy is in the boom, but it is detrimental otherwise, affecting the liquidity of the banks. Excess investment in fixed assets resulted in high liquidity problems that led to the crisis (Guilliani and Aristy, 1991).
3.7 The Dominican financial reform

After a long process of financial repression and a crisis, reform was imminent. The reform efforts started in 1991, with the liberalization of interest rates. In April 1992, the authorities proposed four resolutions to change the rules of the financial game as part of a macroeconomic reform package. The set of resolutions included a multibanco charter (universal banking) and new ownership and control measures. These resolutions belong to the set of regulations that ultimately became the Código Monetario y Financiero (Monetary and Financial Code).

The new financial code is intended to regulate a financial system that had been governed by the general legislation. Earlier, specific resolutions issued by the Central Bank had ruled the system, sometimes contradicting the general commercial legislation. The main policy instruments used by the Central Bank are described below. Financial reform has attempted to improve the implementation of these instruments, following patterns intended to move to more market-oriented measures, adopted in similar countries.

Before the Código was approved, the Junta Monetaria issued a series of resolutions in line with the proposed code. The initial draft of the code underwent numerous changes since it was first proposed in May, 1992 reflecting battles among interest groups. Figure 1 represents the tedious process of enactment in the Dominican Republic. First, the Junta Monetaria issued several drafts of the proposal, subject to bargaining. After several rounds of bargaining with interest groups, the Central Bank approved the proposal, which was then sent to the Senate Commission. The Commission reviewed the proposal and in an open forum accepted additional comments from the public. After that, it went to the Executive. The President evaluates the proposal to be sent back to the Senate, either as a proposal for legislation or with a veto. If it is not vetoed by the President and
if it is approved by both Senate and Congress, the code goes back to the Central Bank for its formal implementation.\textsuperscript{23}

Following the right-hand side of the time line, the starting point was April, 1992, with the adoption of a macroeconomic reform package. The second stage took almost three years, during which interested parties bargained extensively over many drafts, before the Central Bank approved the proposal in January, 1995. The next step took place on September 17, 1996 when the Senate Commission approved the Code on the first lecture. Bargaining groups started the battle again to delay the enactment further. On March 4, 1997 the Senate sent the approved Code to the Executive, where it stays as of June, 1997.

3.7.1 Missing elements in previous reforms

A successful financial reform will reduce transaction costs (González-Vega, 1992). Transaction costs may be reduced by the provision of an adequate institutional framework and the opportunity for intermediaries to develop better financial technologies, as well as by a stable macroeconomic system. Financial reforms will lead to different results if the goal of the authorities is to emphasize the fiscal function of financial services in order to finance government deficits. By addressing key unbalances such as excessive government deficits first, the use of financial services for fiscal purposes will be reduced. Indeed, it has been argued that a macroeconomic reform must precede financial reform, because success in the financial market cannot be achieved without macroeconomic stability (McKinnon, 1991; Edwards, 1995).\textsuperscript{24}

\textsuperscript{23} For this dissertation, the Code is discussed as if it has already been enacted. Although the Code is not yet a law, on March 4, 1997 the Senate approved it and sent it to the Executive for enactment. Since the Code has been effectively in place through resolutions and no major disagreements are now expected, it is likely that the Executive will soon enact it to end the five-year-old enactment process.

\textsuperscript{24} Although not discussed extensively in this dissertation, the timing and sequencing of financial reform has been the subject of intense debate (Harwood and Smith, 1997). There is no
consensus as to which is the best general rule, because it may depend on the institutional structure particular to each country (Edwards, 1995).
The main purpose of a financial reform in the Dominican Republic was to establish a healthy system that allows for lower transaction costs and reduces the fragmentation of the market (González-Vega, 1992). Reform must go beyond the liberalization of interest rates. Restructuring the institutional framework, thereby addressing excessive regulation and inadequate supervision as well as eliminating repressive measures and fostering competition are additional requirements for financial reform to reduce transaction costs. González-Vega (1992) stated that the missing elements in previous reforms that took place in the Dominican Republic were:

(a) Revision of the role of the Central Bank and strengthening of its independence.
(b) Improvement of prudential supervision and monitoring by the Superintendency of Banks.
(c) Revision of restrictions on activity entry to allow competitive neutrality in transactions of different types of banks.
(d) Revision of the system of reserve requirements.
(e) Revision of interest rate policies.

First, because the Central Bank was burdened by functions other than to seek macroeconomic and exchange-rate stability, its effectiveness had been affected. Development-oriented tasks such as targeting credit and subsidizing funds by the Central Bank were in conflict with assuring macroeconomic stability. Because subsidized funds were a source of money creation, they conspired against price stability (González-Vega, 1992). Second, the Superintendency of Banks should strengthen the prudential supervision of financial institutions to prevent financial crises. The Superintendent should be endowed with independence and sufficient powers.

Entry requirements were in place to promote specialized banking and restrict competition in the market. In addition, activity restrictions induced financial agents into the creation of a commercial bank for their commercial short-term transactions, a mortgage bank for housing loans,
and a development bank for long-term loans. Under this setting, the creation of grupos was a regulatory-avoidance response to the restrictions imposed by the promotion of specialized banking. Grupos overcame regulations on activity restrictions because they allowed the resulting holding companies to offer commercial loans through the commercial subsidiary, mortgage loans through the mortgage subsidiary, and long-term loans through the development subsidiary. Thus, these grupos not only avoided activity restrictions, but they were also able to enjoy the differential treatment that arose from incentives to particular institutions. Still, consumers generally had to deal with each bank independently for their different transactions.

Moreover, the existence of grupos allowed financial intermediaries to overcome solvency restrictions. The different leverage ratios that were required for commercial, mortgage, and development banks were more restrictive for commercial banks, with a debt to capital ratio of 10, versus 12 and 20 for development banks and mortgage banks, respectively. Then, grupos invested in their commercial bank the funds resulting from issuing short-term certificates, sold to the public to artificially increase the debt to capital ratio of commercial banks and fulfill the capital requirements of the Central Bank (Guilliani and Aristy, 1991). A review of the consolidated statements would have alerted the authorities. Since there was no regulation that dealt with holding companies, however, the authorities did not have access to consolidated statements.

A consolidated market structure, whereby a given institution is allowed to engage in different types of transactions, may reduce transaction costs by allowing all transactions to be made at once. This issue was addressed by a number of studies of the Dominican system suggesting the formation of multibank firms (Veloz, 1990; Guilliani and Aristy, 1991; Camacho, 1996; González-Vega, 1992; De Castro-Noboa Muñoz, 1994). These recommendations were taken into account in the reform through the introduction of multibanco charters, as explained below.
The last two missing elements in the reform were related to adequate pricing. Banks were penalized with a very high tax in the form of high reserve requirements which increased the opportunity cost of funds for banks. Also, interest rates were restricted, not allowing prices to perform their market-clearing function. Since agents managed to avoid those regulations, however, the regulations were not as effective. Regulatory avoidance, however, involved transaction costs.

### 3.7.2 Changes in the use of instruments

Legal reserve requirements were established for monetary purposes and to force financial institutions into selective credit allocations for target priority sectors. A minimum requirement (*encaje legal mínimo*) is the proportion of their deposit liabilities that depository institutions must keep in cash or as deposits at the Central Bank. In principle, the purpose of this requirement is to facilitate the implementation of monetary policy but in practice the Central Bank uses them mostly for fiscal purposes. Additional reserve requirements were used to influence the allocation of credit. A substantial proportion of deposits had to be surrendered to the Central Bank unless they were channeled to particular sectors (portfolio quotas). The first part of the requirement was a tax on deposit mobilization. The second portion was an instrument of directed credit allocation.

Moreover, the reserve requirement was not uniform. The requirements vary across and within banks according to deposit types. Demand deposits are required the highest rate; this affected, therefore, only commercial banks (Table 5). Reserves on other deposits are required at lower rates, and the requirement on the same type of deposit may even vary across bank types. For example, *certificados financieros* (financial certificates) at commercial banks are required higher reserves than at mortgage or development banks. Additional distortions were introduced by the allocative portion of the requirement. Banks were allowed to keep lower reserve requirements when the funds were used for priority sectors in specific proportions. The scheme was engineered presumably to ensure the proper development of priority sectors of economic activity.
<table>
<thead>
<tr>
<th>Institution</th>
<th>DD</th>
<th>SD</th>
<th>TD</th>
<th>Financial Certificates</th>
<th>Participation Certificates</th>
<th>Short-Term Bonds</th>
<th>Long-Term Bonds</th>
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<td>Multibancos</td>
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<td>Commercial banks</td>
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<td>Mortgage banks</td>
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<td>Development banks</td>
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Source: Central Bank  
DD= demand deposits  
SD= savings deposits  
TD= time deposits

Table 5 Reserve Requirements on Deposits at Financial Institutions, 1994  
(Percentages)

A portion of the reserve requirements is remunerated in the Dominican Republic. This practice started in the early 1960s, earlier than in most developing countries, because the requirements were considered to be too high, and the authorities preferred to reduce their impact on intermediation margins and loan rates rather than reducing the requirement. Over time, the practice has continued but the proportion of reserves that is remunerated and the interest rate paid on them has changed.

After 1971, an encaje marginal was added. This is also a direct tax on deposit mobilization. The main difference between the encaje marginal and the encaje legal is that the former was assumed to be transitory, to be used to increase effective reserve requirements only when the authorities have expectations of devaluation or inflation. The inflationary effects of taxing banks to finance the Government have been analyzed elsewhere (Brock, 1992).
Reserve requirements, however, were not always fully enforced (Guilliani and Aristy, 1991). Many banks found ways of not complying with the requirements. Moving in the right direction, in 1987 the encaje marginal was eliminated and the encaje legal was uniformly applied to all commercial banks.25

Following the trend of reducing reserve requirements as part of financial reforms in many developing countries, the encaje legal was set at 20 percent for all commercial banks in December, 1991 (Table 5). Banco de Reservas, the state-owned bank that was widely used to finance government deficits through loans that were never repaid, was also brought under the Sistema de Encaje Legal Unificado (unified legal reserve requirement system). All targeted-credit features previously attached to the system were eliminated.

When the original multibanco rule was being introduced, these banks were expected to comply with a lower reserve requirement of 17 percent to be gradually reduced to 10 percent.26 This was intended to favor mergers of existing commercial banks with other institutions. Had this measure been implemented, the reform would have resulted in a non-neutral regulation with some types of institutions being subject to lower reserve requirements than others. Private agents should be allowed to decide whether to become a multibanco, however, depending on the existence of economies of scope, the potential to increase efficiency, and other market-based considerations.

The use of rediscount windows (adelantos y redescuentos) and of subsidized credit lines for target sectors accentuated the activity differentiation among financial institutions. Again, the competitive neutrality of regulation was not in the agenda of the policymakers. While development

25 In March, 1997, however, the encaje marginal was reactivated to reduce inflation and devaluation expectations. The requirement was eliminated a month later.

26 This special rate has been changed to a general 20 percent after modifications to the Code were introduced.
banks had access to both rediscount facilities and subsidized funds from FIDE and INFRATUR, mortgage banks were allowed to use only the later. In 1985, after an agreement with the International Monetary Fund (IMF), both sources of funds were no longer available for new loans and old credit lines could be renewed only under a new set of rules. The recent intention is to eliminate FIDE and INFRATUR.

Loan interest rates were kept at their 1919 level of 12 percent per year until 1981. Discretionary rules defined deposit interest rates, which in 1967 were set according to type of bank at 4 percent for savings accounts with savings and loan associations and commercial banks. In 1982, the authorities increased these rates to 5 percent and 6 percent, respectively (Veloz, 1990). As deposit rates became increasingly unrealistic, when inflation accelerated, financial intermediaries adopted innovative methods and organizational adaptation to overcome the regulatory constraint, as predicted in the literature (Kane, 1986). Banks, for instance, established compensating deposits linked to a loan in order to increase effective interest rates on loans. Later, the authorities also allowed commissions to be charged in addition to the flat loan rate, further increasing effective interest rates.

Other changes were introduced in the interest rate regime in 1985 -- a period of major economic reform-- and in 1988. Interest rates on certificates of deposit (certificados financieros) were raised to 15-18 percent per year, while commissions on loans were allowed between 12 and 16 percent. During this period, a common practice of commercial banks was to disregard credit ceilings to allow for more profitable lending activities.27 Finally, in December, 1991 interest rates were left to be freely determined by the market. This was the watershed of the process of financial reform oriented toward liberalized markets.

27 Guilliani and Aristy (1991) illustrated that for instance, during the first 20 weeks of 1990, eight banks did not comply with lending restrictions established by the Central Bank.
3.7.3 Other components of the reform

The Código Monetario y Financiero includes regulations concerning organizational design. Financial supervision and prudential regulation are explicitly established, motivated by the financial crisis of the late 1980s. In addition, by fostering multibancos, the code attempts to modify the traditional structure specialization of banks.

All institutions of the financial system should produce public information to reduce the risks for their customers (Long and Vittas, 1992). Disclosure of information was poor for all institutions of the Dominican financial system (Guilliani and Aristy, 1991). Banks were required to publish their balance sheets quarterly, for instance, but failing banks provided false information with evident inconsistencies. Implementation of uniform accounting norms is in process, as well as the enforcement of information disclosure. Accounting norms should include the evaluation of holding companies with consolidated statements that provide a more precise picture of the grupo activities, when the grupo is likely to merge into a multibanco.

After the start of financial reform, there has been an increasing interest in ownership and control, reflecting concerns about capital adequacy in the Dominican Republic. Common versus preferred stock and restrictions on loans to relatives of bank owners are some of the issues on the reform agenda. This agenda reflects a larger concern for prudential regulation. This is an important step as regulators should focus on prudential rather than economic regulation (Long and Vittas, 1992).

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28 These inconsistencies are evident in the data set and imposed serious constraints on the empirical analysis of this dissertation. The lack of reliability of these data led to a deletion of all the failed banks from the empirical analysis.

29 Issues of capital requirements and capital adequacy related to the introduction of a new charter after the financial reform in the Dominican Republic will be discussed on section 3.9.
The restrictions on loans to insiders were introduced to limit ongoing lending activities with relatives, which are expected to threat the stability of the system. The new rules limits loans to insiders to only up to 100 percent of the equity capital of the bank. Chaves and González-Vega (1994) stated that a reduction of loans to insiders will ensure a more successful enforcement of capital adequacy regulations. By lending to insiders, equity capital loses its function as a deductible because owners are effectively recapturing capital through the loans.

Provisions for loan losses were introduced in the Código to avoid excessive risk taking behavior by banks. The requirement of a provision for loan loses introduces important prudential elements. A provision for loan losses is a deduction from income that represents the periodic allocation that a bank makes to its loan loss reserve on the balance sheet (Kock, 1991). The size of the provision for loan losses, if larger than the required ratio, is taken as an indicator of the perceived quality that bank management has on its own portfolio. There was no such requirement in the Dominican system until 1992. A clearer statement of loss losses should be included in published statements to provide information to interested depositors (Guilliani and Aristy, 1991).

3.8 Prudential supervision

A sound and robust financial constitution should be complemented with a system of effective supervision (Vittas, 1992). Prudential supervision and preventive regulation had been neglected by the Superintendency in the past (Guilliani and Aristy, 1991). The Dominican financial

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30 Indeed, Banco Dominico-Hispano, which was one of the first commercial banks that failed had 56 percent of its loan portfolio with insiders (Guilliani and Aristy, 1991).

31 In terms of consumer protection, equity capital acts as a deductible because it is the amount that bank owners may loose in the event of bankruptcy (Chaves and González-Vega, 1994).
reform includes *Normas de regulación y supervisión prudencial* (Rules for prudential regulation and supervision), implemented since 1992.

Because bank liabilities are mostly fixed-value claims, there is room for opportunistic behavior (Vittas, 1992; Chaves and González-Vega, 1994). Searching for potentially higher returns, banks may use the funds for riskier projects. These banks have to pay the same amount of fixed interest to depositors, regardless of the return on their assets, or otherwise go bankrupt. If the bank’s preference for riskier projects with higher returns leads to failure, however, the depositors lose. The government may bail out an insolvent bank, so depositors do not lose their funds, but the government will incur a fiscal cost.

Carefully-designed prudential controls must reduce the risk of systemic failure and promote stability without undermining efficiency. Prudential regulation promotes efficiency through the minimization of compliance costs and of the costs of reduced competitiveness and innovation (Chaves and González-Vega, 1994). Regulation should allow for financial intermediation to evolve under the lowest possible transaction costs to reduce the waste of real resources. Chaves and González-Vega (1994) stated that, in its role of promoting efficiency, prudential regulation must increase competition and allow for the possibility that inefficient banks exit the market. Nevertheless, allowing for exit may bring instability to the system and consumers may incur in deposit loses. The adequate balance is difficult to achieve because it involves allowing the market mechanism to work, while keeping the system safe.

Chaves and González-Vega (1994) classified prudential regulation into preventive and protective. Protective regulation ensures depositors that regardless of bank actions they individually will not face the losses in the event of bankruptcy. In terms of protective regulations allegedly adopted to achieve stability in the system, the authors cite the role of government as a lender of last resort, to provide liquidity loans to intermediaries likely to fail, and the provision of deposit
insurance, to avoid a run on deposits. Deposit insurance, however, may reduce the incentives of depositors to monitor intermediaries in their risk-taking decisions. Because of the provision of this insurance, banks may choose projects with higher risks, thereby undermining the stability of the system.

Preventive regulation deals with the reduction of the probability of failure by restricting the risk exposure of banks, which avoids runs on deposits. Chaves and González-Vega (1994) provide a list of preventive measures that include, among others, rules of capital adequacy, the prohibition of loans to insiders, and the licensing of financial intermediaries. Liquidity considerations are crucial in the Dominican system, as stated by Guilliani and Aristy (1991). These authors showed that there is a strong link between liquidity ratios and the probability of failure.

Regarding bank charters, it is as important to establish adequate entry requirements as it is to establish exit mechanisms to allow for failing institutions to leave the market (Chaves and González-Vega, 1994). This became evident during the financial crisis. The Dominican reform added a new charter that allowed for universal banking. The following sections explain the design of the rule and how the charter operates, and it evaluates the expected consequences on the productive efficiency of banks.

3.9 Universal banking in the Dominican Republic

Chapter 2 describes the structure of the Dominican financial sector as of early 1992. In April of that year, the Junta Monetaria authorized the creation of multiple service banks (bancos de servicios múltiples or multibancos) --basically, universal banks-- and allowed them to operate as commercial, development, and mortgage bank in a single entity.

Universal banking usually encompasses a wide range of financial services, including deposit-taking and lending, trading financial instruments and foreign exchange, underwriting new
debt and equity issues, brokerage, investment management, and insurance (Saunders and Walter, 1994). Examples of countries with universal banking are Germany and the United Kingdom, which represent typical variants of the universal banking concept. In the Dominican Republic, multibancos were referred to as universal banks because they could undertake all types of loan transactions in a single entity, rather than because their services were broadened in the traditional universal banking sense.

The multibancos were originally conceived as the result of a merger of five institutions, including a commercial, a development, and a mortgage bank, and two other financial institutions. After December of 1992, the number of institutions required for the merger was reduced to three. Created from former commercial, development, and mortgage banks, the resulting institution would be allowed to offer multiple services (servicios múltiples).

Table 6 lists the requirements for a multibanco charter as they have changed over time. By mid-1994, the requirements to become a multibanco were changed to a capital requirement depending upon the number of institutions forming the multibanco. In addition, these new requirements are contingent upon the association of multibancos to grupos.

Table 7 comprises a list of approved multibancos as of April, 1996. Most of the commercial banks in good standing with the Superintendency of Banks became multibancos once the requirements for the charter became less stringent (Table 6). The process through which banks merged changed over time. The first group of six banks to become multibancos went through acquisitions and mergers as required by the original charter requirements. Most of the newer multibancos, however, have transformed through increases in capital, to fulfill recent charter requirements.

In the first group, Banco B.H.D. and Banco Mercantil were the first multibancos, authorized on December 24, 1992 and August 30, 1993, respectively. Banco Gerencial y Fiduciario was
established on November 18, 1993. The following year, Banco del Comercio (August 2, 1994) and 
Bancrédito (December 14, 1994) went through the merging process to become universal banks.

<table>
<thead>
<tr>
<th>Date</th>
<th>Required Components</th>
<th>Capital Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>04/02/92</td>
<td>Commercial+development+mortgage+two or more financial institutions.</td>
<td>Fifty million pesos.</td>
</tr>
<tr>
<td>12/11/92</td>
<td>At least three institutions, including a commercial, a development, and a mortgage bank, plus any other institution.</td>
<td>Fifty million pesos.</td>
</tr>
<tr>
<td>03/03/92</td>
<td>(A) Any commercial bank or any other institution that does not belong to a (legal or de facto) grupo and becomes a commercial bank first.</td>
<td>(A) seventy-five million pesos. (B-1) sixty-five million pesos for a merger of two institutions. (B-2) fifty million pesos for a merger of three or more institutions. (C) In either option, the resulting institution will increase its capital to seventy-five million pesos after six years (1/6 per year).</td>
</tr>
<tr>
<td></td>
<td>(B) Merger of two or more institutions, regardless of their relationship to a grupo.</td>
<td></td>
</tr>
</tbody>
</table>

Source: Second, third, and fifth resolution of the Monetary Board, respectively.

a: the exchange rate was 12.5 pesos per US dollar.

Table 6 Requirements for a multibanco charter

The second group of mergers started with a peculiar case. A development bank, Banco Osaka became a commercial bank by increasing its capital to operate as a multibanco on December 14, 1994. In addition, the Financiera Nacional de Empresas went through a similar process in March, 1995, but it did not start operations until March, 1996. Two other commercial banks became multibancos through acquisition of other banks as had been done by those in the first group: Banco Intercontinental (January, 1995) and Banco Popular Dominicano (January, 1996).
<table>
<thead>
<tr>
<th>Resulting Institution</th>
<th>Components</th>
<th>Method</th>
<th>Resolution, date</th>
<th>Operations starting on</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Banco B.H.D.</strong></td>
<td>C+D+M+f</td>
<td>I</td>
<td>4th, 12/17/92</td>
<td>January, 1993</td>
</tr>
<tr>
<td><strong>Banco Mercantil</strong></td>
<td>C+D(2)+M+f</td>
<td>I</td>
<td>2nd, 07/22/93</td>
<td>September, 1993</td>
</tr>
<tr>
<td><strong>Banco Gerencial y Fiduciario</strong></td>
<td>C+D+M+f</td>
<td>I</td>
<td>3rd, 11/08/93</td>
<td>July, 1994</td>
</tr>
<tr>
<td><strong>Banco del Comercio</strong></td>
<td>C+D+M</td>
<td>I</td>
<td>17th, 08/02/94</td>
<td>October, 1994</td>
</tr>
<tr>
<td><strong>Banco Nacional de Crédito</strong></td>
<td>C+D+M</td>
<td>I</td>
<td>4th, 12/14/94</td>
<td>January, 1995</td>
</tr>
<tr>
<td><strong>Banco de Desarrollo Osaka</strong></td>
<td>f=D</td>
<td>II</td>
<td>5th 12/14/94</td>
<td>July, 1995</td>
</tr>
<tr>
<td><strong>Financiera Nacional de Empresas</strong></td>
<td>f</td>
<td>II</td>
<td>11th,04/20/95</td>
<td>March, 1996</td>
</tr>
<tr>
<td><strong>Banco Intercontinental</strong></td>
<td>C+D+M+f</td>
<td>I</td>
<td>2nd, 07/20/95</td>
<td>September, 1995</td>
</tr>
<tr>
<td><strong>Citibank</strong></td>
<td>C</td>
<td>II</td>
<td>1st, 10/20/95</td>
<td>November, 1995</td>
</tr>
<tr>
<td><strong>Banco Metropolitano</strong></td>
<td>C</td>
<td>II</td>
<td>17th, 01/25/96</td>
<td>February, 1996</td>
</tr>
<tr>
<td><strong>The Bank of Nova Scotia</strong></td>
<td>C</td>
<td>II</td>
<td>18th, 01/25/96</td>
<td>February, 1996</td>
</tr>
<tr>
<td><strong>Banco Popular Dominicano</strong></td>
<td>C+D+M+f</td>
<td>I</td>
<td>16th, 01/25/96</td>
<td>February, 1996</td>
</tr>
</tbody>
</table>

Source: Financial Department, Central Bank of the Dominican Republic.  
a: C=commercial bank D=development bank, M=mortgage bank, f=financiera.  
b: Banco Nacional de Crédito is the only one that did not officially belong to a grupo. However, it was a de facto grupo.  
I=acquisition, II=capital increase.

Table 7   Multibancos approved as of April 1996.
Other banks have applied for the *multibanco* charter by increasing their capital. To complete the list of twelve approved *multibancos* as of April, 1996 these banks are *Citibank* (October, 1995), *Banco Metropolitano* (January, 1996), and *The Bank of Nova Scotia* (January, 1996). In addition, *Banco del Progreso* has approval pending. Between September, 1991 and December, 1994, however, only the first four banks from the first group had effectively become *multibancos*, because the approval date differs from the initiation of operations date.

### 3.10 The rationale behind mergers

The resulting structure of the Dominican financial system, with some *multibancos* mixed with independent commercial, development, and mortgage banks, is interesting. According to Table 7 , the two types of *multibanco* are those that merged through acquisitions and the recent *multibancos* created by increasing their capital. *Multibancos* that resulted after capital increases are the late comers in the market.

This is not a surprising result because it responds to a the agenda of the policymakers. When the *multibanco* requirements were first stated, analysts argued that the requirements were not neutral. The argument was that policymakers wanted to clean up the system through non-market mechanisms. When policymakers have macroeconomic objectives to be achieved through regulation, instead of prudential objectives, market-based mechanisms that do not distort competition among the players operate more efficiently (Vittas, 1992).

The Dominican authorities tried to force a reduction of the number of institutions, given the lack of control resulting from the rapid growth of the financial sector.\(^{32}\) They used regulatory

\[^{32}\text{Guilliani and Aristy (1991) documented the lack of personnel that existed in the supervisory agencies to evaluate all the institutions of the system. For instance, in 1986, the personnel available could only evaluate 86 intermediaries. In addition, timely reports were not produced and qualified personnel was even more scarce.}\]
measures to make the multibanco charter a preferred option, instead of using market-based decisions. They sought to clean up the system by merging into a multibanco those institutions in compliance with the Superintendency with those which were likely to fail or which operated poorly because of lack of compliance. Yet, even if the size of the system was a valid concern, forcing the market to be reduced in the way that the government agenda intended may not lead to the best of outcomes.

The Junta Monetaria has changed the nature of the multibanco charter strategically throughout the process. The timing of the changes implemented by the policymakers reflects an underlying strategy because while some recommendations (criticisms) were taken into account immediately, responses to others were delayed.

Originally, the charter did not allow for a set of institutions to become a multibanco, unless a commercial bank was included (Table 6). Economists argued, however, that even if the number of institutions in the Dominican Republic was large, this rule would force all banks to become multibancos—but there were not enough institutions for banks of all types to become one. Since there were only 21 commercial banks but 36 development banks, some development banks had to exit—because all multibancos were required to include a commercial bank. This may represent a stability risk for the system (Dauhajre et al., 1995).

In any event, if the purpose is to clean up the system, the market had done a good job already, by reducing the number of financial institutions from as many as 600 to about 60 after the crisis. The new system is composed by the 13 commercial banks that survived the crisis—some of
which are *multibancos*. Market shares of each commercial bank on the total deposits of the system are illustrated in Figure 4.

![Graph showing bank market shares of total deposits 1991-1994](image)

> Figure 4 Bank market shares of total deposits 1991-1994

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33 Because most of the earlier *multibancos* resulted from the merger of commercial, development, and mortgage banks, this dissertation attempted to evaluate efficiency for the complete formal system including commercial, development, and mortgage banks. Extremely difficult data problems prohibited such evaluation and the analysis was carried out only for commercial banks. Nevertheless, the merged commercial bank was generally the most important component of the pre-merge.

34 Due to confidentiality, for the analysis of efficiency a number is randomly assigned to each bank. These numbers are not relevant for Figure 4, because the purpose of the graph is to show the evolution of market shares.
After the reform, the commercial banks have exhibited less market concentration.\textsuperscript{35} This trend became evident as some of the smaller banks became larger. Between 1991 and 1993, the market share of two of the three largest banks decreased and then increased slightly in 1994. The pattern of growth observed for the large banks resulted in a decrease in the Herfindhal indexes for the period (Figure 5). The largest bank is the state-owned \textit{Banco de Reservas}.

\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{herfindhal_indexes.png}
\caption{Herfindhal indexes for bank deposits from 1991 to 1994}
\end{figure}

The Herfindhal index is one of many concentration ratios used in the literature of industrial organization. It is the sum of the squares of the shares of individual banks. The index shown in

\textsuperscript{35} Although 14 banks were legally operating during the 1991-1994 period, the \textit{Banco Latinoamericano} was not included in the empirical analysis. This bank was classified by Guilliani and Aristy (1991) and De Castro-Noboa Muñoz (1994), as one of the banks in crisis. For legal purposes, the bank apparently survived the crisis but the data inconsistencies were as large as for other failed banks (see Chapter 6).
Figure 5 was computed from the shares of individual bank deposits in the total of deposits of the system. Lower concentration ratios are a favorable result because they indicate that, after the exit of failed banks during the crisis, there is greater competition among the surviving banks.

The behavior of banks and the resulting market structure also reflect the effects of the financial reform that brought about more liberalized markets. A set of freer regulations decreased concentration in the market, which is consistent with the results predicted in Camacho (1990). The main purpose of Camacho’s study was to evaluate if the oligopolistic structure of the Dominican banking system was the result of economies of scale or if it was related to restrictive regulation that limited competition. Apparently, repressive regulation had led to a more concentrated system.

3.11 Grupos versus multibancos

The new charter requirements allowed grupos to become multibancos more easily than individual banks could. In 1992, there were six grupos (there were five legal grupos and one de facto grupo) in the Dominican Republic, generally formed by commercial, development, and mortgage banks. With the right incentives in place, grupos became multibancos.

Association to a grupo was explicitly considered by the proposed legislation (Table 7). In response to recommendations from recent studies about the Dominican financial system (Veloz, 1990; Guilliani and Aristy, 1991; González-Vega, 1992; Camacho, 1990; De Castro-Noboa Muñoz, 1994). The change from specialized banking to universal banking was expected to reduce market fragmentation, lower liquidity risks, and increase bank efficiency. Camacho (1990), for instance, studied a profit function to estimate bank efficiency in the Dominican Republic before the reform. This author differentiated between banks associated to grupos and other commercial banks. He found

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36 See section 4.7 for a review of the theoretical advantages of universal banks discussed in the literature of mergers and acquisitions.
that grupo-related banks were more efficient than other banks. Since many grupo-related banks became multibancos, he predicted that efficiency increases from mergers. Nevertheless, some of the banks that were encouraged to merge because of the way the multibanco rule was designed, would have not merged otherwise. For these banks, the merger may not result in efficiency gains.

Because grupos were already concentrating their activities in the commercial bank after the preferential incentives for development and mortgage banks were eliminated, the authorities tried to make all grupos officially operate as a commercial bank (multibancos). The authorities were, thus, institutionalizing the status quo, by effectively calling grupos, multibancos. Those easy-to-be multibancos (grupos) only needed to buy two other institutions of small size such as savings and loan associations or financieras.

The standing relationships with grupos and their size may thus be arguments for banks to become multibancos. Although not all multibancos belong to grupos, those that merged through acquisitions did belong to one. The exception is Banco Nacional de Crédito, which did not explicitly belong to a grupo but was part of a de facto grupo, a so-called economic group, which performed the same functions of a legal grupo.

González-Vega (1992) stated that grupos were intended to overcome the fragmentation resulting from the regulation of the market. Such fragmentation resulted in the duplication of the transactions for customers forced to deal with specialized banking, which increased their transaction costs. The lack of adequate regulation of those grupos, however, resulted in a loss of monetary and prudential control by the authorities. Modifications on entry restrictions, such as the multibanco rule, were expected to allow financial institutions to engage in different types of transactions and to reduce the transaction costs incurred by their clients (González-Vega, 1992).

Solvency risks are also expected to decrease with universal banking because the merger eliminates the possibility of holding companies affecting the accuracy of capital adequacy ratios
through transactions between members of the group (Guilliani and Aristy, 1991). Moreover, since differences in reserve requirement across institutional types were eliminated after the reform, the incentive for intra-group transfer declined.

One case comes to attention when reviewing the link between banks that belong to grupos and multibancos. Banco Popular Dominicano, the largest of all commercial banks --besides the state-owned bank-- belongs to a grupo but it did not apply for a multibanco charter until January, 1996. Possibly, part of the benefits of this form of organization had already been exploited through the holding company --as for the other banks that belong to grupos. Before getting the additional benefits that universal banking may bring, this bank had to comply with some requirements, which may have been in conflict with its objectives. Indeed, the compliance costs involved in merging may be larger than the benefits. If this is the case, the bank will choose not to comply.

3.11.1 The multibanco rule and neutrality

Although the multibanco rule is desirable in order to reduce transaction costs and risks, the rule must be neutral to avoid additional distortions. The original rule was not neutral because it included incentives that made a multibanco charter a preferred strategy, but compliance with the rule was not equally feasible for all institutions. The intention must also be to increase competition by allowing for intermediaries to compete with each other in all types of transactions. As stated in Camacho (1990), once the regulatory framework is more market-oriented, banks will tend to engage in multibank activities.

The original purpose of specialized banking was to ensure a market niche by types of banks and to reduce competition (González-Vega, 1992). Allowing for market integration by reducing bank specialization is therefore desirable. Further, a multibanco rule allows for banks to enjoy any economies of scope that may exist. Yet, not all banks should be forced to become multibancos.
because some banks that do not belong to grupos may be more efficient through specialization by
exploiting specific competitive advantages.

Making the multibanco charter the only option is not healthy for the system because
intermediaries must not be forced but merely allowed to merge. The rule was introduced in a non-
neutral way because large banks received a preferential treatment. Indeed, the large banks that also
belonged to grupos were easy-to-become multibancos, able to offer as multibancos a wider set of
services and enjoying a potentially lower reserve requirement than smaller banks that did not own or
could not buy the additional institutions required institutions by the rule.

Any institution was required to buy four additional institutions, despite the capital that it
may have had. This was more burdensome for small institutions. No matter how much capital a
financiera could come up with, it was not able to become a multibanco by itself, if it had chosen to
do so. At the same time, commercial banks that did not belong to a grupo needed to buy four more
institutions to take advantage of the broader range of activities allowed for multibancos. Regardless
of how solid individual institutions were, they were competing with multibancos in unfair terms.

Along with these criticisms, Dominican economists suggested a new rule for reducing the
number of institutions required while at the same time associating the number of institutions
involved in the formation of the multibanco with different minimum capital requirements. As
illustrated in Table 6, the first part of the recommendation was implemented by the authorities, who
reduced the original minimum number of five institutions, first to four, and later on to three. The
recommended changes in capital requirements were not taken into account.

37 This was the particular case of Banco Osaka, a large development bank (originally a
financiera). For this bank, buying a commercial bank to fulfill the requirements was prohibitive.
When the requirements were changed, Banco Osaka and Financiera Nacional de Empresas became
a commercial bank only to comply with the rules for a multibanco.
Meanwhile, a very small bank such as *Banco Metropolitano*, with a 2.7 percent average share of the total assets of the system, was affected by the non-neutral *multibanco* rule. However sound this bank may be, it does not pay for it to buy three other institutions and become a *multibanco* as required by the original rule. After the rule was changed, *Banco Metropolitano* became a *multibanco* by increasing its capital. The motivation was simply to be able to compete with the other banks and be able to offer a wider variety of services. The same argument applies to foreign bank subsidiaries that did not belong to *grupos*.

The agenda behind the non-neutral ruling was to reduce the number of intermediaries by requiring a large number of institutions to merge. The authorities were trying to force the merger of good banks with failing banks or the merger of good smaller banks to fulfill the five-institution requirement. Banks that belonged to a *grupo* were expected to merge with other banks to reduce the size of the system. The agenda became more evident after the authorities established some tailor-made rules in 1994, which were targeted to a specific bank. Only after five of the six *grupos* became *multibancos* under the five-institutions rule, the Central Bank incorporated recommendations of matching capital requirements with the number of institutions merging by allowing *Banco Osaka* to become a *multibanco*, even without a commercial bank. This took place for *Financiera Nacional de Empresas* as well.

As of February 1996, commercial banks that belong to financial groups were still not allowed to become *multibancos* by themselves, regardless of capital structure. Perhaps the intention was to prevent *Banco Popular* to become a *multibanco* by itself without merging with other institutions. This bank was the only remaining commercial bank that belongs to a *grupo* but was not a *multibanco* until it finally merged in February, 1996.
3.12 Summary of findings

This chapter included a review of the market-oriented financial reform that partially replaced a repressive regulatory regime in the Dominican Republic. The way in which regulation has been established, enforced and modified is a complex --and still changing-- process. How the banks anticipated and responded to these regulations generates additional analytical complexities because of the extent of regulatory avoidance by the banks. Their responses were evident in the Dominican system, for instance, through the creation of grupos. Changing macroeconomic conditions and an unchanging regulatory framework were also rapidly met by the banks with different innovations. Indeed, with the resulting reduction in the real return on their assets in regulated markets, financial agents moved to unregulated markets where they could earn higher returns (González-Vega, 1992).

As a result, the financial market became highly fragmented and transaction costs rose. Still, regulatory avoidance diminished the negative impact that repressive regulation would have had (González-Vega, 1992). The reform attempted to reduce the excessive regulation that had resulted in the creation of a large informal sector and to motivate financial agents to move back to regulated markets. At the same time, by providing clearer rules of the game with enactment of the financial code and with the introduction of tighter prudential supervision, the authorities provided a framework where transaction costs were reduced, stability is being enforced, and resource allocation has improved. It is expected that financial intermediaries will be able to search for the best returns for their resources.

Chapter 4 describes the theoretical model used in this dissertation. Attempting to model all specific regulations, expectations and responses and their effects on the market in a detailed manner is a task beyond the purpose of this dissertation. The effects of the multibanco charter on efficiency, however, will be explicitly evaluated. The model allows for banks to deviate from the best attainable outcome, as they maximize profits restricted by regulation.
Ensuring that banks are able to become *multibancos* if they can exploit economies of scope is crucial, but not all banks should be forced to merge. Transaction costs can be reduced by eliminating unnecessary duplications of transactions, but for specific transactions some banks that specialize in a particular market niche may possess comparative advantages. A neutral *multibanco* rule is desirable because it allows banks to choose their best strategy. If the rule forces banks to merge, however, the potential benefits are reduced unless all banks in the Dominican Republic can exploit economies of scope.
CHAPTER 4
THE FINANCIAL FIRM

In recognition of the importance of the financial sector in the economy, an increasing interest in a theory of the financial firm became evident after the mid-1970s (Adar, Agmon, and Orgler, 1975; Sealy and Lindley, 1977; Mullineaux, 1978; Baltensperger, 1980; Santomero, 1984; Lawrence and Shay, 1986; Hancock 1991). In developing a theory of the financial firm researchers adapted results from traditional microeconomic theory.\(^{38}\) Given the special nature of the financial production function, however, the application of the theory of the firm has not been a straightforward process (Sealy and Lindley, 1977).

In modeling the production function of the financial firm the most controversial issue has been the determination of inputs and outputs (Sealy and Lindley, 1977; Benston, 1972; Hancock, 1991). Researchers have made different choices depending on their objectives, but Sealy and Lindley (1977) have argued that the decision must be consistent with the criteria upon which firms base their economic decisions.

Another important issue has been the need to consider the financial firm as a multi-output/multi-input producer. Earlier research neglected the multi-output nature of the financial firm.

\(^{38}\) Before this literature emerged, theoretical analysis of the behavior of financial institutions focused on portfolio choice. This dissertation follows the strand of the literature that uses the theory of the firm as its theoretical framework. When discussing the different approaches to the financial firm, Baltensperger (1980) classifies this strand as the real resource approach. Portfolio models neglect the real resource or production aspect of banking. However, the cost of liquidity management and solvency protection are usually not considered in a real resource approach.
or considered it as engaged in production processes separable from each other (Hancock, 1991). Contrary to what was suggested by earlier work, Adar et al. (1975) have argued that interdependence in bank output decisions is likely. Hence, a model of the behavior of the financial firm must allow for such interdependence, without imposing a priori restrictions on the technology.

This chapter starts with a discussion of the different approaches to the determination of outputs and inputs of the financial firm. A description of the theoretical model follows. Although finance theory deals primarily with perfect markets in which there are no transaction costs and where market participants have perfect information, financial markets cannot be characterized as perfectly competitive (Horvitz, 1986). Indeed, transaction costs, imperfections, and regulations are likely to occur that affect the choice of agents in their profit-maximization efforts. As a result, the conditions for optimization derived from a perfectly competitive model are no longer valid and a modification of the traditional competitive model is required, allowing for imperfect competition.

This dissertation focuses on the existence of regulatory constraints under which agents maximize constrained profits. A full description of a model of constrained profit maximization follows. The extended model is a two-step optimization process where agents minimize costs for given output levels first, and then choose output to maximize profits. The derivation of profits resulting from constrained maximization is the basis for the empirical model of Chapter 6.

4.1 Intermediation versus production approaches

The identification of bank outputs and inputs is related to the way in which the financial firm is conceived. Two widely recognized approaches deal with the theoretical determination of outputs and inputs. The main difference between the two approaches is whether or not to consider deposits as outputs, since most studies agree to classify loans as outputs (Berger et al., 1993a).
The intermediation approach regards the financial firm as engaged in a multistage production process that involves intermediate outputs (deposits). To produce loans and other earning assets the financial firm uses loanable funds (financial inputs), which it borrows from depositors, as well as non-financial inputs such as capital and labor (Sealey and Lindley, 1977). Under this approach both financial and non-financial costs of the firm are included in the analysis, which uses outstanding balances as the output metric.

In turn, the production approach views the financial firm as a producer of financial services. These financial services include both deposits and earning assets, measured as numbers of accounts. In contrast to the intermediation approach, the production approach focuses exclusively on the non-financial costs that the firm incurs by using inputs (capital and labor) in the production of financial services.

This dissertation considers both interest costs and operating costs as proposed by the intermediation approach. This seems more appropriate, because interest costs are an important component of the costs of financial firms. In the United States interest costs represent about 70 percent of total costs (Shay and Lawrence, 1986). In developing countries, however, operational costs are important and the share of interest in total costs is lower but still important.\(^\text{39}\) A bias may emerge if interest costs are not included, because banks are likely to substitute purchased funds with a larger component of interest cost for funds with an intensity in operating costs (Berger, 1992).

Sealy and Lindley (1977) argued that both the technical and economic aspects of the production of financial firms must be taken into account in the decision about what to consider as outputs and inputs. According to their view, which belongs to the intermediation approach, only the

\(^{39}\) In the Dominican Republic, interest costs accounted for up to 50 percent of total costs, as indicated by the data set.
services associated with earning assets adequately qualify as outputs, because they are the economic output of the firm instead of just a technical output.

The financial firm incurs resource costs and explicit interest costs to produce deposits (technical output). Deposits are financial inputs to be combined with additional non-financial inputs (capital and labor) to produce earning assets. Earning assets are then the final economic output of the firm. This view is consistent with the decision making process of the financial firm.

Deposits can play a dual role (Lawrence and Shay, 1986). One role is as outputs to provide liquidity services to depositors. The other role is as inputs in the production process of the firm. Because the first role involves an income in the form of checking account fees and commissions and the later involves a cost, banks pay a net price for all deposits. Then, a net supply of deposits may be derived, unlike the supply developed in Sealy and Lindley (1977) that deals with deposits as inputs only. For ease of exposition, the model that follows describes the supply of deposits without considering it as the net outcome of these two roles. Such an extension, however, is straightforward (Lawrence and Shay, 1986).

4.2 A simple theoretical model

The financial firm is treated here as an example of the agent of microeconomic theory. It produces earning assets (E). Each type of earning asset is payable in full at maturity. The input side is composed of deposits (D)-- demand deposits and other sources of funds. The supply of loanable funds by the public in perfectly competitive markets is infinitely elastic at the interest rate paid on deposits (d). Liabilities involve two cost elements: resource or non-interest payments (NI) and interest (I) payments. Marginal costs MC(.) As a function of deposit volumes include both

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40 This exposition draws on Lawrence and Shay (1986), Baltensperger(1980), and Sealy and Lindley(1977).
components of costs: \( MC(D) = MC_{l}(D) + MC_{n}(D) \). To produce earning assets \( (E) \), the financial firm incurs costs in generating deposits, plus the costs of non-financial inputs (capital and labor) used to produce earning assets.

The marginal cost of the firm is composed of the marginal cost of producing deposits, \( MC(D) \), plus the marginal non-interest cost of producing earning assets \( [MC(E)] \). Although the input market is assumed to be perfectly competitive, the demand for earning assets is inversely related to interest rates, \( r \), to allow for market power. The amount of loans supplied will equate marginal cost with marginal revenue, \( MC(D) = MR(E) \), if all deposits can be used to produce earning assets.

The financial firm thus optimizes a function of prices, inputs, and outputs similar to the profit function of microeconomic theory, maximizing total revenue minus total variable cost. Profits \( (\pi) \) as a function of prices are given by:

\[
\pi = r \cdot f(r) - d \cdot D(d) - \sum_{i} p_{i} \cdot X_{i} \cdot (E \cdot p \cdot D)
\]

(1)

where \( r \) are the interest rates on earning assets an \( p_{i} \) are the unit prices of non-financial inputs and where the last term is the non-interest related cost function, and \( X_{i} \) are amounts of capital and labor. The profit function in (1) is an arbitrary function that satisfies widely-used assumptions. It is nondecreasing in output prices and nonincreasing in input prices, homogeneous of degree one in output and input prices, convex, and continuous (Varian, 1984).
The underlying production function allows for technical interaction between the different activities of the financial firm (Baltensperger, 1980). The transformation function (2) is the technical constraint faced by the firm:

\[ t (E_p, D, X_i) \geq 0 \quad \text{iff} \quad (E_p, D, X_i) \in T \]

\[ T = \{(E_p, D, X_i) \mid E \text{ can be produced with } D, X_i\} \]

The transformation function in (2) is an implicit function of inputs and outputs. It is a common representation of a multiproduct technology, which has a one-to-one relationship to profits (McFadden, 1978; Chambers, 1988). There is no need to estimate a production function directly to get output supply and input demands. Rather, Hotelling's Lemma can be utilized to obtain a system of supply and demand equations from the profit function given by:

\[ E_j(r, d, p) = \frac{\partial \pi}{\partial r_j} \]  

\[ D_j(r, d, p) = \frac{\partial \pi}{\partial d} \]  

\[ X_j(r, d, p) = \frac{\partial \pi}{\partial p_l} \]

41 In Sealy and Lindley (1977) there are two separate production functions for each one of the earning assets and for deposits. The model presented here is more general, because it allows for technical interaction among outputs.
The profit function in (1) corresponds to the family of nonlinear, nonadditive profit functions in Adar et al. (1975), which allow for interdependence of factors of production. Such interdependence is due either to jointness on the supply (cost) side or to interdependence of the demand for financial services. Jointness on the supply side may stem from the joint use of inputs in producing both outputs, as is the sharing of information about clients between different departments of the financial institution (Adar et al., 1975).

4.3 Profit maximization hypothesis revisited

Traditional microeconomic theory assumes that markets are perfect, that there are no information asymmetries, and that property rights are clearly defined. Deviations from traditional neoclassical behavior can arise, however, and the profit maximization assumption may not always hold. Because financial transactions involve a promise to pay from borrowers to lenders, information about the probability of repayment is crucial. In financial markets information asymmetries are frequently present and these markets may not be perfectly competitive.

Principal-agent relationships, incentive problems, diffused property rights, private versus public ownership, monopoly power and regulated markets are some of the concepts used to rationalize deviations from profit-maximizing behavior. Principal-agent theory deals with the relationship between two parties that meet on a contractual arrangement. In the finance literature, the principal owns the resources but delegates the management of those resources to the agent. Conflicts between managers and owners arise when managers pursue objectives other than the maximization of the stock value that the owners pursue (Jensen and Meckling, 1976).

To mitigate the agency costs resulting from these different objectives, owners must establish incentive schemes that make the managers' objectives coincide with the owners' objectives. The separation of ownership and control is one of the most important causes of agency problems.
Incentives and monitoring schemes are part of the solution in narrowing the gap between different objectives. These solutions involve costs, however, and a balance must be achieved between these costs and the agency costs that otherwise prevail.

Fama and Jensen (1983) discuss different organizational forms that are more likely to experience agency costs. These institutional arrangements arise from alternative sets of property rights. When property rights are not clearly defined and/or fully assigned, firms have objective functions other than profit maximization. The ill-defined owner has no incentive to monitor the agent, who then enjoys managerial slack. The utility function of managers includes fringe benefits, prestige, and related elements that have nothing to do with the maximization of profits. The unsupervised agent is free to seek these alternative objectives.

Banks may be under state or private ownership. Because regulation dictates the nature of bank ownership, policymakers have an influence over the optimization process of financial firms. State-owned banks have a diffused structure of property rights that reduces incentives for monitoring managers. Since the quasi-owners exercise little control over managerial actions and managers have their own objectives, deviations from what is optimal for owners are likely to occur.

Camacho-Mejía (1993) explored differences in the behavior of state-owned and private banks in Costa Rica. Private banks were found to be more cost-efficient than state-owned banks in Costa Rica during the 1987-1991 period. State-owned banks hold more non-earning assets than private banks and have a larger than optimal scale of production compared to private banks, which are close to the optimal scale.

The degree of monopoly power enjoyed by a firm also affects the optimization the owners' objective function. Under the managerial discretion theory, Williamson (1963) indicates

\[\text{Cost-efficiency} = \frac{\text{minimum potential cost}}{\text{observed cost}}\]

\[\text{(Lovell, 1993)}\]
that managers that do not face competition use monopoly power to their advantage. Managers not sufficiently monitored have discretionary power over expenses, which they use to pursue their own objectives of reputation, control, and power. Regulated markets may reduce competition through barriers to entry. Banks with have monopoly power will follow a different optimization rule than banks in perfectly competitive markets because monopolists do not take prices as given. As a result, prices tend to be higher and the quantities produced smaller than in perfectly competitive markets.\textsuperscript{43}

Evanoff \textit{et al.} (1990) evaluate the case where regulation induces distortions in the production process that constrain the optimization effort. Chapter 3 described typical regulatory regimes found in banking. Of the three types of regulation distinguished by Hancock (1991), of special interest is the regulation that affects the marginal price of services offered by banks. This type of regulation will distort prices beyond distortions due to the existence of monopoly power.

The marginal costs of inputs may also differ substantially from what these costs would be without binding regulatory constraints. If interest rates on deposits are restricted below the market-clearing interest rate, for instance, this regulation can lead to commitment behavior (Evanoff \textit{et al.}, 1990). In this case, banks signal costumers that they are a secure and viable organization that will prevail in the long-run through a large infrastructure. The firm spends more in physical capital than is optimal from a profit-maximization viewpoint. In such a case, the effective price of capital will be lower than the actual market price that would prevail without regulation.

Leibenstein (1966) introduced the concept of X-efficiency. His analysis is directly applicable to deviations from profit-maximizing behavior. Even if the profit maximization assumption is maintained, less than competitive conditions and inadequate motivational systems lead

\textsuperscript{43} The empirical model of this dissertation explicitly allows for the existence of market power, and it considers the implications of entry barriers in the form of \textit{multibanco} mergers on the relative efficiency of the system.
to behavior that results in less than the maximization of profits. Chapter 5 will retake this concept of X-efficiency when defining deviations from profit maximization as inefficiency.

4.4 Restricted profit maximization

The simple model described above is not suitable for the analysis once one moves away from perfectly competitive behavior. This model can be extended to include additional elements, such as information asymmetries, monopoly power, and other distorting factors. The extended model allows for prices (shadow prices, as explained below) to be different from perfectly competitive prices because of the existence of distorting factors.

Because of the lack of a natural numéraire to define the production function of a multi-output, multi-input bank, the last (Jth) variable input can be chosen as a numéraire, as in Atkinson and Halvorsen (1990). Then, (2) can be expressed in terms of the last variable input as:

\[ X_j = \min \{ Y_j \mid Y_j \text{ can be produced with } X_j Z \} \]

(5)

for \( j = 1, \ldots, J-1 \)

where \( X_j \) is the minimum amount of the last input \( J \), \( Y_j \) represents outputs, \( X_j \) are variable inputs, and \( Z \) are fixed inputs.

This dissertation focuses on distorting factors that affect the optimization efforts of agents. Lau and Yotopoulos (1971) noted that allocative distortions arise mainly from three sources: regulatory distortions, the pursuit of non-profit maximizing behavior, and lack of immediate adjustment of firms to supply and demand shocks leading to price changes.\(^{44}\) Kumbhakar and

\(^{44}\) Regarding price adjustments, however, Dominican financial agents have proven to be rather fast (González-Vega, 1992). Further, the existence of monopoly power is implicit in this lists
Bhattacharyya (1992) stated that if input and/or output markets are not perfectly competitive and if there are institutional, social, and political constraints, market prices will not reflect the opportunity costs of inputs and outputs. Then, input and output decisions are made based on distorted prices, which are called shadow prices, leading to allocative inefficiencies.\textsuperscript{45}

Evanoff \textit{et al.} (1990) stated that agents face distorted prices that have been affected through regulation. Agents then choose from a set of shadow prices (p\textsuperscript{s}), which are different from actual (observed) prices (p\textsubscript{j}). In addition, Horvitz (1986) has argued that regulation affects the extent to which changes in technology are implemented. For instance, the lack of price competition for demand deposits has forced banks to provide payment services below cost, as an alternative mechanism to attract these funds.

Because of regulatory constraints, firms maximize a restricted profit function. Firms maximize revenue minus the sum of the expenditures on variable inputs minus the cost of the last variable input \textit{(numéraire)}, subject to \textit{b} regulatory constraints:

\[
\max \pi_i = \sum_{j=1}^{m} p_j Y_j - \sum_{j=m+1}^{(J-1)} p_j X_{ij} - p_{J} X_{iJ}(Y_{i}, X, Z) \tag{6}
\]

\[
\text{s.t.} \quad R_b (Y_{i\text{r}}, X_{i\text{r}}, X_{iJ}, Z_i; p_{J}, p_{J}) = 0 \tag{7}
\]

for \textit{i}=1,\ldots,n \text{ firms; } \textit{j}=1,\ldots,m \text{ outputs; } \textit{j}=m+1,\ldots,J-1 \text{ variable inputs.}

\hspace{1cm}

through the existence of deviations from perfectly competitive profit maximizing behavior or because of regulation in the form of entry barriers.

\textsuperscript{45} For example, in the case of monopoly power, the monopolists' selling price equals marginal costs plus markup (Applebaum, 1979).
This maximization involves a two-step process (Chambers, 1988; Varian, 1984; Applebaum, 1979; Atkinson and Halvorsen, 1990; Kumbhakar and Bhattacharyya, 1992). The first step is the minimization of costs for given output levels, subject to technological (5), (59) and regulatory constraints (7). The second step of the optimization is to choose output to maximize profits for a given set of inputs. The Lagrangean related to this optimization process follows, where the \( \tau_i \) are lagrangean multipliers associated with the regulatory constraints in (7):

\[
\mathcal{L} = \sum_{j=1}^{m} p_{ji} Y_{ji} - \sum_{j=m+1}^{J-1} p_{ji} X_{ji} - p_{ji} X_{ji} (Y, X, Z) - \tau_i R_i (Y_{ji}, X_{ji}, X_{ji}, Z_i; p_{ji}, p_{ji})
\]

for \( j = 1, \ldots, m \) outputs

\( j = m + 1, \ldots, J-1 \) variable inputs

which implies two sets of first-order conditions. First, the following first-order conditions (with respect to \( X_{ji} \)) are:

\[
-\frac{X_{ji}}{\partial x_{ji}} = \frac{p_{ji} + \sum_b \kappa_b \frac{\partial R_b}{\partial X_{ji}}}{p_{ji}} = \frac{\frac{p_{ji}}{p_{ji}}}{p_{ji}}
\]

for \( j = m + 1, \ldots, J-1 \) variable inputs

where \( -\frac{X_{ji}}{\partial x_{ji}} \) is the marginal rate of technical substitution (MRTS) between variable inputs \( j \) and \( i \). The right-hand side can be interpreted as the ratio of shadow prices of inputs \( \frac{p_{ji}}{p_{ji}} \), which includes a distortion element.\(^{46}\) Agents act as if they minimize variable costs for given shadow

\(^{46}\) The distortion element is assumed to be zero for the last input \( J \).
input prices. If the regulatory constraints are not binding, agents equate the MRTS to the ratio of actual (observed) prices instead of to the ratio of shadow prices.

The second set of first-order conditions (with respect to $Y_j$) are:

$$p_{ji} \frac{\partial X_i}{\partial Y_j} = p_{ji} + \sum_l \frac{\partial p_{ji}}{\partial Y_j} Y_l - \sum_b \kappa_b \frac{\partial R_b}{\partial Y_j} = p_{ji}^s$$

for $j,l=1,\ldots,m$ outputs

where the marginal cost of output $j$ is equated to its marginal revenue minus the relevant marginal effects derived from the regulatory constraints. That is, marginal costs are equal to shadow prices ($p_{ji}^s$) instead of actual (observed) prices. If regulatory constraints are not binding, or if there is no monopoly power in output markets, the right-hand side of (10) reduces to undistorted prices. Given the distortions, firms maximize under $p_{ji}^s$, a vector of shadow prices that are related to actual prices parametrically.

Under this setting, it is assumed that firms equate the marginal costs of each netput to shadow prices in a constant proportion ($\lambda_j$) of the firm-specific prices ($p_j$). Then, shadow prices can be approximated by a first-order Taylor series expansion of an arbitrary shadow price function (Lau and Yotopoulos, 1971):

$$p_{ji}^s = \lambda_j p_j$$

where the value of $\lambda_j$ represents the distortion factor as a net impact of binding regulatory constraints, possession of market power, and other sources of allocative inefficiencies.
of undistorted prices. This function is assumed to satisfy the usual conditions described above.\textsuperscript{47}

To impose linear homogeneity, the function is normalized by the last variable input price \( p_j \). Hence, normalized shadow prices and profits are equivalent to:

\[
P_j^s = \frac{p_j^s}{p_j} \quad ; \quad \Pi_j^s = \frac{\Pi_j}{p_j}
\]

\( \text{for} \ j=1, \ldots, m \text{ outputs} \)
\( j=m+1, \ldots, J-1 \text{ variable inputs} \) \hfill (12)

The normalized restricted shadow profit function is of the following form:

\[
\Pi_j^s = \sum_{j=1}^{m} p_j^s y_j - \sum_{j=m+1}^{(J-1)} p_j^s x_j = \Pi_j^s(p_j^s, Z_j)
\]

\[(13)\]

Let \( Q = (Y, -X) \) be the vector of \((J-1)\) netputs in the model. Netputs include \( Y \) as a vector of \( m \) outputs and \( X \) as a vector of \((m+1 \text{ to } J-1)\) inputs, the later with a negative sign. Using Hotelling's lemma, the first \((J-1)\) actual netput equations are derived from (13).

For the case of outputs, i.e., for \( j=1, \ldots, m \):

\[
\frac{\partial \Pi_j^s}{\partial p_j^s} = \lambda_{j-1} \frac{\partial \Pi_j^s}{\partial y_j}
\]

\[(14)\]

and for variable inputs, or for \( j=m+1, \ldots, J-1 \):

\text{\textsuperscript{47} The function is nondecreasing in output prices and nonincreasing in input prices, homogeneous of degree one in output and input prices, convex, and continuous.}
\[ \frac{\partial \Pi_i^*}{\partial P_{ji}^*} = -\lambda_j^{-1} \frac{\partial \Pi_i^*}{\partial P_{ji}} = X_j \] (15)

The last netput \( X_j \) is obtained from substituting actual prices for shadow normalized prices in (6). After some algebraic manipulations:

\[ X_j = \sum_{j=1}^{m} P_{ji}^* Y_j - \sum_{j=m+1}^{J-1} P_{ji}^* X_j - \Pi_i^* \] (16)

Since shadow profits are unobserved, they are expressed in terms of observable actual profits. Actual (observed) profits are:

\[ \Pi_i^a = \sum_{j=1}^{m} P_{ji} Y_j - \sum_{j=m+1}^{J-1} P_{ji} X_j - X_j \] (17)

Plugging (14), (15), (65), and (16), (66) into (17):

\[ \Pi_i^a = \sum_{j=1}^{m} P_{ji} \frac{\partial \Pi_i^*}{\partial P_{ji} \lambda_j} + \sum_{j=m+1}^{J-1} P_{ji} \frac{\partial \Pi_i^*}{\partial P_{ji} \lambda_j} - \sum_{j=1}^{m} P_{ji} \frac{\partial \Pi_i^*}{\partial P_{ji} \lambda_j} - \sum_{j=m+1}^{J-1} P_{ji} \frac{\partial \Pi_i^*}{\partial P_{ji} \lambda_j} + \Pi_i^* \] (18)

or, after algebraic manipulations:

\[ \Pi_i^a = \Pi_i^* + \sum_{j=1}^{m} P_{ji} (1 - \lambda_j) \frac{\partial \Pi_i^*}{\partial P_{ji} \lambda_j} + \sum_{j=m+1}^{J-1} P_{ji} (1 - \lambda_j) \frac{\partial \Pi_i^*}{\partial P_{ji} \lambda_j} \] (19)
The result in (19) presents profits in a general form. Once a functional form is assumed for profits, an extended model can be derived following the same derivation process. For a translog profit function shadow profits are:

\[
\ln \Pi_i^s = \alpha_0 + \sum_{j=1}^{J-1} \alpha_j \ln P_j \lambda_j + \frac{j-1}{2} \sum_{j=1}^{J-1} \sum_{l=1}^{J-1} \alpha_{jl} \ln P_j \lambda_j \ln P_l \lambda_l + \alpha_z \ln z + \sum_{j=1}^{J-1} \gamma_j \ln P_j \lambda_j \ln z + \gamma_z \ln z^2
\]  

(20)

and shadow shares derived from shadow profits using Hotelling’s Lemma are:

\[
S_{jl}^s = \frac{\partial \ln \Pi_i^s}{\partial \ln P_j} = \alpha_j + \sum_{l=1}^{j-1} \alpha_{jl} \ln P_j \lambda_j + \gamma_z \ln z
\]

(21)

or,

\[
S_{jl}^s = \frac{\partial \ln \Pi_i^s}{\partial \ln P_j} = \frac{P_j \lambda_j}{\Pi_i} \frac{\partial \Pi_i^s}{\partial \lambda_j}
\]

(22)

Then:

\[
\frac{\partial \Pi_i^s}{\partial \lambda_j} = \frac{\Pi_i^s}{P_j \lambda_j} \frac{\partial \ln \Pi_i^s}{\partial \lambda_j} = \frac{\Pi_i^s}{P_j \lambda_j} S_{jl}^s
\]

(23)

Using (23) and after rearranging terms, (19) becomes:

\[
\Pi_i^s = \Pi_i^s \left[ 1 + \sum_{j=1}^{J-1} \frac{(1 - \lambda_j)}{\lambda_j} \frac{S_{jl}^s}{\frac{\Pi_i^s}{P_j \lambda_j}} + \sum_{j=m+1}^{J-1} \frac{(1 - \lambda_j)}{\lambda_j} S_{jl}^s \right]
\]

(24)

Taking logarithms on each side:
\[ \ln \Pi_i^a = \ln \Pi_i^e + \ln M \]

\[ M = [1 + \sum_{j=1}^{m} \frac{(1 - \lambda_j)}{\lambda_j} S_{\mu_j}^{\text{z}} + \sum_{j=m+1}^{J} \frac{(1 - \lambda_j)}{\lambda_j} S_{\mu_j}^{\text{z}}] \]

(25)

Actual shares, in turn, are defined as:

\[ S_{\mu_j}^{\text{z}} = \frac{P_{\mu_j} Y_{\mu_j}}{\Pi_i^a} \]

(26)

for \( j = 1, \ldots, m \)

and,

\[ -S_{\mu_j}^{\text{z}} = -\frac{P_{\mu_j} Y_{\mu_j}}{\Pi_i^a} \]

(27)

for \( j = m+1, \ldots, J-1 \)

Then, using (14), (15), and (23), actual shares in terms of shadow shares are:

\[ S_{\mu_j}^{\text{z}} = \frac{S_{\mu_j}^{\text{z}}}{\lambda_j M} \]

(28)

for \( j = 1, \ldots, J-1 \)

Based on this theoretical model, the empirical model consists of the logarithm of actual profits in terms of shadow profits (25) and a set of share equations similar to (28).
4.5 Production economies

Berger et al. (1993a) refer to production economies as another source of deviations from optimal behavior. Banks reduce transaction costs when taking advantages of economies of scale and economies of scope.\textsuperscript{48} Economics of scale occur when a larger production volume reduces the unit cost of products (Tirole, 1989). These economies may result from an increase in the production of individual products --product-specific economies of scale-- or from an increase in all outputs --overall economies of scale (Clark, 1988).

For a single-output firm, economies of scale are associated with declining average costs. A t-fold increase in all input quantities yields at least a (t+\varepsilon)-fold increase in output, for \varepsilon>0 (Baumol, 1977). Yet, the extension of the notion of declining average costs to a multi-output firm is not straightforward. The difficulty stems from the fact that in this case average costs cannot be easily defined, because of a need for an index of aggregate output by which to divide total costs and because of a lack of a method to separate costs common to all outputs from costs for each output (Baumol, 1977).

Baumol (1977) defines ray average cost (RAC) as the multi-output version of average cost. This assumes that all outputs increase proportionately. Then, all output quantities move along a ray in output space, while input quantities follow the least-cost expansion path --usually not proportionate. Along such a ray, the bundle of outputs increases while keeping a fixed proportion among them, which allows for average costs to be defined. The ray average cost for a firm producing two outputs,

\textsuperscript{48} Innovations also emerge over time for organizations attempting to adapt to economic or institutional changes, thus, reducing transaction costs. While production economies bring about a reduction of costs along the cost curve, innovations result in a shift of cost curves. Regulation can affect the extent or speed with which technological innovations are generated and implemented (Horvitz, 1986). At the same time, production economies may not be exploited because of impediments from regulation that prohibits, for instance, mergers of banks that could take advantage of economies of scope.
loans (E₁) and securities (E₂) is represented in Figure 6. Ray average cost and total cost intersect at the unit output level Eₒ. Declining average costs exist along the portion of RAC before Eₘ, where RAC is at the minimum level. Before Eₘ, the slope of the rays O₁ and O₂ declines as the output bundle E increases.

A declining RAC is determined by:

\[
C(vE₁, ..., vEₙ)/v < C(tE₁, ..., tEₙ)/t \quad \text{for } v > t
\]

(29)

where the output bundle is increased v-fold and t-fold along the ray E=(E₁, ..., En).

Figure 6

Ray average cost

The term economies of scope was coined by Panzar and Willig (1975). This type of production economies deals with the fact that a firm undertaking joint production may produce more cheaply than when two separate firms specialize in the production of each product individually. Formally, the key element for the definition of economies of scope is the concept of subadditivity in

80
costs. A cost function $C(E)$ is strictly and globally subadditive over the production of goods $E_1$ and $E_2$ if:

$$C(E_1, E_2) < C(E_1, 0) + C(0, E_2)$$  \hspace{1cm} (30)$$

where $C(E_1, E_2)$ represents minimized costs for the firm producing loans and securities, at a given set of input prices. The representation in equation (30) refers to global economies of scope, because it compares the cost of joint and separate production (Clark, 1988). Another type of economies of scope is product specific. If an enhancement of production efficiency is brought about by adding a certain product to the output mix, product-specific economies of scope can be realized.

![Figure 7: Economies of scope](image)

Baumol (1977) stated that sufficient conditions for subadditivity of costs are a strictly declining RAC and transray convexity. The latter involves a change in output proportions. “A cost
function is transray convex at output vector \( E = (E_1, \ldots, E_m) \), if along at least one hyperplane through \( E \), a weighted average of the cost of producing separately any two output vectors on this hyperplane is no less than the cost of producing any weighted average of those two outputs together" (p.811).

The convex transray shape of the total cost function is illustrated in Figure 7, following Baumol (1982). The total cost curve \( OST \) is of the usual shape. A ray from the origin (R) combines outputs in a given proportion. A transray cut above \( AB \) yields an U-shaped cross section \( C'TC \), with minimum at \( U \). Therefore, enough complementarity between the two products ensures that producing both outputs at point \( U \) is cheaper than it is for two firms to specialize in the production of each product individually, at points A and B, respectively.

4.6 Potential effects of bank mergers

Due to the large number of mergers and acquisitions of recent years, an extensive literature has emerged to study their potential effects. As evidenced by the stylized fact of more than 1,500 mergers in the United States in the last three years, mergers are expected to bring about gains. In general, consolidation gains occur if the post-merger firm is more valuable than the separate pre-merger firms. Piloff and Santomero (1997) stated that these gains in stockholder’s value may result from performance improvements after the merger arising from expense reduction, increased market power, reduced earnings volatility, and scale and scope economies. Nevertheless, empirical research has not found conclusive results that verify the expected gains. In fact, there has been an intense debate on whether the recent wave of mergers benefits the economy (Carlton and Perloff, 1990).

4.7 Synergies from joint production in banking

Baumol et al. (1988) establish the relationship between economies of scope and joint production. They also explain that joint production occurs because of the existence of public inputs
as factors of production. That is, once these inputs are acquired for the production of a given good, they can be employed for the production of another good at no extra cost. For example, information in general can be viewed as a public good, because if it is supplied to one agent, others can access it at no extra cost (Carlton and Perloff, 1989).

Public inputs are only one technological source of economies of scope. Shared inputs that are used in the production of several outputs are another source. Costumer information can be considered to be a common or a shared input in banking. Because banks produce loans after they have produced deposits, the account history of costumers and their savings habits can be utilized as indicators of repayment capacity. Other examples are the sharing of overheads and fixed capital for the production of different outputs under one roof.

Joint production in banking reflects supply-side and demand-side benefits for the firm (Berger et al., 1987). Supply-side benefits result from cost reductions, while demand-side benefits come from increases in revenue. Piloff and Santomero (1977) classify merger gains into efficiency improvements, increased market power, or heightened diversification. Efficiency gains arise from increased cost efficiency, revenue efficiency, or profit efficiency.\(^{49}\) Cost gains arise from economies of scale, economies of scope (synergies), or improvements in management (X-efficiency).

Cost and revenue benefits that arise from synergies in joint production and improvements in management are derived from the following processes:

(a) Spreading fixed costs

Provided there is excess capacity, economies of scope arise from spreading data processing costs, loan officer and teller expenses, and rental and maintenance costs over a wider variety of products. Excess capacity is likely to be found when there are inputs shared without congestion

\(^{49}\) The cost and revenue (productive) efficiency concepts are relative ideas that compare firms minimum (maximum) theoretical levels to observed levels. Chapter 5 discusses extensively the literature on productive efficiency.
(Gilligan and Smirlock, 1984). Then, producing different outputs that use these same factors without increasing costs leads to economies of scope. As a result, overhead rates are expected to be substantially reduced.

(b) Information economies

One of the most important assets in banking is customer information. Because banking relies on promises to pay in the future, overcoming information asymmetries reduces costs. An evaluation of expected repayment capacity can be derived from the analysis of the consumer’s use of deposits or checking accounts.

(c) Risk reduction

Another aspect to consider in analyzing joint production is risk. Banks are exposed to five types of risk: liquidity risk, interest rate risk, credit risk, operational risk, and capital risk (Koch, 1992).\textsuperscript{50} Liquidity risks arise when banks are not able to meet payment obligations (deposit withdrawals) on time. Interest rate risks make banks sensitive to interest rate changes that may occur. Portfolio diversification reduces liquidity risks, and matching the maturity of assets and liabilities reduces interest rate risks. As a result, banks may choose to incur additional costs to reduce these two types of risk in their revenue streams (Berger \textit{et al.}, 1987). If the risk component to be reduced through asset diversification is larger than the costs incurred in producing the new activity, economies of scope take place.

(d) Costumer cost economies

On the demand side, costumer transaction costs may be reduced by joint production. If revenues increase through higher fee income, larger balances, or by strengthening the bank-costumer

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\textsuperscript{50} A bank deals with credit risks, \textit{i.e.}, the likelihood of default, by screening and monitoring borrowers. Operational risks refer to the operational efficiency of banks and are directly related to the analysis of efficiency that follows in the next chapter. Capital risks are related to the risk of banks becoming insolvent, which is related to the quality of assets. The later is the subject of prudential regulation measures, rather than of issues of joint production.
relationship, enough to cover the increased costs from offering joint services, this will bring about economies of scope.

(e) X-efficiency

Cost gains that arise from improvement in management are related to gains in X-efficiency if managers in the acquired institution are more skilled at reducing expenses for a given output level than the target firm (Pilloff and Santomero, 1997).\textsuperscript{51} Carlton and Perloff (1990) add other economic reasons for mergers related to management. For instance, new management may be able to fire excess workers in down times and reduced costs when the old management cannot. Increased manager ego is another reason that has to do with managers preference for power, which does not coincide with the owners’ objectives (agency issues). Also related to X-efficiency, the acquiring firm may realize that a better management of the target firm could result in increased profits and decide to merge.

The second general source of gains listed in Pilloff and Santomero (1997) is increased market power, as it may enable banks to earn higher profits by raising loan rates and lowering deposit rates. Indeed, arguments in favor of restrictions to mergers have to do with the potential detrimental effect to consumers from increase market power (Saunders and Walter, 1994). No evidence of increased market power has been found, however (Carlton and Perloff, 1990).

The last source of value gains is through bank diversification in the breadth of the products and services offered. This is the case because mergers involve an increase in the number of bank costumers. Pilloff and Santomero (1997) stated that greater diversification of returns reduces the volatility of returns. Lower volatility may arise from tax effects that benefit the merged firm resulting from an unprofitable and a profitable firm. The consolidation of both will result in lower aggregate

\textsuperscript{51} As in Pilloff and Santomero (1997), the terms merger and acquisition are used interchangeably. Although the two processes may be analyzed together, they are slightly different since a merger deals with two (or more) firms consolidating into one and an acquisition deals with one firm purchasing another (Carlton and Perloff, 1990)
profits and, hence, lower taxes to be paid (Carlton and Perloff, 1990). Bankruptcy costs may also be reduced. As returns become more stable, the earnings derived from activities were costumers value bank stability may also rise. In addition, merged banks may engage in riskier but more profitable activities without increasing equity.

A number of efficiency studies, however, have not been able to find sufficient evidence of the value gains of mergers. Still, some gains were found when analyzing a profit frontier, since banking organizations improved their profit efficiency rankings after mergers, although the analysis of traditional return on assets (ROA) and return on equity (ROE) were inconclusive\textsuperscript{52} Besides efficiency frontiers, a different methodology to evaluate value gains studies stock behavior before and after the merger evaluating abnormal returns. This approach has not found conclusive evidence either (Pilloff and Santomero, 1997).

Despite the lack of evidence, on value gains, mergers do happen. In explaining the gap between theoretical and empirical research, Pilloff and Santomero (1997) classified studies into those that believe that value gains exist but where gains are not correctly measured and those that believe that these gains are an illusion. Among the first group, researchers have evaluated methodological problems such as the fact that measured changes between the pre-merger and post-merger period may not be solely due to the merger, or how many days after the merger market returns should be evaluated. Also, since consolidation involves transition costs, no evidence of gains may result from observing short-term costs.\textsuperscript{53}

The second group of researchers suggests that managers are consistently mistaken about their skills to exploit gains form mergers because actually there are no real gains from merging. This is not

\textsuperscript{52} See Pilloff and Santomero, 1997 for a literature review.

\textsuperscript{53} Pilloff and Santomero (1997) reported that cost savings arising from mergers should be achieved within a year. In the Dominican Republic, informal interviews reported a similar time span.
a plausible assumption. Agents may make mistakes but not consistently. Another explanation discussed by Pilloff and Santomero (1997) is related to agency costs where both managers gain from mergers but stockholders do not. This explanation assumes that managers at the target institution know that acquiring managers will be profiting at stockholders expense, and that they will likely be displaced in the process.

Pilloff and Santomero (1997) conclude that a more realistic and successful method may be the study of individual managerial processes in a more detailed manner, thus evaluating the extent to which management plans are designed and implemented. By analyzing a group of mergers one can identify the average trend, but it may be that there are good and bad mergers. In fact, Pilloff and Santomero (1997) reviewed studies that found no evidence of merger gains on average, but that there were large variations among banks. Bad mergers may occur because managers do not plan to downsize or to eliminate excess capacity after the merger. The underlying argument is that value gains do exist but that they require specific know-how to be achieved.

4.8 Summary of findings

This chapter discusses a theoretical framework to analyze the efficiency of commercial banks in the Dominican Republic using the methodology to be described in Chapter 5. The (microeconomic) efficiency of banks deals with the waste of resources in production. Further, the framework is directly amenable to the evaluation of the efficiency of the multibancos that resulted from the Dominican financial reform.

As explained in Chapter 2, commercial, mortgage, and development banks were related to holding companies, which made global decisions for all the institutions. Generally, agents are expected to engage in horizontal expansion to acquire market share, or complementary product lines, or for risk spreading (Saunders and Walter, 1994). Tirole (1989) has argued, however, that even if
a merged firm serving many markets faces less uncertainty than several independent firms, the various firms could potentially develop a contract that obtains a similar result without merging.

Dominican multibancos, however, do not follow the usual universal banking pattern. Dominican banks may choose to merge mostly to reduce the duplication of transactions involved in a purely specialized banking setting by exploiting economies of scope. At the same time, Long and Vittas (1992) have argued that horizontal expansion can increase moral hazard and conflicts of interest. Because mergers involve reductions in duplicate processes, managers at one of the banks who were in charge of a department before the merger may end up as subordinates of managers in the other bank. Given that power is among the objectives of managers, a fight for power will result that may jeopardize the merger. Yet, these authors concluded that after management and supervision systems adapt to the change, universal banking could provide for ways to overcome information asymmetries and investment uncertainty.54

Emerging multibancos in the Dominican Republic may obtain cost reductions and revenue increases partly from the existence of economies of scope. Cost gains are likely because universal banks have combined preexisting specialized banks into one institution (beyond what the grupos had already accomplished), thereby reducing market fragmentation. A reduction in overhead rates is expected, as well as an increase in customer information exchanges. Further, since specialized banking resulted in a costly duplication of loan contracts when the same client was involved in transactions with different banks, lower transaction costs are expected as a result of mergers (González-Vega, 1992). Risks may also be reduced because of the consolidation of grupos and the elimination of reserve requirement differentials described in Chapter 3.

54 Informal interviews with Dominican bankers involved in mergers indicated that some adjustment costs may exist in merging but that the benefits in the form of cost reductions outweigh the organizational costs. Since the mergers are new in the system, the data analyzed in the empirical analysis may still reflect some of these adjustment costs for the most recent multibancos.
Demand-side benefits come from portfolio diversification and duration gap improvements. The duration gap issue was more relevant for mortgage banks that had a mismatch between short-term deposits at high interest rates and long-term loans at fixed lower rates (González-Vega, 1992). The liberalization of interest rates and the portfolio diversification introduced simultaneously with the mergers allowed banks to match terms and to reduce the duration gap. Moreover, customers may become loyal to one multibanco and conduct all their transactions at the same institution, rather than at three different specialized organizations, resulting in higher revenues for the bank through the reduction of transaction costs.

The empirical estimation compares the efficiency of multibancos and non-multibancos in order to evaluate if multibancos are more efficient. Not all of them are expected to be relatively more efficient than non-multibancos, because some were forced to merge through the non-neutral design of the rule. At the same time, it is expected to find banks that did not merge are still relatively efficient. The literature of efficiency frontiers is reviewed next in Chapter 5, which explains the method used to measure efficiency in the Dominican Republic.
CHAPTER 5

FRONTIER ANALYSIS AND THE EFFICIENCY OF FINANCIAL FIRMS

The model developed in Chapter 4 is based on a firm that maximizes constrained profits. It provides a way to estimate efficiency, while incorporating the behavioral objectives of the firm. This estimation is important because the results can help financial agents in their decisions, such as the decision about when to enter into potential mergers, expand their activities, or make portfolio choices (Benston, 1972). Policymakers can evaluate efficiency measures to compare firms that operate under a given regulatory framework. Further, comparative statistics that relate efficiency measures to specific regulatory changes can help in the design of efficiency-increasing policies.

Lovell (1993) defines efficiency as a component of productivity differences. Defining the productivity of a firm as the ratio of its outputs to its inputs, differences in productivity are driven by differences in production technologies, differences in production environments, and differences in efficiency. Efficiency studies isolate one source of productivity differences, comparing observed and best values for the inputs and outputs of a firm for given production technologies and production environments. Since in efficiency analysis agents are described as more or less efficient than others, efficiency becomes a relative concept.

The idea of a frontier is embedded in microeconomic analysis through the definition of production possibility sets, minimum costs, and maximum profits. These maxima and minima delineate the attainable set of outcomes, above (below) which additional production is no longer possible, costs cannot be reduced, and profits cannot be increased. The production function, the cost
function, and the profit function are referred to as frontiers because they characterize optimizing behavior for the efficient producer (Førsund et al., 1980).

The underlying assumptions for the estimation of frontiers are those of economic optimization theory. Frontier analysis methods calculate an efficiency frontier from a sample of firms. The frontier is estimated from the most efficient units in the data set. This methodology defines and compares deviations from the frontier as inefficiency. Deviations can occur either when individual units are pursuing technical goals or when they are pursuing behavioral goals. Goals are technical when firms are trying to produce the maximum level of output from given inputs. Goals are behavioral when firms are pursuing the minimum level of cost to produce outputs at given input prices, or the maximum level of profits that are attainable given input and output prices.

The concept of frontier has been the subject of extensive analysis at both the theoretical and empirical levels. This chapter starts with a review of the literature on the measurement of efficiency, including a definition of the components of inefficiency. Because a variety of choices are available for the estimation of frontiers, a list of alternative methods for estimation is also provided, and the nature of the different choices is discussed.

One theoretical choice concerns the behavioral goal to be pursued by the firm. The choice is among cost minimization, revenue maximization, and profit maximization. At the empirical level, another choice is between parametric or nonparametric models. Also, frontiers can be deterministic or stochastic, and efficiency components may be assumed to have a given statistical relationship with the frontier.

The empirical model used in this dissertation is parametric in nature, and it estimates a stochastic profit frontier. Cost or revenue frontier techniques are compared in this chapter to the profit frontier estimation. Since the profit frontier model was chosen for the empirical estimation, the costs and advantages of such a choice are discussed. A review of the literature on the empirical estimation
of efficiency frontiers and on the separation of the sources of inefficiency follows, including a graphical description of the measures to be derived.

5.1 Researcher choices

Numerous choices must be made for the empirical estimation of efficiency. The following sections discuss the different decision levels that a researcher faces. The modeling process is sketched in Figure 8, which includes an illustration of the choice of model for this dissertation.

At the first level, the choice is between the primal and the dual approach. Once the primal approach is chosen, it is clear that the objective function is the production function. The dual approach offers, however, cost, revenue, or profit functions as alternative objective functions.

The next step is to decide on the separation of efficiency into its components. The analysis can concentrate on technical efficiency and/or allocative efficiency, unless the previous choices lead to the primal approach, which deals exclusively with technical efficiency.

The next decision step is between parametric and nonparametric models. This choice concerns the separation of inefficiency from random noise. This requires a choice among the Data Envelopment Analysis (DEA), Thick Frontier Approach (TFA), Econometric Frontier Approach (EFA), and Distribution Free Approach (DFA) methods, as described below.

Models can also be deterministic or stochastic. While deterministic models can only be specified for cross-sectional data, stochastic models can be specified for cross-sectional and for panel data. Cross-sectional data can be fitted for single equation or multiple equation models. Panel

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55 To facilitate the presentation of the choice tree in Figure 8, the sub-division described later on in Figure 11 among different dual stochastic approaches is not included. Figure 11 connects with Figure 8 at the stochastic end, however, following the dual approach path.
Figure 8  Model choice tree.
data can be estimated by using a fixed-effect model or a random coefficient model, as in the traditional panel data literature (Chapter 6).

The bold line in Figure 8 illustrates the modeling path for this dissertation. A profit frontier will be utilized following the dual approach in Figure 11, under the second alternative. The panel data model employed is a fixed-effect model of the inefficiency parameters, which will be explained in detail in Chapter 6.

5.2 Deviations from the frontier: technical and allocative efficiency

Deviations from a given frontier measure the productive efficiency of a firm. Productive efficiency is defined as the ratio of observed to maximum potential outputs that can be obtained from given inputs or the ratio of minimum potential to observed inputs required to produce given outputs (Lovell, 1993).

The seminal work of Farrell (1957) on efficiency measures brought about two main indicators of productive efficiency: technical and allocative efficiency. Farrell's method uses a linear homogeneous production function to conceptualize efficiency measures. Using a unit isoquant, he conceptualized a measure of economic efficiency, which he decomposed into technical and allocative efficiency.

While technical efficiency is purely an engineering concept, allocative efficiency is purely a behavioral concept (Lau and Yotopoulos, 1971). Technical efficiency compares actual input usage with the best practice usage --holding output constant-- or actual output production with the best practice production, holding inputs constant. Allocative efficiency, in turn, relates to the choice of production technology that maximizes profits or minimizes costs. That is, it evaluates the input mix that allocates factors to their highest valued uses at prevailing prices, thus including the opportunity
costs of inputs (Kopp, 1981). More precisely, technical efficiency is the movement toward the efficiency frontier and allocative efficiency is the movement along the frontier to the point where it is tangent to the prevailing price ratio line.

5.3 Parametric and non-parametric approaches

Parametric and non-parametric approaches are alternative methods for constructing efficiency frontiers. In the estimation of efficiency frontiers, these approaches make assumptions about random noise and flexibility in the structure of the production technology. The differences between the parametric or econometric approach, on the one hand, and the non-parametric approach or Data Envelopment Analysis (DEA), on the other, are represented by two characteristics (Lovell, 1993). First, the econometric approach is stochastic and it differentiates inefficiency from random noise. Apart from being non-stochastic, the non-parametric approach estimates combination inefficiency, composed of both noise and inefficiency. Second, given its non-parametric nature, the DEA or mathematical programming approach is less prone to mispecification errors of the functional form. The econometric approach is likely to involve specification errors of the functional form and confound their effects with inefficiency (Lovell, 1993).

5.4 Separation of inefficiencies from random noise

Deterministic frontiers estimate all the variation in the performance of firms as inefficiency (Forsund et al., 1980). In turn, stochastic frontiers allow for random errors. Random errors result

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56 Lau and Yotopoulos (1971) recognize deficiencies of the original Farell model because it does not allow for multi-output firms. Also, the model is purely deterministic, which makes it sensitive to outliers. However, the original measures have since been improved (Forsund et al., 1980).
from events that are not under the control of agents, such as weather, luck, and particularly in financial markets—macroeconomic crises, which bring noise to the statistical estimation.

To separate the effects of inefficiency from random errors, the available parametric and non-parametric methods introduce arbitrary restrictions (Berger, 1992). The original DEA approach assumes no random fluctuations, so that all deviations from the frontier are called inefficiency.\textsuperscript{57} The TFA approach imposes a different restriction, by allowing inefficiency to vary within a range imposed by the analyst. For cost frontier estimations, for example, the TFA assumes that deviations from predicted costs within the lowest average-cost quartile of the production units represent random errors. Deviations in predicted costs between the highest and lowest quartiles are considered as the inefficiency portion (Berger, 1992).

Another method is the distribution-free approach introduced by Berger (1992). While inefficiencies are assumed to be persistent over time, random errors average out over time. The EFA approach, a widely used method, assumes that inefficiency follows an asymmetric half-normal distribution, but that the random errors follow a symmetric normal distribution.

5.5 Cost/revenue frontier versus profit frontier

The behavioral choice for the estimation of frontiers is independent of the choice of specification between parametric and non-parametric models. Optimization may be specified through a cost, revenue, or profit function estimation. Cost or revenue frontiers are the most widely used method, primarily due to data limitations.\textsuperscript{58} The cost frontier approach concentrates on the input side

\textsuperscript{57} The original DEA model was purely deterministic and included only technical inefficiency as the sole source of inefficiency. Lovell (1993) reviews extensions of the model that have led to stochastic DEA models that also include allocative inefficiency.

\textsuperscript{58} Some of the studies that used the cost frontier approach are Sealy and Lindley (1977), Benston (1972), Ekelund and Higgins (1982), generally for the United States. Nauriyal (1992) is an application to the Chilean banking sector, while Camacho’s (1988), (1990), and (1994) are
of efficiency, while the revenue frontier limits its evaluation to output-side efficiency. Technical efficiency has thus two dimensions: input-conserving or output-augmenting (Koopman, 1951). Under the cost frontier estimation, a firm is technically efficient in the input sense if it cannot reduce the use of an input unless it increases the use of another or it decreases output (Figure 9). On the output side and using a revenue frontier, a firm is technically efficient if it cannot further increase one output without decreasing another or increasing the use of inputs (Figure 10).

Figure 9  
Cost frontier: input space

Parallel lines in Figure 9 are iso-costs. The efficient frontier represents minimum cost achieved for given input prices and output levels. It is determined by the tangency between the isoquant and the minimum iso-cost line at $X_e$. The observed input combination is at $X_a$, where costs

applied to Honduras, the Dominican Republic, and Costa Rica, respectively. Lee (1996) estimated a cost frontier to evaluate the effects of market structure and ownership on Korean commercial banks. A non-parametric cost frontier was estimated by Camacho-Mejía (1993) for commercial banks in Costa Rica. For a literature review of other applications to financial institutions using also the cost frontier method, see Clark (1988).
are higher. Inputs can be reduced radially to the frontier in the proportion $\phi_x$. Total economic inefficiency is the difference between costs at $X_e$ and $X_a$. While technical inefficiency is the difference in isocost lines between $X_a$ and $\phi_x X_a$, allocative inefficiency is the residual, determined as the ratio of technical to economic efficiency. Allocative inefficiency is then the difference in isocosts passing through $\phi_x X_a$ and $X_e$.

By the same token, in Figure 10 the efficiency frontier represents maximum revenues for given input levels. The optimal output for given output prices is $Y_e$, where the isorevenue line is tangent to the efficiency frontier. The observed output combination is at $Y_a$. To increase revenues toward the efficiency frontier, outputs can be increased radially in the proportion $\phi_y$. Total economic inefficiency is the difference between revenues at $Y_e$ and at $Y_a$. Technical inefficiency is the difference in isorevenue lines between $Y_a$ and $\phi_y Y_a$, and allocative inefficiency is the difference in isorevenue lines between $\phi_y Y_a$ and $Y_e$.

![Diagram of efficiency frontier and output space](image)

*Figure 10*  
Revenue frontier: output space
Figure 9 and Figure 10 represent the cases for cost minimization and revenue maximization, respectively. An alternative behavioral goal is profit maximization. This has the advantage for estimation that it does not require a distinction between the firm's outputs and inputs, which is not a simple task for the case of the financial firm. The classification of inputs and outputs for modeling the banking firm has been a dilemma extensively studied in the literature, as discussed in Chapter 4.\(^59\) The choice of inputs and outputs is less relevant for the profit frontier, because both inputs and outputs are treated as similar arguments. Thus, the profit frontier approach is less prone to mis specification errors, since the \textit{a priori} distinction of inputs and outputs has no effect on the specification.

As most studies of the efficiency of financial institutions have used either the cost or the revenue frontier framework, they have focused on either input or output efficiency. Nevertheless, in studying banks it is as important to learn about the input side of both allocative and technical efficiency as it is to learn about the output side. For instance, Dominican banks are likely to exhibit different behavioral patterns in the input and output side that may lead to differences in efficiency.\(^60\) Thus, a profit frontier estimation is preferred because both dimensions of inefficiency can be dealt with.

Berger \textit{et al.} (1993a) stated that a firm may be employing relatively too much labor for the production of a given level of loans due to bank owners/managers not assessing the true cost of employment benefits other than wages, due to an expense preference behavior of managers \textit{a la} Williamson, or because these managers overestimate the costs of using other factors involved in the production process (input side). On the output side, the same bank may be less effective at marketing

\(^{59}\) The nature of the problem is in deciding how to define what is an output and what is an input. Since cost functions only include input data and revenue functions only include output data, these definitions are relevant.

\(^{60}\) The input side is represented by deposits, which have reflected a high elasticity of demand (González-Vega, 1992; Guilliani and Aristy, 1991).
a certain type of asset and hence produce less than a bank at the frontier. In addition to the importance of understanding both sides of inefficiency, a bank may seem inefficient because it incurs higher costs, but it can also earn higher revenues that offset some of those higher expenses. This last issue is related to output quality (Berger et al., 1993a).

In a cost frontier estimation, the higher costs of production of any better quality output may be mistaken for lower efficiency. The profit frontier can handle this problem if higher costs of producing a better quality output are accompanied by higher revenues, which is likely. Since both elements are considered for the profit frontier estimation, their effects tend to cancel each other, thus reducing the probability of estimating higher quality as less efficiency.

The differentiation of economic efficiency into technical and allocative is especially relevant for regulators. Given their interest in the effects of firm actions upon the allocation of resources, regulators should be concerned with both types of efficiency and their sources. As described in Chapters 2 and 3, regulations in the Dominican Republic affect both input and output choices. For example, interest rate ceilings affect both the input and output side while cheap sources of loanable funds affect the input side. Given this, it becomes even more relevant to evaluate both sides of inefficiency.61

Regulatory environments can potentially have an impact on observed measures of efficiency (Mullineaux, 1978). In the Dominican setting, organizational form includes a classification for multibancos. Since this charter is the result of recent regulatory changes, its effect on efficiency is important in the analysis. The analysis of technical inefficiency is thus carried out for the two groups of commercial banks: multibancos and non-multibancos.

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61 Regulatory elements can be introduced in cost and revenue frontiers as well. When these elements are introduced through the definition of prices, however, only input price regulation is included in cost frontiers and output price regulation in revenue frontiers.
The profit frontier model for measuring efficiency is not only theoretically valid but also empirically estimable if the required data are available. In fact, many studies have implemented a theoretical framework similar to that described in Chapter 4 to model and to measure efficiency in banking (Atkinson and Cornwell, 1990; Benston, 1972; Berger et al., 1987; Berger et al., 1993a; Eakin and Kniesner, 1988; Evanoff et al., 1990; Ferrier and Lovell, 1990; Gilligan et al., 1984; Sealy and Lindley, 1977; among others).

5.6 Empirical versus theoretical research

The interesting theoretical questions about efficiency are not exclusively the empirical differentiation of inefficiency from random noise or the classification of the components of firm inefficiency. Rather, the theoretical explanations of such inefficiencies must be at the core of frontier analysis. The development of the literature on efficiency frontiers, however, has taken a methodological path that leaves behind the theoretical circumstances under which inefficiencies may occur (Berger et al., 1993a).

The evident separation of theoretical from empirical research on the measurement of efficiency can be explained by the complexity and variety of issues at both the empirical and theoretical levels. For instance, Fare et al. (1992) explicitly stated that their concern is on measurement rather than causation of inefficiency, although they recognize the importance of establishing the causes of inefficiency. Researchers may choose to focus only on the empirical level because there are even at this level too many elements to deal with and to improve upon.

Theoretical research includes an extensive literature on agency costs, managerial discretion, and X-efficiency to explain the sources of deviations from the efficiency frontier. X-inefficiencies involve differences in managerial ability to reduce costs or increase revenues and profits. Since inefficiency has now been defined as deviations from the frontier, both allocative and technical
efficiency can be identified with X-efficiency. This link between the theoretical and empirical levels defines the direction of research in recent years, when an increasing number of studies that measure efficiency relate efficiency scores to widely known theoretical issues from financial economics (De Young, 1994; Spong et al., 1995; Camacho-Mejia, 1993; Lee, 1996; among others). Berger et al. (1993a) include a literature review of efficiency studies that also deal with X-efficiency.

A recent study by Berger and Mester (1997) calculated two specifications of profit frontiers and a cost frontier to the same data set. The authors attempted to go inside the black box and explain efficiency differences across institutions as reported by numerous efficiency studies. By implementing different methodologies keeping the data constant, the intention was to abstract from methodological differences and to try to evaluate why inefficiencies exist.\footnote{Although the preferred estimation for the Dominican case is a profit frontier, it involved large estimation problems, besides severe data limitations. Similar estimation problems were reported in Atkinson and Cornwell (1995), who estimated a modified cost frontier instead. In trying to provide more precise information, the analysis was carried out for both a profit frontier and a cost frontier (see Chapter 6). Unlike the profit frontier, the cost frontier has been extensively implemented and numerous empirical issues have been resolved.}

5.7 Separation of inefficiency: a further review

Two recent surveys by Greene (1990) and Bauer (1990) review available techniques for the econometric estimation of inefficiency, including its separation from random noise and decomposition into its technical and allocative components. These reviews include a wide range of what are called primal and dual models. The dual model assumes a behavioral objective while the primal model estimates the production frontier directly.

Førsund et al. (1980) indicate that most of the earlier work on stochastic efficiency frontiers was carried out for production frontiers (Aigner, Lovell, and Schmidt (1977); Färe and Lovell (1978), among others). Recent developments of the primal approach have included innovative elements such
as time-varying inefficiency (Cornwell et al., 1990). Nevertheless, the most recent literature has taken advantage of duality theorems in the estimation of stochastic frontiers, mostly cost frontiers, which has led to a large set of studies using the dual approach.

Under the dual approach there are two main ways of estimating efficiency (Figure 11). These methods are distinguished by the way they separate inefficiency from random errors as well as technical from allocative inefficiency. The first method under the dual approach estimates a production frontier such as in the primal approach, but it also includes the first-order conditions for profit/cost maximization/minimization. The second method is to estimate the profit frontier directly, with the demand and supply (netput) equations derived from Hotelling’s lemma.

![Diagram of stochastic frontiers: the dual approach](image)

**Figure 11** Stochastic frontiers: the dual approach.

The profit frontier has received increasing attention in the last decade as a choice of behavioral goal. The discussion here will be presented using the profit frontier to reflect the
behavioral choice of agents, unless otherwise noted. However, the choice of a behavioral goal among cost, revenue, or profit frontier is theoretically irrelevant for important issues in separating efficiency from random noise and technical from allocative inefficiency.\textsuperscript{63}

Among stochastic frontiers, the estimation of profit frontiers plus demand and supply equations can be carried out following two methodologies. The first methodology (A) estimates profit frontiers and netput equations plus a two-part composed error (Aigner, Lovell and Schmidt, 1977). As shown in Figure 11, within the second type of dual models, methodology B uses shadow prices as the behavioral assumption, introducing the inefficiency element parametrically.

5.7.1 A composed error term: methodology A

Methodology A estimates the objective function by adding a composed error term. One part of the composed error term is statistical noise, generally assumed to follow a normal distribution. The other part is a combination of technical and allocative inefficiency, which is assumed to follow some one-sided distribution (Bauer, 1990). The typical specification for the distribution of the composed error term is a half-normal distribution, although some studies have implemented other specifications, such as the gamma distribution, truncated normal distribution, and exponential distribution.

The choice of distribution is arbitrary, unless panel data are available.\textsuperscript{64} When using panel data, the decision about the distribution is potentially avoided, because panel data adds more information on the same firm, which allows for inefficiency to be estimated over time (Schmidt and

\textsuperscript{63} At the empirical level, however, there are numerous issues related to estimation of profit frontiers, which are data hungry and require the definition of input and output prices with consequent estimation problems. These estimation problems (discussed in Chapter 6) led to the estimation of a cost frontier in addition to the profit frontier in order to provide some robustness to the results from the dissertation. Cost frontiers have been widely estimated, which results in well-established estimation methods.

\textsuperscript{64} Berger and Mester (1997) reported a wide variety of studies assuming different distributions. When inefficiencies are not constrained to a specific distribution, however, the distribution of these inefficiencies was closer to a symmetric normal distribution than to half-normals. The choice of the wrong distribution may, thus, invalidate efficiency scores.
Sickles, 1984). Cross-sectional data, regardless of the size of the data set, cannot provide enough information on the inefficiency terms without some distributional assumptions.

The estimation of a system of cost/profit frontier and netput equations includes allocative and technical inefficiency as part of the netput shares (Kumbhakar, 1987; Bauer, 1987 and 1990; Schmidt and Lovell, 1980; Jondrow et al., 1982; among others). Inefficiency is translated into lower profits—or increased costs. For the translog cost system, the general specification of this first type of models is:

\[
\begin{align*}
C_i &= C(w, y) + U_i + A_i + \epsilon_i \\
S_{e(i)} &= S_{e(i)}(w, y) + a_i + \nu_i
\end{align*}
\] (31)

where \(C_i\) is the logarithm of observed cost for the \(i\)th firm, \(C(w, y)\) is the minimum cost (deterministic) frontier at the prevailing set of input prices \(w\) and output quantities \(y\). Observed share equations are \(S_{e(i)}\) and the optimal shares \([S_{e(i)}(w, y)]\) are derived by using Shephard’s Lemma. The random noise components are \(\nu_i\) and \(\epsilon_i\) for the share equations and the cost equations, respectively. The allocative inefficiency component in the share equations is \(a_i\), which is translated into greater costs in the amount \(A_i\), and it is assumed to be non-negative. Technical inefficiency also increases costs in the amount \(U_i\), but there is no equivalent component in the input share equations, because there output is exogenous.

Similarly, in terms of the translog profit system:

\[
\begin{align*}
\Pi_i &= \Pi(p, q) + U_i + A_i + \epsilon_i \\
S_i &= S(p, z) + u_i + a_i + \nu_i
\end{align*}
\] (32)

\[65\] Since the data set available for the Dominican Republic is a panel of monthly data, modeling advantages can be explored. Further explanation of this issue is included in Chapter 6.
where \( \Pi \) stands for actual profits, \( \Pi(p, y) \) is maximum (frontier) profits for the prevailing set of netput prices (\( p \)) and netput quantities (\( q \)). The second equation \( S_p \) which is derived as the partial derivative of the log of profits with respect to \( p \), (evaluated at the maximum), depends on \( p \) and the fixed input quantity \( z \). The remaining variables specify the composed error term in both the first and second equation, where \( v_i \) and \( e \), are the corresponding random noise components. Inefficiency components in the share equations are \( u_i \) for technical and \( \eta_i \) for allocative inefficiency. Inefficiency in \( S_i \) is translated into a reduction of profits in the amounts \( U_i \) and \( A_i \) for technical and allocative inefficiency, respectively.

The main problem to be solved in this type of model is the specification of the relationship between elements across equations. In the cost frontier framework, the main concern is the relationship between the \( a+\nu \) in the input share equations, and the \( U_i + A_i + \epsilon_i \) in the log of cost equation. While the former can result in an increase of inputs (overuse) or decrease of inputs (underuse), the element in the log of cost equation is nonnegative, because it always yields increased costs. A similar problem arises in the profit system, with the additional complication of having both technical and allocative terms in the profit function and in the share equations, for which relationships must be determined.

Modeling these relationships between the share equation and the frontiers is an issue known in the literature of efficiency frontiers as the Greene problem (Greene, 1980; Bauer, 1987 and 1990). Bauer (1990) summarizes three approaches to modeling the Greene problem (Figure 12). Besides ignoring the relationship between the two error terms (Greene, 1980), the analysis can be carried out by finding the analytical relationship between the terms, or by using approximate mathematical methods imposing the structure \( a \) \( a \) priori.

These estimation problems are still challenging and have not been resolved by the literature on cost and profit frontiers (Bauer, 1990; Greene, 1993). The analytical solution attains an analytical
closed form only because it is based on the Cobb-Douglas production function. More flexible functions do not allow for analytical solutions, so approximate solutions are found instead.

The approximate solution class in Figure 12 represents the relationship between $A_i$ in the cost function and $e_i=a_i+v_i$, in the share equations. The specification ensures that $\ln A_i$ and $e_i$ are positively related. The parametric form of this relationship utilizes a function $F$, which is a positive semi-definite matrix. The function $F$ has to be determined, however (Bauer, 1987 and 1990). There is no consensus yet about the best functional form. Some questions have been partially answered but others are still enigmas, because it may be as bad to ignore the relationship between the elements
5.7.2 Alternative method of separating efficiency: methodology B

Methodology (B) compares observed netputs with the demand and supply functions consistent with maximization under observed prices. This second specification measures inefficiency as the difference in profits evaluated at observed demand and supply levels—or shares, for a translog specification—, minus profits evaluated at the levels that are consistent with maximization under observed prices (maximum profit attainable). The logic behind this methodology can be illustrated graphically.

The graphical explanation is provided following Lovell (1993) and Berger et al. (1993a), who illustrate the frontier for one variable input and one variable output in a way similar to Figure 13. Production is at point C, on the observed isoprofit line C'C'. Maximum isoprofit is given by A'A' of slope [1/(p1/p0)], i.e., at observed prices, which is tangent to the efficiency frontier at point A.

![Figure 13: Inefficiency measures one output/one input.](image)
The shadow maximum isopfrofit is depicted by B'B' which corresponds to shadow relative prices ($\mu \lambda / p j \lambda j$). This is tangent to the efficiency frontier at B, which represents the level of shadow output and input (B). Profit differences between the isopfrofit lines A'A' and C'c' determine overall economic inefficiency. Economic inefficiency measures can be separated into technical an allocative following radial or nonradial techniques. While leading to the same measure for economic inefficiency, the two methods differ in their separation into technical and allocative.

To measure overall inefficiency in banking, Berger et al., (1993) separated technical and allocative inefficiency in a nonradial manner by means of the profit frontier.\footnote{Previous attempts to use non-radial measures were made by Färe and Lovell with the Rusell technical efficiency measure (Färe et al., 1992).} Using nonradial measures, allocative inefficiency is measured as the difference in profits between isopfrofit lines A'A' and B'B', leaving the technical portion as the failure to be at the frontier at the shadow level B or the difference between isopfrofit lines B'B' and C'C'. This way of measurement relies on a set of definitions of technical and allocative inefficiency that differ from the traditional Farrell measures (radial), introduced more than three decades ago.\footnote{Radial measures consider part of the described (non-radial) allocative portion as technical. In the graph, radial measures classify technical inefficiency as the difference in profits between isopfrofit lines crossing through D and C'C', while the allocative portion is the difference between isopfrofit lines crossing through A and D. Point D represents the same input mix as at point C. Because it keeps the same output mix as in point C, the measure is considered as radial.}

Using nonradial techniques, technical inefficiency is still measured as a deviation from the efficiency frontier, but it is not restricted to be radial. That is, it does not involve a proportionate change in the use of inputs or in the production of outputs. Once at the frontier, allocative inefficiency will mean not to maximize profits. Because the firm maximizes based on shadow relative prices ($\mu \lambda / p j \lambda j$), it is not at the point of the efficiency frontier where profits are maximized for actual relative prices ($p j / p j$). These inefficiencies reflects the fact that the producer overuses inputs and
underproduces outputs, compared to the best practice frontier in the sample (a hypothetically fully efficient firm).

5.8 Optimal scope economies and frontier efficiency

Berger et al. (1993a) tested a concept of optimal scope economies. These authors argue that the traditional concept of economies of scope fails to address the question of either joint production or specialization being optimal. This optimal scope economies concept evaluates how joint production may reduce costs and whether this production mix is optimal. In applications of the traditional method, tests for economies of scope assume that banks are producing at the efficiency frontier. If this is not true, the estimation could lead to conclusions about the existence of economies of scope, when what is being observed are differences in efficiency.

The easy-to-measure alternative evaluates if the optimal input-output combination for an economically efficient firm shows positive values for all outputs. If, at the given values of prices and fixed netputs, the optimal quantities of all outputs are determined to be greater than zero, there are optimal scope economies. This test allows for some sort of asymmetric jointness where, under certain conditions, joint production may be optimal for a set of firms, but specializing will be optimal for other firms. The evaluation of optimal scope economies through a profit function avoids output to be fixed, contrary to the cost function case. Then, one can determine whether there are optimal scope economies at a production point input- and output-efficient, avoiding confusion between scope economies with differences in efficiency.

To illustrate the multi-output case, including both optimal scope economies and sources of inefficiency, the concepts of economies of scope and efficiency frontier are combined. Figure 14 combines Figure 7, where the traditional concept of scope economies was depicted, with Figure 13, which is the representation of the efficient profit frontier and sources of inefficiency. Figure 13 dealt
with the one input-one output case, which is irrelevant for the study of scope economies. An extension of the efficiency frontier and sources of inefficiency is depicted in the top panel of Figure 14, for the case of one input and two outputs.

The lower panel is a replication of Figure 7. A point such as E is optimal because it is at the frontier and because it also exploits scope economies, as it corresponds to the lowest point of the U-shaped RAC curve. At E' the firm is overusing inputs in the amount $\phi_1$ and underproducing outputs in the amount $\phi_2$. This is the technical inefficiency portion of total inefficiency, which is the difference in profits between the isoprint line crossing through E' and the isoprint line through E. As before, the allocative inefficiency portion is the movement on the frontier toward the optimum E.

This framework was developed to evaluate optimal scope economies in the context of the frontier analysis in the Dominican Republic. Nevertheless, attempts to estimate these economies of scope were not successful. Economies of scope are expected to exist between the production of loans of different terms to maturity. The lack of sufficiently dissaggregated output data and the failure to find a reasonable alternative measure provided the data constraints did not allow for this estimation (see Chapter 6). \(^{69}\)

\(^{69}\) Originally, one of the hypothesis of this dissertation was to evaluate if there were optimal economies of scope in the system. This hypothesis, however, could not be tested.
Figure 14 Efficiency frontier and economies of scope.
5.9 Summary of findings

The literature on efficiency frontiers includes a wide variety of modeling choices for researches, as illustrated in Figure 8. A stochastic profit (and cost) frontier will be utilized here, where inefficiency components are introduced parametrically in the model (methodology B). Since panel data are available, a fixed-effect model of the inefficiency parameters is fitted, as explained in Chapter 6.

Deviations from a given frontier, such as the stochastic profit frontier, measure the productive efficiency of a firm, which can be divided into technical and allocative. Technical inefficiency measures indicate how agents combine inputs and outputs to produce as many outputs with given inputs and/or produce given outputs with the least amount of inputs. Unless prices are involved in the analysis of efficiency, allocative inefficiency cannot be estimated.\[^70\] As explained in Chapter 4, allocative inefficiency can be caused by distorted prices—referred to as shadow prices—because of regulation, market power, and other distorting factors, which lead to differences between observed shares and the shares that would result from maximization under observed prices (Lau and Yotopoulos, 1971). Agents base their decisions on shadow input and output relative prices, instead of the actual (observed) relative prices. This result makes it possible to allow for the existence of X-inefficiency.

Lau and Yotopoulos (1971) start with the traditional theory of the profit frontier and introduce the two components of productive efficiency: technical and allocative efficiency. Their formulation evaluates the difference between observed demand and supply, and the demand and supply resulting from the maximization of profits under observed prices. While the first set of equations include technical and allocative inefficiency, the second set of equations does not include these elements.

\[^70\] Because allocative efficiency is relevant only when prices are involved, it is also referred to as price efficiency in the literature.
Although Lau and Yoepoulos (1971) include both technical and allocative inefficiency, most of the work under this approach concentrates on the allocative portion of inefficiency, using a shadow price method for estimation (Sickles, 1986; Eakin and Kniesner, 1988; Evanoff et al., 1990). The implementation of this method is thus based on the concept of shadow prices. Recalling from Chapter 4, agents face distorted prices, which force agents to choose from a set of shadow prices. The parameter \( \lambda \), which represents the distorting factor in the model, measures the forces leading to allocative inefficiency.

Besides the existence of regulatory constraints, allocative inefficiency may occur because of managerial discretion and the existence of monopoly power. In this case, the optimality condition indicated for profit maximization may not be met even if there are no regulatory constraints. Inefficiency arises from the combined effect of expense-preference behavior and the presence of regulatory constraints. A complete mathematical explanation and implementation of the methodology used (methodology B) is included in Chapter 6. This implementation is based on the theoretical model of Chapter 4. Intuitively, the profit frontier that includes shadow prices instead of the prices without distortions is the shadow profit frontier. Although the firm maximizes shadow profits, these are non-observable. As a result, observable (actual) profits and netputs are expressed in terms of shadow profits to allow for the empirical analysis.

Actual netputs are derived from the shadow profit frontier (maximum profits given shadow prices) through Hotelling’s lemma.\(^{71}\) Actual profits can then be obtained by using the actual netput equations and the mathematical definitions of shares and profits, after some algebraic manipulations. Then, efficiency measures are determined by comparing actual to maximum profit levels.

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\(^{71}\) Since banks maximize under shadow prices, observed demands and supplies result from shadow profit maximization, minus the technical element (\( \phi \)).
Lovell and Sickles (1983), Eakin and Kniesner (1988) and Evanoff et al. (1990) have implemented this approach to measure allocative efficiency, but ignoring technical inefficiency. Recently, Berger et al. (1993a) and Atkinson and Cornwell (1995) implemented the shadow profit frontier technique while introducing both elements of efficiency, in line with the original work of Lau and Yotopoulos (1971).\footnote{The functional form in Berger et al. (1993a) is the Fuss profit function.} Apart from an allocative inefficiency term such as \( \lambda \), these models also include a technical inefficiency factor (\( \phi \)), added to actual shares. The technical parameter \( \phi \) is a scaling element that measures to what extent observed output (input) is less (more) than output (input) at the frontier.
CHAPTER 6
EMPIRICAL ESTIMATION

This chapter discusses the data and the econometric estimation of a profit frontier for the Dominican banking system using panel data.\textsuperscript{73} The sources of the data set are described and the limitations of the data are discussed. Financial inputs and outputs as well as non-financial inputs are defined. Each variable involved in the estimation process is represented by descriptive statistics for each year of the period.

Following the decomposition of the return-on-equity approach, a financial ratio analysis is completed as a preliminary step to the frontier estimation. This analysis is also carried out to shed light into the intra-group bank differences as well as inter-group differences.\textsuperscript{74} Because the data set is a panel of monthly observations, the data were annualized to calculate the yearly financial ratios. These yearly ratios were then averaged to get a set of ratios for the period. In Chapter 7, the partial financial ratio analysis will be compared to the more complete frontier estimations.\textsuperscript{75}

\textsuperscript{73} Although the main focus of this dissertation is the estimation of a profit frontier, a cost frontier estimation was also carried out to provide robustness to the efficiency estimates (See appendix A).

\textsuperscript{74} Since the universal banking rule is recent, the data on merged banks during the period is not sufficient to carry out the empirical estimation by bank groups, i.e., multibancos and non-multibancos. For lack of a better alternative, the classification of banks into types for illustration purposes considers as multibancos banks that merged at some point during the period. As a result, even banks that merged at the end of the period are considered as multibancos for this classification.

\textsuperscript{75} The financial ratio analysis is partial because it does not consider the multi-output and multi-input nature of banks.
Next, this Chapter includes a review of the relevant panel data model. The modeling process is also described, providing a mathematical definition of the components of inefficiency to be estimated. The process of econometric estimation is outlined and any estimation problems are reviewed.

6.1 Data sources and limitations

Monthly bank financial statements from January, 1991 to December, 1994 are available for commercial banks, some of which are multibancos. For 1991, however, data for June and December were not recorded systematically. Because of these missing observations, the data panel is unbalanced. In addition, as described in Chapter 3, the financial crisis of the late 1980s and regulatory interventions in the Dominican Republic left behind seven fragile institutions that eventually failed. Between 1991 and 1994, these seven commercial banks had been intervened by the Superintendency, liquidated, or were in process of liquidation. When this happens, there are missing observations in the data set, or observations are repeated from the previous period and reported as this period’s observation. Eventually, these banks had to be deleted from the analysis because they contributed more noise than information.

Indeed, there are large inconsistencies in the data for failed banks (Guilliani and Aristy, 1991; De Castro-Noba Muñoz, 1994). These banks were not offering services to the public but still reported unreliable financial statements to the Central Bank. Efforts to clean the data were not successful. In addition to these seven banks, Banco del Caribe had to be excluded from the estimation

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76 The use of monthly rather than yearly or quarterly data, besides increasing degrees of freedom, reduces noise of the estimation.

77 The efficiency estimation requires the definition of a dummy variable for each bank in the sample. Besides the fact that the available data on failed banks were not reliable they were also scarce. Efforts to keep those banks in the analysis were not successful.
process because it was an extreme outlier in the sample, and it drove estimation errors to figures of five digits versus errors of four digits without it. As estimated by Guilliani and Aristy (1991), this particular bank survived the crisis up to 1994, but it failed soon thereafter. Indeed, for Banco del Caribe the probability of failure for September 1990 was estimated to be 86 percent. The data set utilized for the estimation consisted of 472 monthly observations for 12 commercial banks, three of which are multibancos.

While the elimination of these observations was unavoidable, a selection bias, however, may be introduced. The bias arises because banks that failed are expected to be less efficient. This bias is not random and the estimation equation could have been corrected following the process outlined in Heckman (1976). Because the purpose of this dissertation is not prediction but the estimation of the relative efficiency of banks in the sample, however, this correction is not relevant.

For the period of analysis (1991-1994), Table 8 shows the number of commercial banks that failed or merged or that were suspended or liquidated in order to illustrate the irregularities of the data set. Not all banks remained inactive for the whole period. Some banks went under suspension, to recover later on and become active again, while others failed or merged. The first column in Table 8 shows the number of banks placed under suspension each year. The second column shows failed or merged banks from previous years plus banks that failed or merged in the current year. The last column shows a cumulative record of how many banks were inactive, per year.

Between 1991 and 1994, a total of seven commercial banks were not considered as active at some point or another. Of these, three commercial banks were placed under suspension in 1991, and one additional bank failed, for a total of four inactive banks. In 1993, those banks previously suspended started operations again but two other banks entered a process of liquidation and two additional banks were suspended. The two banks in liquidation since 1993 and a bank that failed in 1991 are counted as inactive in 1994. The total of different inactive banks adds to seven: three banks
suspended and one liquidated from 1991, plus two additional banks suspended in 1993, plus another bank that failed in 1993.

<table>
<thead>
<tr>
<th>Year</th>
<th>Suspended</th>
<th>Liquidated</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991</td>
<td>3</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>1992</td>
<td>0</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>1993</td>
<td>2</td>
<td>1+2</td>
<td>7</td>
</tr>
<tr>
<td>1994</td>
<td>0</td>
<td>1+2</td>
<td>7</td>
</tr>
</tbody>
</table>

Source: Data set provided by the Central Bank of the Dominican Republic. Total=total number of inactive banks (cumulative, without including banks that recovered in the period).

Table 8 Record of inactive commercial banks between 1991-1994.

Besides these banks, an additional bank (*Banco del Comercio*) exhibited larger data problems than the rest of the banks in the sample. This bank was kept in the sample for all the preliminary estimations of the model. The matrix of right-hand side variables in the model, however, was ill defined. That is, it was close to being singular, resulting in serious convergence problems (see Appendix B). Even in a model that does not consider allocative inefficiencies, which is linear in the parameters, the deficiencies of the data limited the estimation. Jennings and McKeown (1992) and Judge et al. (1988) discuss the empirical implications of near singularities. Models with this condition are very sensitive to the scaling of the variables, *i.e.*, when all the variables are expressed in similar magnitudes and, for instance, decimal values are not related to values of the order of three figures.

In order to evaluate the magnitude of the problem, the observations in the data set were visually analyzed for each bank, checking for outliers that would explain high standard deviations for some variables. Different problems were encountered. The first problem is related to the fact that
monthly flows are reported as accumulated figures so that each observation had to be transformed to obtain flows for each month. As reported in Nauriyal (1992), this type of problem results in some negative flows for some months, which are nonsensical.

When this was encountered, the figures were replaced by the average of the previous and following months, unless it was the first month of the year, in which case the following two months were averaged. The availability of additional (also accumulated and incomplete) quarterly data helped verify some of the observations and provided for more accurate figures than the average rule. The two data sets, however, come originally from the same source and share most of the problems. Similar to the Chilean experience explained in Nauriyal (1992), the period of analysis was subsequent to a financial crisis. Newer sets of regulations and prudential supervision measures forced banks to reduce the window dressing of the data, thus, resulting in inconsistencies with previous observations.

After correcting for this, inspection of the data indicated that some of the calculated model variables (prices and shares) ranged from one digit figures to three digit figures. By plotting each price for all banks, extreme outliers were spotted. The data on Banco del Comercio was particularly dispersed. Three additional outliers drove that result. Further, the erratic pattern of some of the observations made it difficult to estimate an alternative figure in many cases.

The remaining 12 banks did not exhibit as many problems and, when encountered, these problems were more manageable. The model was initially estimated with 13 banks.\footnote{The preliminary estimation for 13 banks resulted in almost identical bank rankings as in the model with 12 banks and most of the parameters were of similar sign. The omitted bank was always ranked last. Although this bank was not one of the failed banks, numerous persistent problems that prevailed during the period of analysis resulted in the temporary closing of the bank in March, 1996, to avoid a run on deposits. This bank is very large and probably “too big to fail.” The authorities took over the administration until it was sold in early 1997 to another bank.} Still, the non-linearities of the model together with the data problems did not allow for the estimation of the
allocative inefficiency parameters, even leading to negative R^2 for the estimation. Thus, the final model excluded this bank.

### 6.2 Bank outputs, inputs, and prices

Under the intermediation approach followed in this dissertation, banks in the Dominican Republic use financial inputs (deposits) and non-financial inputs (labor and fixed assets) to produce earning assets (Ei) as outputs (Figure 15). Following the rationale described in Chapter 4, investments in securities and loans are outputs. This choice of outputs is consistent with previous research on the banking industry. Indeed, loans as outputs are the only non-controversial variable, because most of the studies under the different approaches to the financial firm agree in classifying them as outputs (Benston, 1972; Sealy and Lindley, 1977; Berger et al., 1993a; Berg et al., 1993).

Despite the controversy on selecting bank inputs and outputs but in line with similar studies, financial inputs (Di), include demand deposits and other deposits: time deposits, savings deposits and non-deposit liabilities. Non-financial inputs (Xi) are the number of workers and physical capital (fixed assets). No matter how flexible the functional form is, the selection of inputs and outputs has to be parsimonious, to keep sufficient degrees of freedom. There are many parameters to estimate even for a few outputs and inputs, a reason why some aggregation is necessary.

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79 A negative R^2 results when the residual mean square error for the model is larger than the variance of the dependent variable (Sas/ets user’s guide). The model that excluded this bank did not encounter these problems. Further discussion on convergence issues having to do with collinearities in the data are presented in Appendix B.

80 In view of the problems encountered with the profit frontier, a cost frontier was also estimated to provide additional information that could be compared with the profit efficiency estimates. The estimation details are presented in Appendix A. A correlation analysis is presented in Chapter 7, relating bank rankings according to the profit frontier with rankings according to the cost frontier and financial ratios.

81 Input and output quantities are measured in value, except the number of workers.
The level of aggregation of outputs is critical because large numbers of outputs may lead to an unmanageable estimation, but more disaggregation allows for a better evaluation of economies of scope. Unfortunately, as it will become evident below, data limitations prohibited the estimation of sufficiently disaggregated output data to evaluate economies of scope. Moreover, with the lack of disaggregated data on loans of different terms to maturity—where economies of scope are expected to exist—the original intention of this dissertation to evaluate efficiency across commercial, development, and mortgage banks, which specialized in loans of different terms, became impossible.

The variables of the profit frontier are input and output prices and the quantity of fixed assets. The accounting monthly data are deflated using the 1980 consumer price index, to adjust for the impact of inflation. In principle, the required data on input and output prices should correspond to market prices. Since these data are seldom available, the consensus in the empirical research is to construct input and output prices from the data (Berger and Mester, 1997). Then, input and output
prices are proxied by an effective yield calculated as the ratio of monthly interest income or expense and the corresponding monthly balances. This yield may incorporate noise.

When calculating prices as effective yields, flow variables (income and expenses) are divided by the corresponding stock variables (balances as of the end of the month). Flow variables are loan interest income (LII), investment interest income (III), deposit interest expenses (DIE), and wage expenses (WAGE). Stock variables included in the model are net loans (NLOANS), investments (INV), total deposits (demand deposits and other deposits) (TD), fixed capital (FA), and number of workers (WN).

The dependent variable for the empirical model of the profit frontier is profits, measured as interest income minus the sum of interest expenses and wage expenses.\textsuperscript{82} For the cost frontier the dependent variable is cost measured as the sum of interest and wage expenses. For the cost frontier the prices of outputs used for the profit frontier are substituted by the corresponding quantities in real terms, but input prices are the same. Typically, the arguments of the cost frontier are input prices and the quantity of outputs. In order to compare the two frontiers, however, fixed assets were also included in the cost specification, as implemented by Berger and Mester (1997). Still, the typical specification without fixed assets is also estimated.

Table 9 presents a statistical description of relevant variables, illustrated for the representative commercial bank during each year of the period. All variables, except the number of workers, are expressed as monthly averages in thousands of constant Dominican pesos of 1984. The relevant variables are presented in pairs of balances and the corresponding flows utilized to calculate the prices for the model.

\textsuperscript{82} Even after deleting failed and two other banks from the data set further close examination of the data was required. There were a few negative observations (14) that were deleted from the pooled sample used for the empirical estimation.
<table>
<thead>
<tr>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>INV</td>
<td>7,002, 7,844</td>
<td>4,784, 7,645</td>
<td>7,106, 8,972</td>
<td>7,999, 7,034</td>
<td>7,635, 7,037</td>
</tr>
<tr>
<td>III</td>
<td>65, 139</td>
<td>51, 148</td>
<td>71, 165</td>
<td>74, 121</td>
<td>64, 115</td>
</tr>
<tr>
<td>NLOANS</td>
<td>126,243, 142,051</td>
<td>60,310, 70,787</td>
<td>113,109, 125,263</td>
<td>150,675, 153,424</td>
<td>165,627, 166,560</td>
</tr>
<tr>
<td>LII</td>
<td>3,146, 3,145</td>
<td>2,016, 2,197</td>
<td>2,877, 2,914</td>
<td>2,680, 3,471</td>
<td>3,782, 3,432</td>
</tr>
<tr>
<td>TD</td>
<td>197,892, 232,257</td>
<td>108,877, 184,948</td>
<td>193,196, 230,123</td>
<td>236,299, 260,073</td>
<td>233,626, 245,868</td>
</tr>
<tr>
<td>DIE</td>
<td>1,408, 1,168</td>
<td>996, 470</td>
<td>1,314, 1,092</td>
<td>1,693, 1,204</td>
<td>1,572, 1,141</td>
</tr>
<tr>
<td>FA</td>
<td>16,993, 16,993</td>
<td>9,061, 12,082</td>
<td>16,917, 23,244</td>
<td>19,153, 25,109</td>
<td>20,736, 26,291</td>
</tr>
<tr>
<td>WN</td>
<td>655, 22</td>
<td>540, 89</td>
<td>674, 37</td>
<td>663, 28</td>
<td>704, 82</td>
</tr>
<tr>
<td>WAGES</td>
<td>394, 488</td>
<td>242, 327</td>
<td>384, 479</td>
<td>442, 514</td>
<td>472, 544</td>
</tr>
<tr>
<td>PR</td>
<td>1,408, 1,758</td>
<td>829, 1,141</td>
<td>1,250, 1,609</td>
<td>1,619, 19,815</td>
<td>1,802, 1,950</td>
</tr>
<tr>
<td>N</td>
<td>472, 91</td>
<td>143, 100</td>
<td>138</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Mean values with the standard deviation below. The row labeled N includes the number of available banks. Values are in thousands of constant RD of 1984.

Table 9 Bank descriptive statistics during 1991-1994

124
Investments in securities are monthly balances for each bank. This classification pools different types of investments. The corresponding interest income includes income from all types of investments. In general, the components of investments are particularly important for the analysis of efficiency. Bank investments include different types of securities that are held to earn interest and help meet liquidity needs (Koch, 1992). These securities may vary in terms and interest earned. In the United States, for instance, short-term investments are usually time deposits due from other banks, federal funds sold, Treasury bills, repurchase agreements, and municipal tax warrants. They are very liquid because of the existence of a well-developed securities market. Long-term investments consist of Treasury notes and bonds that generate taxable or tax-exempt income. Banks in the United States, however, may not purchase corporate stock as investment.

In the Dominican Republic, investments are different. Although banks are allowed to buy stock as investment, most investments are composed of bonds from the Central Bank and time deposits due from other banks. In order to implement monetary policy, the Central bank uses government bonds as an instrument. Banks are encouraged to buy government bonds that may not offer competitive returns. As a result, these investments may be considered as an additional reserve requirement levied on the banks.

Moreover, the incipient stock market in the Dominican Republic does not provide for a source of bank liquidity. The alternative is to exchange favors among banks by issuing bonds to other banks when facing liquidity needs. For the bank that issues these bonds, the return is not as significant as is the opportunity to use the same mechanism when it has liquidity needs. Under this setting, investments may, thus, not be considered as traditional outputs.83

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83 This issue became relevant in the estimation of a profit frontier where investment prices were found to have a negative effect on profits. This result is consistent with the Camacho (1990) findings. In choosing between alternative models, Camacho (1990) excluded this variable for its lack of statistical importance. The model presented here is highly non-linear and was not stable when the variable was excluded. As a result, the empirical results are reported including
Net loans are monthly balances outstanding of credit to the private sector, net of interbank credit. Loans include credit to different sectors of the economy such as agriculture and commerce. The available data on interest income on loans correspond to interest earnings from loans at all terms to maturity. Commissions and other charges were also included as part of the revenues from loans.

Although the data on net credit were available by term, the corresponding interest income was provided as the aggregate for all terms to maturity. Had interest income been available by term, the analysis would have included further differentiation among outputs. This data constraint limits the analysis of economies of scope significantly. Diversification benefits derived from multibanco activities are expected to arise from providing short- medium- and long-term loans under the same roof. Pooling loans into an aggregate, thus, eliminates the possibility of evaluating economies of scope.84

On the input side, the models include deposits as the financial input, and labor as the non-financial input. Total deposits pool demand deposits and other deposits. Demand deposits comprise monthly balances of checking accounts. The category of other deposits pools monthly balances of savings deposits, term deposits and other non-deposit liabilities. Interest expenses are the flow of expenses paid in interest to depositors. This monthly flow was aggregated and not available by type of deposits. Since total deposits pool deposits of different terms to maturity and different returns, it would have been better to carried out the analysis using disaggregated data, which were not available for interest expenses.

Still, the analysis takes into consideration that the categories of deposits within total deposits are subject to different reserve requirements. An index was calculated for the reserve requirement of investments.

84 In the absence of the required data, the existence of economies of scope may in principle be evaluated between investment and aggregate loans. Nevertheless, investments are not a typical output and synergies between these products are not expected. They are not evaluated here.
total deposits taking into account the proportion of each type of deposits in the total (Table 10). The resulting reserve requirement (RR_{td}) is a weighted average for the different deposit types, weighted by the proportion of the amount of each type of deposit to total deposits. Differences among reserve requirements are more relevant in 1991, when demand deposits were subject to 40 percent, savings and time deposits to 30 percent, financial certificates to 20 percent, and non-deposit liabilities to zero percent (see Chapter 3). After 1992, the reform brought about the unification of reserve requirements to 20 percent for all types of deposits, but there are no requirements for non-deposit liabilities.

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>DD/TD</td>
<td>29.3</td>
<td>27.5</td>
<td>26.6</td>
<td>25.7</td>
</tr>
<tr>
<td>OD/TD</td>
<td>70.6</td>
<td>72.5</td>
<td>73.4</td>
<td>74.3</td>
</tr>
<tr>
<td>RR_{dd}</td>
<td>40</td>
<td>20</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>RR_{od}</td>
<td>23.2</td>
<td>16.8</td>
<td>17.4</td>
<td>17.4</td>
</tr>
<tr>
<td>RR_{td}</td>
<td>28.3</td>
<td>17.8</td>
<td>18.2</td>
<td>18.1</td>
</tr>
</tbody>
</table>

Percentages calculated from the data set with yearly averages of monthly observations.

RR_{td} = Reserve requirement on demand deposits.
RR_{od} = Reserve requirement on other deposits accounting for liabilities not subject to reserve requirements.
RR_{td} = (RR_{dd}*(DD/TD)+RR_{od}*(OD/TD))/100.

Table 10 Calculated yearly average reserve requirements for the sample.

After 1991, the difference between the 20 percent required for all deposits and the RR_{td} in Table 10 indicates the effect of non-deposit liabilities. These non-deposit liabilities are mostly
rediscout funds from the Central bank, which have decreased as a proportion of other deposits since 1992, and the RR$_{od}$ for 1993 and 1994 are larger.\footnote{Although not evident from the rounded figures, the percentage for 1994 is slightly lower (18.08) than the percentage for 1993 (18.18). For 1991, the proportion of rediscout liabilities cannot be derived from the difference between RR$_{od}$ and the 30 percent rate of savings and time deposits. This is the case because financial certificates, which are also included in other deposits, were required a lower rate of 10 percent.}

Demand deposits as a proportion of total liabilities provide additional information for the analysis of mergers. The traditional merger literature discussed in Piloff and Santomero (1997) suggests that merged banks will experience an increase in the number of bank costumers simply through the addition of newly acquired assets and deposits. Nevertheless, mutibancos that are closely related to grupos are not expected to increase their costumer pool as much as other mergers because they might have been sharing costumers already with the development bank and the mortgage bank of the originating grupo. Demand deposits are also less likely to increase, because the only type of bank that could offer demand deposits was the commercial bank and only one commercial bank is part of each mutibanco. Still, since some of the grupo costumers may not have been costumers of the commercial bank, the resulting mutibanco gain more costumers.

The non-financial input of the model is the number of workers. Numbers of workers are reported monthly to the Central Bank. Sometimes banks do not send these figures for a given month, so that reported figures are equal to those for the previous month. Some banks even report averages for several months instead of the actual figures. Therefore, there is little variation in the number of workers for some months. The variable is included in the analysis to avoid large reductions in the number of observations.

Moreover, since the data are not classified into skilled and not skilled labor, the number of workers may not change but the composition of the pool of workers is likely to be different. Guilliani and Aristy (1991) discussed the high turn-over ratio of managers in the banking sector as of 1991,
which resulted from the lack of qualified personnel. Before the boom of emerging banks during the 1980s, only a few banks operated, and they faced little competition. Many of these banks were government-owned banks or subsidiaries of foreign banks. As competition rose, when more private banks entered the market, many banks did not train their personnel to deal with tighter competition. Guilliani and Aristy (1991) documented that, after the boom, banks had to compete for the relatively few qualified workers. This resulted in a high turn-over ratio for managers. Banks had some time to adapt to these changes, however, and as of 1994 trained personnel may not be as scarce, as of 1994.

Mergers are expected to result in reductions in worker expenses. These reductions arise if redundant personnel are eliminated. Table 11 shows the yearly rate of growth in the number of workers and of wages expenses for each multibanco. The number of workers at multibancos increased during the year of the merger but decreased the following year.

<table>
<thead>
<tr>
<th></th>
<th>First Multibanco</th>
<th>Second Multibanco</th>
<th>Third Multibanco</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>WN</td>
<td>WAGES</td>
<td>WN</td>
</tr>
<tr>
<td>1991</td>
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<td>1992</td>
<td>68</td>
<td>56</td>
<td>7</td>
</tr>
<tr>
<td>1993</td>
<td>107</td>
<td>87</td>
<td>42</td>
</tr>
<tr>
<td>1994</td>
<td>13</td>
<td>14</td>
<td>-3</td>
</tr>
</tbody>
</table>


Table 11 Yearly rate of growth in the number of workers and real wages expenses of each multibanco (Percentages)
In general, average real wages per worker increased throughout the period, as wage expenses grew at a higher pace than the number of workers. This result may have to do with the composition of the pool of workers, which now includes more skilled personnel.

In addition to outputs, variable inputs the model includes the level of fixed capital as the fixed asset of the model. Fixed capital includes real estate assets, furniture, and equipment as monthly balances. This is the accounting value of fixed capital instead of its market value, because of lack of data. Fixed assets are an important variable in the Dominican system since banks increased fixed assets dramatically during inflationary times. Guilliani and Aristy (1991) indicated that failed banks had large liquidity problems resulting from increases in fixed capital investments in the late 1980s.

6.3 Profits

Profits are the dependent variable of the model and are calculated as total income minus total expenses, expressed in constant Dominican pesos of 1984. Total income is the sum of loan interest income, investment interest income, deposit interest income, commissions and other income. Expenses add administrative costs, deposit interest expenses, and commissions and other expenses. Average monthly profits for commercial banks increased 2.3 times between 1991 and 1994, from RD$800 thousands to RD$1,800 thousands (Table 9). Since profits are income minus expenses, separating the effect on profits into income and expense items is useful. The following analysis of financial profitability ratios decomposes these ratios into their income and expense components.86

86 The financial ratio analysis, although partial in nature, offers information on these differences. A more complete identification of the sources of profit differences is achieved through the frontier analysis. In Chapter 7, the efficiency rankings from the financial ratio analysis will be compared to the rankings from the frontier analysis.

130
6.4 Profitability ratios: ROE and ROA

Bank performance is usually summarized by two main financial ratios: return on equity (ROE) and return on assets (ROA). It is important, however, to decompose the two aggregate measures of profitability into their determinants to provide more precise information about bank performance. The decomposition of ROE described in identity (33) relates ROE to ROA and financial leverage. ROA is further decomposed into its components. This decomposition is used to analyze bank profitability, and it identifies specific measures of credit risk, liquidity risk, operational risk, and capital risk (Koch, 1992).

\[
ROE = \frac{Net\ income}{Total\ equity}
\]

\[
ROE = \frac{Net\ income \times Total\ assets}{Total\ assets \times Total\ equity} = ROA \times EM
\]  

where EM stands for equity multiplier. Bank EM ratios compare assets to equity indicating the proportion of debt financing relative to capital.\(^{87}\) Equity multipliers measure the financial leverage of banks. Financial leverage refers to the use of debt paying fixed rates as part of a firm’s capital structure (Koch, 1992).

\(^{87}\) Because of the accounting identity of total assets equal to liabilities plus equity, a large proportion of total assets to equity indicates a lower proportion of liabilities (debt) to equity. Then, the greater the asset-to-equity ratio (EM), the more debt there is in the capital structure of banks.
The financial leverage of banks is a relevant variable for prudential regulation to evaluate the capital risk position of banks.\textsuperscript{88} Koch (1988) discusses that this ratio indicates both a profit and a risk measure. High EM raises ROE when net income is positive but it also increases capital risk. The inverse of the EM ratio, the ratio of total equity to total assets, will be larger for a bank with a less risky position. That is, the bank with a larger equity-to-assets ratio can potentially have more assets in default and still be solvent.

Generally, banks will tend to increase their leverage ratios to earn higher but riskier profits. Capital adequacy restrictions that control the size of these ratios become relevant to reduce the risk involved in too high EM ratios. In order to provide for a general rule of what is “too high,” international standards have been established. Still, capital adequacy restrictions may vary from one country to another. In the Dominican Republic, the new Code established a standard EM ratio of 10 percent.

The next step in the decomposition of ROE is to further decompose ROA into the profit margin (PM) element that relates to the expense side of ROA and the asset utilization (AU) element that relates to the income side of ROA.

\[
ROA = PM \times AU
\]

\[
= \frac{\text{Net income}}{\text{Total operating income}} \times \frac{\text{Total operating income}}{\text{Total assets}}
\]

(34)

where net income equals total operating income minus expenses, and total operating income includes interest and non-interest income. The PM ratio measures the ability of banks to control expenses.

\textsuperscript{88} As described in Chapter 3, capital risks are related to the risk of banks becoming insolvent, \textit{i.e.}, when they have negative equity. In contrast, an illiquid bank faces a timing problem. That is, the bank could have the assets to fulfill payments, but if these assets cannot be transformed into cash fast enough, this illiquid bank will not be able to meet its costumers’ demands on time.
Interest expense differences across banks are related to rate effects, composition effects, and volume effect (Kohl, 1992). Expenses are higher for banks with higher interest costs per liability. These higher costs, however, may be the result of using longer-term deposits instead of short-term deposits since longer terms usually involve higher rates (rate effects).

The composition of liabilities also affects interest expenses. Banks with larger proportions of demand deposits to total deposits have lower interest expenses because demand deposits pay no interest (composition effect). In addition, interest expenses may be higher when a particular bank deals with larger amounts of debt. Then, banks with higher EM ratios will tend to have higher expense ratios (volume effect).

Table 12 shows rankings of the banks according to ratios that were calculated for the 1991-1994 period. Before calculating these financial ratios, the monthly data were annualized for each bank. The annual flow variables were taken as the accumulated flow as of the end of the year. In some cases, the data for December were not available either from the data set or from additional quarterly data and the November figure was used instead. For stock variables, the average for the year was calculated, to provide equal weights to all the months. The averages were taken over the number of observations available for each bank per year. Calculated yearly financial ratios were averaged for each bank to get individual financial ratios for the period.

The average individual ratios were then ranked. Banks ranked with number 1 had the best ratio and banks with the worse ratio were ranked with number 12. For instance, the bank with the highest ROE of the period was ranked as number 1. Banks with higher ROA, PM and AU ratios were ranked with lower numbers. Banks with higher EM ratios were ranked with lower numbers, so that higher EM refer to banks with a higher proportion of debt financing.
When ranking banks with respect to the banks at the median (banks ranked 6 and 7), two of three multibancos exhibit lower average PM ratios than other banks (Table 12).\(^{89}\) These same two banks (banks 12 and 13) showed higher average EM ratios. In contrast, bank number 15, the remaining (and oldest) multibanco, was ranked below the median for its average EM ratio, and it showed a higher average PM ratio.

In terms of AU ratios, multibancos exhibited an outstanding performance relative to non-multibancos. Differences in AU can also be related to rate, composition, and volume effects. Rate effects are reflected in different returns on loans. In general, longer-term loans earn higher yields that short-term loans. Then, banks could undertake riskier but also more profitable lending activities, **ceteris paribus**, which result in a better AU ranking.\(^{90}\) The composition of the portfolio will also affect the AU ratio. Regarding volume effects, a large earnings base defined as the proportion of earning assets to total assets will yield higher returns.

\(^{89}\) The fourth multibanco, which was not included in the final empirical analysis, could barely be classified as a multibanco because it did not start merged operations until October 1994. Since it had to be excluded from the frontier model, this bank is not presented in the financial ratio analysis. Still, in preliminary versions of the model and when calculating its financial ratios, this bank was generally ranked the lowest. The efficiency frontier rankings of banks including this bank were almost identical to the rankings shown here. The estimation problem was related to the \(\lambda\)s, as described above.

\(^{90}\) The supervisory agency, however, has to deal with the fact that the more profitable returns for banks are related to higher risks.
<table>
<thead>
<tr>
<th>Bank</th>
<th>ROE</th>
<th>EM</th>
<th>ROA</th>
<th>PM</th>
<th>AU</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10</td>
<td>4</td>
<td>11</td>
<td>7</td>
<td>12</td>
</tr>
<tr>
<td>2</td>
<td>7</td>
<td>5</td>
<td>8</td>
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<td>11</td>
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<td>3</td>
<td>2</td>
<td>9</td>
<td>1</td>
<td>1</td>
<td>4</td>
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<tr>
<td>4</td>
<td>8</td>
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</tr>
<tr>
<td>12*</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>13*</td>
<td>6</td>
<td>6</td>
<td>7</td>
<td>9</td>
<td>3</td>
</tr>
<tr>
<td>15*</td>
<td>4</td>
<td>8</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>19</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>20</td>
<td>11</td>
<td>12</td>
<td>5</td>
<td>6</td>
<td>6</td>
</tr>
</tbody>
</table>

*multibancos*

Table 12 Average ranking of all banks during 1991-1994
In aggregate terms, the ROE ratios of *multibancos* were ranked at or above the median. These rankings result from having higher ROA ratios that compensate for not as high EM for at least one bank. Overall, all five ratios indicate a better performance for *multibancos* with respect to *non-multibancos*. Since banks were classified as *multibancos* depending on whether they merged at some point during the period, however, average rankings from the period for *multibancos* include periods when these banks had not yet merged. These rankings represent only the average tendency of those banks with respect to their peers.

### 6.5 Mergers: profitability ratios by year

Due to data limitations, the frontier analysis estimates average efficiencies for the whole period. The financial analysis was also carried out by calculating the average of yearly ratios as the representative ratio for the period. Table 13 shows, however, the changes in the yearly rankings of *multibancos* with respect to all banks in the sample according to yearly financial ratios, to illustrate the changes of the financial ratios of these banks before and after the merger. A closer observation of the financial ratios of *multibancos* is consistent with the most recent trend of studies in the literature of mergers that was discussed in Chapter 4.

A number of efficiency studies have not been able to find sufficient evidence of the value gains of mergers when analyzed as a group. Piloff and Santomero (1997) concluded that a more realistic and successful method is to study each merged bank individually, evaluating the extent to which new management plans were designed and are being implemented. Indeed, even if value gains from mergers were not found on average, the literature found a large variation among the gains for individual merged banks. Some banks may be more successful at designing and implementing new strategies. The learning process of the development and implementation of these strategies, however, is not costless.
The theory of mergers discussed in Chapter 4 states that merged banks are able to increase levels of lending, which are risky but profitable activities without increases in capital (Pilloff and Santomero, 1997). That is, EM ratios are not expected to decrease after the merge. After the first merger effective January, 1993, however, Table 13 shows that the banks that eventually merged decreased their leverage. This result is reflecting a higher capital required for the merger not immediately followed by increased deposits.

<table>
<thead>
<tr>
<th></th>
<th>First Multibanco</th>
<th>Second Multibanco</th>
<th>Third Multibanco</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROE</td>
<td>3,3,7,8</td>
<td>6,1,11,5</td>
<td>4,2,2,3</td>
</tr>
<tr>
<td>EM</td>
<td>5,8,8,9</td>
<td>8,4,6,6</td>
<td>2,3,2,5</td>
</tr>
<tr>
<td>ROA</td>
<td>3,1,4,6</td>
<td>4,3,11,8</td>
<td>6,4,3,5</td>
</tr>
<tr>
<td>PM</td>
<td>3,2,7,6</td>
<td>8,9,6,11</td>
<td>7,6,8,9</td>
</tr>
<tr>
<td>AU</td>
<td>4,3,3,7</td>
<td>2,1,12,4</td>
<td>3,4,2,2</td>
</tr>
</tbody>
</table>

Figures in bold indicate the years when the banks were already multibancos at least for part of the year.

Table 13  Ranking of multibancos for 1991, 1992, 1993, and 1994 with respect to the median bank

In general, ranked by ROE and ROA ratios the multibancos have not performed as well as before the merger. Still, when ranked with respect to the banks at the median (banks ranked 6 and 7), the second and third multibancos exhibit ROE ratios above the median after the merge, and the first and third multibancos exhibit higher ROA ratios. The rankings according to PM ratios was worse
after the merger. Since PM ratios are an indicator of the control that banks have over expenses, a lower PM ratio for multibancos may reflect the fact that these banks are in the transition period were merger costs are still high. In informal interviews, this period has been estimated to last at least a year. In fact, the rankings show that for the case of the first multibanco, which is the only bank that had been merged for two full years, the rank of the PM ratio improved in the last merged year (ranked 6) with respect to the first year of the merge (ranked 7).

Regarding AU ratios, the outstanding average AU ratios that were presented in Table 12 for all multibancos -- ranked 5, 3, and 2, for the first, second, and third multibancos-- are consistent with generally higher yearly AU ratios, even after the merge (Table 13). These banks are earning higher operating incomes that other banks.

6.6 Advantages of panel data

The great power of panel data is in isolating individual effects of certain actions and policies, by specifying parameters that vary over individuals and over time. The simple regression model in (35) is an illustration of a panel data model. For the model, $Y_{it}$ is the value of the dependent variable, $X_{kit}$ is the value of the $k$ exogenous variables, and $e_{it}$ is the error term, all three terms for the $i^{th}$ individual at time $t$. The parameters $\beta_{kit}$ may be different across individuals and across time:

$$Y_{it} = \beta_{1it} + \sum_{k=2}^{K} \beta_{kit}X_{kit} + e_{it}$$

$i=1, \ldots, N$ cross-sectional units

$t=1, \ldots, T$ time periods

(35)
Panel or longitudinal data are cross-sections of a given sample of individual units over time. The additional data allow for the estimation of more realistic models than cross-sectional or time series alone, by providing for multiple observations on the same individual units. The use of panel data increases the degrees of freedom in the econometric estimation of empirical models, which increases the efficiency of estimators. Also, panel data allow for the estimation of more complicated behavioral models than could be achieved with either cross-sectional data or with time series (Hsiao, 1986).

Schmidt and Sickles (1984) stated potential advantages of using panel data to estimate efficiency frontiers. Shortcomings from the use of cross-sectional data can be classified into three types. The first shortcoming relates to the fact that, although a firm-specific technical inefficiency parameter can be estimated by using the composed error-term model, the estimation is not consistent. In contrast, the error term can be consistently estimated using the composed error-term model, but the issue of the separation of inefficiency from random noise remains (Jondrow et al., 1982).

Second, as described in Chapter 5, distributional assumptions on the error term and on the inefficiency component are required for the estimation. The difficulty of determining the adequate distributional assumption was discussed on occasion of analyzing the distributional assumptions needed for the estimation of inefficiency using the composed error-term model in Chapter 5. Since the choice of distribution is arbitrary, an approach using panel data, which avoids such assumptions, may be useful.

The third difficulty that affects cross-sectional data models is the assumption of inefficiency being orthogonal to the regressors (Greene, 1993). Panel data can potentially solve these problems. Depending upon which assumption one is to target, there are a variety of panel data models that can be implemented.
6.7 Fixed-effect versus random coefficient models

Models involve different assumptions about the $\beta_{xt}$ in (35). Consider the $\beta_{1xt}$ as the intercept and the other $\beta_{xt}$ as slope parameters. Depending upon whether these sets vary over individual units and/or over time, the panel data model will be specified differently. The most general case is to have all the coefficients vary over time and over individual units. An alternative specification may be to have the intercept vary only over individual units, while the slope coefficients vary over individual units and time, or any other combination (Judge et al., 1985).

Further, there are mainly two ways to pool time series and cross-sectional data into panel data depending upon the nature of varying coefficients (constant term and/or slope coefficients). That is, if the coefficients are assumed to be fixed or random, the appropriate panel data model is a fixed-effect or a random-effect model, respectively. The choice between models is not straightforward because a trade-off is involved. While the assumption of fixed effects may not be plausible under some circumstances, the implementation of the random-effect model, also known as the error-component model, requires an assumption about the distribution of the random parameters.\footnote{The error-component model should not be mistaken for the efficiency methodology described in Chapter 5 as the composed-error term (methodology A), for they are not synonymous. A composed-error term model can be estimated with a panel data error-component model.}

The use of the error-component estimator hinges upon the correctness of the distributional assumption and on whether the coefficients are expected to be related to the regressors. If the later is true, the fixed-effect model is preferred because the error-component estimator will be biased much like it is the case with an omitted variable misspecification (Judge et al., 1985). In turn, if time invariant variables are regressors, the use of dummy variables characteristic of the fixed-effect model will not allow for the identification of such elements.

As a result, for the empirical estimation of the efficiency frontiers, the fixed-effect model is preferred if inefficiency is expected to be related to the regressors. The empirical model treats
inefficiency as fixed effects instead of random effects.\footnote{The choice between fixed effects or random effects has been subject to extensive discussion (Judge et al., 1988; Hsiao, 1986). Since the fixed-effects model is used to make inferences conditional on the effects that are in the sample, it is preferred. The empirical model calculate relative efficiency for the banks in the sample. Thus, the fixed-effect model is an adequate specification because inferences are only relevant for the banks in the sample. Moreover, the greater difference between the two specifications occurs when $N$ is large and $T$ is very small. The contrary is true for the Dominican sample.} Then, for example, the inefficiency term $U_t$ in equation (32) in Chapter 5 is fixed and it does not vary over time but only over individual units. It can be estimated as the intercept of the equation like in the panel-data fixed-effect model. If the number of firms is small, one dummy variable is introduced for each firm. Otherwise, the within estimator can be estimated without assuming that the fixed effect (inefficiency) is not related to the regressors (Mundlak, 1978).

The within estimator (36) is equivalent to the dummy variable model (fixed-effect) but more convenient for the estimation of a model with many firms, for which the introduction of $N$ dummy variables may be cumbersome. It uses a transformed version of the model where variables are deviations from their means. The name of “within” comes from the fact that this model uses the variation within each individual unit to get the estimators. The within model is given by:

\[
(Y_u - \bar{Y}_t) = \sum_{c=2}^{C} \beta_{ct} (X_{ctu} - \bar{X}_{ct}) + \epsilon_{ut} - \frac{\sum_{t=1}^{T} \epsilon_{ut}}{T}
\]

for,

\[
\bar{Y}_t = \frac{\sum_{t=1}^{T} Y_u}{T}
\]

\[\text{(36)}\]

6.8 Modeling process

The empirical model estimates and compares efficiency derived from both a profit frontier and a cost frontier. The model will be discussed in terms of the profit frontier, leaving a summarized
discussion of the cost frontier to Appendix A. In terms of the traditional panel data literature, technical inefficiency is estimated through varying intercepts that are individual-specific, and allocative inefficiency is estimated through varying slope coefficients that are netput specific. These allocative inefficiencies will reflect the average effect of regulation on the banks in the sample.

6.8.1 Functional form

The first set of studies that used a profit frontier instead of cost/revenue frontiers assumed the Cobb-Douglas as the arbitrary profit frontier (Yotopoulos and Lau, 1971). This selection was due to the simplicity of this functional form, but with the high cost of being too restrictive with respect to the substitution between inputs and outputs. A series of studies followed, using more general functional forms. The translog function seems to be more appropriate as it is less restrictive.

The choice of functional form from a set of theoretically plausible models is an empirical question that depends largely on the specific estimation objectives (Chambers, 1988). Because of its flexibility, the translog function is employed for the study of the Dominican financial system. This is a widely used functional form that was implemented in Camacho (1990). Moreover, Berger and Mester (1997) evaluated the effect of using a Fourier specification to evaluate bank efficiency, which includes the translog as a special case compared to the translog implementation. Their findings indicated that the implementation of a translog form resulted in small differences in average efficiencies and very little difference in efficiency dispersion or bank ranks.

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93 One of the data problems encountered with failed banks was the existence of several negative profit values in the data, which cannot be handled by a translog function. The empirical solution is to transform the data through ad-hoc methods. Berger and Mester (1997) transformed profit data using: \( \ln(\pi) = \ln(\pi_{\text{max}}) \cdot \frac{\pi + 1 - |\pi_{\text{min}}|}{|\pi_{\text{min}}|} \), where \( |\pi_{\text{min}}| \) is the absolute value of the largest negative profits in the data set. Since failed banks were not considered in the final empirical estimation, this problem did not become an issue. The fact that for failed banks numerous observations involved negative profits, however, is not the most important limitation. Indeed, the lack of confidence in the inconsistent data reported by these banks posed a greater constraint.
The translog profit function is represented in the following set of equations, where $P_j$ stands for prices of both inputs and outputs and $z$ stands for fixed inputs:

$$\ln \pi_i^* = \alpha_0 + \sum_{j=1}^{J-1} \alpha_j \ln P_j + \frac{1}{2} \sum_{j=1}^{J-1} \sum_{l=1}^{J-1} \alpha_{jl} \ln P_j \ln P_l + \alpha_z \ln z + \sum_{j=1}^{J-1} \gamma_j \ln P_j \ln z + \gamma_z \ln z^2$$  \hspace{1cm} (37)

The usual regularity restrictions are imposed: $\alpha_j = \alpha_z$ to satisfy symmetry; for equality to hold, the price parameters of the profit function are the same as in the share equations obtained through Hotelling's lemma. These equations are shares because the profit function is expressed in logarithm form so that its derivative with respect to the logarithm of prices is equivalent to $[(p_j^* q_j^*)/\pi_i^*]$, or the share of profits from the $j^{th}$ netput over total profits, namely:

$$s_{jt}^* = \frac{\partial \ln \pi_i^*}{\partial \ln P_j} = \alpha_j + \sum_{l=1}^{J-1} \alpha_{jl} \ln P_l + \gamma_j \ln z$$  \hspace{1cm} (38)

6.8.2 Frontier efficiency

Implementation of the model starts from the shadow profit frontier described in Chapter 4. If agents maximize shadow instead of actual profits, they will be away from the unconstrained optimum. Besides regulatory constraints, shadow prices may diverge from actual prices for other reasons such as expense preference behavior by bank managers. The net effect of regulation and non-profit maximizing behavior can be measured by the divergence parameter $\lambda$ under a restricted profit maximization model.

Restricted optimization models have been implemented for either cost or profit functions (see Table 14). Atkinson and Halvorsen (1984), Evanoff et al. (1990), Kumbhakar and Bhattacharyya.
(1992), Atkinson and Cornwell (1994 and 1995) evaluate a single-output firm. While the last three studies estimate allocative and technical inefficiency, the first two assume technical efficiency in order to concentrate on the estimation of allocative inefficiency. Atkinson and Halvorsen (1990) also concentrate on allocative inefficiency but their model considers a multi-output firm.

Berger et al. (1993a) estimate both components of inefficiency for a multi-output banking firm. They estimate a profit frontier using a Fuss functional form instead of the most familiar translog. Berger et al. (1993a), Atkinson and Cornwell (1994), and Atkinson and Cornwell (1995) use panel data but only the later estimate firm-specific allocative parameters. Another difference between these studies is that Berger et al. (1993a) study multi-output banking firms while the other two studies estimate inefficiency for single-output airline firms.

The model that follows includes multiple inputs and multiple outputs, and it estimates both technical and allocative inefficiency. In addition, the data set is a panel of cross-section and times series allowing for price efficiency parameters that are bank-specific, unlike the data set used in Atkinson and Halvorsen (1984 and 1990) and Kumbhakar and Bhattacharyya (1992).
<table>
<thead>
<tr>
<th>Authors</th>
<th>Frontier</th>
<th>Efficiency Measures</th>
<th>Outputs</th>
<th>Functional Form</th>
<th>Data Set</th>
<th>Industry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atkinson and Halvorsen (1984)</td>
<td>profit</td>
<td>price</td>
<td>single</td>
<td>translog</td>
<td>cross-section</td>
<td>regulated utilities</td>
</tr>
<tr>
<td>Atkinson and Halvorsen (1990)</td>
<td>profit</td>
<td>price</td>
<td>multiple</td>
<td>translog</td>
<td>cross-section</td>
<td>regulated utilities</td>
</tr>
<tr>
<td>Evanoff et al. (1990)</td>
<td>cost</td>
<td>price, technical and scale</td>
<td>single</td>
<td>translog</td>
<td>panel</td>
<td>banking</td>
</tr>
<tr>
<td>Kumbhakar and Bhattacharyya (1992)</td>
<td>profit</td>
<td>price</td>
<td>single</td>
<td>translog</td>
<td>cross-section</td>
<td>Indian agriculture</td>
</tr>
<tr>
<td>Berger et al. (1993a)</td>
<td>profit</td>
<td>price and technical</td>
<td>multiple</td>
<td>Fuss</td>
<td>panel</td>
<td>banking</td>
</tr>
<tr>
<td>Atkinson and Cornwell (1994)</td>
<td>cost</td>
<td>price and technical</td>
<td>single</td>
<td>translog</td>
<td>panel</td>
<td>airline</td>
</tr>
<tr>
<td>Atkinson and Cornwell (1995)</td>
<td>cost and profit</td>
<td>price, technical and scale</td>
<td>single</td>
<td>translog</td>
<td>panel</td>
<td>airline</td>
</tr>
</tbody>
</table>

1 Although Atkinson and Cornwell (1995) modelled both cost and profit frontiers at the theoretical level, the empirical estimation was limited to a cost frontier.

Table 14 Applications of the Shadow Price Method.
The profit function equation (37) is modified to account for the possibility of allocative inefficiency. The resulting shadow profit function and shadow share equations are:

\[
\ln \pi^{f}_{i} = \alpha_{0} + \sum_{j=1}^{J} \alpha_{j} \ln \lambda_{j} P_{n}^{j} + \frac{1}{2} \sum_{j=1}^{J} \sum_{l=1}^{J} \alpha_{j l} \ln \lambda_{j} P_{n}^{j} \ln \lambda_{l} P_{n}^{l} + \alpha_{z} \ln z + \sum_{j=1}^{J} \gamma_{j} \ln \lambda_{j} P_{n}^{j} \ln z + \gamma_{z} \ln z^{2}
\]

\[
s^{s}_{j l} = \frac{\delta \ln \pi^{f}_{i}}{\delta \ln \lambda_{j} P_{n}^{j}} = \alpha_{j} + \sum_{l=1}^{J} \alpha_{j l} \ln \lambda_{l} P_{n}^{l} + \gamma_{j} \ln z
\]  

(39)  

(40)

Recalling from Chapter 4, translog actual profits in terms of shadow profits are:

\[
\ln \Pi^{s}_{i} = \ln \Pi^{f}_{i} + \ln M
\]

\[
\text{for } M = [1 + \sum_{j=1}^{m} \frac{(1-\lambda_{j}) S^{s}_{j}}{\lambda_{j}} - \sum_{j=m+1}^{J} \frac{(1-\lambda_{j}) S^{s}_{j}}{\lambda_{j}}]
\]

(41)

In turn, actual shares in terms of shadow shares are:

\[
S^{a}_{j l} = \frac{S^{s}_{j l}}{\lambda_{j} M}
\]

(42)

\[
\text{for } j=1, \ldots, J-1
\]

\[94\] For the case of the last netput \( \lambda_{J} = 1 \) by assumption, which implies that the shadow price and actual price of this netput are the same. Since the profit frontier is linear homogeneous in netput prices, absolute \( \lambda_{j} \) cannot be estimated. The estimates are then relative measures. The choice of the normalization netput is arbitrary. In order to compare allocative inefficiency estimates from the profit frontier and the cost frontier, however, an input instead of an output most be chosen as the numéraire because output prices do not enter into the cost frontier.
The empirical model consists of the logarithm of actual profits in terms of shadow profits (41) and of a set of share equations similar to (42). Yet, thus far the model has not considered technical inefficiency. A technical inefficiency parameter \( \phi_j \) can be introduced in the profit function. The resulting observed profits are actual profits (41) minus the technical efficiency factor \( \phi \), which reduces profits to:

\[
\ln \Pi_i^* = \ln \Pi_i + \ln M - \phi_i
\]

(43)

where both the allocative inefficiency component \( \lambda_b \) embedded in the \( \Pi_i \) and \( \Pi_i^* \) and the technical inefficiency component \( \phi_i \) are as defined in Chapter 5, and they are treated here as fixed-effect components, as is commonly done in the panel data literature.

For estimation purposes, two error terms are added to the system formed by the logarithm of observed profits (43) and the set of share equations (42). Inefficiency is incorporated parametrically in this model through the assumption of shadow profit maximization (allocative inefficiency) and the scaling factor (technical inefficiency) so that the remaining error term is indeed the classical error once freed of the inefficiency components (Atkinson and Cornwell, 1994).

Total allocative inefficiency (TAI) is measured as the loss of profits that is due to the existence of shadow prices that diverge from actual prices. This is equivalent to the difference between actual profits evaluated at \( \lambda = 1 \) (shadow prices equal to actual prices) minus actual profits including the allocative distortion \( \lambda \).

\[
\text{TAI} = \ln \pi_i \| (\lambda = 1) - \ln \pi_i \| (\lambda)
\]

(44)
Total technical inefficiency (TTI) is the loss of profits due to a technical factor $\phi$. This is equivalent to the difference between actual (observed) profits evaluated at $\phi=0$ (no evidence of technical inefficiency) minus observed profits including the element $\phi$:

$$\text{TTI} = \ln \pi_i^*(\phi=0) - \ln \pi_i^*(\phi)$$

$$= [\ln \pi_i^*(\phi=0) - \ln \pi_i^*(\phi)] + [\ln M(\phi=0) - \ln M(\phi=0)] - \hat{\phi}_i$$

(45)

Given that:

$$\ln \pi_i^*(\phi=0) = \ln \pi_i^*(\phi), \quad \land \ln M(\phi=0) = \ln M(\phi),$$

(46)

then,

$$\text{TTI}_i = \hat{\phi}_i$$

(47)

which is directly estimable from the varying intercepts of the frontier.

6.9 Econometric estimation

The system of equations to be estimated consists of the profit function (43) including inefficiency factors, plus an error term $\varepsilon$, together with the $(n-1)$ share equations (42) plus $(n-1)$ error term $\nu$, correlated with $\varepsilon$. It is useful to recall that $\phi$ is a firm effect representing technical inefficiency, which varies over individual units.

$$\ln \pi_i^* = \ln \pi_i^* + \ln [1 + \sum_{j=1}^{J-1} \frac{1 - \lambda_j}{\lambda_j}] [\alpha_j + \sum_{l=1}^{J-1} \alpha_l \lambda_l P_u + \gamma_k \ln z] - \hat{\phi}_i + \varepsilon_i$$

(48)
\[ s^*_{H} = \frac{\left( \alpha_j + \sum_{l=1}^{J-1} \alpha_{\mu l} \ln \lambda_{l H} P_{\mu l} + \gamma_{H} \ln z \right)}{\lambda_j \left[ 1 + \left| \sum_{j=1}^{J-1} (1 - \lambda_j) \left( \alpha_j + \sum_{l=1}^{J-1} \alpha_{\mu l} \ln \lambda_{l H} P_{\mu l} + \gamma_{H} \ln z \right) \right| \right]} + v_l \]  

(49)

This system is estimated using a Nonlinear Iterated Seemingly Unrelated Regression (NITSUR) method to account for likely correlation between the error terms of the different equations at a certain point in time (Judge et al., 1988). The model includes two outputs and four inputs. Among the later, fixed assets are the fixed non-financial input in the production of earning assets.

There are two alternative ways to model the \( \phi_i \) as fixed for the estimation of technical inefficiency. The methods are taken from the traditional panel data literature with little adaptation to the estimation of frontiers (Schmidt and Sickles, 1984). One method is to implement a within estimation by transforming the data to deviations from the mean (Mundlak, 1967). Alternatively, one can achieve an equivalent estimator by using the least square dummy variable estimation (LSDV), where the inclusion of \( (n-1) \) dummy variables allows for the estimation of technical inefficiency. The \( \phi_i \) can be estimated consistently when \( N \) is fixed and \( T \) increases (Balestra, 1992). This is the case of the Dominican Republic panel, which has \( N=12 \) and \( T=45 \).

Because the technical inefficiency is obtained with respect to the most efficient bank, the estimated \( \phi_i \) are normalized. Recalling that \( \phi_0 \leq 0 \), the bank with the largest \( \phi_0 \), \( i.e. \), the bank with the smallest \( |\phi| \) labeled with the superscript \( \text{max} \), is the most efficient bank \( (te) \). Then, the technically inefficient parameters for all the banks are normalized by:

\[
\phi_i = \begin{cases} 
\phi_i - \phi_{te}^{\text{max}}, & i \neq te \\
\phi_i - \phi_{te}^{\text{max}} = 0, & i = te 
\end{cases}
\]

(50)

149
To estimate firm-specific $\lambda_j$ (allocative inefficiencies), panel data are generally required (Atkinson and Cornwell, 1995). Without panel data, firm-specific allocative inefficiency can be estimated by replacing the parameters with functions of exogenous variables that are firm-specific. The choice of these exogenous variables is an empirical question. For instance, Kumbhakar and Bhattacharyya (1992) were interested in the effects of education and farm size on the allocative efficiency of Indian farms and made the allocative parameters a function of those two factors.

Atkinson and Halvorsen (1990), in turn, were interested in the allocative efficiency of regulated electric utilities and specified the output-side allocative parameter in terms of the prices of alternative types of energy. For the allocative efficiency on inputs, these authors used a different approach. They made input prices (fuel prices) a function of a dummy variable that reflected whether the corresponding utility was subject to a fuel-amount clause regulation.

Berger et al. (1993a) assumed that the $\lambda_j$ were constant across banks. Instead of individual parameters, they got an average $\lambda_j$ for the industry, by estimating a single set of $(n-1)\lambda_j$ (one for each netput). Provided that panel data were available, Atkinson and Cornwell (1995) estimated firm-specific price inefficiency without defining these parameters as a function of exogenous variables because they included an additional set of equations to the more traditional cost plus share estimation. These authors added to the estimation the first-order condition of the second stage of the maximization process, where shadow prices are equal to marginal cost, replacing shadow prices by an approximation that includes a firm-specific parameter to be estimated.$^{95}$

Even though panel data are available for this dissertation, the $\lambda_j$ are not bank-specific but rather netput-specific. Originally, allocative efficiency was intended to be estimated by bank groups, i.e., a set of parameters for multibancos and another set for non-multibancos. Nevertheless, pooling the banks that eventually merged as if they had been merged for the entire period is not adequate. $^{95}$ This specification was also attempted for the Dominican case without successful results.
The estimate of $\lambda_j$ indicates the average tendency of the sample with respect to each relative netput. For instance, if the $\lambda_j$ related to loans or investments is found to be less (greater) than one, then the financial system, on average, produces too little (too much) loans or investments relative to labor. On the input side, if the $\lambda_j$ related to total deposits is estimated to be less (greater) than one, the financial system on average holds larger than optimal amounts of deposits relative to labor. For the case of the cost frontier, however, only the $\lambda_j$ related to total deposits can be estimated, since output prices do not enter the cost frontier. The results of the profit frontier estimation and the allocative and technical parameters are discussed in Chapter 7.
CHAPTER 7

EMPIRICAL RESULTS

This chapter discusses the empirical results of the econometric estimation of a profit frontier for the Dominican Banking system (1991-1994). Technical inefficiency is estimated for each bank while allocative inefficiency is treated as netput-specific. The estimation made it possible to rank the individual banks according to technical inefficiency. Individual banks are then compared while specifying if they are multibancos or non-multibancos, in order to derive some conclusions about the impact of mergers on efficiency.96

Because of the intrinsic non-linearities of the profit frontier model and of important data limitations, the model proved difficult to converge (see Appendix B). In contrast, when the cost frontier is derived for a shadow cost model similar to the shadow profit model of this dissertation, the specification is simpler than the specification of the profit frontier in terms of non-linearities.97 This alternative estimation was also carried out in the expectation that the results would bring some

---

96 An important element to evaluate the effect of mergers on the profit efficiency of banks is the evaluation of economies of scope. Economies of scope, however, could not be estimated with the data available. Moreover, for this dissertation, the classification of banks into multibancos depends on whether they merged at some point during the period. This classification is not completely accurate because some banks merged at the end of the period but are classified as a multibanco for the whole period. As a result, the estimation of efficiency was carried out without pooling banks, to avoid misleading results. Still, after individual banks were ranked by the technical inefficiency scores that result from the estimation, the banks that merged during the period are pooled as a group. The pooling is intended to highlight characteristics of banks that turned out to be multibancos, compared to non-multibancos, in terms of efficiency rankings and financial ratio rankings.

97 The model specification for the cost frontier is presented in Appendix A.
robustness to the rankings of the banks obtained from the profit frontier. Further, additional information was obtained by comparing the rankings according to efficiency to rankings according to financial-ratios. A correlation analysis was carried out to establish the consistency among these different rankings of the banks. An interpretation of the results is also offered.

The profit frontier estimation is still important, however, because it provides information on the output side of bank activity. Berger and Mester (1997) argued that the scope of information of the profit estimation is wider because it is based on the assumption that managers pay attention to increasing revenues as well as to reducing costs. Moreover, these authors considered that since the measurement of cost efficiency is based on the performance of the best bank, holding output constant at its current level, the same bank may not be considered as efficient when evaluated at the optimal output level. This is the case because the current output level may differ from the optimal output level. In contrast, the profit estimation is not subject to this problem.\footnote{Still, the cost frontier can bring additional informational value, as discussed below.}

\section{Profit-frontier estimates}

The parameter estimates for the profit frontier are reported in Table 15.\footnote{The reported coefficients correspond to the final model, after dealing with the convergence problems detailed in Appendix B.} Reported coefficients for the relative prices of outputs are \((\alpha_1)\) for investments and \((\alpha_2)\) for loans. On the input side, \((\alpha_4)\) is the coefficient for total deposits and \((\alpha_5)\) for fixed assets. The profit elasticities of netputs are obtained from taking the derivative of the logarithm of profits with respect to each netput price. For the restricted profit maximization implemented in this dissertation these profit elasticities are a complex expression.
<table>
<thead>
<tr>
<th>Parameter</th>
<th>variable</th>
<th>Estimate</th>
<th>t-statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha_1$</td>
<td>ln $P_1$</td>
<td>-0.33</td>
<td>-3.54**</td>
</tr>
<tr>
<td>$\alpha_2$</td>
<td>ln $P_2$</td>
<td>3.94</td>
<td>3.66**</td>
</tr>
<tr>
<td>$\alpha_4$</td>
<td>ln $P_4$</td>
<td>-3.84</td>
<td>-5.89**</td>
</tr>
<tr>
<td>$\alpha_{11}$</td>
<td>ln $P_1*ln P_1$</td>
<td>0.10</td>
<td>7.53*</td>
</tr>
<tr>
<td>$\alpha_{12}$</td>
<td>ln $P_1*ln P_2$</td>
<td>-0.44</td>
<td>-7.39**</td>
</tr>
<tr>
<td>$\alpha_{14}$</td>
<td>ln $P_1*ln P_4$</td>
<td>0.22</td>
<td>5.98**</td>
</tr>
<tr>
<td>$\alpha_{22}$</td>
<td>ln $P_2*ln P_2$</td>
<td>-2.94</td>
<td>-15.24**</td>
</tr>
<tr>
<td>$\alpha_{44}$</td>
<td>ln $P_4*ln P_4$</td>
<td>-2.53</td>
<td>-25.05**</td>
</tr>
<tr>
<td>$\alpha_z$</td>
<td>ln $z$</td>
<td>0.87</td>
<td>2.75**</td>
</tr>
<tr>
<td>$\gamma_{1z}$</td>
<td>ln $P_1*ln z$</td>
<td>0.02</td>
<td>2.03**</td>
</tr>
<tr>
<td>$\gamma_{2z}$</td>
<td>ln $P_2*ln z$</td>
<td>-0.15</td>
<td>-2.15**</td>
</tr>
<tr>
<td>$\gamma_{4z}$</td>
<td>ln $P_4*ln z$</td>
<td>0.04</td>
<td>1.18**</td>
</tr>
</tbody>
</table>

**significant at the 1-percent level

$P_j=p/p_{j5}$, where: $j=1, \ldots, 5$

j=1 for investments.
j=2 for loans.
j=4 for total deposits.
j=5 for labor.
Z=fixed inputs.

Table 15 Parameter estimates for the profit frontier
The elasticity of profits with respect to netput \( j \) is:

\[
(profit \ elasticity)_j \text{mean} = \frac{(\alpha_j + \sum_{i=1}^{j-1} \alpha_i \ln \lambda_i P_i + \gamma_j \ln z)}{\lambda_j \left(1 + \sum_{j=1}^{j-1} \frac{(1 - \lambda_j)}{\lambda_i} \left(\frac{1}{\lambda_j} \left[ (\alpha_j + \sum_{i=1}^{j-1} \alpha_i \ln \lambda_i P_i + \gamma_j \ln z) \right] \right) \right)}
\] (51)

Given that the derivatives of the logarithm of profits with respect to netput prices represented in equation (51) are equivalent to the netput shares derived in Chapter 6 in equation (42), the profit elasticities are calculated from the estimated shares evaluated at the geometric means of the right-hand side variables (Table 16).¹⁰⁰

<table>
<thead>
<tr>
<th>Netput</th>
<th>Estimate</th>
<th>interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>investments</td>
<td>1.39</td>
<td>elastic</td>
</tr>
<tr>
<td>loans</td>
<td>2.96</td>
<td>elastic</td>
</tr>
<tr>
<td>total deposits⁴</td>
<td>1.81</td>
<td>elastic</td>
</tr>
<tr>
<td>labor⁵</td>
<td>1.54</td>
<td>elastic</td>
</tr>
<tr>
<td>fixed assets</td>
<td>0.42</td>
<td>inelastic</td>
</tr>
</tbody>
</table>

a: The estimation of the model is carried out for the negative share of inputs to represent an expense. The actual shares, i.e. the elasticities, are positive.
b: Since homogeneity was imposed by normalizing all prices by the price of labor, the parameters for labor are derived from the estimated parameters for the other netputs. In addition, the model is estimated for n-1 shares to avoid singularity. The share for labor is equivalent to 1 minus the sum of the other shares.

Table 16 Price elasticities of profits

¹⁰⁰ Fitted shares evaluated at the geometric means are positive for all netputs, thus satisfying monotonicity.
Since fixed assets are the only size variable included in the model, the profit elasticity with respect to fixed assets reflects the size elasticity of profits (Chambers, 1988). There are economies of size when the size elasticity of profits is greater than one. Banks exhibit diseconomies of size when the elasticity is smaller than one, and the banks exhibit constant returns to size when the elasticity is equal to one.

The profit elasticities of netputs are different for the restricted shadow-profit model presented in this dissertation and for the unrestricted profit model without shadow prices. In terms of equation (51), only the numerator is considered for the unrestricted profit model with the \( \lambda_j \) equal to one. For the restricted profit model, the expression is more complex but the denominator is common to all shares, except for the \( \lambda_j \) parameter outside the brackets, which varies by netput. As estimated, this denominator is positive, as it is the equivalent to the sum of the shadow shares of the J-1 netputs, scaled by a factor that is a function of the \( \lambda_j \). By monotonicity, the sum of the J-1 shadow shares is positive and the scale factor was estimated to be positive, because of positive values of the \( \lambda_j \) that are not large enough to change the sign of the denominator. For all the shares, the numerator of equation (51), \( \text{NUM}_{e_{jp}} \), is the critical element that determines differences in elasticities.

The profit elasticity of investments evaluated at the geometric means is greater than one. That is, a one-percent increase in the price of investments increases profits by 1.39 percent. This possibly reflects a fixed cost of managing investments. In the Dominican Republic, however, investments are a mechanism of monetary policy rather than a production choice of banks. In implementing the monetary policy, the Central bank offers the banks government bonds and Central Bank bonds, which generally earn a low interest rate, as an alternative to an increase in reserve requirements. The government is thus imposing a tax on banks in the form of investments in government bonds. When

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\(^{101}\) When referring to the elasticity of profits with respect to fixed assets as the size elasticity, fixed assets are taken as a poor proxy for size.
the Central Bank has to meet a large fiscal deficit, however, it raises the interest rate in order to further induce the banks to hold these bonds and reduce aggregate liquidity. Higher returns on these investments increase bank profits.

For investments, the NUMe is given by:

\[ NUMe_{t1} = -0.53 + 0.1 \ln \lambda P_1 - 0.44 \ln \lambda P_2 + 0.22 \ln \lambda P_4 + 0.02 \ln z \]  \hspace{1cm} (52)

The profit elasticity of investments is positively related to the price of investments, the price of deposits, and the level of fixed assets, but inversely related to the price of loans.\textsuperscript{102} The constant term (-0.53) that reduces the elasticity is the \( \alpha \) parameter of the profit equation corresponding to the logarithm of the price of investments, while (0.1) is the coefficient of the square of the logarithm of the price of investments in the profit equation.\textsuperscript{103} This possibly reflects the heterogeneous composition of investments and their link to monetary policy. Although the net effect of the price of investments

\textsuperscript{102} There is still another complexity with the shadow profit model for the elasticities of profits with respect to netput prices. In addition to the usual profit frontier parameters, the numerator of the estimated elasticities includes the parameter \( \lambda_j \), which estimates the netput-specific allocative inefficiency. For simplicity, the discussion of the relationships between the elasticities and each netput price will abstract from the partial effect of the allocative parameters on the elasticities. Since the \( \lambda_j \) were taken into account to calculate the elasticities, their main effects were already considered. Besides, all the \( \lambda_j \) are positive (see below), so that if the price of a given input is said to be positively related to the elasticity of profits with respect to that netput, the effect of the \( \lambda_j \) will not distort the direction of the change but the magnitude.

\textsuperscript{103} Camacho (1990) found a negative (\( \alpha_i \) ) parameter in a preliminary version of the model, when fitting a profit function to Dominica data for the period (1980-1988). The final model presented in Camacho (1990) excluded this parameter, which is the coefficient of the price of investments in the profit frontier. The negative \( \alpha \) was excluded together with 19 other parameters, in order to reduce the multicollinearity found in the model. In this dissertation, the (\( \alpha_i \) ) estimated parameter was also negative. Multicollinearity was also encountered in this dissertation but a different approach to correction only indicated the exclusion of the square of fixed assets, and the cross-price parameter of loans and deposits. The multicollinearity test was carried out using the methodology of variance-decomposition proportions (Judge, et al., 1985), which is detailed in Appendix B. Still, as explained in Appendix B, scaling of the share of investments was necessary to get some meaningful results. The scaling factor was to divide this share by its mean to expressed the new scaled mean, 1, in terms that were comparable to the means of the other shares.

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in the elasticity of profit with respect to the price of investment is negative, this is compensated by the positive effects of interactions with the price of deposits and with fixed assets.

Profits are elastic with respect to the price of loans. A one-percent increase in the price of loans increases profits by 2.96 percent. For loans, the NUMe_{nj} is given by:

$$NUMe_{nj} = -3.94 + 0.44 \ln \lambda_1 P_1 - 2.49 \ln \lambda_2 P_2 + 2.43 \ln \lambda_4 P_4 - 0.15 \ln \nu$$  \hspace{1cm} (54)

This elasticity is positively related to the price of investments and the price of deposits, but it is negatively related to the level of fixed assets. The net effect of the price of loans is positive through the large $\alpha_4$ (3.94) from the profit frontier, despite the negative impact of the square of this price. There is a negative partial effect of fixed assets on the elasticity. This relationship indicates that a further increase in fixed assets reduces the elasticity of profits with respect to loans. This is consistent with the finding of diseconomies of size indicated by the elasticity of profits with respect to fixed assets (see below).

Profits are elastic with respect to the price of deposits. A one percent increase in the price of deposits decreases profits by 1.81 percent. Since for the estimation of the profit model the share of deposit expenses over profits entered the model with an added negative sign --to indicate an expense--, a negative sign was added to the fitted shares. In terms of the relevant numerator for the elasticity of profits with respect to the price of deposits, the general equation is:

$$NUMe_{n4} = -3.83 + 0.22 \ln \lambda_1 P_1 + 2.42 \ln \lambda_2 P_2 - 2.53 \ln P_4 - 0.04 \ln \nu$$  \hspace{1cm} (55)

Because of the added negative sign for estimation, a negative sign in the numerator implies an increase in the elasticity. The $\alpha_4$ parameter adds a large positive component to the elasticity. The price of deposits and the level of fixed assets are positively related to the profit elasticity of deposits.
As reported in Table 16, the elasticity of profits with respect to the level of fixed assets is less than one, indicating the presence of diseconomies of size at the geometric means. A one-percent increase in the level of investments in infrastructure results in a less than proportional (0.42 percent) increase on profits. This results is consistent with the findings in Camacho (1990), who estimated diseconomies of size for the Dominican banking system. His model had a different specification, as he included the level of employment and the value of total productive assets as additional size variables. Due to the large number of parameters already in the shadow profit model of this dissertation, only fixed assets are included. The elasticity here is the same as the elasticity with respect to fixed assets in Camacho (1990), who estimated it at 0.4.

Since the derivative of the logarithm of profits with respect to fixed assets is not a trivial function, an alternative approach was implemented to calculate the elasticity of profits with respect to size. Fitted profits ($\pi$) were evaluated at the geometric means. Then, a modified version of fitted profits ($\pi'$) was calculated, by evaluating profits at the geometric means of all of its arguments but incrementing the level of fixed assets by one percent. The two estimated values for fitted profits were compared, calculating the elasticity of size as:

$$
\epsilon_{\pi} = \frac{e^{\log \pi'} - e^{\log \pi}}{e^{\log \pi}} \times 100
$$

(55)

The existence of diseconomies of size in terms of the level of fixed assets is not a surprising result. As discussed in Chapter 3, the financial crisis of the late 1980s in the Dominican Republic was highly related to excessive investment in fixed assets that threatened the liquidity of the system. When faced with unfavorable regulation that resulted in negative real rates of interest, banks had to protect their assets against the erosion of inflation by investing in inflation hedges such as fixed assets and holdings of foreign currency.
The findings indicate that the elasticity of profits with respect to fixed assets has not changed from the value calculated for the period (1980-1988) by Camacho (1990), even after the reform resulted in positive real returns on financial assets. Once all the banks that merged during or that will merge after the period (1991-1994) have occurred, a reduction of the excessive investment in fixed assets is expected. At that time, a larger elasticity of size (closer to one) is expected.

7.2 Technical inefficiency

For the estimation of technical inefficiency, the profit equation included a dummy variable for each bank. To avoid singularity, the constant term of the equation ($\alpha_0$) is eliminated for estimation and calculated later on from the estimated dummy parameters ($\phi_i$), as suggested by Schmidt and Sickles (1984). As explained in Chapter 6, the technical inefficiency parameter $\phi_i$ will reduce profits of individual banks from its optimal level. Since technical inefficiency reduces profits, the estimated dummies have a negative sign. The bank with the largest estimated dummy variable ($\phi_i$) will be the bank with the smallest parameter in absolute terms.

The empirical model derived in Chapter 6 showed that the inefficiency parameters are multiplicative to profits.$^{104}$ Thus, the (T-ineff) scores estimate the percentage of inefficiency of each bank with respect to the best practice of the system. That is, they measure the ratio of predicted profits for bank $i$ to predicted profits for the most efficient bank, for a given vector of netput prices and fixed assets.

---

$^{104}$ Since the functional form used for profits is translog and the inefficiency parameters are also expressed in logarithms reducing profits, profits expressed in levels are multiplicative to the inefficiency parameters.
Since the parameters are expressed in logarithms the technical inefficiency score is calculated as:

\[(T-ineff)_t = e^{(\hat{\phi}_t - \hat{\phi}_{max}) - \frac{\pi^{max}}{\pi_t}} \tag{56}\]

\[\hat{\phi}_{max} = \max \hat{\phi}_t = \min |\hat{\phi}_t|, \forall t\]

Technical inefficiency is estimated with respect to the best-practice bank. The bank with the largest estimated dummy value, \(\phi_{max}\), --the smallest in absolute value-- was used as an anchor so that this bank is ranked as fully technically efficient. That is, the \((T-ineff)_{max} = 1\) for the bank with the largest estimated technical inefficiency dummy.

A rule for the normalization of the dummy parameters is needed to obtain the constant term. By subtracting estimated dummies for each bank from the estimated dummy of the technically efficient bank, the resulting parameter for the anchor bank is equal to zero and the value of \(\alpha_0\) was estimated as the dummy of the anchor bank (Schmidt and Sickles, 1988). After this normalization, the parameters for technical inefficiency in logarithms (\(\phi_t - \phi_{max}\)) ranged from -3.4 for the least efficient bank to zero for the most efficient bank.

Using the transformation in (56), Figure 16 shows the distribution of the technical inefficiency parameters for all banks in the sample, with an average score of 0.23, ordered from the most inefficient bank (0.03) to the fully efficient bank (1). Then, banks earned only 23 percent of their potential (optimum) profits because of technical inefficiency. That is, on average, banks wasted 77 percent of their resources due to technical inefficiency (1-0.23).\(^{105}\)

\(^{105}\) Berger and Mester (1997) reported the results of a few studies that have estimated the profit efficiency of banks in the United States. From these studies, the measured profit efficiency ranged from 26 percent of potential profits earned to 67 percent. The estimates for the Dominican Republic are, thus, at the lower end of that range.
in Figure 16, numbers are randomly assigned to each bank. Numbers 12, 13, and 15 correspond to *multibancos*. Among *non-multibancos*, bank number 1 is the state-owned bank and banks number 2 and 3 are domestic subsidiaries of foreign banks. As a case in point, the state-owned bank (number 1 in Figure 16) was among the two most inefficient banks, as was found in specific studies of state-owned versus private ownership in similar countries (Camacho-Mejia, 1993).

![Bar chart showing technical inefficiency estimates](chart)

**Figure 16** Technical inefficiency estimates

Two *non-multibancos*, banks 19, which defines the frontier, and bank 3, which is closer to the frontier than all other banks, are the most efficient. In particular, bank 3 is one of the subsidiaries of foreign banks. These two banks (19 and 3) at the higher end form a class by themselves as their average score is 0.77 for a loss of profits due to inefficiency of 23 percent, while the rest of the system has a score of 0.12, for a loss of profits of 88 percent. Although a *non-multibanco* defines the frontier
(bank 19), the most inefficient bank is also a *non-multibanco* (bank 4). This dispersion is indicated by an average score of 0.24 for all the *non-multibanco*.

The average score was 0.20 for *multibancos*, for a loss of 80 percent of potential profits, which is similar to *non-multibancos*. During the period under analysis, however, of the three *multibancos* in the sample only two functioned as such for more than a year. In informal interviews with Dominican banks, it was reported that gains from mergers are not expected to be realized until a year after the merger. This period of adjustment is similar to that reported in Pilloff and Santomero (1997) for the United States. Then, at least one of the *multibancos* is still expected to realize gains from merger, beyond the period of analysis.

Since the two least inefficient banks in the sample (19, 3) can be considered as outliers, the scores for inefficiency were recalculated excluding these banks. After taking out these two outliers, the new best-practice bank is bank 12 (*a multibanco*). For the reduced sample, the new set of inefficiency parameters yields an average of 0.40, versus 0.23 for the full sample. Figure 17 shows the inefficiency ratios for all banks per group for the reduced sample.

For *non-multibancos*, the average score is 0.35, compared to 0.24 for the full sample. For *multibancos*, the average score increased to 0.66, from a previous score of 0.20 for the full sample. A t-test was carried out to evaluate whether the means of the technical inefficiency estimates for each group are statistically different from each other for both the full sample and the truncated sample. An F-test is also carried out to test the hypothesis of equal variances (Table 17).
The F-tests reported in Table 17 indicate that the variances for both bank groups are not statistically different from each other at the 5-percent level, for both samples. The test evaluates the hypothesis of equal means under the assumption of equal variances between the two bank groups and also under the assumption of unequal variances. Since the f-test could not reject the hypothesis of equal variances in neither sample, the relevant t-test is for the case of equal variances. Table 17 shows that both t-statistics were not significant at the 5-percent level for the full sample. This indicates that the hypothesis of equal means cannot be rejected for multibancos and non-multibancos. For the reduced sample, however, the hypothesis of equal means was rejected at the 5-percent level. That is, once the two outliers are excluded, multibancos have a different mean score than non-multibancos and are more efficient.
| H0: $\text{Mean}_m = \text{Mean}_{nm}$ | t-statistic | DF | Prob>|T| |
|----------------------------------------|-------------|----|---------|
| full sample: equal variances           | 0.20        | 10 | 0.84    |
| reduced sample: equal variances        | -2.53       | 8  | 0.04    |

| H0: $\sigma_m = \sigma_{nm}$         | F-statistic | DF | Prob>|F'| |
|----------------------------------------|-------------|----|---------|
| full sample                            | 10.31       | (8,2) | 0.18   |
| reduced sample                         | 4.16        | (2,6) | 0.15   |

Mean$_m$ and Mean$_{nm}$ are the means of the efficiency rankings for multibancos and non-multibancos. $\sigma_m$ and $\sigma_{nm}$ are the variances for multibancos and non-multibancos.

Table 17 T-test and F-test of equal means and variances between bank groups

Since the two groups of banks have similar means and variances for the full sample, neither group can be classified as being more technically efficient than the other. This result does not hold, however, for the reduced sample. Multibancos were found to experience significantly lower inefficiency than non-multibancos. Nevertheless, it is difficult to evaluate if there is an intrinsic characteristic of these banks that gives them a comparative advantage in terms of profit efficiency over non-multibancos, based only on the comparison of inefficiency parameters.

The difficulty stems from the fact that the sample has only three multibancos compared to seven (or nine for the full sample) non-multibancos, one of which is a state-owned bank (typically more inefficient). Also, no estimation of economies of scope was possible with the data available. The empirical analysis may lead to different results after all bank mergers have taken place and have lasted long enough for the expected gains from mergers to be realized. If these gains exist, the superiority of multibancos will be even greater than found here. Moreover, some of the multibanco mergers were motivated by the incentives of the original rule rather than by potential merger gains.
Thus, one of that was ranked among the least efficient, merged into a multibanco after the period of analysis to follow the same regulation path as the others.\footnote{In addition, bank 8, which was excluded from the sample due to data problems (see Chapter 6) was a multibanco that was ranked as the most inefficient bank in all the preliminary runs of the model. Had this bank been included, the average inefficiency of multibancos would have been higher. The merge of this bank was probably regulation-induced.}

Under these circumstances, the estimation of a cost frontier and the evaluation of financial ratios was important to provide additional information about the efficiency estimates and about the profitability of banks. In addition, the estimation of a shadow cost frontier is intended to bring robustness to the estimation of allocative inefficiency. This was the case, because there were a number of data problems encountered in the process of estimating the profit frontier (see Chapter 6). In addition to the limitations of the data, the shadow profit frontier that includes the $\lambda_j$ is highly non-linear, and the estimation of these parameters hinges upon the explanatory power of the share equations, because the profit equation is under-identified in those parameters.

In terms of adjusted $R^2$, however, the share equations provided much less information to the system than the profit equations, making it difficult to estimate the $\lambda_j$ parameters. For instance, Table 18 shows that while the goodness of fit for the equation of the logarithm of profits of the profit model was an adjusted $R^2$ of 0.81, the goodness of fit of the share equations was an adjusted $R^2$ of 0.51, at the most.

The share of labor expenses was not used in the estimation because one share is redundant. Theoretically, the likelihood function of the ITSUR estimation should not be sensitive to the share chosen. Since only input shares are estimated for the cost function, however, an input share had to be chosen as the redundant share to keep the same specification for the profit and cost frontier. Alternative to the model estimated using the price of labor as the numéraire, the estimation could be
carried out using the price of deposits as the numéraire and leaving the share of deposits as the redundant share.

<table>
<thead>
<tr>
<th>Equation of the profit model</th>
<th>Adjusted R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>logarithm of actual profits</td>
<td>0.81</td>
</tr>
<tr>
<td>share of investments</td>
<td>0.46</td>
</tr>
<tr>
<td>share of loans</td>
<td>0.41</td>
</tr>
<tr>
<td>share of total deposits</td>
<td>0.51</td>
</tr>
</tbody>
</table>

Table 18  Adjusted R² for each equation of the profit model

Empirically, however, this alternative model was difficult to estimate because of multicollinearity issues that had to do with the scale of this share. As explained in Appendix B, models that exhibit high multicollinearities are very sensitive to variables that are expressed in different scales. Indeed, one of the recommended solutions for correcting multicollinearity is to expressed the relevant equation variables in a similar scale, as it was necessary for the share of investments.

7.2.1 Comparisons across frontier models

Similar to the profit frontier, a normalized cost frontier is derived here (See Appendix A). The cost frontier estimation was carried out for the following system of actual costs plus shares:

$$\ln c_t = \ln c_{t}^{\ast} + \ln S_{t}^{\ast} - \xi_t + \eta_t$$ (57)
\[ s_{ui}^a = \frac{S_{eui}^a}{\frac{1}{K_j} \left[ 1 + \sum_{j=m+1}^{J-1} \frac{(1 - K_j)}{K_j} S_{eui}^a \right]} + \mu_i \]  

(58)

where, \( K_j \) is the allocative inefficiency parameter similar to the \( \lambda_j \) in the profit frontier and \( \ln C^a \) is equivalent to the shadow costs that result from introducing shadow input prices as the arguments of a typical translog cost function.

Using this cost frontier model, technical inefficiency estimates were obtained using the same methodology used for the profit frontier. In addition, a financial ratio analysis was carried out to shed some light on the possible differences in inefficiency across banks and among the three methodologies. The ROE, EM, ROA, PM, and AU profitability ratios derived from the financial ratio analysis of Chapter 6 are averaged over the period, and rankings are compared to those derived from the efficiency estimates. Because efficiency is a relative concept, banks were ranked from 1 to 12 according to their average technical inefficiency as derived from both the profit and cost frontiers and according to their average profitability ratios. The bank ranked as 1 is the least inefficient bank and the bank ranked as 12 is the most inefficient.

Table 19 provides the average rankings for all banks over the period. The first column shows the identification number for all banks. The second column shows the efficiency rankings using the profit frontier estimates. The third column shows the rankings corresponding to the cost frontier. Finally, the last five columns show the rankings resulting from the financial ratios.
<table>
<thead>
<tr>
<th>Bank</th>
<th>Profit efficiency</th>
<th>Cost efficiency</th>
<th>ROE</th>
<th>EM</th>
<th>ROA</th>
<th>PM</th>
<th>AU</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a</td>
<td>11</td>
<td>12</td>
<td>10</td>
<td>4</td>
<td>11</td>
<td>7</td>
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<td>6</td>
<td>9</td>
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<td>1</td>
<td>10</td>
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<td>8</td>
<td>12</td>
<td>10</td>
<td>12</td>
<td>12</td>
<td>8</td>
</tr>
<tr>
<td>12b</td>
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<td>7</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>13b</td>
<td>7</td>
<td>4</td>
<td>6</td>
<td>6</td>
<td>7</td>
<td>9</td>
<td>3</td>
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<td>15b</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>8</td>
<td>3</td>
<td>4</td>
<td>5</td>
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<td>2</td>
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<td>1</td>
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<td>8</td>
<td>2</td>
<td>11</td>
<td>12</td>
<td>5</td>
<td>6</td>
<td>6</td>
</tr>
</tbody>
</table>

a: State-owned bank.
b: Mutibancos.

Table 19 Efficiency and profitability rankings of banks
A correlation analysis was carried out to evaluate the correspondence among the three alternative rankings. Table 20 shows the rank-order correlations among the rankings from the two technical inefficiency measures and the rankings from the profitability ratios, using Spearman correlation coefficients. The correlation coefficients indicate that profit-efficiency rankings and cost-efficiency rankings are positively and statistically significantly correlated with each other, with ρ=0.61. Most profit efficiency appears to emerge from cost efficiency.

In addition, a statistically significant positive correlation was found between efficiency rankings using the ROE ratio and the profit frontier (ρ=0.67), and an even higher correlation was found between the profit frontier rankings and the ROA rankings (ρ=0.85). Thus, low ROA ratios are related to low profit frontier rankings. A lower but still high correlation exists between ROA rankings and the cost frontier rankings (ρ=0.70), indicating that banks that are more efficient according to the cost frontier framework show higher ROA ratios.

Regarding ROE rankings, the cost-frontier rankings are somewhat positively correlated (ρ=0.22), but the correlation coefficient is not statistically significant. As a result, banks with low ROE may or may not be ranked as experiencing a large cost inefficiency. In contrast, banks with higher ROE ratios tend to be ranked as more profit efficient (ρ=0.67). Differences in the rankings between the cost and the profit frontier may result from differences in ROE ratios. This became evident, for example, for the rankings of bank 20. Table 19 shows that this bank was ranked as very cost-efficient (2) but relatively profit-inefficient (8). The examination of the rankings using the profitability ratios indicate that this bank had a very high ROA ranking, but a very low ROE ranking, due to a low EM.
<table>
<thead>
<tr>
<th>RANK</th>
<th>Pr-Eff</th>
<th>C-Eff</th>
<th>ROE</th>
<th>EM</th>
<th>ROA</th>
<th>PM</th>
<th>AU</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-eff</td>
<td>1</td>
<td>0.64</td>
<td>0.67</td>
<td>0.14</td>
<td>0.85</td>
<td>0.49</td>
<td>0.71</td>
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<td></td>
<td>0</td>
<td>0.02</td>
<td>0.02</td>
<td>0.66</td>
<td>0</td>
<td>0.11</td>
<td>0.01</td>
</tr>
<tr>
<td>C-eff</td>
<td>0.64</td>
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<td>0.22</td>
<td>-0.43</td>
<td>0.70</td>
<td>0.22</td>
<td>0.60</td>
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<td>0.17</td>
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<td>0.48</td>
<td>0.04</td>
</tr>
<tr>
<td>ROE</td>
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<td>0.60</td>
<td>0.57</td>
<td>0.34</td>
<td>0.63</td>
</tr>
<tr>
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<td>0.50</td>
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<td>0.04</td>
<td>0.05</td>
<td>0.28</td>
<td>0.03</td>
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<td>EM</td>
<td>0.14</td>
<td>-0.43</td>
<td>0.60</td>
<td>1</td>
<td>-0.08</td>
<td>0.03</td>
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<tr>
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<td>0.80</td>
<td>0.93</td>
<td>0.63</td>
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<tr>
<td>ROA</td>
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<td>0.57</td>
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<td>0.51</td>
<td>0.76</td>
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<td>0.80</td>
<td>0</td>
<td>0.09</td>
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<td>PM</td>
<td>0.49</td>
<td>0.22</td>
<td>0.34</td>
<td>0.03</td>
<td>0.51</td>
<td>1</td>
<td>-0.04</td>
</tr>
<tr>
<td></td>
<td>0.11</td>
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<td>0.28</td>
<td>0.93</td>
<td>0.99</td>
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<td>0.76</td>
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<td>1</td>
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<tr>
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<td>0.03</td>
<td>0.63</td>
<td>0</td>
<td>0.90</td>
<td>0</td>
</tr>
</tbody>
</table>

Spearman coefficients (R), with Prob>|R| under H0: (p=0), reported below.
C-eff = cost efficiency.
Pr-eff = profit efficiency.

Table 20 Spearman correlation matrix of the efficiency and profitability rankings of banks
When the 12 banks are classified into relatively-less efficient and relatively-more efficient according to their position with respect to the two banks at the median, only two banks are ranked differently with the cost frontier than with the profit frontier. Table 21 shows this new classification of inefficiency in more aggregated terms. If two banks were at the median, they were considered as being either relatively-more or relatively-less efficient. This classification indicates that cost and profit frontiers tend to rank banks similarly, so that the differences in rankings are in terms of degree of inefficiency rather than of order of inefficiency.107

All three multibancos are above the median under both the cost and profit specification, and therefore are ranked as relatively-more efficient, using the aggregated rankings of Table 21. Table 19 indicates that overall multibancos had relatively-high ROE, EM, ROA, and AU ratios, while having relatively-low PM ratios. The low PM ratios may reflect the costs of merging, as discussed in Chapter 6.

Although both methodologies were found to rank banks similarly, there were two exceptions (banks 2 and 20). These exceptions provide important information because they may reveal differences in output quality that are reflected in the profit frontier but not in the cost frontier. In fact, unmeasured differences in output quality may be incorrectly measured as differences in cost inefficiency (Berger and Mester, 1997).

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107 As discussed in Chapter 5, Berger and Mester (1997) compared diverse efficiency measurements using different functional forms (translog versus Fourier), different assumptions on the error term (stochastic frontier approach (SFA) versus distribution free approach (DFA), and different efficiency concepts (cost versus two specifications for profits). The authors found little differences in terms of average efficiencies for the banking industry or when ranking individual firms. Measured efficiency, however, differed across efficiency concepts (cost versus profits). They found a low correlation between these two specifications, contrary to the findings for the Dominican case. Nevertheless, the profit and cost dependent variable used for their estimation were profits and costs divided by capital. Then, they were actually comparing ROE to costs/capital, which is consistent with the findings reported here for the non-significant correlation between cost efficiency and ROE.
<table>
<thead>
<tr>
<th>Bank</th>
<th>Profit efficiency</th>
<th>Cost efficiency</th>
<th>P-eff / median</th>
<th>C-eff / median</th>
<th>aggregate efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a</td>
<td>11</td>
<td>12</td>
<td>below</td>
<td>below</td>
<td>below</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>9</td>
<td>above</td>
<td>below</td>
<td>above-above</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>1</td>
<td>above</td>
<td>above</td>
<td>above</td>
</tr>
<tr>
<td>4</td>
<td>12</td>
<td>11</td>
<td>below</td>
<td>below</td>
<td>below</td>
</tr>
<tr>
<td>5</td>
<td>6</td>
<td>6</td>
<td>median</td>
<td>median</td>
<td>median</td>
</tr>
<tr>
<td>6</td>
<td>9</td>
<td>10</td>
<td>below</td>
<td>below</td>
<td>below</td>
</tr>
<tr>
<td>9</td>
<td>10</td>
<td>8</td>
<td>below</td>
<td>below</td>
<td>below</td>
</tr>
<tr>
<td>12b</td>
<td>3</td>
<td>7</td>
<td>above</td>
<td>median</td>
<td>above</td>
</tr>
<tr>
<td>13b</td>
<td>7</td>
<td>4</td>
<td>median</td>
<td>above</td>
<td>above</td>
</tr>
<tr>
<td>15b</td>
<td>4</td>
<td>3</td>
<td>above</td>
<td>above</td>
<td>above</td>
</tr>
<tr>
<td>19</td>
<td>1</td>
<td>5</td>
<td>above</td>
<td>above</td>
<td>above</td>
</tr>
<tr>
<td>20</td>
<td>8</td>
<td>2</td>
<td>below</td>
<td>above</td>
<td>below-above</td>
</tr>
</tbody>
</table>

a: State-owned bank.
b: Mutibancos

P-eff / median and C-eff / median represent the relative position of the profit efficiency and cost efficiency rankings with respect to the median banks (banks 6 and 7).

Table 21 Aggregate rankings of relative efficiency
Of the two banks that were ranked differently with the cost and profit frontier, bank number 2 was ranked as relatively-more efficient (5) with the profit frontier but relatively-less efficient with the cost frontier (9). In contrast, bank number 20 was ranked as relatively-less efficient with the profit frontier (8) and relatively-more efficient with the cost frontier (2).

In general, better profit rankings than cost rankings may be explained by differences in output quality (Berger and Mester, 1997). That is, banks with higher costs may be producing outputs of higher quality that result in higher revenues. Bank 2 falls into this category. The analysis implies that bank number 2, a subsidiary of a foreign bank, has relatively higher costs together with relatively higher profits. Traditionally, the domestic subsidiaries of foreign banks play a passive role that follows the dictates of the main office abroad. They usually have low leverage ratios and mobilize few deposits through the subsidiary--because they would rather direct those deposits to their main office. As a result, foreign banks typically provide fewer services than other private banks.

The opposite is true for the foreign bank in question. In terms of services provided, this bank is one of the pioneers in car loans in the country. It is engaged in an aggressive activity that may bring about relatively higher costs but also higher revenues. Further, Table 22 shows the average holdings of demand deposits over the total deposits for the period. Bank number 2 exhibited a large proportion of demand deposits to total deposits (0.37), compared to the average proportion obtained for the system as a whole (0.27).

The third column of Table 22 shows that when ranking the holdings of demand deposits for all banks from high to low, bank number 2 was ranked as 4. By mobilizing large amounts of demand deposits, this bank is probably building a pool of costumers that will provide important information for its lending activities. In contrast, the other foreign bank, bank 3, was ranked as 10 in the proportion of demand deposits to total deposits, showing the typical less aggressive behavior of foreign banks.
<table>
<thead>
<tr>
<th>Bank</th>
<th>DD/TD</th>
<th>Bank rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a</td>
<td>0.46</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>0.37</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>0.15</td>
<td>10</td>
</tr>
<tr>
<td>4</td>
<td>0.37</td>
<td>13</td>
</tr>
<tr>
<td>5</td>
<td>0.41</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>0.36</td>
<td>5</td>
</tr>
<tr>
<td>9</td>
<td>0.21</td>
<td>8</td>
</tr>
<tr>
<td>12b</td>
<td>0.14</td>
<td>11</td>
</tr>
<tr>
<td>13b</td>
<td>0.26</td>
<td>7</td>
</tr>
<tr>
<td>15b</td>
<td>0.10</td>
<td>12</td>
</tr>
<tr>
<td>19</td>
<td>0.16</td>
<td>9</td>
</tr>
<tr>
<td>20</td>
<td>0.30</td>
<td>6</td>
</tr>
<tr>
<td>all</td>
<td>0.27</td>
<td>1-12</td>
</tr>
</tbody>
</table>

a: State-owned bank.
b: Mutibancos

Table 22  Holdings of demand deposit to total deposits
The other controversial ranking is for bank 20, which is a very small bank. This bank is ranked as relatively-less efficient by the profit frontier and relatively-more efficient by the cost frontier (Table 21). As suggested above, the low correlation between cost frontier rankings and the ROE rankings may explain the differences in rankings between the two measures with respect to bank 20. That is, a bank with a low ROE as bank 20 can be classified as relatively cost-efficient but it is still likely to be classified as relatively profit-inefficient.

Moreover, a low ROE together with a high ROA suggests a low EM. Since the rankings according to EM are negatively related to the rankings according to cost efficiency, a low EM for such a small bank will result in high rankings according to costs but low rankings according to profits.

7.3 Allocative inefficiency

Regarding allocative inefficiency the analysis is carried out estimating different parameters for each netput ($\lambda_j$), which do not vary across banks, due to data and estimation limitations. The $\lambda_j$ parameters reflect the average inefficiency of the system with respect to each netput. In the Dominican Republic, regulation was typically non-neutral. Some types of banks had preferential treatment with respect to reserve requirements, taxes, and access to rediscount facilities. These differences in treatment, however, existed between commercial, mortgage, and development banks but not within each type of bank.

Since all the banks studied in this dissertation were commercial banks affected by similar rules, it seems reasonable to estimate the average allocative efficiency of the system for each netput. Nevertheless, one main differential treatment did occur among commercial banks in terms of the multibanco charter (see Chapter 4). By specifying the technical inefficiency parameters for each individual banks, these differences are expected to be accounted for, leaving the $\lambda_j$ as the common parameter for all banks.

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Because significant coefficients were found for the distortion parameters, regulation is said to have an effect over the allocative efficiency of the financial system. This is one of the hypotheses of the dissertation. Indeed, the estimation of \( \lambda_1 \) indicated the existence of price distortions (Table 23). These coefficients were estimated relative to labor. The \( \lambda_1 \) and \( \lambda_2 \) are the coefficients for investments and loans, respectively. A \( \lambda_1 \) greater than one suggests that banks act as if they produce more investments relative to labor than it is profit maximizing. Recalling that banks are induced to keep larger investments in government bonds, this is not a surprising result.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Estimate</th>
<th>interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \lambda_1 )</td>
<td>1.92**</td>
<td>too many investments</td>
</tr>
<tr>
<td>3.97</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \lambda_2 )</td>
<td>0.47**</td>
<td>too few loans</td>
</tr>
<tr>
<td>5.42</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( \lambda_3 )</td>
<td>0.45**</td>
<td>too many deposits</td>
</tr>
<tr>
<td>4.71</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a: Parameter estimates with t-ratios below.
** are significant at the 1 percent level
\( \lambda_1 = \lambda_1/ \lambda_2, \lambda_2 = \lambda_2/ \lambda_3, \lambda_4 = \lambda_4/ \lambda_5 \)

Table 23 Allocative inefficiency parameters

In contrast, a \( \lambda_2 \) smaller than one indicates that banks act as if they produce less loans that it is profit maximizing. In this case, loans are perceived as less profitable than they should, have bankers maximized under actual prices (when \( \lambda_2 = 1 \) ) These two results are consistent with the argument that banks are keeping excess liquidity in the Dominican system, and that they are lending too little.\(^8\)

\(^8\) During the period of analysis, some banks have had reserves in the Central Bank in excess of reserve requirements instead of finding more rewarding uses for their funds.
The result of producing too few loans may be explained by the fact that banks are now subject to tighter prudential regulation, which is also being enforced more effectively. Because of the learning process involved in the establishment of tighter prudential regulation, together with new restrictions on lending to insiders, banks have to undertake a more adequate screening and monitoring of clients. Banks are choosing their borrowers more carefully to maintain compliance with the dictates of prudential regulation. The excess liquidity resulting from lending less is channeled to investments or deposited in the Central Bank.\footnote{Alternatively, banks could invest in the stock market, which represents an alternative and more rewarding investment, but the stock market in the Dominican Republic is just starting to develop.}

The estimation of a $\lambda_2$ parameter smaller than one, indicating that banks lend relatively too little could then be identified with the operation of more prudent banks. Banks are in an intense and costly learning process to understand what it really means to screen borrowers and monitor them. In the meantime, deposits and other sources of funds are allocated to less profitable uses such as investments. Indeed, for the proportion of investments that is in the form of government bonds, banks are induced to invest in less profitable uses of funds. Nevertheless, for the remaining investments, banks may be compromising higher lending returns because the costs of learning how to lend are high. After the banks adapt to the new prudential regulations and have had time to learn the appropriate lending technologies, they will lend more and invest less, \textit{ceteris paribus}.

On the input side, the model suggests an over-utilization of total deposits relative to labor. Banks were found to act as if deposits were cheaper relative to labor than what is indicated by the profit maximizing level of deposits. As indicated in Chapter 6 (Table 10), the proportion of other deposits to total deposits was at least 71 percent for all years of the period (1991-1994), and it was 73 percent on the average for the period, (Table 22). Other deposits resulted in larger part from access
to rediscount facilities from the Central Bank. After the reform, these non-deposit liabilities have been limited and the banks have had less access to subsidized funds.

In terms of allocative inefficiency, the estimation of the cost frontier derived in Appendix A allows for the estimation of at least the $\lambda_4$ coefficient for deposits relative to labor. The other two parameters ($\lambda_1$ and $\lambda_2$) cannot be estimated because output prices are not considered as arguments of the cost frontier. The estimated $\lambda_4$ parameter from the cost function was 0.32, which is consistent with the parameter estimated with the profit frontier (0.45). This is not a surprising result, because of the existence of artificially cheaper sources of funds allowed by regulation.

The fact that banks were found to have too many deposits relative to labor involves two possible distortions.\textsuperscript{110} Besides the effect of regulation on the holdings of other deposits, bank managers may prefer suboptimal uses of resources to increase their own utility. Under the managerial discretion theory discussed in Chapter 4 as an explanation for the deviations from profit maximizing behavior (Williamson, 1963; Edwards, 1977), managers may be able to increase their non-pecuniary income through higher expenses.

This theory considers the utility of managers as a function of reputation, status, control, salary, and power, which may be reflected in a larger firm size, staff size, and more luxurious offices. Increasing the number of workers under their supervision, managers may increase their salary. They will also have more power and control in the bank and their prestige may be increased.

\subsection{Shadow shares versus optimal shares}

In general, the existence of non-profit maximizing behavior is related to imperfections in the market. In this dissertation, deviations from profit maximizing behavior are estimated by the allocative parameters $\lambda_j$. To evaluate the aggregate effect of market power and of regulation

\textsuperscript{110} This is also true for the allocative elements for investments and loans, which will be discussed in more details below.

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estimated by the $\lambda_j$ shadow shares were evaluated at their geometric means. That is, the fitted shares that result from the assumption of $\lambda_j$ different from one (shadow shares) were compared to optimal shares resulting from the model with $\lambda_j=0$. If the fitted optimal share is smaller (greater) than the fitted shadow share, then the net effect of regulation and market power is to increase (decrease) shadow shares.

<table>
<thead>
<tr>
<th>Netput</th>
<th>Optimal shares</th>
<th>Shadow shares</th>
<th>optimal-shadow</th>
</tr>
</thead>
<tbody>
<tr>
<td>investments</td>
<td>1.04</td>
<td>1.40</td>
<td>smaller than 0</td>
</tr>
<tr>
<td>loans</td>
<td>3.20</td>
<td>2.96</td>
<td>greater than 0</td>
</tr>
<tr>
<td>total deposits$^b$</td>
<td>2.00</td>
<td>1.81</td>
<td>greater than 0</td>
</tr>
<tr>
<td>labor$^{eb}$</td>
<td>1.24</td>
<td>1.54</td>
<td>smaller than 0</td>
</tr>
</tbody>
</table>

a: Since homogeneity was imposed by normalizing all prices by the price of labor, the parameters for labor are derived from the estimated parameters for the other netputs. In addition, the model is estimated for n-1 shares to avoid singularity. The share for labor is equivalent to 1 minus the sum of the other shares.

b: The estimation of the model is carried out for the negative share of inputs to represent an expense. The actual shares, however, are positive.

Table 24 Optimal and shadow shares

Regarding market power, the empirical evidence on the behavior of Dominican banks suggests that banks are not likely to enjoy monopoly power on the input side. As documented by Zinser and Gonzalez-Vega (1987), when faced with low returns on deposits at commercial banks, bank clients decreased their holdings of deposits at commercial banks and increased their holdings of deposits at development and mortgage banks, at informal market and abroad. Since the empirical evidence suggests a prompt reaction of bank customers to deposit prices, it seems reasonable to assume that the allocative (price) effect measured by $\lambda_4$ is less related to market power than the effect of $\lambda_1$ and $\lambda_2$ are.
From the difference between the optimal and shadow shares of investments, Table 24 shows that banks are producing more investments than it is optimal, which is consistent with the interpretation of the $\lambda_1$ parameter. In contrast, banks produce less loans than is optimal, as is suggested by the estimated of $\lambda_2$. These deviations arise from the net effect of having some monopoly power in the market for loans, and the effects of prudential regulation discussed above.\footnote{Because investments are not a typical output for Dominican banks, the analysis of market power is not addressed in terms of investments but in terms of loans.} Monopolistic banks would restrict output to keep loan rates above competitive levels.

Regarding the difference between the optimal and shadow shares for deposits, Table 24 shows that banks actually have less deposits than it is optimal. The result indicated by $\lambda_4$ may thus be related to the effects of labor. The optimal share of labor is smaller than the actual share that was estimated with the profit frontier.\footnote{Since the technical inefficiency element does not enter the share functions, actual and shadow shares are the same. (See Chapter 6).} This evidence suggests that banks have discretionary power in hiring labor beyond the optimal level, as stipulated by the managerial discretion theory. Also, the composition of employees between skilled and non-skilled labor could be important. Banks may still have too large a pool of unskilled labor that do not bring about more efficient outcomes.

In terms of allocative efficiency on the loans side, it is important to calculate the differences between optimal profits and shadow profits to evaluate the importance of the two distorting effects involved in the $\lambda_2$. As discussed in Chapter 6, the difference between the two is that optimal profits are evaluated assuming no inefficiencies ($\lambda_j=0, \phi_r=0$), while shadow profits are evaluated considering allocative inefficiencies ($\lambda_j, \phi_r=0$). The predominance of learning costs in the production of loans will result in lower shadow costs. When monopoly power prevails, however, agents reduce the quantity produced to exploit monopoly profits, which are larger than optimal profits under the price-taker
assumption. Shadow profits were calculated from the econometric estimation and evaluated at the sample means of the data as reported in Table 25. Indeed, these shadow profits are larger than optimal profits also evaluated at their geometric means. This may be evidence of market power.

<table>
<thead>
<tr>
<th>Profits</th>
<th>calculated profits</th>
</tr>
</thead>
<tbody>
<tr>
<td>optimal</td>
<td>846,575.8</td>
</tr>
<tr>
<td>shadow</td>
<td>849,505.8</td>
</tr>
<tr>
<td>Optimal-shadow</td>
<td>-2,909.98</td>
</tr>
</tbody>
</table>

Table 25     Optimal and shadow profits

The evidence of market power is typically reflected in a smaller quantity of output. In this dissertation, however, the model considers shares instead of quantities. Still, fitted shadow shares smaller than fitted optimal shares, together with larger shadow profits than optimal profits suggest the presence of some degree of monopoly power in the market for loans. The shadow profits were calculated to be 0.3 percent higher than optimal profits. The existence of the learning costs induced by prudential regulation, however, may have reduced the effect of market power on the production of loans.
CHAPTER 8

CONCLUDING REMARKS

In the Dominican Republic, the number of financial intermediaries grew rapidly during the 1980s and then declined during 1990s. The rapid growth of the 1980s was rooted in a series of regulations that favored the creation of specialized banks. Commercial bank failures and mergers occurred in the 1990s, after a financial crisis that ignited a process of financial reform, which included the liberalization of interest rates. The reform changed the rules of the financial game towards a more market-oriented environment. Also, the reform introduced tighter prudential regulations and supervisory mechanisms as well as a charter for universal banking.

As illustrated in Chapter 2, the existence of a large number of institutions did not imply greater financial deepening. In fact, many of these institutions were artificially sustained through non-neutral regulation but were not effectively providing financial services. Moreover, at least seven banks had large liquidity problems but were not suspended until later, and this provoked a financial crisis. An earlier empirical study documented that a number of banks had a high probability of failure, and they did fail (Guilliani and Aristy, 1991).

The crisis made evident the importance of having an exit mechanism for failing banks to leave the market. Trying to keep them artificially running is detrimental to the market because of the possibility of negative externalities (domino effects). These externalities arise when a bank that has liquidity problems faces a run on deposits that spills over to other banks, triggering a financial crisis.
Still, a number of banks in the Dominican system survived the crisis. These banks were studied in this
dissertation to evaluate the efficiency of the system after the reform.

Chapter 3 extensively discusses the process of financial reform in the Dominican Republic.
Policymakers, by enacting the new financial code, moved away from financially repressive regulation
to prudential regulation. The introduction of changes in the pattern of prudential supervision
strengthens the system and prepares it to face potential problems. This is the case, for instance, of
the provisions for loan losses and the restrictions on lending to insiders. After the reform, the
authorities have been less lenient with banks in terms of their compliance with requirements to avoid
additional failures. They have also reduced substantially the preferential treatment for development
and mortgage banks to allow bankers to choose the most profitable activities.

Recent research on the Dominican banking system recommended the introduction of universal
banking to substitute for specialized banking (Veloz, 1990; Guilliani and Aristy, 1991; González-
Vega, 1992; Camacho, 1990; De Castro-Nobo Muñoz, 1994). Following these recommendations,
an important change introduced with the reform is the multibanco charter. The multibanco mergers
have occurred through two different paths. The first path was followed until 1994 through mergers
of specialized banks into a multibanco. These mergers of otherwise development, mortgage, and
commercial banks effectively functioned as a commercial bank but with a wider set of activities. The
second path involved an increase in the capital of banks to qualify for the right to provide additional
services. The first path is analyzed in this dissertation because it is a completed path for which data
were available. The second path is described, but the period of analysis that starts in 1991, the year
of the reform and ended in 1994, does not include multibancos of this type.

Earlier researchers proposed the introduction of the multibanco rule expecting that it would
reduce the fragmentation of the system evident during the late 1980s. The fragmentation that resulted
from a large proportion of financial transactions in the informal sector involved high transaction costs
Moreover, the existence of repressive and excessive regulation led to regulatory avoidance, as with the creation of *grupos*. A freer set of rules reduces the need to avoid regulation. By complying to uniform reserve requirement, for instance, banks can allocate resources to the best use and not to the activities that regulation was intended to favor with differential requirements.

Bank inefficiencies are estimated based on the theoretical model developed in Chapter 4 whereby the existence of regulation distorts the ratios of relative prices under which banks maximize profits. It was argued that prices are distorted by a certain factor so that the behavior of banks is consistent with profit maximization under these (distorted) shadow prices. The distortion factor is introduced into a restricted profit maximization model and it measures the extent of allocative (price) inefficiency in the system. Allocative inefficiency is modeled as the net effect of regulation-distorting prices and the existence of market power. The estimation of a profit frontier is implemented as a way to measure these distortions and identify allocative and technical inefficiency components.

Chapter 5 reviews the literature on the estimation of efficiency. Diverse methods are discussed and the choice of the shadow price alternative is justified because it involves regulatory distortions parametrically and, thus, allocative inefficiency can be evaluated directly. The technical inefficiency component is also measured directly, through the introduction of a dummy parameter for each bank. These technical inefficiency estimates were used to rank banks relative to the best-practice bank.

The measurement of profit frontiers is a complex process and this dissertation had to deal with numerous empirical issues, mostly related to data problems, for the implementation of the empirical model. As a result, a cost frontier was also estimated to provide additional information on the rankings of banks resulting from technical inefficiency estimates (Appendix A). The cost frontier was not exempt from estimation and data issues, but it added information by allowing for the ranking of banks according to their technical cost inefficiency, which could then be compared to profit frontier
rankings and financial ratio rankings. In addition, the cost frontier allows for the estimation of the input-side allocative parameters, which can then be compared to the estimates for allocative inefficiency from the profit frontier.

In order to provide a more complete picture of the system, Chapter 6 presents a financial ratio analysis as a benchmark for comparison with the frontier rankings. In Chapter 7, after banks have been ranked using the three alternative methods, a rank-comparison is carried out between the two frontier models and compared to five financial ratios that are a partial measure for efficiency. A correlation analysis of the ranks is carried out to establish the consistency among these different rankings of the banks.

8.1 Summary of Results

In estimating a profit frontier for the Dominican Banking system, the elasticities of profits with respect to each netput price were calculated. All the elasticities indicated elastic responses of profits to changes in netput prices, with the largest elasticity for loans. Regarding size-related variables, the size-elasticity of profits is lower than one, indicating diseconomies of size with respect to fixed assets, consistent with the Camacho (1990) findings. The Dominican system invested in fixed asset as inflation hedges during the high inflationary period of the late 1980s through 1991. Banks may still have higher fixed asset holdings because they kept high inflationary expectations even after price stability prevailed. Moreover, the lack of liquidity of fixed assets may not have allowed banks to reduce them significantly.

In terms of technical inefficiency, the estimation indicated that, on average, banks in the Dominican Republic have a ratio of predicted individual profits to the predicted profits of the best-practice bank of 0.23. Banks were ranked according to the estimates of technical inefficiency. As a case in point, the state-owned bank is at the most inefficient end and the foreign banks are among the
least inefficient banks. Two of the multibancos were also ranked among the least inefficient banks. The average ratio of profits to best-practice profits was 0.20 for all three multibancos and 0.24 for non-multibancos as a group. The two means were tested to evaluate if they are statistically different from each other and the t-test could not reject the hypothesis of equal means.

The technical inefficiency parameters showed a large dispersion. In fact, there are extreme outliers. The most inefficient bank was a non-multibanco and the least inefficient bank was also a non-multibanco. The two banks that were the closest to the frontier were two non-multibancos (including a foreign bank). These two banks were considered as outliers, as they had an average ratio of individual to best-practice profits of 0.77, but the rest of the system had a ratio of 0.22. While the system on average, cost 88 percent of potential profits, the two best-ranked banks cost 23 percent. The ranks of bank were then recalculated taking out the two outliers. Under the reduced sample, a multibanco defines the frontier. The average inefficiency score for all banks in the reduced sample improved to 0.40.

The average inefficiency score for non-multibancos improved from 0.24 for the full sample to 0.35 for the reduced sample. Multibancos, however, tripled their average score from 0.20 for the full sample to 0.66 for the reduced sample. Significance test were also carried out between the two means and they were found to be statistically significantly different from each other at the 5-percent level.

Based on this evidence, multibancos seem to be less inefficient than non-multibancos. This statement has to be qualified, however, because there are only three multibancos in the sample compared to seven non-multibancos. Among the non-multibancos there is the state-owned bank, which is ranked among the least efficient banks. Moreover, as explained in Chapter 6, one of the banks that had to be excluded from the original data set was a multibanco. In preliminary estimations of the model, this multibanco was found to be the most inefficient bank. A closer inspection of the
financial ratios of all banks showed that this *multibanco* exhibited very low performance throughout the period.

In addition, the criterion to classify banks into *multibancos* was based on whether they merged at some point during the period. This classification would call banks *multibancos* for the whole period, even if they were only merged for less than a year. Moreover, economies of scope could not be estimated to indicate the potential gains derived from mergers.

In order to obtain more information on the ranking of banks, two other methods were employed. Bank rankings resulting from the profit frontier estimation were compared to rankings from a cost frontier estimation and from the financial ratio analysis. Estimating a cost frontier was necessary to provide more conclusive statistical information about the efficiency estimates. Besides large data problems, the shadow profit frontier proved difficult to estimate because of a high level of non-linearity in the model. In efforts to bring robustness to the efficiency estimation, a cost frontier was also estimated. When banks are organized as more efficient and less efficient depending on whether they ranked below or above the median bank, both methodologies were found to rank banks similarly, with two exceptions.

These exceptions are two *non-multibancos*; one of them a subsidiary of a foreign bank, and a very small bank. The first bank was ranked as relatively efficient according to the profit frontier but relatively inefficient according to the cost frontier. The ranking for the second bank was the opposite: it was ranked as relatively inefficient according the profit frontier but relatively efficient according to the cost frontier. Regarding the first type of divergence, a high profit ranking and low cost ranking may indicate that cost inefficiencies are confounded with differences in output quality (Berger and Mester, 1997). Higher costs may be related to the production of higher quality outputs that result in higher revenues. This is the case for the foreign bank, which is aggressively involved
in exploring lending in new market niches as well as extensively involved in the mobilization of demand deposits to increase its clientele base.

In contrast, the other bank is relatively inefficient according to the profit frontier but not according to the cost frontier. The reason for this difference may reflect a low equity multiple, despite a high ROA. Profit frontier rankings are correlated with ROE and cost frontier rankings are highly correlated with ROA rankings but not to ROE rankings.

Allocative inefficiency was also estimated. Due to data limitations, the analysis of allocative efficiency is not bank-specific but rather netput-specific, so that it indicates the average allocative inefficiency of the system. Because significant coefficients were found for the distortion parameters, regulation is said to have an effect over the allocative efficiency of the financial system. Banks may be affected by regulation through price effects. This hypothesis could not be rejected, as allocative inefficiency parameters were found to be statistically significant.

In terms of estimated allocative inefficiency on the output side, banks were found to hold more investments relative to labor than it was indicated by the profit maximizing level. The opposite is true for loans. Because of the learning process following the establishment of tighter prudential regulation, banks are less willing to lend without adequate screening and monitoring. In the meantime, funds are mobilized (in order not to lose clients) but are allocated to less profitable uses of funds such as investments. As a result, the system is experiencing excess liquidity as shown by excess reserves at the Central Bank. The costs of learning reflect real resource uses and banks are expected to increase their lending activity once the costs of learning are outweighed by the benefits from lending.

On the input side, the allocative inefficiency coefficient for deposits indicated that banks are holding more deposits relative to labor than they should at the optimum. Since allocative parameters were estimated relative to labor, distortions reflected by the estimated parameters may arise from the specific netput or from labor. To evaluate these alternatives, fitted shadow shares were calculated at
their geometric means. Recalling that shadow shares are the observed shares, which include the allocative inefficiency parameter, they represent the choice of banks. In contrast, optimal shares reflect the shares that would prevail if there were no allocative inefficiencies in the system. The comparison of shadow and optimal shares indicated the direction of change in share due to the existence of allocative inefficiency.

Calculated fitted shares indicated that shadow shares of investments were larger than optimal and that loan shadow shares were smaller than optimal, which is consistent with the findings of the relative allocative parameters discussed above. Regarding deposits, however, banks were found to keep less deposits than it was optimal contrary to what was suggested by the relative allocative estimate. The explanation comes from the fact that banks are keeping more labor than it is optimal. This is evidence of the existence of market imperfections that allow banks to hire excess number of employees. That is, bank managers may be hiring more employees to increase their own salaries, control, and prestige, as discussed by the managerial discretion theory.

The composition of employees between skilled and non-skilled labor seems important, as discussed in Chapter 6. Banks may have too large a pool of unskilled employees. Bureaucratic processes and intrinsic institutional factors may prevent banks from firing these employees but they still have to hire more skilled labor resulting in an increase in the number of workers, or they need to train existing employees and not enjoy the benefits until the training process is over.

Because the allocative parameters estimate the net effect of regulation and market power, shadow profits calculated as predicted actual profits evaluated at the geometric means of right-hand side variables without the technical inefficiency parameters were compared to optimal profits calculated as predicted profits without inefficiencies being considered. Shadow profits were found to be 0.3 percent higher than optimal profits, indicating the existence of some degree of monopoly power in the Dominican system.
8.2 Conclusions and recommendations

The tendency toward a more liberalized market introduced with the financial reform has led to a more flexible system that allowed for the least liquid banks to fail. In terms of Herfindhal indexes, competition among the remaining banks seems to be more intense, as indicated by a decreasing concentration ratio throughout the period. There is evidence of more aggressiveness in the financial game that has proven profitable for some bank.

Still, the process of adjustment to the reform may not be over, even if banks in the Dominican Republic have been found to react quickly to changes in regulation. The process of more careful lending practices, however, does take time, and it should pay off in the near future. Since evidence was found on the existence of monopoly power, the economy may benefit from more competition. A possible increase in the average efficiency of the system may occur through the reduction some banks that are too large.

8.2.1 Policy implications

The main policy recommendations have to do with maintaining policy neutrality and enabling banks to make their own production decisions. The authorities should still avoid excessive risk-taking behavior that could undermine the stability of the system. Regarding economic policy, mechanisms other than investment directives should be used to achieve monetary objectives. Providing for an adequate institutional framework, the authorities might enable the development of the stock market, which would provide for alternative sources of funds for firms. Ensuring transparency in the system will be crucial for the broadening of the stock market.

The empirical results of this dissertation suggest that banks should not be forced but merely enabled to become multibancos in order to increase efficiency. The tailor-made multibanco regulation that has made being universal banks a preferred strategy seems to have affected at least one of the banks that merged into a multibanco, which was found to be more inefficient than the rest of the
system. While it may be optimal for some banks to merge, it is not for others. Nevertheless, optimal economies of scope should be evaluated before arriving at conclusions regarding the efficiency of multibancos. Moreover, these banks were classified as multibancos even if they only merged toward the end of the period, so that additional research is needed after all the mergers have taken place, and the new banks have had a chance to overcome transitional merge costs.

Still, the results indicate that merging has not hurt the efficiency of banks, since the three multibancos remaining in the final estimation were found to be among the relatively least inefficient banks. In addition, it was found that banks do not need to be multibancos to be efficient, as evidenced by the fact that some non-multibancos are among the least inefficient banks as well. Perhaps, the most positive outcome from the multibanco charter regulation was to ensure compliance with the tighter prudential measures, as may be reflected in the restructuring of the multibanco that was found to be inefficient. This bank had been having problems throughout the whole crisis period but no corrective measure was implemented until years later, after it had become a multibanco.

Since banks had to comply with tighter prudential requirements to be eligible for the multibanco charter. The charter was used as an enforcement mechanism. In order for the mechanism to be effective, however, banks had to be multibancos. Banks know better what is the desirable pace of change of their institutional structure. Further, there is a learning process involved in the banks understanding how the new rules affect them and how they should screen borrowers and monitor them.

The shadow prices of inputs and outputs reflect the direction and relative magnitude of distortions. Loan shares were found to be lower than the shares that would result under unrestricted profit maximization. In contrast, investment shares were found to be smaller than the shares at the profit maximizing level. This result is partly an indication of the learning process followed by banks, which makes them cautious to lend under the new set of rules, but it is also related to the findings of
some degree of monopoly power in the market. Perhaps the main policy implication is related to the sequencing of reform to avoid large losses in potential profits. A tighter mechanism of prudential supervision to enforce prudential regulation is required prior to an enforcement of institutional change.

### 8.2.2 Contributions to the literature

Important methodological issues became evident in this dissertation. Although the estimation of a profit frontier is preferred because it provides more complete information on the behavior of banks, this preferred empirical model was difficult to estimate. Still, the need to find out about the output side of bank activity is reason enough to engage in a profit estimation. Because of the required data on prices, however, the model is data demanding. Surmounting these data problems was one of the most important obstacles to this research. The panel data nature of the model provided added degrees of freedom over cross-sectional models because repeated observations of the same units add more information.

In this dissertation, the measurement of efficiency using two different frontier techniques with the same data set adds to the few studies that compare techniques to add robustness to the efficiency measurements. The central tendency of average efficiency values for financial institutions is similar regardless of the frontier method employed, but firm rankings resulting from the different frontier estimations may differ (Berger and Mester, 1997). Few studies have carried out this approach.

Besides data limitations, the implementation of a restricted shadow profit frontier imposed non-linearities in the model, which are also present for the cost frontier but to a lesser extent. It seems reasonable to complement the profit frontier estimation with cost frontier estimations that provide additional information to the analysis. The result of such comparison for the Dominican case indicated that although cost and profit frontier rankings may differ in two individual cases, there are intrinsic characteristics of those institutions that make them different from a cost or profit point of view.
view. The analysis suggested that different rankings may not be considered as inconsistencies between techniques.

The fact that this research is based on the financial sector of the Dominican Republic is *per se* a contribution. Besides the fact that very little efficiency analysis has been carried out in the country, in general, the vast literature of efficiency frontiers has been concentrated on financial institutions in the United States. It is important to provide estimates from other countries, to compare estimates and to improve techniques that may be less implementable under different settings.

Finally, the evaluation of individual mergers adds to the reduced number of studies that analyze mergers in an individual basis, this has been found to be an important research path to follow in the evaluation of merger gains. Still, more detailed research is needed in this regards.

### 8.3 Suggestions for future research

A recent consensus in the literature suggests, that more research is needed in comparing different efficiency techniques to add robustness to the estimation. The results from the study of Dominican banks suggested that cost and profit frontier estimates may differ but that the resulting rankings are highly correlated ($p=0.64$). Although the most widely-used technique is the cost frontier, it becomes relevant to implement profit frontiers, because of their larger informational value, despite the fact that this estimation involves many obstacles at the empirical level. It is important to improve and implement profit frontier techniques when the rankings of financial institutions are relevant.

For the Dominican case, more research is needed that uses more disaggregated data, to evaluate sources of inefficiency within netput groups that are relevant, such as loans and deposits other than demand deposits. Moreover, this disaggregation is needed to estimate the economies of scope that are likely to exist in the system. The analysis of economies of scope is crucial for the evaluation of gains from merger.
In this analysis, the largest banks were found to have higher inefficiency rankings. This suggests that the estimation of individual frontiers for groups of small versus large banks is relevant if there are enough degrees of freedom for the estimation. In addition to netput-specific, bank-specific allocative efficiency estimates are needed to provide information on which banks are the least allocative efficient with respect to a certain input.

In terms of merger analysis, it is important to evaluate multibancos sometime after the banks merge to evaluate merger gains. For regulatory effects, it will be relevant to compare multibancos that resulted from merger with those that resulted from capital increases. Moreover, more research is needed to take into account risk. Lack of data prohibited this consideration in this dissertation, but it is expected that the new established rules will ensure that banks provide more information about their activities, allowing for a risk-corrected analysis. For instance, the effect of problem loans on efficiency could be evaluated and compared across firms (De Young, et al., 1993). Also, time varying efficiency estimation will bring about important information about the evolution of the system.
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APPENDIX A

THE SHADOW COST FRONTIER

The estimation of a cost frontier is based on a restricted cost model similar to the restricted profit model derived in Chapter 4. The restricted cost model is based on the existence of shadow prices that diverge from actual prices. As it was described for the case of profit maximization, because of the lack of a natural numéraire good to define the production function of a multi-output, multi-input bank, the last (Jth) variable input can be chosen as a numéraire as in Atkinson and Halvorsen (1990). Then, the transformation function can be expressed in terms of the last variable input as:

\[ X_j = \{(y_j x_j z) | y_j \text{ can be produced with } x_j z\} \]

for \( j = 1, \ldots, J-1 \)

where \( X_j \) is the minimum amount of the last input \( J \), \( Y_j \) represents outputs, \( X_j \) are variable inputs and \( Z \) are fixed inputs, as before.

Because of regulatory constraints, firms minimize a restricted cost function. Firms minimize the sum of the expenditures on variable inputs minus the cost of the last variable input (numéraire), subject to \( b \) regulatory constraints:

\[ \min c_t = \sum_{(j=m+1)}^{(J-1)} p_j x_j + p_{J} x_J (y, x, z) \]

\[ \min c_t = \sum_{(j=m+1)}^{(J-1)} p_j x_j + p_{J} x_J (y, x, z) \]

\[ \min c_t = \sum_{(j=m+1)}^{(J-1)} p_j x_j + p_{J} x_J (y, x, z) \]

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\[
\text{s.t.} \quad R_b(Y_j, X_{jm}X_{j0}Z_i p_j p_m) = 0
\]  
(61)

for \( j = m+1, \ldots, J-1 \) variable inputs, were \( c \) are minimum costs, and \((p_m)\) and \((p_j)\) are input prices.

To impose homogeneity, costs are normalized by the last variable input price \( p_m \), so that normalized shadow prices and costs are equivalent to:

\[
P_j^* = \frac{p_j^*}{p_j^s}, \quad C_j^* = \frac{c_j^*}{p_j^s}
\]  
(62)

\( \text{for } j = 1, \ldots, m \text{ outputs} \)
\( j = m+1, \ldots, J-1 \text{ variable inputs} \)

Similar to the profit model, the restricted cost minimization model is derived from shadow costs:

\[
C^* = C^s(\kappa_j p_m Y_j X_{jm} Z_i)
\]  
(63)

where \( C^s \) are shadow costs normalized by the last input price \( J \) and the value of \( \kappa_j \) represents the distortion factor of allocative inefficiencies on the input side, similar to the \( \lambda_j \) of the profit model.

The shadow price function is:

\[
P_j^* = \kappa_j p_j
\]  
(64)

By Shephard's Lemma, the derived input demands are:
\[
\frac{\partial C_i^t}{\partial P_{j\mu}} = \kappa_{j\mu}^{-1} \frac{\partial C_i^t}{\partial P_{j\mu}} = X_{j\mu} 
\] (65)

The last netput \(X_j\) is obtained from substituting actual prices for shadow normalized prices in (60). After some algebraic manipulations:

\[
X_j = C_i^t - \sum_{(j-m+1)} P_{j\mu} X_{j\mu} 
\] (66)

Since shadow costs are unobserved, they are expressed in terms of observable actual costs. Actual (observed) costs are:

\[
C_i^s = \sum_{(j-m+1)} P_{j\mu} X_{j\mu} - X_{j\mu} 
\] (67)

Plugging (15), (65) and (16), (66) into (67),

\[
C_i^s = \sum_{j=m+1}^{J-1} P_{j\mu} \frac{\partial C_i^t}{\partial P_{j\mu}} - \sum_{j=m+1}^{J-1} P_{j\mu} \frac{\partial C_i^s}{\partial P_{j\mu}} + C_i^s 
\] (68)

or, after algebraic manipulations:

\[
C_i^s = C_i^s + \sum_{j=m+1}^{J-1} P_{j\mu}(1 - \kappa_j) \frac{\partial C_i^t}{\partial P_{j\mu}} 
\] (69)
The result in (69) presents costs in a general form. Once a functional form is assumed for costs, an extended model can be derived following the same derivation process. For a translog cost function shadow costs are:

\[ C^s_i = \sum_{j=m+1}^{J-1} \beta_j \ln c_j \ln P_j + \frac{1}{2} \sum_{l=m+1}^{J-1} \beta_l \ln c_l \ln \kappa_l \ln P_l + \sum_{q=1}^{Q} \beta_q \ln c_q \ln y_q \ln \kappa_q \ln y_q \ln r_l + \]

\[ \beta_i \ln z_i + \sum_{j=m+1}^{J-1} \beta_j \ln z_j \ln \kappa_j \ln P_j + \frac{1}{2} \beta \ln z \ln z \ln z_i \quad (70) \]

and shadow shares derived from shadow costs using Shephard’s Lemma are:

\[ S^{eff}_i = \frac{\partial \ln C^s_i}{\partial \ln P^s_i} = \beta_j + \sum_{l=m+1}^{J-1} \beta_j \ln c_j \ln P_j + \sum_{q=1}^{Q} \beta_j \ln c_j \ln y_q \ln \kappa_q \ln y_q \ln r_l + \beta_j \ln z_i \beta \ln z \ln z_i \quad (71) \]

or,

\[ S^{eff}_i = \frac{\partial \ln C^s_i}{\partial \ln P^s_i} = C_i^s \frac{\partial C_i^s}{\partial P^s_i} \]

\[ \beta_j \ln c_j \ln P_j \quad (72) \]

Then:

\[ \frac{\partial C_i^s}{\partial P_j \kappa_j} = \frac{C_i^s}{P_j \kappa_j} \frac{\partial \ln C_i^s}{\partial \ln P_j \kappa_j} = \frac{C_i^s}{P_j \kappa_j} \frac{\partial S^{eff}_i}{\partial P_j \kappa_j} \quad (73) \]

Using (73) and after rearranging terms, (69) becomes:
\[ C_i^a = C^a_i \left[ 1 + \sum_{j=m+1}^{J-1} \frac{(1-K_j)S_{cij}}{\kappa_j} \right] \] (74)

Taking logarithms on each side,

\[ \ln c_i^a = \ln c_i^a + \ln S_{cij} - \ln H \]

for \( H = \left[ 1 + \sum_{j=m+1}^{J-1} \frac{(1-K_j)S_{cij}}{\kappa_j} \right] \) (75)

Actual cost shares in turn, are defined as:

\[ S_{cij}^a = \frac{P_{ij}}{C_i^a} \]

for \( j = m+1, \ldots, J-1 \) (76)

Then, using (15), (65) and (73) actual cost shares in terms of shadow cost shares are:

\[ S_{cij}^a = \frac{S_{cij}^x}{\kappa_j H} \] (77)

for \( j = 1, \ldots, J-1 \)

Based on this theoretical model, the empirical model consists of the logarithm of actual costs in terms of shadow costs (75) and a set of share equations similar to (77). Yet thus far the model has no considered technical inefficiency. A technical inefficiency parameter \( [\xi - (\xi_0)] \) can be introduced.
in the cost function as it was done with the profit model. The resulting observed costs are actual costs (75) plus the technical efficiency factor \( \xi \), which increases costs to:

\[
\ln c^a_i = \ln c^s_i + \ln S^s_{eff} - \ln H + \xi_i 
\]  

(78)

For estimation purposes, two error terms are added to the system formed by the logarithm of observed costs and shares. Since the empirical model has only one input share the econometric model is:

\[
\ln c^a_i = \ln c^s_i + \ln S^s_{eff} - \ln H + \ln \xi_i + \eta_i 
\]

(79)

\[
s^a_{4i} = \frac{S^s_{eff} + \mu_i}{1 \cdot \frac{1}{\kappa_i} + \sum_{j=m+1}^{r-1} \frac{(1-\kappa_j)}{\kappa_j} S^s_{eff}} 
\]

(80)

Using this cost frontier model, technical inefficiency estimates were obtained with the same methodology used for the profit frontier. The resulting efficiency rankings are presented in Chapter 7. The specification presented above, however, included fixed assets. The final implementation of the model excluded this variable because of multicollinearity problems and because of low correlation between the cost rankings using fixed assets and the profit rankings.
APPENDIX B

MULTICOLLINEARITY AND CONVERGENCE ISSUES

The estimation of profit and cost frontiers encountered multicollinearity problems that made it difficult for the models to converge. Multicollinearity is a common problem found in empirical estimation (Hsiao, 1991), which arises from poor data collection. The determination of the severity and form of near-exact linear dependencies among the variables of the model has to precede the evaluation of remedial measures (Judge, et al., 1988).

Following the description in Judge, et al., (1988), for the linear model:\(^{113}\)

\[ y = X\beta + e \]  

where \( y \) is a \((T \times 1)\) vector of observations, \( X \) is a nonstochastic \((T \times K)\) matrix of observations on explanatory variables, \( \beta \) is a \((K \times 1)\) vector of unknown regression coefficients, and \( e \) a \((T \times 1)\) vector of normally distributed random disturbances with zero mean and common variance \( \sigma^2 \). Extreme multicollinearity exists when there is at least one linear dependency among the columns of \( X \), so that the \( X \) matrix is less than full column rank. If \( X \) has rank \( K-J \), then \( X'X \) has \( J \) characteristic roots that are zero, and \( J \) parameters cannot be estimated from the available observations \( X \).

\(^{113}\) This analysis is taken directly from Judge et al., (1988), p.899-904. The same variable names were kept to allow for further reference to the book. Unfortunately, the \( \lambda \) parameter that is used to measure allocative inefficiency in the empirical model of this dissertation is also a typical representation of characteristic roots.
The results in section 22.2 in Judge et al. (1988) show that an analysis of the characteristic roots and vectors of $X'X$ can reveal the presence and perhaps the nature of multicollinearity in a sample with poor design. If $p_1$ and $p_2$ are normalized characteristic vectors of $X'X$ corresponding to a nonzero characteristic root vector $\lambda = \lambda_1, \ldots, \lambda_k$, the spectral decomposition of $X'X$ is:

$$X'X = \sum_{i=1}^{k} \lambda_i p_i p_i'$$

which identifies the presence of multicollinearity by one or more characteristic roots $\lambda_i$ being small. If one or more characteristic roots are small, there will be near-singularities in the data that will prevent convergence in the model. In order to address how small the characteristic root has to be to prevent estimation, a simple rule of thumb is to evaluate the condition numbers of the independent variables. The largest condition number is a measure of the sensitivity of the parameters to changes in the design matrix, i.e., the accuracy of the solution vector (Judge et al., 1988; Jennings and McKeown, 1992). This elasticity is calculated as the square root of the ratio of the largest characteristic root to the smallest characteristic root (see Table 26). There is one condition number for each characteristic root, calculated as the ratio of the corresponding characteristic root to the smallest characteristic root.

The larger the condition number the higher the sensitivity of the estimated parameters to a change in one of the right-hand side variables and the greater the loss of accuracy of the estimates. For instance, a condition number of 148,000,000 indicates that the estimates cannot be relied upon to have any accuracy at all, unless the computation is carried out to more than 12 significant figures. For models that involve large condition numbers the Jacobian matrix is referred to be ill-conditioned, of which singularity is the extreme form. Jennings and McKeown (1992) indicated that this is the most common cause of difficulty in the solution of non-linear equations. Although in theory the
convergence rate of the mathematical algorithm used for the estimation of non-linear equations is independent of the condition number, in practice extreme ill-conditioning will have serious effects (Jennings and McKeown, 1992). The existence of extreme ill-conditioning is more common in the particular case of fitting non-linear models, because of the ease with which redundant variables or variable-groups could be included in the model, and because of poorly-chosen units of the independent variables.

B.1 Variance-decomposition proportions

Given the identification of the existence of near exact linear dependencies through the spectral decomposition of $X'X$, it is important to evaluate the nature and extent of the effect on parameter estimates. For a single coefficient in $b$, the variance of the coefficient is:

$$\text{var}(b_k) = \sigma^2 \sum_{j=1}^{K} \frac{p_{kj}^2}{\lambda_j}$$  \hspace{1cm} (83)

where $k_j$ are constants, and $K$ is the smallest characteristic root. The proportion of $\text{var}(b_k)$ associated with any single characteristic root is:

$$\phi_{kj} = \frac{p_{kj}^2 / \lambda_j}{\sum_{j=1}^{K} \frac{p_{kj}^2}{\lambda_j}}$$ \hspace{1cm} (84)

The presence of two or more large values of $\phi_{kj}$ in any given row of Table 26 indicates that multicollinearity, and in particular the linear dependence associated with the corresponding

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$^{114}$ For the purposes of estimation the algorithm employed was Gauss-Newton.
characteristic root, is adversely affecting the precision of estimation of the associated coefficients. Since \( \phi_{i} \) are proportions they will be between 0 and 1, being considered as large if greater than 0.50. This methodology thus, consists in the evaluation of the proportion of the variance of the estimate accounted for by each principal component, where the principal components are constructed from the eigenvalues (characteristic roots) and the eigenvectors of the \( X'X \) matrix (SAS/ETS User’s guide). If two or more of the parameters to be estimated have large proportion values associated with the same principle component, the computation of the parameter estimates are slow or nonconvergent and the parameter estimates have inflated variances.

To evaluate multicollinearity, the values of \( \phi_{i} \) are organized as in Table 26, which can be obtained directly using SAS (the computer package), from the largest characteristic root \( (\lambda_{1}) \) to the smallest characteristic root \( (\lambda_{k}) \):

<table>
<thead>
<tr>
<th>Characteristic root</th>
<th>condition number</th>
<th>var( (b_{1}) )</th>
<th>var( (b_{2}) )</th>
<th>\ldots</th>
<th>var( (b_{k}) )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \lambda_{1} )</td>
<td>( (\lambda_{1}/\lambda_{k})^{1/5} )</td>
<td>( \phi_{11} )</td>
<td>( \phi_{21} )</td>
<td>\ldots</td>
<td>( \phi_{k1} )</td>
</tr>
<tr>
<td>( \lambda_{2} )</td>
<td>( (\lambda_{2}/\lambda_{k})^{1/5} )</td>
<td>( \phi_{12} )</td>
<td>( \phi_{22} )</td>
<td>\ldots</td>
<td>( \phi_{k2} )</td>
</tr>
<tr>
<td>\ldots</td>
<td>\ldots</td>
<td>\ldots</td>
<td>\ldots</td>
<td>\ldots</td>
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<td>\ldots</td>
<td>\ldots</td>
<td>\ldots</td>
</tr>
<tr>
<td>( \lambda_{k} )</td>
<td>( (\lambda_{k}/\lambda_{1})^{1/5} )</td>
<td>( \phi_{1k} )</td>
<td>( \phi_{2k} )</td>
<td>\ldots</td>
<td>( \phi_{kk} )</td>
</tr>
</tbody>
</table>

Table 26 Collinearity diagnostic: variance-decomposition proportions

Then, the characteristic roots being small (or the condition number being large) will not prevent the estimation of the parameters unless the variance proportions are large for two or more coefficients.
From the point of view of diagnosing the presence and nature of multicollinearity, the main recommendation is to scale the data so that the residual errors of the function used to solve the non-linear equations of the model (the Gauss-Newton algorithm, for instance) is equally sensitive to all the $X$ in the data. In simple terms the idea behind it is that if a model is fitted for equations that are not in expressed in comparable scales, the algorithm will assume that the equation with the smallest scale is less important and can be allowed to have a larger error.

Before correcting for multicollinearity, the linear profit model estimated the $R^2$ for the share of investments to be negative and sometimes larger than one. The SAS manual states that this results is obtained when the residual mean square error for the model is larger than the variance of the dependent variable. Since the dependent variable was the share of investments, which was very small relative to the other shares, the solution allowed a larger estimation error to this share. The error was so large that it was greater than the variance of the dependent variable.

Jennings and McKeown (1992) stated that the best course of action when facing ill-defined data is to ensure that the data is well scaled, that arithmetic is sufficiently precise and that the starting point is never too far from the likely solution. They also argued that the scaling of the data should result in variables that are roughly expressed in the same units at the starting point. When faced with convergence problems, these authors recommended that scaling is worth trying.

Then for the purpose of estimation of the profit model in the Dominican Republic the share of investments was scaled to be expressed in similar units than the other shares. That is, since the average share for loans and deposits were 2.89 and 1.6, but the share for investments had an average of 0.05, the share of investments was scaled by $1/0.05$ to express the new mean after scaling as 1. A mean of one is closer to the means of 1.6 and 2.89 for the other shares. Another possibility to correct for data problems is to center the data around their means. That is, to express each observation as deviations from its mean. This approach is not advisable, because centering the data will obscure any
linear dependence that involves the constant term (Judge et al., 1988) and in the specific case of the empirical model at hand, it will also obscure linear dependencies involved with the dummy variables for technical inefficiency.

For this dissertation, the condition numbers were high for both profit and cost frontier data, even for the linear version of the model which results from assuming that the \( \lambda_j \) parameters are equal to 1 (no allocative inefficiency). Since the model with allocative inefficiency is highly non-linear, the multicollinearity analysis was carried out for the linear version of the model to eliminate the effect of ill-conditioned data before introducing additional non-linear complexities.

B.2 Empirical implementation

To evaluate the nature and extent of the effect on the parameter estimates of near-singularities, the variance-decomposition proportions approach was implemented. For the linear profit model, the condition numbers increased dramatically for the last two characteristic roots. With the lineal specification, the model had 26 parameters (\( k=26 \)). The 26 characteristic roots are calculated, one for each parameter ordered from the largest to the smallest, as shown in Table 26. The characteristic roots of the linear model deteriorated to close to zero values for the last two principal components. The characteristic root 24 was 0.0000145, which is small but still manageable. Nevertheless, the characteristic root 25 was 8.38E-6 and the characteristic root for 26 was 4.7E-6 which indicate that the parameter estimates will have little precision, because of near linear dependencies in the data.

Next, the \( \phi \) proportions corresponding to the last two characteristic roots were evaluated. For the root 25, the coefficients \( \alpha_{12} \), \( \alpha_{22} \), \( \alpha_{34} \), and \( \alpha_{44} \) from the profit specification had proportions larger than 0.5. That is, the model will benefit from removing any of these parameters. For the characteristic root 26, all the technical inefficiency dummies, the coefficient for fixed assets, and the coefficient for the square of fixed assets had large variances.
In dealing with the first characteristic root, the parameter for the square of fixed assets was eliminated from the estimation, because in the first run this parameter was not significantly different from zero, and then the model was run again. The new model with 25 parameters had only one additional characteristic root relatively small, root 25, as expected. The next step was to choose one of the four parameters related to this root that had large variances. After a few tests, the best parameter to consider was \( \alpha_{24} \). Nevertheless, instead of assuming that the parameter was zero it had to be kept at its initial value, i.e., at the estimated value under the linear model. Since multicollinearity affects the variances of the estimates but the parameters are still unbiased, it seemed reasonable to keep this value at its estimate from the linear version that still had collinearities.

The analysis of collinearity indicated no problems with the new data matrix and these estimated values were used as the initial values for the non-linear model, which includes the allocative parameters. After these corrections the model allowed for the estimation of all the remaining parameters with no additional problems of collinearities, as indicated by the existence of reasonably large characteristic roots for all the parameters. The resulting model is what was presented in Chapter 7, which excludes the coefficient for the square of fixed assets and assumes that the \( \alpha_{24} \) parameter remained at the estimated value obtained for the linear model.

For the cost frontier model the analysis was carried out in a similar manner. In this case, the linear version of the model indicated the redundancy of five parameters because of five characteristic roots being too small. This result was for the original specification of costs that included fixed assets as an additional argument. Indeed, the three coefficients involved in the fixed asset specification (see Appendix A) were associated with the smallest characteristic roots. The final cost frontier model excluded fixed assets altogether. The variance decomposition analysis for the new specification of costs resulted in two small characteristic roots. For the model with 21 parameters, the smallest
bearable characteristic root was root 19=0.0000217, but roots 20 and 21 deteriorated to close to zero values as 4.96E-6 for root 20 and 9.75E-7 for root 21.

The variables associated with root 21 were $Y_1$, $Y_2$, $Y_{12}$, and $Y_{22}$, i.e., parameters that had variances greater than 0.5. For root 20, the associated parameters were all the dummies. After a few tests the model was run with $Y_{12}$ and $Y_{22}$ fixed at their initial estimation values, and the characteristic roots became well-behaved. The parameter estimates from the modified linear model were then used as starting values for the model with allocative inefficiency include, which is non-linear. The final model is presented in Appendix A, which was the basis for the ranking of banks presented in Chapter 7.