THE EFFECTS OF RESERVE REQUIREMENTS AS AN IMPLICIT TAX ON BANKING: THEORY AND EMPIRICAL EVIDENCE

by

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The Effects of Reserve Requirements as an Implicit Tax on Banking - Theory and Empirical Evidence

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Reserve requirements act as an implicit tax on the balances of a financial intermediary required by law. This tax creates an incentive for financial intermediaries to innovate liabilities that minimize their burden. The objective of this thesis is to investigate the role of legal reserve requirements as an implicit tax in encouraging innovations in the banking sector.

In the theoretical part, various measures of the implicit tax rates of required reserves are developed using alternative definitions of bank output. The effects of legal reserve requirements on costs and profitability of banks are theoretically studied using micro-static models of bank portfolio behaviour. Two types of models are discussed: a) perfect certainty models and b) stochastic models.

The effects of reserve requirements on bank portfolio behaviour can be studied at two levels: 1) there are the primary effects on bank decision variables, affecting the levels of deposits, loans, interest rates paid on them and 2) there are the secondary effects by which banks find ways to get around or minimize the effects of regulations such as substituting non-traditional liabilities for traditional ones. In the theoretical part of the thesis I have discussed both (1) and (2), whereas in the empirical part, I have focused on the secondary effects of reserve requirements. In particular, I have
tested the hypothesis that the incentive to innovate new financial instruments on the liability side is directly related to the cost or implicit tax of required reserves.

In the empirical chapters, attempts are made to compute the implicit tax rates of reserve requirements for banks in the United States and the United Kingdom. Conventional regression models are applied to relate these tax rates to the major innovations that have occurred in the financial sectors of these two countries during the period from 1965 to 1980.

The innovations considered are offshore banking conducted by U.S. banks and the development of international banking in the United Kingdom. The evidence indicates that the implicit tax of reserve requirements played a significant role in these innovations.
DEDICATION

Dedicated to my father, Syed Abdur Razzaque
and mother, Jahanara Begum,
who taught me how to read and write
my wife, Sunjida Akther (Shampa)
and son, Tahsin
"Almost anything a Government does in the way of regulations, prohibitions, quotas and quantitative restrictions licensing and so on, will alter the relative price structure, which will in turn lead to either a temporary or permanent shift in the distribution of income and assets."

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CHAPTER ONE
INTRODUCTION

1.1 The problem addressed

Reserve requirements act as an implicit tax on transactions intermediated through banks. By forcing a commercial bank to commit a portion of its assets to non-earning reserves, reserve requirements lower the effective rate of return on bank portfolios, and therefore create an incentive for innovations that minimize the holding of such reserves. So far, very little attention has been paid to the effects of this tax on bank portfolio behaviour, particularly to its role in developing substitutes for traditional liabilities. The purpose of this thesis is to quantify the burden of the implicit tax of reserve requirements and determine the impact of this tax on the portfolio behaviour of banks in the United States and the United Kingdom.

Most studies concerning reserve requirements are directed towards macroeconomic stability considerations with implications for monetary control. The neglect of the 'efficiency' implications of reserve requirements has been due to the fact

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1Grubel (1983) developed a measure of the effective tax rate of reserve requirements and discussed its role in the development of international banking in Canada. Baltensperger (1982a) discussed the efficiency aspects of the tax of reserve requirements in a general equilibrium model.

2See, for example, Laufenberg (1979), Santomero and Siegel (1981) and Baltensperger (1982b).
that reserve requirements have been traditionally viewed as an important tool for monetary policy, specifically for regulating the supply of money. The indirect tax on banks through reserve requirements is viewed as incidental to the overriding needs of stabilization policy. The effects of reserve requirements on the profitability of banks and on their portfolio selection have been either sidestepped or just given casual treatment. The motivation of this thesis is to fill the gap left by this approach.

The central argument of the thesis is that reserve requirements tax those liabilities against which the banks are legally required to keep reserves. The legal necessity of keeping idle non-earning reserves, in addition to the minimum they would have kept as a protection against insolvency and as an inventory against unexpected withdrawal of reserves, forces banks to choose techniques that circumvent this binding regulation. More specifically, banks have always an incentive to avoid this tax by developing substitutes for the reserve-constrained liabilities. Reserve requirements, by lowering the rate of return on bank portfolios, put the commercial banks at a competitive disadvantage compared to other depository institutions.

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See Greenbaum (1983).

"An offsetting benefit of reserve requirements has typically been costless clearing and other services from the Central Bank."
The effective profit advantage for a bank not having to maintain legal reserves can be very high compared to one having to maintain some reserves. The advantage is a monotonically increasing function of the interest rate level. This explains why devising new substitutes for the traditional liabilities requiring reserves and developing institutions that minimize the holding of reserves is especially rewarding in periods of high interest rates.

Technology plays a significant role in the development of innovative liabilities. The recent advances in technology lower the cost of innovating new liabilities to avoid reserve requirements. In particular, the process of deposit substitution is immensely aided by the lower-cost transfer technology and the new cash management techniques. This is particularly true in the case of the eurodollar market.

The possible effects of the 'hidden' tax of reserve requirements and the options facing banks to avoid this tax are briefly summarized below.  
1. It leads to the development of substitutes requiring less or no reserves such as repurchase agreements, bankers' 

---

5 The effective profit advantage is the relative profit of a deregulated bank expressed as percentage of profit in the regulated sector. This is illustrated with a definition and a numerical example in Chapter Two.

6 These points are further investigated at the theoretical level in the following chapters.

7 A repurchase agreement is a loan secured by collateral in the form of securities. One side, usually a depository institution, borrows money in exchange of securities issued by the government.
acceptances, borrowings from the Federal funds market and eurodollar market. If reserve requirements are likely to continue as an instrument of policy, the bank will wish to diversify into other areas to retain the profit potential it had in the unregulated state.

2. It initiates the process of disintermediation by which financial transactions are rechanneled through parallel markets to avoid the banking system and the regulations. Development of markets for commercial bills, treasury bills, and money market funds are some of the examples. Exit from the Federal Reserve membership for US banks and the development of subsidiaries by UK clearing banks are also part of the same disintermediation process.

3. It encourages the development of an offshore market for the domestic currency, and the expansion of overseas banking.

4. The 'implicit' tax is in the ultimate sense a tax on users of bank money.\(^7\) Banks often pass on the 'tax' to the depositors in the form of lower rates on their deposits. This induces depositors to seek alternative investment of their deposit funds. Banks can also shift the 'tax' of reserve requirements to the borrowers by charging higher rates on their loans. In both the cases, the extent of the shift depends on the competitiveness of the relevant markets.

\(^7\) (cont'd) or Federal agencies. The other side, usually a corporation, lends money in exchange of these securities.

\(^8\) See Benston (1978).
1.2 Importance of this study

A study of the costs of reserve requirements as a regulatory measure is important for a number of reasons:

1. This study is necessary for examining the issue of tax equity among the depository institutions, specifically to find out whether banks are treated unfavourably amongst all financial institutions. If reserve requirements are not imposed at a uniform level on all depository institutions, it creates a competitive distortion in the financial sector. A knowledge of the cost of reserve requirements gives an idea of the extent of this distortion.

2. Tax policy statements on the banking sector prepared by government agencies usually do not take into consideration the impact of government regulations on the economic income of a bank. Therefore these policy statements usually underestimate the total tax borne by banks.

3. The welfare effects of bank regulations need to be considered. Regulations induce adjustments on the part of banks to minimize their burden, and therefore lower the private cost of regulations. But sometimes these adjustments may involve a choice of techniques that raises the social cost. For example, the expansion of offshore banking to avoid domestic regulations may cause both the bank and its customers to incur extra costs of communication and loss of domestic employment opportunities. It would be useful to know, for policy purposes, whether these welfare costs
exceed the alleged benefits of having reserve requirements as an instrument of monetary policy.

4. Even the benefits of reserve requirements as an instrument of monetary policy are questionable. The proliferation of substitutes for reserve-constrained claims may cause problems of monetary control. The distinction between money and other financial claims is blurred. It becomes difficult for the government to keep pace with the process of substitution and select an appropriate monetary target for stabilization.

1.3 An outline of the thesis

The thesis is divided into two parts, Part I (the theoretical part) and part II (the empirical part). Part I contains Chapters Two to Four. Part II contains Chapters Five to Eight. In the theoretical part, the effects of reserve requirements on bank behaviour are investigated, setting apart stability considerations, using some firm-theoretic models of bank behaviour. More precisely, the objective is to explore whether innovations in bank liability management can be explained within the framework of simple theoretical models of profit-maximizing behaviour. In the empirical part, I have tried

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9See Greenbaum (1983).

10Given that there are recognition lags and monitoring cost for extending reserve requirements to the newly created deposit-substitutes. See Kantas and Greenbaum (1982).

11In the sense of intra-liability substitution.
to quantify the burden of the implicit tax of reserve requirements in the United Kingdom and the United States, and to
determine the impact of this tax on in encouraging portfolio innovations banks in these two countries. A brief description
of the contents of the various chapters is given below.

Chapter Two presents some basic definitions and concepts of reserve requirements as an implicit tax on banking. I develop
measures of implicit taxation in a simple model of given assets and liabilities. In a later section, I use a simple model of two
types of deposits to show the substitution between liabilities in response to the imposition of reserve requirements. It is shown
that a system of differential reserve requirements reduces the relative supply of the deposit on which higher reserve
requirements are imposed. Reserve requirements increase the effective cost of deposit funding.

In Chapter Three using a static perfect certainty model of bank behaviour, I investigate the effects of reserve
requirements on bank assets, liabilities and the interest rate. Under a particular set of assumptions, it is shown that
the level of deposits, interest rate paid on deposits, and the

\[ \text{---------------------} \]

\[ ^1 \text{In the empirical part, I investigate the impact of the implicit tax on only one type of portfolio innovation, the development of international banking. While doing the regression work, I measured the rate of innovation by the increased supply of the innovative financial liability (the increased amount of international banking activities of US and UK banks).} \]

\[ ^2 \text{The basic model of this chapter is drawn from the works of other writers. See the references cited in Chapter Three. I examine the effects of reserve requirements in a traditional model.} \]
profit, in the regulated sector are lower than those in the unregulated sector. It is also shown that the measures of the implicit tax rates developed in Chapter Two are substantially modified when we consider the adjustment on the part of banks in response to the reserve requirements tax.

In Chapter Four, the model of Chapter Three is extended to include the uncertainty case. The role of reserve requirements is explored using a model of expected profit maximization which incorporates stochastic inflow and outflow of deposits. The model determines the optimal amount of deposit and cash flows given the random nature of cash flows and the reserve requirements constraint it must meet. I develop some modified measures of the implicit tax of reserve requirements in the extended model. The loss of earnings from reserve requirements depends on the parameters of the deposit withdrawal function as well as the penalty for reserve deficiency.

It should be noted here that in the empirical chapters of part II, I use the measures developed in Chapter Two to compute the implicit tax burden of reserve requirements. The motivation of Chapters Three and Four is to explore the effects of reserve requirements and develop measures of implicit tax rates in more realistic models of bank behaviour, and in particular, to see how the measures developed in Chapter Two are modified when we relax some of the assumptions. The measurement of implicit tax rates from the more realistic models involves computational difficulties because one has to know the parameters of the
deposit supply function in the case of the certainty model of Chapter Three and also the deposits withdrawal function in the case of the uncertainty model of Chapter Four. Estimation of the supply function for the banking sector as a whole also involves aggregation problems to the extent that individual banks may have dissimilar cost structures and earnings functions. In view of these problems, I have used the simplified measures developed in Chapter Two. However, these measures suffer from the limitation that they do not take into consideration the primary effects of reserve requirements described briefly above and investigated in detail in Chapters Three and Four.

Chapters Five to Eight are the empirical chapters of the thesis. In Chapter Five, I have discussed the structure of reserve requirements in the United States during the period 1960 to 1980. The formulae of measures of implicit taxation developed in Chapter Two are applied to estimate, at an aggregate level, the loss of earnings for U.S. banks from required reserves and the various implicit tax rates.

In Chapter Six, I investigate the role of the implicit tax of reserve requirements in the development of offshore banking by U.S. banks during the period January, 1965 to November, 1980. Conventional regression models are used to determine the impact of various regulatory and non-regulatory factors.

In Chapter Seven, a brief overview of the reserve requirements system in the United Kingdom is presented. I have
used the measures developed in Chapter Two to compute the various implicit tax rates of cash reserves, secondary reserves and special deposits. The effects of supplementary special deposits are also investigated.

In Chapter Eight, I examine the role of various implicit tax rates in the development of international banking in the United Kingdom during the period from first quarter of 1963 to the second quarter of 1980.

Chapter Nine is the concluding chapter. It summarizes the thesis and provides welfare and policy implications of the study.
PART I

THE EFFECTS OF RESERVE REQUIREMENTS ON BANK BEHAVIOUR

--- A THEORETICAL ANALYSIS
In this chapter, section 2.1 explains the concept of the implicit tax of reserve requirements and develops alternative measures of the implicit tax rates in a simple model of bank behaviour with given assets and liabilities. Then I extend the definitions of tax rates to a general case with n types of liabilities. In section 2.2, I present a testable hypothesis about the relation between bank innovations and the implicit tax of reserve requirements. In section 2.3, the effects of reserve requirements on the inter-liability substitution within bank portfolios are studied using a simple model of bank behaviour. The summary and conclusions of this chapter are presented in section 2.4.

2.1 The concept of reserve requirements as an implicit tax

Banks forego interest on the deposits that they are required by law to keep with the central bank. These foregone interest earnings constitute an implicit tax from the bank's viewpoint. The tax is 'implicit' because the government does not recognize it as a tax. There are however, some differences between the concept of 'tax' in the ordinary sense and the one used here.

1. The size of the required reserves is not a measure of the implicit tax for the bank. Rather the foregone earnings on the required reserves are the actual measure of the burden
of the tax. The foregone earnings are an increasing function of:

a. the size of the required reserves and

b. the rate of interest on additional assets which the banks would have acquired, had there been no legal reserve requirements. Since there is a whole range of assets which the bank could acquire in the absence of reserve requirements, there is no 'unique' interest rate which we could use to measure the burden of this tax.

2. Taxes generate revenue for the government. The corresponding revenue from the reserve requirements tax stems from the increase in assets of the reserve bank by the same amount. The government revenue therefore depends on interest earned on these assets. The required reserves only constitute the 'base' from which the tax can be calculated. The stream of earnings for the government is not the same as the stream of earnings the bank has to give up because of the implicit tax of reserve requirements, unless the central bank and commercial bank assets have the same yield.

2.1.1 Alternative measurements of the reserve requirements tax

This section develops and illustrates various measures of the hidden tax of reserve requirements using a simple model of bank portfolio behaviour.

This is a static, perfect certainty model. I assume that equity (E) and deposits (D) are the only liabilities of the bank
and cash reserves (R) and loans (L) are the only assets. The bank has two types of deposit liabilities, D₁ and D₂ on which it pays interest at the rates i₁ and i₂ respectively. The bank's return on loans is given by r.

It is assumed that there are no secondary reserve requirements and the bank keeps the legal minimum as cash reserves. The latter assumption is justified on the grounds that in a world of perfect certainty, as is postulated here, there is no need for excess reserves.¹ The bank is required by law to keep reserves on deposits D₁ and D₂ at the rate ρ₁ and ρ₂ respectively.

This is a model with given assets, liabilities and interest rates and therefore does not involve any optimization process. This is used only to illustrate the various definitions of implicit tax rates of legal reserve requirements. In later models, I introduce the behavioural responses of the banking firm and the industry to these 'implicit' taxes.

The balance sheet equation of a bank is given by

\[ L + R = D₁ + D₂ + E \]  \hspace{1cm} (2-1)

and the legal reserves constraint is given by

\[ R = ρ₁D₁ + ρ₂D₂ \]  \hspace{1cm} (2-2)

The profit equation is

\[ \Pi^* = rL - i₁D₁ - i₂D₂ - C \]  \hspace{1cm} (2-3)

where C is the operating costs facing the bank.

¹The role of excess reserves in a world of uncertainty will be explored in Chapter Four.
Substituting (2-1) and (2-2) into (2-3), we have
\[ \Pi^* = r[(1-\rho_1)D_1+(1-\rho_2)D_2+E] - i_1D_1- i_2D_2-C \]  
(2-4)

In the absence of reserve requirements, (2-4) is reduced to
\[ \Pi^{**} = r(D_1+D_2+E) - i_1D_1-i_2D_2-C \]  
(2-5)

where \( \Pi^{**} \) is the level of unregulated profit.

Therefore, the reduction in profit is \( \Pi^{**} - \Pi^* = r(\rho_1D_1 + \rho_2D_2) \), which measures the opportunity cost of funds tied up in reserves.

The tax of reserve requirements can be calculated in one of the following alternative ways.\(^2\)

1. The implicit tax on bank's real capital (IT\(\text{TXK} \)). This is given by
   \[ (\Pi^{**} - \Pi^*)/E = r[\rho_1D_1 + \rho_2D_2]/E \]

2. The implicit rate of taxation per dollar deposit (IT\(\text{XD} \)) is given by
   \[ (\Pi^{**} - \Pi^*)/(D_1+D_2) = r[\rho_1D_1 + \rho_2D_2]/(D_1+D_2) \]

3. The effective profit advantage (EPRO) is given by
   \[ [\Pi^{**} - \Pi^*]/\Pi^* = r(\rho_1D_1 + \rho_2D_2)/\Pi^* \]

4. The implicit rate of taxation per dollar of net interest earnings on deposits and equity (IT\(\text{XI} \)) is given by
   \[ (\Pi^{**} - \Pi^*)/I = r[\rho_1D_1 + \rho_2D_2]/[r{(1-\rho_1)D_1+(1-\rho_2)D_2+E} - i_1D_1-i_2D_2] \]

\(^2\)These measures do not take into account the adjustment on the part of banks to these tax rates. These adjustments and the consequent effects on the tax rates are explored in Chapter Two.
2.1.2 A numerical example of alternative measures of tax rates

Assume $D_1 = 100$, $D_2 = 80$, $E = 30$, $r = .15$, $i_1 = .08$, $i_2 = .12$, $C = 4.00$, $\rho_1 = .10$, $\rho_2 = .05$

The deregulated profit is:

$$\Pi^{**} = r(D_1 + D_2 + E) - i_1 D_1 - i_2 D_2 - C$$

$$\Pi^{**} = .15(100 + 80 + 30) - .08 \times 100 - .12 \times 80 - 4 = 9.90$$

The regulated profit is:

$$\Pi^* = r[(1-\rho_1)D_1 + (1-\rho_2)D_2 + E] - i_1 D_1 - i_2 D_2 - C$$

$$\Pi^* = .15[.9 \times 100 + .95 \times 80 + 30] - 17.6 - 4$$

$$\Pi^* = 7.80.$$ 

The difference between the two is,

$$\Pi^{**} - \Pi^* = r[\rho_1 D_1 + \rho_2 D_2] = 2.10.$$ 

The rate of tax on bank's real capital is $2.1 + 30 = .07$ or 7%.

The implicit tax rate per dollar deposit,

$$= 2.10 + (100 + 80) = .01$$ or 1.5%.

The effective profit advantage is,

$$2.1 + 7.8 = .27$$ or 27%. This implies an effective profit advantage of $27$ for operating in a deregulated bank for every $100 of profit in the regulated sector.

The rate of tax per dollar of interest earnings is,

$$= 2.10 + 11.8 = 1.78$$ or 17.8%.

Two implications stand out clearly from the definitions of implicit tax rates.

1. The banks have an incentive to substitute liabilities with higher reserve requirements for liabilities with no or less reserve requirements and therefore, lower the effective
reserve ratio. For example in the definitions of ITXD or ITXK, an increase in \( D_2 \) relative to \( D_1 \) will lower the implicit tax per dollar deposit as well as per unit of real capital, given \( \rho_1 > \rho_2 \). In the above example, if we reduce \( D_1 \) to $50 and increase \( D_2 \) to $130, ITXD is reduced from 1.5% to .95% and ITXK is reduced from 7% to 5.75%. The offshore market for dollars provides a good example of banks' attempt to lower the effective reserve ratio. Since the offshore banks do not have to keep reserves against their deposits, the banks with offshore branches can pool their reserves against offshore deposits and domestic deposits. The effective reserve ratios for banks with offshore branches are lower than banks without such branches.

2. For given levels of \( D_1, D_2, \) and \( E \), the various measures of the implicit tax of reserve requirements are increasing functions of the loan rate \( r \) and the legal reserve ratios \( \rho_1 \) and \( \rho_2 \). Differentiating ITXD and ITXK with respect to \( r \),

\[
\frac{\partial \text{ITXD}}{\partial r} = \frac{(\rho_1 D_1 + \rho_2 D_2)}{(D_1 + D_2)} > 0 \quad \text{and,} \\
\frac{\partial \text{ITXK}}{\partial r} = \frac{(\rho_1 D_1 + \rho_2 D_2)}{E} > 0
\]

This explains why in periods of rising interest rates, there is more incentive to move into liabilities requiring no or fewer reserves. The sensitivity of the implicit tax rates to different levels of reserve requirements and interest rates is shown in Table 2.1. The values assumed for the levels of the variables, \( D_1, D_2, \) and \( E \) are same as in

\[\text{See Aliber (1980).}\]
Table 2.1
Implicit Tax Rates* for Different Hypothetical Values of Interest Rates and Reserve Requirements
\( (r - i_1 = .06, r - i_2 = .04) \)

<table>
<thead>
<tr>
<th>( r )</th>
<th>ITXK</th>
<th>ITXD</th>
<th>ITXI</th>
<th>EPRO</th>
</tr>
</thead>
<tbody>
<tr>
<td>.10</td>
<td>4.7</td>
<td>.8</td>
<td>13.0</td>
<td>20.1</td>
</tr>
<tr>
<td>.15</td>
<td>7</td>
<td>1.2</td>
<td>18.1</td>
<td>27.6</td>
</tr>
<tr>
<td>.20</td>
<td>9.3</td>
<td>1.6</td>
<td>22.6</td>
<td>33.3</td>
</tr>
<tr>
<td>.25</td>
<td>11.7</td>
<td>1.9</td>
<td>26.5</td>
<td>38.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>( r )</th>
<th>ITXK</th>
<th>ITXD</th>
<th>ITXI</th>
<th>EPRO</th>
</tr>
</thead>
<tbody>
<tr>
<td>.10</td>
<td>7.1</td>
<td>1.2</td>
<td>21.3</td>
<td>35.3</td>
</tr>
<tr>
<td>.15</td>
<td>10.7</td>
<td>1.8</td>
<td>30.6</td>
<td>49.5</td>
</tr>
<tr>
<td>.20</td>
<td>14.3</td>
<td>2.4</td>
<td>39.2</td>
<td>61.9</td>
</tr>
<tr>
<td>.25</td>
<td>17.8</td>
<td>3.0</td>
<td>47.1</td>
<td>72.8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>( r )</th>
<th>ITXK</th>
<th>ITXD</th>
<th>ITXI</th>
<th>EPRO</th>
</tr>
</thead>
<tbody>
<tr>
<td>.10</td>
<td>9.9</td>
<td>1.6</td>
<td>32.0</td>
<td>56.5</td>
</tr>
<tr>
<td>.15</td>
<td>14.8</td>
<td>2.5</td>
<td>48.0</td>
<td>84.4</td>
</tr>
<tr>
<td>.20</td>
<td>19.7</td>
<td>3.3</td>
<td>63.8</td>
<td>112.1</td>
</tr>
<tr>
<td>.25</td>
<td>24.7</td>
<td>4.1</td>
<td>80.5</td>
<td>139.6</td>
</tr>
</tbody>
</table>

* expressed as percentage
the above example, i.e., \( D_1 = \$100, \ D_2 = \$80, \ E = \$30, \ C = \$4 \).

Three sets of reserve ratios and four sets of loan rates are considered. I assume a constant spread of 6 per cent and 4 per cent between the interest rates on \( L \) and \( D_1 \) and the rates on \( L \) and \( D_2 \) respectively. This latter assumption is made to simplify calculations. Table 2.1 shows the results of computations of different tax rates using the above definitions.

2.1.3 Measurement of reserve requirements tax: a general case

In this section I extend the simple model of the previous section to \( k \) types of liabilities and \( n \) types of assets. As in the previous model, the bank has two types of liabilities, deposits and equity (\( E \)). There are \( k \) categories of deposits. I assume that the bank issues deposit liabilities \( D_1, D_2, \ldots D_k \) at the interest rates \( d_1, d_2, \ldots d_j \). Assuming that \( C \) represents other costs of deposit production, the total cost to the banking firm is,

\[
\Sigma d_j D_j + C
\]  

(2-6)

Suppose the bank invests in \( n \) types of assets \( L_1, L_2, L_3, \ldots L_n \) at the interest rates \( r_1, r_2, \ldots r_n \). The profit for the bank is given by,

\[
\Pi^{**} = \Sigma r_i L_i - \Sigma d_j D_j - C
\]  

(2-7)

where the balance sheet constraint is given by,

\[
\Sigma L_i = \Sigma D_j + E
\]  

(2-8)
Now suppose the bank is required by law to keep reserves at the rate \( \rho_1, \rho_2, \ldots, \rho_k \) on its deposits, \( D_1, D_2, \ldots, D_k \).

Let \( R \) be the amount of legal reserves. Then the legal reserves constraint is given by,

\[
R = \rho_1 D_1 + \rho_2 D_2 + \ldots + \rho_k D_k
\]

The balance sheet constraint becomes,

\[
\Sigma L_i = \Sigma D_j (1-\rho_j) + E
\]  \hspace{1cm} (2-9)

The profit is given by,

\[
\Pi^* = \Sigma r_i L_i - \Sigma d_j D_j - C
\]  \hspace{1cm} (2-10)

The difference between \( \Pi^{**} \) in (2-7) and \( \Pi^* \) in (2-10) is the loss of earnings from legal reserves. Unlike the model presented above with two types of liabilities, the balance sheet constraints cannot be substituted into the profit function to provide a measure of this loss. I make a simplifying assumption to derive a measure of this loss which will be carried over to the empirical part of this study.

Assume that the bank invests the proportion \( \alpha_i \) of total liabilities in the asset \( L_i \). With this assumption, the profit in (2-7) becomes,

\[
\Pi^{**} = r_1 L_1 + r_2 L_2 + \ldots + r_n L_n - \Sigma d_j D_j - C
\]

\[
= \Sigma r_i \alpha_i (\Sigma D_j + E) - \Sigma d_j D_j - C
\]  \hspace{1cm} (2-11)

The profit in (2-10) becomes, on the assumption \( L_i = \alpha_i \Sigma D_j (1-\rho_j) \)

\[
\Pi^* = \Sigma [(1-\rho_j)D_j + E] (\Sigma r_i \alpha_i) - \Sigma d_j D_j - C
\]  \hspace{1cm} (2-12)

The difference in profit between (2-11) and (2-12) is given by,

\[
\Pi^{**} - \Pi^* = [\Sigma \rho_j D_j] [\Sigma r_i \alpha_i]
\]  \hspace{1cm} (2-13)

This is the opportunity cost of reserve requirements. We can
derive the different tax rates by dividing this (2-14) by the appropriate bases.

1. \( \text{ITXK} = \frac{\sum \sigma_j D_j \left[ \sum \alpha_i \right]}{E} \)
2. \( \text{ITXD} = \frac{\sum \sigma_j D_j \left[ \sum \alpha_i \right]}{D} \)
3. \( \text{EPRO} = \frac{\sum \rho_j D_j \left[ \sum \alpha_i \right]}{\Pi^*} \)
4. \( \text{ITXI} = \frac{\sum \rho_j D_j \left[ \sum \alpha_i \right]}{\left[ \sum (1-\rho_j) D_j \sum \alpha_i - \sum d_j D_j \right]} \)

2.1.4 Choice among the alternative measures

Each of these measures has some merits. The choice between these various measures of calculating the effective tax rates for the banking sector depends on the purpose for which we are using the definition.

The rate of tax on real capital (ITXK) is in conformity with the traditions of public finance. Since the amount of equity capital is a standard measure of investment in banking, the tax rate should be calculated as a percentage of this investment. If one is interested in examining how the profitability of investment is affected by the reserve requirements tax, ITXK is the appropriate measure.

Reserve requirements are seen as a tax on transactions intermediated through banks. Since deposit liabilities are, in a sense, measures of the extent of financial intermediation, one can easily justify the use of the implicit rate of taxation per dollar of deposits (ITXD). If one is interested to know how the tax affects the size of intermediation, then ITXD is the relevant measure.
The effective profit advantage (EPRO) provides a measure of the advantage of operating in an unregulated environment as compared with a regulated one. Therefore it indicates the incentive for circumventing the regulation of reserve requirements by either developing substitutes or opening overseas branches. For a comparative analysis of the profit of the regulated sector relative to the profit of the unregulated banking sector, EPRO is a suitable measure. ITXI gives a measure of the implicit tax as a percentage of the interest earnings of the bank.

2.2 The relation between the implicit tax of reserve requirements and innovations: a testable hypothesis

It is evident from the definitions of implicit taxes on required reserves that the main incentive for (reserves minimizing) innovations arises from the profit differential between the regulated regime and the unregulated regime. In the simple model presented above, \( \Pi^* < \Pi^{**} \). The greater the profit differential, the greater are the effective profit advantage (EPRO) and the implicit taxes of reserve requirements (ITXD, ITXK or ITXI) as defined above and therefore, the higher the incentive for innovation. It is hypothesized that the incentive for innovation is directly related to this profit differential, \( (\Pi^{**} - \Pi^*) \) or to the implicit tax rates of reserve requirements.

\[\text{------------------}\]

\[\text{This may not be so when we consider the possible adjustment of bank behaviour when reserve requirements are imposed. See the model presented in Chapter Three.}\]
We postulate the following relationships:

\[ \frac{N}{M} = f(\Pi^{**}-\Pi^*) \], where \( f_1 > 0 \)

\[ \frac{N}{M} = g(\text{ITAX}^i) \], where \( g_1 > 0 \)

where, \( N \) = an innovation defined as a liability substituting for a traditional liability, \( M \) = a traditional liability, \( \text{ITAX}^i = \text{ITXK, ITXD, ITXI or EPRO} \). These relationships form the basic empirical model that I will test statistically in Part II.

In the following section the effects of a system of differential reserve requirements on the relative supply of deposits are investigated using a simple price-theoretic model of bank behaviour.

2.3 Effects of reserve requirements in a simple model of bank behaviour

Imposition of differential reserve requirements on various types of deposits affects the relative demand for, and the relative interest rates paid on, these deposits. This can be explained by the following partial equilibrium approach to bank equilibrium. This approach is built on the neo-classical foundation of the theories of consumption and production and takes into account both the relative supply of and demand for deposits as functions of the relative interest rates paid on them.
The demand side of the model is based on the standard neo-classical theory of production. This approach views the deposit liabilities as inputs. The banking firm transforms these inputs into its output, in the form of loans. The firm needs different types of deposits to produce loans. This type of input-output relationship between inputs and outputs was assumed by Sealey and Lindley (1977).

This is also a model of liability management since it is assumed here that the bank can alter the mix of its deposit liabilities in an attempt to maximize its profit and in response to changes in the parameters of the model. Liability management in this model is perceived as a profit-maximizing response by the banking firm in the form of changing the mix of its liabilities in response to the imposition of regulations on the banking sector.

Assume that the bank issues two types of deposit liabilities, \( D_1 \) and \( D_2 \). Assume also the bank produces a given amount of loans with the various combinations of these deposits. Assuming that \( D_1 \) and \( D_2 \) are imperfectly substitutable factors.

\[ \text{------------------} \]

\[ 5\text{I ignore other cost of production such as land, labour etc.} \]

\[ 6\text{See the survey of models of bank behaviour in the next chapter.} \]

\[ 7\text{Deposits are imperfect substitutes for the bank because they may vary as to the maturity, liquidity, transferability, tax treatment or currency of denomination. For example, demand deposits and time deposits vary as to their maturity, liquidity and differential treatment of regulations. Local currency and foreign currency denominated deposits vary as to the currency of denomination. A banking firm could sell its liability instruments on both a local and a national market. See Spellman (1982).} \]
in the production of loans $L$, the loans production function, $L = L(D_1, D_2)$, can be represented by a smooth, downward sloping, convex indifference curve as shown in Figure 2.1.1 for a particular level of loans. Thus a loan indifference curve shows various combinations of the two types of deposits to produce a given amount of loans. The banking firm is assumed to possess a map of such curves.

The downward slope of the loan indifference curve indicates that there is a trade-off between the two types of deposits and the convexity implies that the more the bank has of one type of deposit, the higher is the opportunity cost for the other type of deposit. This in turn, implies that there is an optimal mix of the two types of deposits to produce a given amount of loanable funds. This optimal mix depends on the relative costs of the deposits and the regulatory parameters of the model.  

Assuming that the bank's costs of production consist of interest costs only, the cost function is, 

$$C = i_1D_1 + i_2D_2$$

This is represented by the iso-cost line AB in Figure 2.1.2. The relative interest rates on the liabilities are given by the slope of this line.

Given a state of loan demand and deposit-mix, the firm faces a given level of loans, $L_0$. The objective facing the firm is to produce $L_0$ at a minimum cost. Alternatively, I can assume that

---

* I have assumed an interior solution of the model.
FIGURE 2.1.1 Loan indifference curve

D2

(Deposit type 1)

L2

L1

L0

D1 (Deposit type 1)

FIGURE 2.1.2 Demand for Deposits at Equilibrium
the bank has a given amount of available funds to allocate between two types of deposits (as interest payments) with the objective of maximizing the production of loans. Here I take the former approach.

In Figure 2.1.2, deposit costs are minimized at a point P where the loan indifference curve is tangent to the iso-cost line. Therefore, the most efficient way of producing a given amount of loans, \( L_0 \), is to use \( OM \) of deposit type 1 and \( ON \) of deposit type 2 when the relative interest rates are given by the iso-cost line \( AB \).

Suppose reserve requirements are imposed at the rate \( \rho_1 \) and \( \rho_2 \) on \( D_1 \) and \( D_2 \) respectively \( (\rho_1 > \rho_2) \). The effective interest rates\(^9\) facing the bank for \( D_1 \) and \( D_2 \) are \( i_1^e = \frac{i_1}{(1-\rho_1)} \) and \( i_2^e = \frac{i_2}{(1-\rho_2)} \), respectively, \( (i_1^e > i_1, i_2^e > i_2) \).

The new, reserve-requirements adjusted, cost function is,

\[
C^* = i_1^e D_1 + i_2^e D_2 = \frac{i_1 D_1}{(1-\rho_1)} + \frac{i_2 D_2}{(1-\rho_2)}. 
\]

This is represented by the iso-cost line, \( A*B^* \) in Figure 2.2.1. Here \( C^* > C \), since \( \rho_1, \rho_2 > 0 \).

\( C^* \) represents the effective interest costs, for the bank. \( P \) is now non-optimal, because \( A*B^* \) is not tangent to the loan indifference curve \( L_0 \). The bank finds that as the relative (effective) interest rates change, the bank can lower its costs by changing the mix of its liabilities. To obtain the new

\(^9\)The effective interest rates are interest rates on deposits adjusted for reserve requirements.
FIGURE 2.2.1 Equilibrium after the Imposition of Reserve Requirements

FIGURE 2.2.2 Gains from Innovation
equilibrium, I draw a line EF parallel to A*B* such that EF is
tangent to the indifference curve at point Q. Bank demand for
deposit type 1 falls from OM to OR and deposit type 2 increases
from ON to OS. The new equilibrium at Q represents a higher
level of costs than the old equilibrium at P. The proof is given
as follows:
Proof:

In Figure 2.2.2, I draw a line CD such that OC = C(1-ρ₁)/i₁,
and OD = C(1-ρ₂)/i₂; CD represents the same level of costs,
after the imposition of reserve requirements, as AB in the
pre-reserve requirements situation. CD is steeper than AB
because,
OD/OC = i₁(1-ρ₂)/i₂(1-ρ₁) > i₁/i₂, since ρ₁>ρ₂. EF and CD are
parallel because their slopes represent the reserve
requirements-adjusted interest rates, i₁(1-ρ₂)/i₂(1-ρ₁).
However, EF represents a higher level of costs than CD.
Therefore, EF represents higher level of costs than AB.

It is evident from Figure 2.2.1 that the relative demand for
liabilities has changed in the post reserve-requirements
situation. D₂/D₁ is higher at Q than at P.

The cost savings or quasi-rent from liability substitution
can be represented by the distance B*F in Figure 2.2.1. If the
bank does nothing in response to the imposition of reserve
requirements, it bears costs represented by the iso-cost line
A*B*. By altering the deposit-mix it can move to point Q, saving
costs by the distance $B^*F$ or $A^*E$.

Imposition of differential reserve requirements leads to the following results:

1. It raises the effective interest costs of the banking firm and lowers the level of loans at the interest costs in the absence of reserve requirements. The iso-cost line $CD$ is tangent to a lower level loan indifference curve than $L_0$.

2. It leads to substitution of a liability with lower reserve requirements for a liability with higher reserve requirements.

3. There are positive cost savings from inter-liability substitution.

2.3.1 Derivation of relative demand curve for deposits

The derivation of a relative demand curve for deposits is shown in Figures 2.3.1 and 2.3.2. I assume that the interest rate on deposit type 1 is fixed at $i_1^0$ and the interest rate on deposit type 2 varies. The initial equilibrium on the demand side is at $A$. By allowing the interest rate on deposit type 2 to fall while keeping the interest rate on deposit type 1 fixed at $i_1^0$, I trace the points of tangency between the loan indifference curves and the iso-cost lines, $A$, $B$ and $C$. Plotting the levels of $D_2/D_1$ at $A$, $B$ and $C$ against corresponding interest ratios, I derive a curve similar to the price consumption curve. I call this curve the relative deposit demand curve (RD in Figure 2.3.2).
Derivation of Relative Demand Curve for Liabilities (RD)

FIGURE 2.3.1

FIGURE 2.3.2
Along the relative deposit demand curve RD, as the interest on deposit type 2 falls, the banking firm increases the use of D_2 relative to D_1. The curve is downward sloping indicating that the bank demands more of the relatively cheaper input. On the assumption that interest on D_1 is fixed, it is evident from the diagrams and above analysis that the same relative deposit demand curve represents a higher amount of loans at lower levels of interest ratios (i_2/i_1^0).

The effects of imposition of differential reserve requirements on deposit liabilities are shown in Figures 2.4.1 and 2.4.2. The effective iso-cost lines representing effective interest-ratios are steeper than their corresponding iso-cost lines. Before the imposition of reserve requirements, the equilibria were at points A, B, and C. After the imposition of reserve requirements, the new equilibria are represented by A', B' and C'. The new equilibria are associated with higher levels of deposit-ratios, D_2/D_1, than the corresponding points of old equilibria, A, B and C. By plotting the deposit ratios at A', B', and C' against their corresponding interest ratios, I derive the relative interest demand curve, RD' in Figure 2.4.2. For each interest ratio i_2/i_1, there is a lower effective interest ratio i^{e}/i^{e}_1, assuming ρ_1>ρ_2. This lower effective interest ratio is associated with a higher deposit-ratio, D_2/D_1. Thus for every point on the RD curve, there is a new point to the right, for given values of ρ_1 and ρ_2. Therefore the RD curve shifts to the right. Higher levels of this curve indicates higher
Effects of Reserve Requirements on the Demand for Deposits

FIGURE 2.4.1

FIGURE 2.4.2
reserve-ratios, $\rho_1/\rho_2$.

The extent of the shift depends on the elasticity of substitution of the loan indifference curve and the change in reserve-ratios. To capture both these influences, I define the effective elasticity of substitution as the rate of change of deposit-mix with respect to a change in the relative effective interest rates for the two types of deposits.

\[ e^* = \frac{(A/B)\partial(D_2/D_1)}{\partial(i_1^e/i_2^e)} \]

where, $i_1^e = i_1/(1-\rho_1)$, $i_2^e = i_2/(1-\rho_2)$, $A = (i_1^e/i_2^e)$, $B = D_2/D_1$.

For $\rho_1 = \rho_2 = 0$, the effective elasticity of substitution $e^*$ is same as $e$, the ordinary elasticity of substitution along an isoquant.

2.3.2 The relative supply function of deposits

To complete the model, I consider a simple deposit supply function. It shows a relationship between the relative interest rates and the relative supply of deposits by the depositors. The deposit supply function can be written as follows:

\[ D_2/D_1 = f(i_2/i_1) \text{ where } f'>0; \]

As the interest rate on $D_2$ increases relative to $D_1$, depositors prefer to have more of $D_2$ relative to $D_1$. The deposit supply function is shown by line RS in Figure 2.5.
FIGURE 2.5 Effects of Reserve Requirements in the Complete Model
2.3.3 The complete model

The intersection of the deposit demand function, RD and the deposit supply function RS gives the point of equilibrium at P in Figure 2.5. The equilibrium interest-ratio is given by $(i_2/i_1)_1$, and the deposit-ratio is given by $(D_2/D_1)_1$. If differential reserve requirements are imposed on $D_1$ and $D_2$, the deposit demand function shifts to RD' for reasons explained before. At the equilibrium interest rate, $(i_2/i_1)_1$, the bank has excess demand for $D_2$ relative to $D_1$. The interest-ratio rises to $(i_2/i_1)_2$ and the equilibrium deposit-ratio rises to $(D_2/D_1)_2$.

It can also be shown that the loans at the post-reserve requirements equilibrium at Q represent a lower level of loans than the pre-reserve requirements equilibrium at P. Point Q on RD' represents the same level of loans as N on RD because both these points are associated with the same loan indifference curve. Point P represents a higher level of loans than point N. Therefore Q represents a smaller amount of loans than P. Thus, reserve-requirements raise the levels of the deposit ratio, $D_2/D_1$, and the interest-ratio, $i_2/i_1$, and lower the level of loans.

2.4 Summary and Conclusions

In this chapter, I have developed various measures of the implicit tax rate of reserve requirements, using a simple model
of bank behaviour with given assets and liabilities. These measures, using alternative definitions of bank output, capture the opportunity cost of non-interest bearing reserves for banks. This was followed by an examination of the impact of the introduction of differential reserve requirements on the relative supply of deposits and interest rates under simplified assumptions about bank behaviour. The conclusion of this simple model was that the bank has a tendency to substitute the deposit liability with lower reserve requirements for the one with higher reserve requirements. In the next chapter I investigate further the implications of reserve requirements in a static model of bank behaviour. That model deals with the absolute levels of liabilities, unlike the model of this chapter which deals with the ratio of these liabilities.
CHAPTER THREE
THE EFFECTS OF RESERVE REQUIREMENTS IN STATIC MODELS OF BANK BEHAVIOUR

The objective of this chapter is 1) to explore the effects of reserve requirements on bank portfolios using a traditional firm-theoretic model of bank behaviour and 2) develop measures of implicit tax rates which take into account the adjustment of bank behaviour in response to the imposition of reserve requirements.

This chapter is organized as follows: In section 3.1, I provide a brief survey of existing models in order to find out what types of bank models are suitable for analyzing the impact of the implicit tax of reserve requirements on bank portfolio behaviour. In section 3.2, I investigate the primary effects of reserve requirements in a conventional model of bank behaviour. I derive an iso-profit function to show the interaction of the reserve-ratio with the other variables of the model. In section 3.3, the loss of income from reserve requirements is decomposed into several components to identify the sources of gains and losses from regulation. I formulate measures of the implicit tax of reserve requirements from the model of section 3.2 and compare them with the measures derived in Chapter Two. This is followed by a discussion of the secondary effects of reserve requirements. More specifically, I discuss how the incentive for innovation arises in this model. The testable hypothesis developed in Chapter Two is reformulated in the light of
modified measures derived in this chapter. Section 3.4 provides a summary of this chapter.

3.1 A brief Survey of literature

Recently there has appeared a substantial body of literature on the portfolio behaviour of banks. In this literature, the bank models range from the traditional analysis of banks as investors channeling funds from surplus to deficit units, to recent studies that regard the banking firm as a production unit rather than as an intermediary.

We can detect two main approaches in these studies:
1. Macro-economic studies of the banking sector and

The macro-oriented banking models usually contain equations for excess reserves and borrowing from the Federal Reserve, bank demand for treasury bills and mortgage loans, as well as equations for the rate that banks set on commercial and different types of deposit liabilities. The models developed by Goldfield (1966), Pierce (1967) and Silber (1970) belong to this group. Pierce (1972) contains a description of this type of model.

The micro theories of bank portfolio selection can be classified into three categories:
1. The first approach represents an application to commercial banking of the theory of efficient portfolio selection
pioneered by Tobin (1958) and Markowitz (1959). It is assumed that the bank maximizes expected utility subject to the trade-off between risk and rate of return available from that set of efficient portfolios. This maximization usually implies a diversified portfolio for a risk-averse bank.

2. The second is an inventory-theoretic approach, first applied to banking by Porter (1961). This approach uses more conventional tools developed to describe the inventory behaviour of the non-financial firm to analyze bank portfolio selection. These models show that a bank that maximizes expected profit will usually hold a diversified portfolio given i) different transactions costs on various assets, ii) borrowing costs, iii) legal portfolio constraints and iv) uncertainty with respect to deposit flows and market yields.

3. The third approach is the application of the theory of the firm to the portfolio behaviour of banks. Since the pioneering publication by Klein (1971), a number of models have been developed using this approach. Attempts have been made, in these models, to develop a positive theory of price and output decisions of banks. This approach emphasizes the role of production and cost within the context of some objective function (profit, deposit etc) maximization. A great deal of controversy still exists about the definition of input and output for a banking firm. Sealey and Lindley (1977) contains an excellent discussion of these problems.
Studies of the portfolio behaviour of banks on a firm-theoretic level can be categorized as partial and complete models. The partial models are characterized by the assumption that the total size, as well as the structure, of the bank liabilities are exogenously determined and not subject to optimizing behaviour. These models deal with the problem of optimal allocation of given funds among various assets, and pay particular attention to the choice between earning assets and reserve assets.

The complete models of the banking firm not only provide an integrated view of the firm's assets and liabilities choice, but also the endogenous determination of total scale of the operations of the bank.

I have chosen the firm-theoretic approach1 for investigating the effects of an implicit tax of regulations because this type of model provides a convenient framework to study the implications of such a tax on the earnings of an individual bank, its deposit rate decision and the loan rate.

In the following sections, the role of reserve requirements in profit maximization models is investigated. Profit maximization models of a banking firm have been developed by Monti (1971), Loo (1980), Slovin & Sushka (1975), and Goldfield and Jaffee (1970). All the models developed in this chapter are perfect certainty models patterned after the works of Monti and

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1That is, the third approach mentioned above, using complete models.
3.2 A simple model involving one type of liability

In this section, I present a simple model of bank behaviour to explain the determination of the interest rate on deposits and the level of deposits. I show that neo-classical price theory can be applied to explain the effects of reserve requirements on a bank's decision regarding purchase of funds and acquisition of earning assets.

The balance-sheet of a representative bank is shown in Table 3.1

Table 3.1
Balance Sheet of a Representative Bank

<table>
<thead>
<tr>
<th>Asset</th>
<th>Liability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loans (L)</td>
<td>Deposits (D)</td>
</tr>
<tr>
<td>Reserves (R)</td>
<td></td>
</tr>
</tbody>
</table>

The assumptions of this model are,

1. The bank has two assets, loans, L and legal cash reserves, R. The bank earns interest at rate r on its loans but earns nothing on its legal reserves.

2. The bank has just one type of deposit, D.

3. Interest on deposits, i, is the only cost of intermediation facing the bank. Therefore, the difference between r and i
4. I assume that the bank faces an upward sloping deposit supply curve i.e. it has to pay higher interest rates in order to attract more deposits. The justification for this assumption is that since a bank normally attracts deposits from a limited geographical area and any given area contains only a limited number of institutions, the supply schedule of deposits to the banking firm should be less than perfectly elastic. It is also assumed that there is a positive level of deposit supply at a zero interest rate. Some depositors prefer to hold deposits for convenience and precautionary reasons.

The deposit supply function, \( D = D(i) \) (where \( D' > 0 \)), represents a relationship between deposit supply by the depositors and the various interest rates offered on these deposits by the bank. Since deposits are regarded as inputs in this model, the supply function is also the average factor cost curve. The supply function is represented by the curve labelled AFC in Figure 3.1.\(^2\) Corresponding to the average factor cost curve, there is a marginal factor cost curve. This is represented by MFC curve in Figure 3.1. The marginal factor cost curve shows the cost to the bank, at the margin, of acquiring one more unit of deposit funds.

Since the average cost curve is upward sloping, the marginal factor cost curve is also upward sloping and lies

\(^2\)AFC stands for average factor cost.
FIGURE 3.1 Effects of Reserve Requirements on Bank Equilibrium

Interest rate on loans and deposits
above the average factor cost curve. The marginal factor cost is higher than the average factor cost because the firm has to pay a higher interest rate not only to the marginal depositor, but to all the intra-marginal depositors as well.

5. I assume that the interest rate on loans received by the bank is determined in a perfectly competitive market. Thus the bank faces a given interest rate on its loans. The assumption that the bank is a yield-taker in the market for loans, implies two things: 1) the bank cannot influence the yield on its loans and 2) each dollar of deposits is equally productive in generating additional earning assets.

The loan demand function, \( L = L(r) \), shows the relationship between the amounts of loans demanded by the bank's customers and the interest rates offered on them. This is also the marginal revenue product curve for the bank because the interest rate on a loan is the marginal revenue from the expansion of loans. The marginal revenue product is equal to the average revenue product by assumption.

The loan demand function is shown by the perfectly elastic MRP curve in Figure 3.1. The height of this line is \( r_0 \).

6. The firm is assumed to maximize profit.

There are two regimes in the model, regulated and unregulated. In the regulated regime, the bank keeps cash reserves equal to its legal minimum on which it is paid no
interest. In the unregulated regime, the bank is not required by law to keep any reserves. The assumptions of no cash reserves in the unregulated regime and no excess cash reserves in the regulated regime are justified on the grounds that in a world of perfect certainty as is postulated here, there is no need for such reserves.

3.2.1 Equilibrium for the banking firm

In the unregulated regime the bank reaches equilibrium at point A in Figure 3.1 where the marginal factor cost curve (MFC) cuts the marginal revenue product curve (MRP). The profit-maximizing level of deposits is D'. This is also the profit-maximizing level of loans. The firm invests all its deposit funds in acquiring loans in this simple model.

The profit maximizing interest rate that the bank offers to its depositors can be traced by taking a point on the average factor cost curve (AFC) vertically below point A. Let this point be denoted by B. Then the equilibrium interest rate is BD' (=i'). The difference between r₀ and i' represents average profit for the bank.

3.2.2 Primary effects of legal reserve requirements

One can distinguish between two types of effects of legal reserve requirements on bank portfolio behaviour: a) primary effects and b) secondary effects. In this section, I will
discuss the primary effects of reserve requirements.

Imposition of reserve requirements forces banks to reallocate their assets and liabilities in such a way as to maximize their profits subject to the legal reserve requirements constraints. In other words, banks internalize their legal constraints in their decision-making process.

To investigate the effects of reserve requirements in the model discussed in the preceding section, assume that reserve requirements are imposed at the rate of \( p \) (where \( 0 < p < 1 \)) per dollar of deposits. This initiates a process of disequilibrium for reasons to be explained below. The process of adjustment towards a new equilibrium can be analyzed by the following two alternative approaches.

1. If \( p \) portion of its deposits are to be left aside as legal reserves, the bank's average earnings on loans fall by \( \$r(1-p) \) for each dollar of loans. Thus reserve requirements cause a parallel downward shift of the marginal revenue product curve from MRP to MRP'.

Point A no longer represents an equilibrium situation because the marginal factor cost at A exceeds the marginal revenue product. The equilibrium is restored at A' where the new marginal revenue product equals marginal factor cost.

The bank is forced, by profit-maximization considerations, to cut back its deposits to D". The interest rate on deposits falls from \( i' \) to \( i" \). Loans are reduced to
D'(1-\rho) from D'. Since the borrowers from the bank have to pay the same rate \( r_0 \) to the bank, they are not affected in terms of price, rather they are affected in terms of quantity since they can only get loans of the amount \( D'(1-\rho) \) instead of \( D' \).

2. The process of adjustment to the new equilibrium after the imposition of reserve requirements can also be analyzed by shifting the marginal factor cost curve. This is shown in Figure 3.2. The (effective) average cost of deposits for the bank is raised from $i to $i/(1-\rho). This causes a vertical upward shift of the supply curve, AFC by the amount $i\rho/(1-\rho). The new supply function is represented by AFC'. The MFC curve also shifts upward by the amount of MC.\rho/(1-\rho), where MC is the dollar amount of marginal factor cost in the absence of reserve requirements. The new marginal factor cost curve is represented by MFC'.

The equilibrium, in the pre-reserve requirements situation is at P. If reserve requirements are imposed on the bank, at the initial level of deposits OD', the marginal factor cost exceeds the marginal revenue product. The new equilibrium is attained at Q. The effects on deposits, loans, interest on deposits are same as in Figure 3.1. The interest paid to depositors is obtained by taking a point, T on the original average fixed cost curve vertically below Q. The effective average interest cost, however is given by

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3 The total cost of \((1-\rho)D\) deposits is $iD. So, cost per dollar of deposits is $iD/(1-\rho)D = $i/(1-\rho).
FIGURE 3.2 Effects of Reserve Requirements on Bank Equilibrium - an alternative Approach
point \( S \) on the new AFC curve, AFC'. Deposits fall from OD' to OD".

Below I have provided a mathematical treatment of the model assuming a particular deposit supply function. The objective is to gain additional insights from the model.

From the preceding assumptions, the profit function can be written as follows:

\[
\Pi = rL - iD \quad (3-1)
\]

subject to

\begin{align*}
R + L &= D \quad \text{Balance sheet constraint} \quad (3-2) \\
R &= \rho D \quad \text{Legal reserve constraint} \quad (3-3) \\
D &= a + bi, \quad a > 0, \quad b > 0 \quad \text{Deposit supply function} \quad (3-4)
\end{align*}

where, \( R = \) cash reserves, \( D = \) deposits, \( L = \) loans, \( i = \) interest on deposits, \( \rho = \) legal reserve ratio, \( r = \) interest on loans.

Substituting (3-2) and (3-3) into (3-1), the profit function can be written as follows:

\[
\Pi = r(1-\rho)D - iD \quad (3-5)
\]

The choice variables in this model are \( i \) and \( D \). The profit function can be maximized with respect to \( D \) or \( i \).

Differentiating (3-5) with respect to \( D \),

\[
\frac{\partial \Pi}{\partial D} = r(1-\rho) - i - D\frac{\partial i}{\partial D} = 0 \quad (3-6)
\]

or,

\[
r = \frac{i + D\frac{\partial i}{\partial D}}{(1-\rho)}
\]
That is, equilibrium is attained when the marginal gain from intermediation equals the marginal cost of intermediation adjusted for reserve requirements. Manipulating equation (3-6) further, I get the expression for the optimal interest on deposits,\(^4\)

\[ i^* = \frac{r(1-\rho)}{1+1/e_d} = f(r, \rho, e_d) \text{ where } f_1 > 0, f_2 < 0 \text{ and } f_3 > 0 \]

where \( e_d \) (elasticity of deposit supply with respect to own rate)

\[ \frac{d}{d} = (i/D). (\partial D/\partial i) \]

If \( \rho = 0 \), \( i^{**} = \frac{r}{1+1/e_d} = f(r, e_d) \)

Differentiating the profit function with respect to \( i \), the optimal \( D \) is,\(^5\)

\[ D^* = \frac{r(1-\rho)}{(1+e_d). (\partial D/\partial i)} \text{ or,} \]

\[ D^* = g(r, \rho, e_d, \partial D/\partial i) \]

where \( g_1 > 0, g_2 < 0, g_3 < 0, g_4 > 0 \)

In the absence of reserve requirements,

\[ D^{**} = \frac{r}{1+e_d}. \partial D/\partial i = g(r, e_d, \partial D/\partial i) \]

To derive explicit expressions for the optimal interest rate and deposit level, substitute the deposit supply function (3-4) into the profit function to obtain

\[ D^* = b\frac{r(1-\rho)+a/b}{2} \quad (3-7) \]

The optimal interest rate on deposits is,

\[ i^* = (D-a)/b = \frac{r(1-\rho)+a/b}{2-a/b} = \frac{br(1-\rho)/2-a}{2b} \quad (3-8) \]

where \( D^* \) is the profit-maximizing level of deposits.

\(^4\)See Appendix 3.I.1.

\(^5\)See Appendix 3.II.2
If $\rho = 0$ in the expression for $D*$ and $i*$, $D*$ is increased by $rb\rho/2$ and $i*$ increases by $rp/2$. Therefore, it follows that elimination of legal reserves increases the size of deposits and the interest rate on deposits. Since the interest on loans, $r$ is exogenously given, depositors share the burden of the implicit tax rate along with the bank, whose profit is reduced. This can be shown as follows.

The optimum level of profit,

$$\Pi^* = r(1-\rho)D-iD$$

$$\Pi^* = r[(1-\rho)(a+br(1-\rho))]/2-iD = [a+br(1-\rho)]^2/4b$$

(3-9)

The level of profit, $\Pi^*$ in the absence of reserve requirements (i.e. when $\rho = 0$)

$$\Pi^{**} = [a+br]^2/4b$$

where $\Pi^{**}$ is the level of unregulated profit.

$$\Pi^{**}-\Pi^* = [2abr+br^2(2-\rho)]/4b > 0,$$

(3-10)

since, $a>0$, $b>0$, $0 < \rho < 1$

Because of reserve requirements, the bank loses $\$\rho r$ for every dollar of deposits and gains $i_1-i_2=\$r\rho/2$ because it has to pay a lower interest rate to its depositors, and therefore the net loss for the banking firm is $\$r\rho/2$ for every dollar of the new level of deposits. Since the borrower pays the same loan rate he is not affected in terms of price but he is affected in terms of quantity. The optimal quantity of loans is reduced from $D'$ in the unregulated regime to $D'(1-\rho)$ in the regulated regime.

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6The assumption that $a>0$ is critical to the result that profit is reduced. If $a<0$, then profit may increase, decrease or remain the same.
### Table 3.2

<table>
<thead>
<tr>
<th></th>
<th>With reserve requirements</th>
<th>without reserve requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>$D$</td>
<td>$b(r(1-\rho)+a/b)/2$ &lt; $b(r+a/b)/2b$</td>
<td></td>
</tr>
<tr>
<td>$i$</td>
<td>$[br(1-\rho)-a]/2b$ &lt; $b(br-a)/2$</td>
<td></td>
</tr>
<tr>
<td>$\Pi$</td>
<td>$[a+br(1-\rho)]^2/4b$ &lt; $(a+br)^2/4b$</td>
<td></td>
</tr>
</tbody>
</table>

In the unregulated regime, the levels of deposits and loans are the same, but in the regulated regime, the level of loans is lower than the level of deposits by $\rho D$.

#### 3.2.3 Effects of reserve requirements on profit

Differentiating $\Pi^*$ with respect to $\rho$,

$$\partial \Pi^*/\partial \rho = -[a+br(1-\rho)]/2 < 0$$

This implies that an increase in the reserve ratio, $\rho$ always reduces profit. The amount of reduction in profit depends on $\rho$ and parameters of deposit supply function.

Taking the second derivative of $\Pi^*$ with respect to $\rho$,

$$\partial^2 \Pi^*/\partial \rho^2 = br/2 > 0$$

This implies that profit decreases at an increasing rate as $\rho$ increases as shown in the Figure 3.3.

In Figure 3.3, profits are shown along the vertical axis and $\rho$ is shown along the horizontal axis. The profit curve, labelled
FIGURE 3.3 Effects of Change in Reserve Ratio on Bank Profits

\[ \Pi_1^{**} \]

\[ \Pi_2^{**} \]

\[ \Pi_1(r=r_1) \]

\[ \Pi_0(r=r_0) \]

Reserve ratio

Profits
\[ \Pi_0, \text{ shows profits as a function of } \rho \text{ for a given loan rate } r_0. \]
\[ \Pi^{**}_0 \text{ represents profit in the absence of reserve requirements.} \]
As the value of \( r \) increases, the profit function shifts upward. Thus the curve labelled \( \Pi_1 \) represents profit when the loan rate is given by \( r_1 \), where \( r_1 > r_0 \). Point \( \Pi^{**}_1 \) represents profits in the unregulated regime when the loan rate is given by \( r_1 \).

From the first and second derivative of the profit function with respect to \( \rho \), it appears that although the slope of the profit function depends on the reserve ratio \( \rho \), the parameters of the deposit supply function, \( a \) and \( b \) and the loan rate \( r \), the curvature depends on the slope of deposit supply function, \( b \), and the loan rate, \( r \). The higher the level of \( r \), the more the decline in profit for a given change in \( \rho \). This is because the loss of income for the bank varies directly with the loan rate. The rate of decline in profit also depends on the slope of deposit supply function. For a flatter deposit supply function (see Figure 3.1),\(^7\) the reduction in deposits and profit will be greater than the reduction in the case of a steeper supply function.

3.2.4 Derivation of the iso-profit function

The profit function, in the presence of reserve requirements, is
\[ \Pi^* = f(r, \rho) = [a + br(1 - \rho)]^2 / 4b \]
using (3-9)

\(^7\)A flatter deposit supply function has a higher value of \( b \).
I define an iso-profit function as the locus of all combinations of \( r \) and \( \rho \) that yield the same profit. Along an iso-profit function, the change in profit is zero, that is, \( d\Pi^* = 0 \). 

Totally differentiating equation (3-9),
\[
d\Pi^* = (1-\rho)dr - rdp = 0 \quad \text{or,} \quad \frac{dr}{dp} = \frac{r}{(1-\rho)} > 0
\]

Therefore, the slope of the iso-profit function is positive. This implies that if \( \rho \) increases, profit can be maintained at the old level only by increasing \( r \). The rate of such an increase in \( r \) necessary to keep profit same for a given change in \( \rho \) can be obtained from the second derivative, \( d^2r/d\rho^2 = r/(1-\rho)^2 > 0 \). This implies that the curve representing the iso-profit function is convex to the horizontal axis. That is, it increases at an increasing rate as shown in the Figure 3.4.

3.3 Decomposition of loss of income for bank from regulation

There are several components of the net loss of profit occuring to the bank because of keeping idle reserves. I examine them here in detail. Let \( \Pi^{**} \) and \( \Pi^* \) be the levels of unregulated and regulated profits respectively.
\[
\Pi^{**} - \Pi^* = (r-i^{**})D^{**} - [r(1-\rho) - i^*]D^*
\]
\[
= rD^{**} - i^{**}D^{**} - [r(1-\rho) - i^*]D^* \quad \text{where i^{**} and i^* are the unregulated and regulated levels of interest rates and D^{**} and D^* are the unregulated and regulated levels of deposits, respectively.}
\]
\[
= (r-i^{**})D^{**} - [r(1-\rho) - i^*]D^*
\]
FIGURE 3.4  Iso-profit Functions

$r$ (Loan rate)
\[(r-i^*)(D^*+br\rho/2) - [r(1-\rho) - i^*]D^*\]
\[(i^*-i^*)D^* + rpD^* + br\rho/2(r-i^*)\]
\[(i^*-i^*)D^* + rpD^* + r(D^{**}-D^*)(r-i^*) \text{ since } D^{**}-D^*=br\rho/2 \quad (3-11)\]

Here, \((i^*-i^*)D^* < 0\), since \(i^* < i^{**}\)
\[rpD^{**} > 0\]
\[r(D^{**}-D^*)(r-i^*) > 0\), since \(D^{**} > D^*\)

The first term of the above expression, \((i^*-i^*)D^*\), represents the loss of earnings because of the higher interest rate the bank has to pay in the unregulated regime to the deposit holders of the regulated regime.\(^8\)

The second term represents the total increase in returns because of the release of reserves in the unregulated regime. The last expression represents the extra benefit from having deposit expansion from \(D^*\) to \(D^{**}\).

The first two terms can be combined to derive the expression, \([(i^*-i^*)]D^* + (D^{**}-D^*)(r-i^*)\). This represents the net gain, in the unregulated regime, for the regulated level of deposits.

The last expression of \((3-11)\) represents the scale effect of deregulation. In order to derive an expression for the implicit tax rate per dollar deposit \((ITRD)\), divide \((\Pi^{**}-\Pi^*)\) by \(D^*\).
\[ITRD = (\Pi^{**}-\Pi^*)/D^* = (i^*-i^{**}) + rp + r(D^{**}-D^*)(r-i^{**})/D^*\]
This is the implicit tax rate, in the ex post sense, since I

\(^8\)I use the terms unregulated and regulated regimes to denote the situations in the absence of reserve requirements and the presence of reserve requirements respectively.
have taken into consideration the adjustments of bank behaviour in response to reserve requirements. Since data on the optimal rates of interest and volume of deposits in the absence of reserve requirements are unavailable, I will use, in my empirical study, the measures of ITRD in the ex ante sense, i.e. measures derived without assuming any adjustment on the part of the bank in response to the imposition of reserve requirements.

3.3.1 Secondary effects of reserve requirements

In addition to the instantaneous adjustment by banks in response to the imposition of legal reserve requirements, there are also secondary effects which I discuss here. In the model I have discussed above, I have shown that reserve requirements force banks to adjust to a lower level of profits and deposits. Also depositors have to accept a lower level of interest. This has the following consequences.

1. If the optimal level of profit is lower than the potential (or unregulated profit), then there is an incentive for innovation. Banks will seek untaxed (unregulated) sources of deposits to narrow the differential between the potential profit and the actual profit they make. For example, repurchase agreements which were exempt from reserve requirements, were an alternative source of funds for US banks during the late 60's and the 70's.

The incentives for innovations are implicit in the profit differential expression (3-11). If we look at this
expression carefully, it will be apparent that the incentive for innovation, from the bank's viewpoint, in this model originates from two sources.

a. The potential increase in earnings through lowering \( \rho \).

   This is captured by the second term of expression (3-11). If banks can develop substitutes requiring less or no legal reserves, the effective reserve ratio falls and the differential between the regulated and the unregulated profit is narrowed.

b. The potential gain from the expansion of scale of deposits in the unregulated regime. This is captured by the third term of the expression.

2. Since the level of deposits and the interest rate on deposits is lowered because of regulations, depositors will explore alternative uses of their funds. This is how the demand for an alternative financial instrument is created if it is a new instrument, or expanded if it already exists.

3.3.2 A testable hypothesis of the model

As in the model with given assets and liabilities of Chapter Two, the main incentive for innovation arises from the profit differential between the regulated regime and the unregulated regime. The incentive to innovate is directly related to the extent of this profit differential and any of the measures of implicit tax rates as defined in the previous chapter. The difference between the model of the previous chapter and the present one is that whereas in the former model, the profit in
the absence of reserve requirements is unambiguously higher than the profit in the presence of reserve requirements, this may not be so in the present case. The profit differential, may be positive, negative or zero depending on the parameters of the deposit supply function. In particular, if \( a < 0 \) (assuming \( b > 0 \)) in the deposit supply function (3-4), the profit differential may be zero or negative.  

If \( \Pi^{**} < \Pi^* \), the bank's profit is greater in the regulated regime than in the unregulated regime, therefore there is no incentive for innovation. However, the incentive for innovation on the demand side still exists, because depositors faced with the lower rate of return will seek alternative uses of funds.

For statistical testing of the relationship between the profit differential and innovations one can measure the profit differential as given by expression (3-11). The difficulty with (3-11) is that one should know the parameters (or elasticities) of the deposit supply function or the levels of the interest rate and deposits in the unregulated regime in order to measure the profit differential. The measures of the tax rates developed in Chapter Two correspond to the second term \( r\rho D^* \) in the expression (3-11).

The model and the discussion presented here provide additional insights into the measurement of the implicit tax rate and the extent to which the measures used in the empirical

\[ ^9 \text{If } a < 0, \text{ the interest rate must exceed a minimum level for the deposits to be positive.} \]
chapters differ from more realistic models of this chapter.

3.4 Summary and conclusions

In this chapter, the optimal level of deposits and the interest rate paid on them are determined in a simple model of a single deposit liability employing the assumption that the bank is a price setter in the market for deposits but acts as a price taker in the market for loans. The effects of legal reserve requirements on bank decision variables are investigated. Since there are no excess reserves in this model, loans are determined as the residual after the legal cash requirements are met from the total funds the bank has at its disposal. Reserve requirements lower the levels of deposits, interest paid on deposits and bank profits. The reduction in profits provides an incentive to bank management to regain the lost income using alternative sources of funds. This creates supply of a new financial instrument. The lowering of interest on deposits gives incentive to depositors to seek alternative uses of funds. This creates demand for a new financial instrument.

In this chapter I developed measures of implicit taxation after taking into consideration the response behaviour of the banks to the imposition of reserve requirements, and therefore these measures are theoretically more realistic than the measures developed in Chapter Two.
The model of this chapter can be extended to \( n \) types of liabilities. Given the assumptions of perfect segmentation of deposit classes, the extension will not add much insight into bank portfolio behaviour since the results regarding the effects of the changes in reserve ratios will not change.
Appendix to Chapter Three

3.I.1

\[ r(1-\rho) - i - D \delta i/\delta D = 0 \quad \text{from equation (3-6)} \]

or, \[ r(1-\rho) - i - (D/i) \cdot (\delta i/\delta D) = 0 \]

or, \[ r(1-\rho) = i + i/e_d, \quad \text{[since} \quad e_d \text{ (elasticity of deposit supply with respect to own rate) = (i/D)(\delta D/\delta i)} \]

or, \[ r(1-\rho) = i(1+1/e_d) \]

or \[ i^* = r(1-\rho)/(1+1/e_d) = f(r, \rho, e_d) \text{ where } f_1 > 0, f_2 < 0 \text{ and } f_3 > 0 \]

\[ \delta \Pi/\delta i = r(1-\rho)(\delta D/\delta i) - i(\delta D/\delta i) - D = 0 \]

or, \[ r(1-\rho)(\delta D/\delta i) - (i/D)(\delta D/\delta i) - D = 0 \]

or, \[ D(1+e_d) = r(1-\rho) \cdot (\delta D/\delta i) \]

or, \[ D^* = (r(1-\rho))/(1+e_d) \cdot (\delta D/\delta i) \]

3.I.2

\[ \delta \Pi/\delta D = 0 \]

or, \[ r(1-\rho) = (D-a)/b + D[(D-a)/b]/\delta D \]

or, \[ r(1-\rho) = (D-a)/b + D \cdot (1/b) \]

or, \[ r(1-\rho) = 2D/b - a/b \]

or, \[ 2D/b = r(1-\rho) + a/b \]
CHAPTER FOUR
UNCERTAINTY MODELS OF BANK BEHAVIOUR

4.1 Introduction

The effects of reserve requirements on bank portfolio behaviour were studied and the implicit tax rates were computed in Chapters Two and Three using static, perfect certainty models. But these models as presented in Chapters Two and Three are too unrealistic to characterize bank behaviour because they leave out a very important characteristic of the environment in which a bank operates, namely uncertainty. In this chapter, I explore the role of legal reserve requirements in a model of bank behaviour that incorporates an important type of uncertainty in bank operations, namely stochastic withdrawal of deposits. I also derive measures of implicit tax rates from this model.

This chapter begins with a brief discussion of the importance of uncertainty in models of bank behaviour in section 4.2. A brief survey of literature on uncertainty models of bank behaviour is provided in section 4.3. In section 4.4, the expected cost of reserve deficiency is computed under various assumptions about the initial amount of cash holdings relative to reserve requirements. I also provide a geometrical exposition of reserve deficiency to illustrate these costs. In section 4.5, the demand functions for the deposit liabilities and reserves are derived. The solutions are compared with those of Chapter
Three. In section 4.6, some formulae for calculating the implicit tax rates of reserve requirements are derived from the model of section 4.6. In section 4.7, some concluding comments are provided.

4.2 Importance of uncertainty in modelling bank behaviour

The importance of uncertainty in modelling bank behaviour cannot be overemphasized. The banking firm has to operate constantly in an environment of uncertainty. To quote Porter (1961),

It is uncertainty, in its various guises far more than anything else which makes the banker's job a difficult one. (p. 325)

The main areas of uncertainty, as noted by Porter (1961), and Hester and Pearce (1975) are:

1. Stochastic withdrawal of deposits which makes the size of deposit liabilities at any moment in the future probabilistic.
2. Default risk associated with loans.
3. Market risk which is a function of the type of asset held by the bank.
4. Cost of funds risk, that is, uncertainty associated with the marginal and the average cost of deposit liabilities.
5. Degree of frozenness of the loan portfolio."

In this chapter, I will limit myself to discussion of uncertainty of deposit flows. Uncertainty about deposits greatly

"The frozenness of loans implies that banks may not be able in an emergency to reduce its loans sufficiently (Porter, 1961)."
extends the complexity of the maximization problems considered in the 'perfect certainty' models of Chapter Three. The complexity occurs because the solution is dependent on the time path of deposits. The bank is assumed to maximize expected profits. If a bank is uncertain about the time path of its deposits, its realized profits will fall short of profits that it could make with perfect foresight. This shortfall occurs because some bank decisions are imperfectly reversible, and over a number of periods random deposit sequences will cause some decisions to be wrong ex post. In other words, it requires extra resources to deal with an uncertain environment.

4.3 A brief survey of the banking literature on uncertainty models

Models of stochastic withdrawal of deposits have been developed by Porter (1961), Orr and Mellon (1961), Morrison (1966), Poole (1968), Klein (1971), Brown and Lloyd (1971), Baltensperger (1980) and Spellman (1982). With the exception of Porter (1961), all of these models address the choice between earning and reserve assets in the face of uncertainty about the levels of deposits at any moment in time in essentially similar ways. All of these studies incorporated the probability of expected reserve deficiency as an additional cost of deposit funding and maximize an expected profit function which

\[ \text{-------------} \]

\[ ^2 \text{See Hester and Pearce (1975).} \]
explicitly takes into consideration the costs of reserve deficiency.\(^3\)

Orr and Mellon (1961) investigated how optimal credit expansion is affected by uncertainty in reserve loss, taking the lead from Edgeworth (1888).\(^4\) They compared the optimal value of new deposit creation in a stochastic model with a deterministic model and found that the difference between the two solutions depends on 1) the size of excess reserves compared to the variability of reserve losses and 2) the relative sizes of the market rate of interest, the penalty rate and a lump-sum penalty. The optimal values of deposits, \(D\), in the stochastic case of reserve outflow are generally higher than in the deterministic case except in the case where the lending rate exceeds the penalty rate. In that case it pays the bank to expand credit indefinitely.\(^5\)

The most comprehensive treatment of bank portfolio selection under uncertainty was provided by Porter (1961). He considered all the possible aspects of uncertainty.\(^6\) According to Porter, \--------------------\nThe calculation of these costs is discussed in the following section.

\(^3\)The calculation of these costs is discussed in the following section.

\(^4\)They worked out some of the theoretical and empirical implications of Edgeworth model.

\(^5\)Orr and Mellon made the following observations about the portfolio behaviour of banks in the presence of uncertainty: a) the ratio of marginal credit expansion to excess reserves will be less than that of total credit expansion to total reserves. b) credit expansion is as sensitive to the lump-sum penalty cost of reserve shortages as it is to the rate the bank earns on its marginal investments on loans.

\(^6\)For example, he considered stochastic withdrawal of deposits,
the level of deposits may follow many alternative paths during the planning "period", but the bank is really concerned with the lowest possible level of deposits termed as "deposit-low" for each of these paths, because at this low level of deposits, "the bank is forced to make the most radical adjustment in its asset portfolio in order to meet the demand of its depositors" (Porter, 1961, p 328). For simplicity he did not consider the time path of deposits. The banking firm chooses between assets, securities and loans in such a way as to maximize its expected net worth in Porter's model.

Poole (1968) examined the significance of excess reserves, bank borrowings from the Central bank and the Central bank lending rate in a model of bank reserve management. The calculation of the cost of reserve deficiency is similar to Orr and Mellon (1961) and Morrison (1966). In this model, the bank chooses the amount of borrowings in such a way that the probability of a reserve deficiency is equal to the ratio of the federal funds rate to the discount rate.

Brown and Lloyd (1971) dealt with the issue of optimal expansion or contraction of credit when there is an exogenous change in the bank's reserves, assuming a penalty for violation of legal reserve requirements. They also investigated the impact of legal reserve requirements on banks' credit expansion. They compared the certainty solution with the uncertainty solution

------------------
6(cont'd) market value of securities at any moment in future, proportions of loans defaulted, and the degree of intra-period "frozenness" of the loan portfolio.
and concluded that the optimal credit expansion under uncertainty can exceed that under certainty under specified conditions. In practice, the presence of a large fixed penalty for violation of reserve requirements prohibits such expansion. They concluded that a finite optimum solution is not necessarily guaranteed given the structure of the model. Their model requires more stringent conditions for a finite optimum than the earlier works suggested.

4.4 Computation of reserve deficiency cost: a single type of deposit liability

In the face of unexpected withdrawal of deposits, a bank may face reserve deficiency in the sense that it is unable to pay its creditors or cannot satisfy the legal requirements without borrowing on 'unfavourable' terms. In times of such 'liquidity' crises, a bank is forced to make some out-of-routine adjustments. The type of adjustment depends on how serious the reserve deficiency is.

7For computation of reserve deficiency cost in the case of two types of deposits, see appendix II of this chapter.

8According to Porter (1961), a bank may pass through several stages of a 'liquidity' crisis. In the first stage it meets its deposit withdrawal from its cash assets. In the second stage, it sells its most liquid assets, for example, securities. If the sale of securities is insufficient, the bank borrows from the Federal Reserve bank in stage three. Stage four is Edgeworth's greatest 'disaster' facing the bank when the bank is unable to handle its liquidity crisis.
The cost of reserve deficiency is defined as the cost of illiquidity that the bank has to face given a certain amount of reserve deficiency. These include the penalty rate of borrowing, and loss of reputation and goodwill. Here, I have shown the calculation of reserve deficiency cost under various assumptions about the initial amount of cash holdings drawing on the works of Orr and Mellon (1961), Poole (1968), Klein (1971) and Baltensperger (1980).

Let us assume that a bank has accepted deposits D which it can allocate between two assets, reserves, R and an earning asset, L. Let the net outflow of deposits and therefore of reserves, u, be defined as deposit outflow minus deposit inflow during the period. We assume that the bank has knowledge of the probability distribution of this net outflow of deposits based on past experience. Let \( f(u|D) \) be a continuous and differentiable conditional probability density function of u given D, the initial amount of deposits. We can identify three possible cases depending on the assumption about the initial amount of cash holdings and legal reserve requirements.

**Case I: No legal requirements, no initial cash holdings**

Assume that there are no legal reserve requirements and that the bank has no cash holdings at the beginning of the period.\(^9\)

\(^9\)This is an unrealistic case, because banks always hold some amount of cash as a precaution against unexpected withdrawal of deposits. I discuss this case as a theoretical possibility and also to show the marginal reduction in liquidity costs because of holding some amount of cash. See case II.
In this case any net reserve outflow causes reserve deficiency. The size of the reserve deficiency is given by \( u \) where \( u > 0 \).\(^{10}\)

If the penalty per dollar of reserve deficiency is \( n \), the expected loss is,

\[
L = n \int_0^c u f(u | D) \, du
\]

where \( f(u | D) \) is the probability density function of \( u \), and \( c \) is the largest net outflow of deposits to which the bank assigns a non-zero probability.\(^{12}\)

**Case 2: No legal requirements, initial cash holdings**

The bank has cash holdings, \( R \), at the beginning of the period. Reserve deficiency occurs if the net reserve outflow exceeds \( R \), beginning-of-the-period reserves.\(^{13}\) The size of reserve deficiency is \( u - R \) and the expected loss is,

\[
L = n \int_0^{u_c} (u - R) f(u) \, du
\]

where \( c \) is defined above and \( u_c \) is the critical level of net outflow of reserves beyond which any further outflow causes reserve deficiency. In this case \( u_c = R \), the initial size of cash holdings.

---

\(^{10}\)A negative \( u \) is reserve inflow and never causes reserve deficiency.

\(^{11}\)\( n \) represents the associated cost of reserve deficiency such as forced selling of assets at a lower price, loss of reputation among customers, etc. For the sake of simplicity, I assume a constant cost per dollar rather than a variable penalty rate where the penalty rate depends on the size of reserve deficiency. In fact, a penalty scheme may have both a fixed and a variable component.

\(^{12}\)Theoretically, \( c \) could be any amount from zero to \( D \), the initial amount of deposits.

\(^{13}\)See Klein (1971), Baltensperger (1982).
Obviously, \( n\int_0^\infty uf(u)du > \int_R^n (u-R)f(u)du \). The difference between (4-1) and (4-2) is the gain from holding reserves equal to \( R \) in terms of reduction in adjustment cost or the cost of illiquidity.\(^{14}\)

**Case 3: Legal Reserve Requirements**

If the bank is required by law to keep reserves equal to \( \rho D \), where \( \rho \) is the legal reserve ratio, there are three possibilities.

1. The bank holds cash just equal to the legal reserves i.e. \( R = \rho D_0 \).
2. Reserve deficiency would occur, if \( R - u < \rho (D_0 - u) \),
3. or, \( R - \rho D_0 < u(1 - \rho) \),
4. or, \( (R - \rho D_0)/(1 - \rho) < u \) or, \( u > 0 \), since \( R = \rho D_0 \).

This shows that if the bank does not hold any excess reserves, the bank will face reserve deficiency whenever there is any net deposit outflow. The size of reserve deficiency (RD) is given by,

\[ RD = \rho (D_0 - u) - (R - u) = \rho D_0 - u - R + u = u(1 - \rho), \]  

since \( R = \rho D_0 \).

The above analysis is illustrated in Figure 4.1. The level of deposits is shown along the horizontal axis and amount of reserves is shown along the vertical axis. The line OP shows the amount of required (legal) reserves. At the initial amount of deposits \( D_0 \), \( \rho D_0 \) amount of reserves is

\(^{14}\)Baltensperger (1980).
FIGURE 4.1 Effects of Deposit Outflow in a Situation of no Excess Reserves

FIGURE 4.2.1 Effects of Deposit Outflow in a Situation of Excess Reserves: Possibility of Reserves Surplus
maintained. If there is a deposit outflow of \( u \) dollars, the amount of deposits is \( D \), and the legal reserves are \( \rho(D_0 - u) \).

To determine the actual reserves in this situation, we take a point \( C \) on \( D_0A \) such that \( u = D_0C \) and draw a line, \( CE \), parallel to \( \rho D_0 \) from the point \( C \) such that \( BE = AC = \rho D_0 - u \). \( BE \) is the actual amount of reserves. The amount of reserve deficiency is given by the difference between required and actual reserves, that is, \( \rho(D_0 - u) - BE = u(1 - \rho) \).

It can be easily shown that for any amount of positive \( u \), there will be a reserve deficiency. The size of the reserve deficiency is inversely related to the reserve requirement ratio. Differentiating the size of reserve deficiency with respect to \( \rho \) gives us \(-u\), that is, for every marginal increase in \( \rho \), the size of reserve deficiency will decrease by \( u \) dollars. Intuitively, the higher the reserve ratio, the higher will be the initial holding of cash reserves and therefore, the lower the size of the reserve deficiency for given \( u \). The total adjustment cost is

\[
\int_0^C u(1-\rho)f(u) \]

2. The bank holds excess reserves, i.e. \( R > \rho D_0 \) where \( \rho \), \( D_0 \) and \( R \) are as defined previously. Reserve deficiency would occur in this situation, if

\[
R - u < \rho(D_0 - u) \quad \text{or} \quad R - \rho D_0 < u(1 - \rho)
\]

\[
u > \frac{(R - \rho D_0)}{(1 - \rho)} \quad \text{or} \quad u_C < u, \quad \text{where} \quad u_C = \frac{(R - \rho D_0)}{(1 - \rho)}.
\]

Intuitively, if \( u \) exceeds the beginning-of-period excess
reserves corrected for reserve requirements, there is a reserve deficiency. This is because withdrawal of each dollar of deposits also releases reserves of $\rho$ dollars, i.e. the bank has to keep $\rho$ less dollars as reserves if one dollar of deposit is withdrawn.

The size of the reserve deficiency is given by,

$$\rho(D_0 - u) - (R - u) = u(1 - \rho) - (R - \rho D_0) = (1 - \rho)\left[u - (R - \rho D_0)/(1 - \rho)\right] = (1 - \rho)(u - u_c).$$

The expected reserve deficiency cost is,

$$\int_{u_c}^{C} [u(1 - \rho) - ER_0]f(u)du$$

where $ER_0 = R - \rho D_0$, $f(u)$ is the probability density function of $u$ and $u_c$ and $c$ are as defined above.

In Figure 4.2.1, I provide an illustration of the above case.

At a given level of deposits $OD_0$, the amount of reserves is $AD_0$, required reserves are $BD_0$, and therefore the amount of excess reserves is $AB$. With a deposit outflow of $u$ dollars, the actual amount of deposits is $D_0 - u$ and the actual amount of reserves is found by the following graphical method. As in diagram (4-1), take a point $C$ such that $D_0 C = u$. Draw $AF$ parallel to $CD$, so that $AC = FD_1$. The amount of actual reserves is given by $FD_1$. The amount of excess reserves is $FG$. Reserve deficiency would occur only if the line parallel to $CD$ cuts the vertical line at $D_1$ at a point below $G$. Reserve deficiency would be zero if that line cuts the vertical line at $G$. These possibilities are shown in the Figures (4.2.2) and (4.2.3).
FIGURE 4.2.2 Effects of Deposit Outflow in a Situation of Excess Reserves: Possibility of Reserve Deficiency

FIGURE 4.2.3 Effects of Deposit Outflow in a Situation of Excess Reserves: Possibility of Zero Reserve Deficiency
In the following section, I discuss the equilibrium in a single deposit liability model. The objective is to explore theoretically the effects of reserve requirements in this model and then develop measures of implicit taxation from these models.

4.5 A model of bank behaviour with a single deposit liability

One of the central tasks facing bank management is to allocate funds between cash reserves and loans in the face of uncertainty about deposit withdrawal and therefore reserves withdrawal. The cash reserves serve the important function of reducing the adjustment cost that the bank faces if there is a cash deficiency and the bank has to borrow at a penalty rate. Also, persistent deficiency lowers the goodwill of the bank and invites stringent restrictions by the Central bank on additional credit to the bank. On the other hand, for every dollar held as cash, the bank loses interest earnings and this opportunity cost gets higher as the interest rate rises. Thus the cash management problem is essentially a problem of optimal allocation of funds between earning assets and cash reserves.

4.5.1 Assumptions of the model

Assume that:
1. This is a one-period model.
2. The bank has two assets: L, loans and R, cash reserves. The
bank earns r per dollar of loans. The loan market is assumed to be perfectly competitive. Its cash reserves earn nothing.

3. The bank has only one type of liability, D, on which it pays interest at the rate id.

4. The bank is subject to a series of random additions to and depletions from its reserves through inflow and outflow of deposits. Net outflow of deposits is measured by $u$. \(^{15}\)

5. The bank is required by law to keep a certain portion of its deposits in the form of reserves.

6. The bank considers its reserves deficient if its actual reserves fall short of legal reserves. The bank has to pay a penalty rate, n, per dollar of reserve deficiency.

7. The cost of uncertainty of deposit withdrawal and consequent reserve deficiency is captured by the expected reserve deficiency cost. The calculation of reserve deficiency cost has been discussed in the previous section.

8. The bank maximizes expected profit.

The problem facing the profit maximizing bank is to determine the optimal amount of deposits and cash reserves, given the random nature of its cash flows and the legal reserve requirements it must meet.

\[^{15}\text{The assumption about the distribution of } u \text{ is discussed in the following section.}\]
The expected profit function is given by,
\[ E\Pi=r(D-R)-id.D-n\int_{u_c}^{D} (u(1-\rho)-(R-\rho D))f(u|D)du \]  
(4-3)
where,
\[ u_c=(R-\rho D)/(1-\rho) \]

The deposit supply function is given by,
\[ D = a + bid, \quad b>0 \]  
(4-4)

The decision variables of the model are D and R. Assume for simplicity that u follows a uniform density function with a range of u from -D to D i.e., the bank expects that the maximum inflow or outflow is equal to the amount of deposits at the beginning of the period. In this case, 
\[ f(u)=1/[D-(-D)]=1/2D. \]

The expected profit function is,
\[ E\Pi=r(D-R)-id.D-n/2D\int_{u_c}^{D} (u(1-\rho)-(R-\rho D))du \]
= \[ r(D-R)-id.D-nD(1-\rho)/4 -n[R-\rho D]^2/4D(1-\rho) +n(R-\rho D)/2 \]  
(4-5)

Differentiating E\Pi with respect to D and R, the first order conditions for maximization are,
\[ \frac{\partial E\Pi}{\partial D} = r-(2D-a)/b-n(1-\rho)/4-n\rho(\rho D)/2D(1-\rho) +n(\rho D)^2/4(1-\rho)D^2 = 0 \]  
(4-6)
\[ \frac{\partial E\Pi}{\partial R} = -r +n/2-2n(\rho D)/4D(1-\rho) = 0 \]  
(4-7)

Solving for D and R from (4-6) and (4-7), we get the optimal

\textsuperscript{16} Spellman worked with a similar assumption, though he worked with an implicit function of deposit outflow and he did not have reserve requirements in his model.
values for D and R.\textsuperscript{17}
\begin{equation}
D^*=\left[a+b(1-\rho)r^2/n \right]/2
\end{equation}
\begin{equation}
R^*=D^*[1-2r(1-\rho)/n]
\end{equation}

The deposit level is directly related to the loan rate and inversely related to the penalty rate. The deposit level also depends on the loan rate relative to the penalty rate. Comparing the optimal values of the variables in the certainty regime of chapter two (see Table 3.2) and those of the uncertainty regime presented above, I can arrive at the following conclusions. If $r=n$, deposit levels in the certainty and uncertainty regimes are the same. If $r>n$, deposits in the uncertainty model are greater than deposits under certainty. If $r<n$, deposits in the uncertainty models are less than under certainty.

The reserve ratio in the presence of legal requirements is $\rho^*=R^*/D^*=[1-2r(1-\rho)/n]$. Then reserve ratio in the absence of reserve requirements is $\rho^{**}=R^{**}/D^{**}=(1-2r/n)$. The difference between the two, $\rho^*-%\rho^{**}=2r\rho/n$ is greater than zero. Thus, legal requirements raise the reserve ratio by $2r\rho/n$.

It also follows from (4-9) that the bank keeps reserves in excess of legal requirements if

\begin{equation}
[1-2r(1-\rho)/n] > \rho
\end{equation}

i.e if $1 > \rho+2r(1-\rho)/n$

i.e if $(1-\rho) > 2r(1-\rho)/n$

i.e if $1 > 2r/n$

\textsuperscript{17}See Appendix 4.1.1.
i.e if \( n > 2r \)
The bank will keep reserves equal to the legal minimum if \( n = 2r \).

In the absence of legal requirements, the optimal values of \( D \) and \( R \) are,

\[
D^{**} = \frac{(a + br^2/n)}{2} > D^*
\]
\[
R^{**} = D^{**}(1 - 2r/n)
\]

As in the perfect certainty models of Chapter Three, deposits in the unregulated regime are higher than in the regulated regime. As regards the absolute level of reserves, it is not easy to compare the regulated and unregulated situations because on the one hand the deposits are lower, on the other hand the reserve ratio is higher.

4.6 Computation of implicit tax rates of reserve requirements

The 'ex post' opportunity cost of legal reserves can be computed by taking the differential between the profit in the regulated and unregulated regimes, \( \Pi^{**} - \Pi^* \). But substituting the optimal values of \( D^* \) and \( R^* \) in the expected profit function, (4-5) and calculating the optimal value of \( \Pi^* \) is algebraically a very tedious process; hence I apply an alternative method of computing the cost of required reserves discussed below.

The opportunity cost of required reserves = Market interest rate* [optimal (profit-maximizing) reserves in the regulated regime - voluntary optimal reserves in the unregulated
regime \[ ^8 \]
\[ = r(\rho D^* - \rho^* D^*) \]
\[ = \left[ a + b(1 - \rho) r^2 / n \right] \left( 1 - 2r(1 - \rho) / n \right) / 2 - \left[ a + b r^2 / n \right] (1 - 2r / n) / 2 \]
\[ = r \rho / n \left[ a + b r \left( \frac{r(2 - \rho)}{n} - \frac{1}{2} \right) \right] \tag{4-10} \]

The implicit tax rates of reserve requirements per unit of net income, deposits and interest earnings on deposits can be computed dividing (4-10) by \( \Pi^* \), \( D^* \) or \( (r-i)D^* \).

The measures of implicit tax rates derived in this chapter are not used in the empirical testing of hypotheses about bank innovations. This is because the measurement of implicit tax rates using the above formulae requires a knowledge of the parameters of the deposit supply function and the reserves withdrawal function. Also there is a problem of aggregating these functions over the entire banking sector. The main difference between this model and the models of the earlier chapters is that in the previous models, the amount of voluntary reserves that a bank keeps is zero, and therefore the earnings on the entire amount of required reserves represent a loss of income. The present model shows the necessity of keeping involuntary reserves and the opportunity cost of the excess of reserves over the voluntary reserves represents the loss. The voluntary reserve holdings depend on the expected earnings from those reserves and the cost of reserve deficiency.

\[ ^8 \text{This is only one component of the expected profit differential. See Appendix 4.I.2} \]
4.7 Summary and conclusions

Because of uncertainty in the pattern of deposits withdrawal, banks find it useful to keep reserves. The optimal trade-off between reserves and loans depends on the expected cost of the reserve deficiency and the expected benefit from loan expansion. Static models usually assume the fulfillment of the reserve requirements constraint. We found that the optimal amount of reserves may exceed or fall short of the required reserves. Finally, I have computed the opportunity costs and various implicit tax rates of reserve requirements in the uncertainty model.
4.I.1.

From (4-7),

\[ 4(1-\rho)(r+n/2)/2n = (R-\rho D)/D \quad \text{or,} \]

\[ R = D[1-2r(1-\rho)/n] \quad \text{or,} \]

\[ (R-\rho D)^2/D^2 = (1-\rho)^2(n-2r)^2/n^2 \hspace{1cm} (4-7a) \]

From (4-6),

\[ r-n(1-\rho)/4 - r\rho + (1-\rho)(n-2r)^2/4n = (2D_1-a)/b \quad \text{[using the deposit supply function, (4-4) and (4-5b)] or,} \]

\[ (1-\rho)r^2/n = 2D-a/b \quad \text{or,} \]

\[ D^* = [a+b(1-\rho)r^2/n]/2 \]

4.I.2.

\[ \Pi^{**} = r(D^{**}-R^{**}) - ERDC^{**} \]

\[ \Pi^{*} = r(D^{*-R^{*}}) - ERDC^{*} \]

where \( ERDC^{**} \) and \( ERDC^{*} \) are expected reserve deficiency costs in the regulated and unregulated regimes. The difference between the two is,

\[ \Pi^{**} - \Pi^{*} = r(D^{**}-D^{*}) - r(R^{**}-R^{*}) - (ERDC^{**} - ERDC^{*}) \]

\[ = r(D^{**}-D^{*}) - r(\rho^{**}D^{**}-\rho^{*}D^{*}) - (ERDC^{**} - ERDC^{*}) \]
Appendix II

Computation of reserve deficiency cost: two types of deposit liabilities

Let $u_1$ and $u_2$ denote net outflows of deposit types $D_1$ and $D_2$, respectively. The bank assumes continuous and differentiable probability density functions for $u_1$ and $u_2$. There can be four possible pairs of $u$'s depending on the signs of $u_1$ and $u_2$ as shown in the following table.

<table>
<thead>
<tr>
<th>$u_1$</th>
<th>$u_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

There is no problem of reserve deficiency in the $-$ $-$ case because the bank has reserve inflow into both types of deposits. Here I have developed an alternative approach to Miller (1975) which can analyze the three cases of reserve deficiency.

Let

$$t = (1-\rho_1)u_1 + (1-\rho_2)u_2$$

where, $t$ is the required reserves adjusted net outflow of deposits.

$$E(t) = (1-\rho_1)E(u_1) + (1-\rho_2)E(u_2) = 0$$
We assume a uniform distribution for $t$ such that the range for $t$ is from $t_{\text{min}}$ to $t_{\text{max}}$, where

$$t_{\text{max}} = (1-\rho_1)u_{1\text{max}} + (1-\rho_2)u_{2\text{max}}$$

$$= (1-\rho_1)D_1 + (1-\rho_2)D_2$$

on the assumption that $D_1$ and $D_2$ are the maximum values of $u_1$ and $u_2$, and $t_{\text{min}} = (1-\rho_1)u_{1\text{min}} + (1-\rho_2)u_{2\text{min}} = (1-\rho_1)(-D_1) + (1-\rho_2)(-D_2)$

on the assumption that $-D_1$ and $-D_2$ are the minimum values for $u_1$ and $u_2$.

Reserve deficiency occurs when actual reserves fall short of required reserves, i.e. when

$$R - u_1 - u_2 < \rho_1(D_1 - u_1) + \rho_2(D_2 - u_2)$$

$$R < \rho_1D_1 + \rho_2D_2 + (1-\rho_1)u_1 + (1-\rho_2)u_2$$

$$R < \rho_1D_1 + \rho_2D_2 + t \quad (4-A-1)$$

The size of reserve deficiency is given by the difference between the actual reserves and the required reserves,

$$\rho_1D_1 + \rho_2D_2 + t - R$$

$$= t - ER$$

where $ER$ is the excess reserves.

The expected reserve deficiency cost (ERDC) is,

$$\int_{t_{\text{crit}}}^{t_{\text{max}}}(t-ER)f(t)\,dt$$

Where $f(t)$ is the probability density function of $t$.

$t_{\text{crit}}$ is the critical level of $t$ beyond which reserve deficiency occurs.

$t_{\text{crit}}$ can be obtained by writing $(4-A-1)$ as an equality.

$$R = \rho_1D_1 + \rho_2D_2 + t$$

$$So, \quad t_{\text{crit}} = R - \rho_1D_1 - \rho_2D_2.$$
FIGURE 4.11.1 Critical Reserve Deficiency Line

Region of Reserve Deficiency
In Figure 4.II.1 the range of values of $u_1$ and $u_2$ that causes reserve deficiency can be shown in the following way:

The net outflows from both types of deposits, $u_1$ and $u_2$ are shown along the $x$-axis and $y$-axis respectively. Let the line represented by the equation, 

$$t = ER \text{ or } u_1(1-\rho_1)+u_2(1-\rho_2) = R-\rho_1 D_1-\rho_2 D_2$$

be called the (critical) reserve deficiency line. The reserve deficiency line shows the level of $u_2$ for a given level of $u_1$, beyond which any further increase in $u_2$ causes reserve deficiency for given values of $D_1$, $D_2$ and $R$. The critical reserve deficiency line is shown by PQ in Figure 4.II.1. The region of reserve deficiency is shown by the shaded area. The slope of the reserve deficiency line is $-(1-\rho_1)/(1-\rho_2)$. An increase in the level of excess reserves, ER shifts out the reserve deficiency line.

If $\rho_1 = \rho_2 = 0$, the slope of this line is $-1$, that is, reserve outflow from any one of the deposit liabilities causes the same level of reserve deficiency. In this case, the equation of the reserve deficiency line is given by $u_1+u_2 = R$. An increase in $\rho_1$ relative to $\rho_2$ makes the line flatter (the absolute value of the slope smaller) than the reserve deficiency line in the unregulated case.

The above analysis can easily be extended to the n-deposit case. If there are two deposit liabilities, there are four possible patterns of deposit flows. If there are three types of
deposits, the possible patterns are:

<table>
<thead>
<tr>
<th>Sign of u's</th>
<th>No. of cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>All positive</td>
<td>( ^3C_3 = 1 )</td>
</tr>
<tr>
<td>Two positive</td>
<td>( ^3C_3 = 3 )</td>
</tr>
<tr>
<td>One positive</td>
<td>( ^3C_1 = 3 )</td>
</tr>
<tr>
<td>None positive</td>
<td>( ^3C_0 = 1 )</td>
</tr>
</tbody>
</table>

Total Possible cases \( \Sigma^3C_r = 8 \)

Therefore, if there are \( n \) deposits, there are \( \Sigma^nC_r \) possible cases. The probabilities of each of the pattern can be represented by the terms of the binomial distribution \( (1/2+1/2)^n \), since the probability of reserve inflow/outflow is .5. There will be no reserve deficiency if all u's are negative. Therefore, reserve deficiency may occur in any of the remaining \( \Sigma^nC_r-1 \) cases.
PART II
THE ROLE OF RESERVE REQUIREMENTS IN BANK INNOVATIONS IN THE
UNITED STATES AND THE UNITED KINGDOM - EMPIRICAL EVIDENCE
5.1 Introduction

This chapter is an introductory chapter to the empirical work presented in the following chapter. In section 5.2, I discuss the major reforms in the structure of reserve requirements from the period 1960 to 1980 and review the empirical literature on the effects of reserve requirements on the United States (U.S.) banking system. In section 5.3, a short review of the literature on the implicit tax of reserve requirements is presented. Alternative measures of implicit tax rates of reserve requirements for the U.S. banking sector are computed in section 5.4. Section 5.5 summarizes the results.

5.2 The structure of reserve requirements in the United States (1960-1980)

The structure of reserve requirements has passed through several phases during this period. See Table 5.1.1 and 5.1.2 for the structures of reserve requirements in 1960 and 1980. Most of these changes were introduced by the monetary authorities in response to the increasing exodus of member banks from the Federal Reserve System.
# Table 5.1.1
Depository Institutions Reserve requirements in the 1960's
(Per cent of deposits)

<table>
<thead>
<tr>
<th>Net demand deposits</th>
<th>Percentage of deposits</th>
<th>Effective from</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central reserve city banks</td>
<td>17.5</td>
<td>9/1/60</td>
</tr>
<tr>
<td>Reserve city banks</td>
<td>16.5</td>
<td>4/24/58</td>
</tr>
<tr>
<td>Country banks</td>
<td>12</td>
<td>11/24/60</td>
</tr>
<tr>
<td>Time deposits</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Central reserve and</td>
<td></td>
<td></td>
</tr>
<tr>
<td>reserve city banks</td>
<td>4</td>
<td>10/25/62</td>
</tr>
<tr>
<td>Country banks</td>
<td>4</td>
<td>10/25/62</td>
</tr>
</tbody>
</table>

# Table 5.1.2
Depository Institutions Reserve Requirements in the 1980's
(Per cent of deposits)

<table>
<thead>
<tr>
<th>Net demand deposits (In millions of dollars)</th>
<th>Percentage of deposits</th>
<th>Effective from</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-2</td>
<td>7</td>
<td>12/30/76</td>
</tr>
<tr>
<td>2-10</td>
<td>9.5</td>
<td>12/30/76</td>
</tr>
<tr>
<td>10-100</td>
<td>11.75</td>
<td>12/30/76</td>
</tr>
<tr>
<td>100-400</td>
<td>12.75</td>
<td>12/30/76</td>
</tr>
<tr>
<td>over 400</td>
<td>16.25</td>
<td>12/30/76</td>
</tr>
</tbody>
</table>

Time and Saving deposits

<table>
<thead>
<tr>
<th>Time</th>
<th>Percentage of deposits</th>
<th>Effective from</th>
</tr>
</thead>
<tbody>
<tr>
<td>Savings</td>
<td>3</td>
<td>3/16/67</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Time</th>
<th>Percentage of deposits</th>
<th>Effective from</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-5, by maturity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30-179 days</td>
<td>3</td>
<td>3/16/67</td>
</tr>
<tr>
<td>180 days to 4 years</td>
<td>2.5</td>
<td>1/8/76</td>
</tr>
<tr>
<td>4 years or more</td>
<td>1</td>
<td>10/30/75</td>
</tr>
<tr>
<td>over 5, by maturity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30-179 days</td>
<td>6</td>
<td>12/12/74</td>
</tr>
<tr>
<td>180 days to 4 years</td>
<td>2.5</td>
<td>1/8/76</td>
</tr>
<tr>
<td>4 years or more</td>
<td>1</td>
<td>10/30/75</td>
</tr>
</tbody>
</table>

Source: Federal Reserve Bulletin.
The major defects of the system as it existed during the early sixties were:

1. the basing of reserve requirements on geographic location,
2. the discrimination against member banks because of reserve requirements placing them at a competitive disadvantage to other financial institutions not subject to comparable reserve requirements,
3. the exclusion of cash reserves as part of the required reserves,\(^1\)
4. the size of reserve ratios which were regarded by many\(^2\) as higher than necessary for the efficiency of the financial sector.

The declaration of vault cash as part of required reserves in July 1959 was the first major post-war reform. This reduced the effective reserve requirements for the banks because banks would keep some amount of cash reserves for their day-to-day business regardless of legal requirements.

Since the early sixties the banking sector gradually moved to a system of graduated reserve requirements through a series of regulation changes. In 1966 the Federal Reserve Board instituted a split reserve requirements system by raising the requirement on time deposits in excess of $5 million from 4 to 6 percent. In January, 1968, the principle of graduation was

\(^1\)The small country banks were hurt most by this law because they used to keep larger cash reserves for their operating needs than the large banks.

\(^2\)See, for example, Goodfriend and Hargreaves (1982).
reinforced by raising the reserve requirement on demand deposits in excess of $5 million by one-half percent. The most significant change took place in November, 1972 when a sharply graduated system of reserve requirements on net demand deposits was introduced for all member banks.3

In September of 1968, the Federal Reserve Board introduced the lagged reserve adjustment method in place of the contemporaneous reserve adjustment method. The lagging procedure made it possible for banks to target a known required reserve and plan well in advance to meet this target.4 The banks, under the new system, could carry forward any excess or deficiency of reserves into the following statement period without penalty, provided the carried-over reserves did not exceed 2 per cent of the required reserves.

Over the years, opposition increased to the classification of banks as country or reserve-city banks on the basis of their correspondent balances due to other banks. This classification was held by many to be outdated because a small group of country banks had developed deposit bases larger than many reserve city banks. Also, many banks opposed the inequities of such a system because banks of similar sizes had been classified differently in different geographical categories for reserve requirements

3See Knight (1974a and 1974b).

4There is a great deal of controversy surrounding the issue whether the new method increased or moderated the reserve adjustment pressure. See Poole and Lieberman (1972) and Gilbert (1973).
purposes. In 1972, the reserve city-country classification was abolished.

The Federal Reserve in late 1974 for the first time tied reserve requirements to the maturity structure of two rapidly growing categories of bank liabilities - large negotiable certificates of deposits and small denomination time deposits. Lower reserves were required for deposit maturities equal to or longer than 180 days. Reserve requirements on the longer term components of these two instruments were further reduced in 1975 and 1976. Humfrey (1979) empirically investigated the significance of these changes.

During the late 1970's the Federal Reserve authorities proposed to pay interest on required reserves but to limit the interest payments to 7 per cent of Federal Reserve net earnings. The plan also included a provision to price the Federal Reserve services. The 1980 monetary control act introduced universal reserve requirements for banks and non-banks. It relieved member banks of the competitive disadvantage vis-a-vis non-members. It also reduced the competitive disadvantage of reservable deposits relative to competitive non-reservable instruments such as money market mutual funds, repurchase agreements and eurodollar deposits.
5.3 Review of the literature on the implicit tax of reserve requirements

There have been many discussions and empirical studies about the evidence of legal reserve requirements as an implicit tax and its effects on the banking sector. Most of these studies were directed at estimating the net benefits and costs of membership from services rendered by the Federal Reserve to banks and the legal reserves they were required to maintain. Therefore these studies were oriented towards finding whether the membership decision depends on the comparison of costs and benefits. Here I review briefly some of these studies.

Results of various surveys of bankers' opinions by Brimmer (1966), Mayne (1973) and Rose and Rose (1976) suggest that member bank shareholders bear the burden of reserve requirements through depressed earnings. Rose's survey of findings indicated that more than 90 per cent of the banks that withdrew from the system between 1965 and 1973 achieved their withdrawal goals. The most often cited withdrawal goal was an increase in net earnings by investing more in earning assets. The other goals which they achieved were,

1. charging a higher price for services and/or paying lower prices for liabilities and other inputs.
2. managing operations more efficiently.
3. restructuring balance sheets to accept greater risk along

---

5See, for example, Mayne (1973), Knight (1974a and 1974b), Prestopino (1976), Gilbert (1977) and Frodin (1980).
with improved earnings.

Humfrey (1979) assessed the impact of reserve requirements changes on the intradeposit maturity composition of certificates of deposits (CD's) and small denomination time deposits for large U.S. banks. Some of Humfrey's conclusions were:

1. Reserve requirement changes were associated with variations in CD and small time deposit rates paid by banks.
2. About two-thirds of all of the potential increase in banks's earnings appeared to have been directly passed to CD holders in the form of rate increases.
3. Depositors view short and long term CD and small time deposit instruments as strong substitutes for one another.

Frodin (1980) considered the tax and subsidies of the Federal Reserve System and found the net rates to be a very important factor in bank decisions to retain membership. He also found positive evidence that the Federal Reserve had reacted to bank behaviour in a manner designed to retain membership. In particular, the Federal Reserve took actions to reduce taxes or increase subsidies for the sub-group of banks accounting for most of the exodus, the small banks.

In the next section, I compute the burden of reserve requirements for U.S. banks for the period from 1960 to 1980.
5.4 Measurement of burden of reserve requirements for U.S. banks

The 'implicit tax' burden of reserve requirements can be measured either by estimating the total loss of earnings from reserve requirements, or computing various implicit tax rates of reserve requirements. The formulae derived in Chapter Two are used here.

5.4.1 Estimation of the loss of earnings from legal reserve requirements

The loss of earnings from reserve requirements is the opportunity cost of reserves that the bank has to maintain in non-interest-bearing forms. The general formula for this opportunity cost was derived in section 2.1.3 in Chapter Two and was given by the expression (2-11) in that chapter. This is reproduced here:

\[ C = \sum \rho_j D_j \star \sum a_i r_i \]

where \( \sum a_i = 1 \)

\( \alpha_i \) (the weight of ith type of asset) = \( L_i / L \)

\( D_j \) = Deposit of jth category

\( \rho_j \) = Reserve ratio on the jth category of deposits

\( C \) = Opportunity cost of reserves

\( r_i \) = Market interest rate on ith type asset.

\( L_i \) = Asset of type i

The reasons for not using the formulae derived in Chapters Three and Four were explained in the introductory chapter.
\[ L = \text{Total size of assets.} \]

The \( \alpha_i \)'s are generally unknown since we do not know how the banks would have allocated their reserves among the various assets, had they not been required to keep their reserves in non-interest bearing forms. To overcome this problem, I assume that the return on required reserves is the same as the return realized on bank loans. As a simplification, I have assumed the prime lending rate as representative of the structure of interest rates. This method of using a unique rate yields only an approximation of the total loss suffered by banks because banks have a diversified portfolio of assets which earn different interest rates depending on the maturity, demand and supply of those assets. With the above simplification, equation (5-1) is reduced to:

\[ C = \rho \sum D_j \]  

(5-2)

Since banks would voluntarily keep some vault cash for day-to-day need given uncertain deposit inflows and outflows,\(^7\) the estimates provided by equation (5-2) slightly overestimate the actual losses that banks incur. I assume that banks keep 3 per cent of their deposit liabilities in cash reserves for these needs.\(^8\) Therefore, the amount of loss is estimated by

\(^7\)See Chapter Four on the role of uncertainties on bank cash management.

\(^8\)The assumption of a constant reserve ratio may not be a realistic assumption in view of the changing demand for voluntary reserves by banks. The voluntary reserve ratio may have declined over time because of the development of a low-cost transfer technology and new cash management techniques. Since no empirical work has been done estimating this ratio, I followed
\[ C' = C - 0.03rD \] (5-3)

The monthly loss of earnings of U.S. banks for the period from January, 1960 to December, 1980 is computed using equation (5-3). D is measured by the total amount of deposits of the banks. Data on the amount of required reserves, the total amount of deposits and the prime lending rate are taken from various issues of the Federal Reserve Bulletin. I use monthly data to compute the loss and various implicit tax rates. The annual averages are reported in the tables of this chapter. The monthly figures are used in the regression analysis of the following chapter. Table 5.2, column (a), shows the estimates of annual (average of monthly figures) loss of earnings for the period from 1960 to 1980.

The above estimates show that the loss of earnings for U.S. banks from non-interest-bearing reserves has increased significantly during the period. As the Table shows, the loss of earnings increased 237 per cent during the decade 1960-1970 and 226 per cent during the decade 1970-1980. The growth rate for the entire period is 538 percent, an average annual growth rate of about 27 percent.\(^8\)

In order to be sure that this high growth of loss of earnings was not due to inflation, I computed the real loss of

\(^8\) (cont'd) Lermer (1980) in assuming a three per cent voluntary reserve ratio.

\(^9\) These growth rates are somewhat misleading because of within-series variability. They nevertheless give some sense of the growth of the series over the period under study.
Table 5.2

Estimates of Loss of Earnings from Reserve Requirements for U.S. Banks (1960-1980)*
(In millions of dollars)

<table>
<thead>
<tr>
<th>Nominal loss (C')</th>
<th>Real loss</th>
<th>Effective reserve ratio (p)</th>
<th>Prime lending rate (r)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)</td>
<td>(b)</td>
<td>(c)</td>
<td>(d)</td>
</tr>
<tr>
<td>1960 636.52</td>
<td>1157.49</td>
<td>11.30</td>
<td>4.82</td>
</tr>
<tr>
<td>1961 610.82</td>
<td>1098.93</td>
<td>11.00</td>
<td>4.50</td>
</tr>
<tr>
<td>1962 624.46</td>
<td>1110.64</td>
<td>10.60</td>
<td>4.50</td>
</tr>
<tr>
<td>1963 609.47</td>
<td>1070.82</td>
<td>9.89</td>
<td>4.50</td>
</tr>
<tr>
<td>1964 627.28</td>
<td>1087.46</td>
<td>9.60</td>
<td>4.50</td>
</tr>
<tr>
<td>1965 655.70</td>
<td>1119.10</td>
<td>9.28</td>
<td>4.53</td>
</tr>
<tr>
<td>1966 852.04</td>
<td>1412.03</td>
<td>9.17</td>
<td>5.62</td>
</tr>
<tr>
<td>1967 884.98</td>
<td>1426.80</td>
<td>8.95</td>
<td>5.63</td>
</tr>
<tr>
<td>1968 1078.28</td>
<td>1668.09</td>
<td>9.06</td>
<td>6.28</td>
</tr>
<tr>
<td>1969 1460.48</td>
<td>2143.57</td>
<td>9.27</td>
<td>7.95</td>
</tr>
<tr>
<td>1970 1510.50</td>
<td>2093.32</td>
<td>9.35</td>
<td>7.91</td>
</tr>
<tr>
<td>1971 1138.62</td>
<td>1513.61</td>
<td>8.77</td>
<td>5.72</td>
</tr>
<tr>
<td>1972 1095.21</td>
<td>1409.38</td>
<td>8.47</td>
<td>5.25</td>
</tr>
<tr>
<td>1973 1633.67</td>
<td>1979.20</td>
<td>7.73</td>
<td>8.02</td>
</tr>
<tr>
<td>1974 2401.82</td>
<td>2620.41</td>
<td>7.73</td>
<td>10.80</td>
</tr>
<tr>
<td>1975 1474.39</td>
<td>1574.13</td>
<td>7.01</td>
<td>7.86</td>
</tr>
<tr>
<td>1976 1278.61</td>
<td>1209.09</td>
<td>6.64</td>
<td>6.84</td>
</tr>
<tr>
<td>1977 1267.73</td>
<td>1125.80</td>
<td>6.39</td>
<td>6.82</td>
</tr>
<tr>
<td>1978 1810.78</td>
<td>1493.74</td>
<td>6.31</td>
<td>9.05</td>
</tr>
<tr>
<td>1979 2851.37</td>
<td>2113.83</td>
<td>6.59</td>
<td>12.65</td>
</tr>
<tr>
<td>1980 3426.66</td>
<td>2247.66</td>
<td>6.36</td>
<td>16.36</td>
</tr>
</tbody>
</table>

* Using formula (5-3)

Sources: Federal Reserve Bulletin, various issues.
earnings using the U.S. consumer price index. Table 5.2, column (b), shows the real loss of earnings. As the Table shows, there has been a 194 per cent growth of loss of real earnings during the entire period, which implies an average annual growth rate of 10 per cent.

Columns c and d of Table 5.2 show the annual effective reserve ratios (the effective reserve ratio, \( \rho \), is calculated by dividing the amount of required reserves by total deposits) and the prime lending rates (\( r \)) respectively. As these columns show, the effective reserve ratio steadily declined over the time period while the interest rate fluctuated much. This fluctuation in the interest rate accounts for the fluctuation in the nominal loss of earnings and the implicit tax rates of reserve requirements derived below. Table 5.2 is supplemented by Table 5.A.1 (see appendix to Chapter Five) which shows decomposition of the changes in nominal loss of earnings (column a) into changes in reserve ratios (column b), interest rate (column c) and deposits (column d) changes.

5.4.2 Estimation of implicit tax rates of reserve requirements

Different types of implicit tax rates have been computed by dividing \( C' \) in equation (5-3) by the appropriate base.

1. The implicit rate of taxation per dollar deposit, ITXD has been calculated in the following way:

\[
ITXD = \frac{C'}{\Sigma D} \tag{5-4}
\]

where \( C' \) is given by (5-3) and \( D \) is defined before. For \( \Sigma D \),
I have used the total deposits subject to reserve requirements. Column (a) in Table 5.3 shows ITXD. The range of ITXD is from .23 per cent (in 1977) to .52 per cent (in 1980). The variance of ITXD is .009.

2. The rate of taxation per dollar of interest earnings (ITXI) is computed by dividing $C'$ in (5-3) by the total interest earnings on deposits. This is shown below

$$\text{ITXI} = \frac{C}{\sum \alpha_i r_i \Sigma (1-\rho_j)D_j - \sum d_j D_j}$$  (5-5)

where $d_j$ = interest on deposit type $j$.

On the assumption that $r_i = r$ for all $i$, (5-5) is reduced to

$$\text{ITXI} = \frac{C}{\sum (1-\rho_j)D_j - \sum d_j D_j}$$  (5-6)

Assuming a weighted average interest rate on deposits, $d$, as a proxy variable for all $d_j$'s, (5-6) can be written as:

$$\text{ITXI} = \frac{C}{\sum [r(1-\rho)-d]D}$$  (5-7)

where $\rho$ is the effective reserve ratio calculated by dividing the total amount of required reserves by the total amount of deposits.

Interest earnings are obtained by multiplying the interest spread between the lending and the deposit rates\(^{10}\) by the amount of deposits. Since no interest is paid on demand deposits and data on service charges are not available, I have considered the three-month time deposit

\(^{10}\)After adjusting for legal reserves as shown in equation (5-7).
Table 5.3

Estimates of Various Implicit Tax Rates of Reserve Requirements per Dollar Deposit (1960-1980)*

<table>
<thead>
<tr>
<th>ITXD (a)</th>
<th>ITXK (b)</th>
<th>ITXI (c)</th>
<th>ITXY (d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960 .40</td>
<td>3.66</td>
<td>11.40</td>
<td>21.73</td>
</tr>
<tr>
<td>1961 .36</td>
<td>3.28</td>
<td>11.01</td>
<td>20.61</td>
</tr>
<tr>
<td>1962 .34</td>
<td>3.15</td>
<td>10.92</td>
<td>22.26</td>
</tr>
<tr>
<td>1963 .31</td>
<td>2.89</td>
<td>9.84</td>
<td>20.95</td>
</tr>
<tr>
<td>1964 .30</td>
<td>2.74</td>
<td>9.39</td>
<td>21.48</td>
</tr>
<tr>
<td>1965 .29</td>
<td>2.63</td>
<td>9.30</td>
<td>21.95</td>
</tr>
<tr>
<td>1966 .35</td>
<td>3.24</td>
<td>10.93</td>
<td>27.60</td>
</tr>
<tr>
<td>1967 .34</td>
<td>3.15</td>
<td>10.71</td>
<td>24.50</td>
</tr>
<tr>
<td>1968 .38</td>
<td>3.58</td>
<td>11.61</td>
<td>28.01</td>
</tr>
<tr>
<td>1969 .50</td>
<td>4.56</td>
<td>12.50</td>
<td>26.73</td>
</tr>
<tr>
<td>1970 .50</td>
<td>4.43</td>
<td>12.28</td>
<td>26.41</td>
</tr>
<tr>
<td>1971 .33</td>
<td>3.05</td>
<td>9.10</td>
<td>21.37</td>
</tr>
<tr>
<td>1972 .29</td>
<td>2.66</td>
<td>8.20</td>
<td>19.23</td>
</tr>
<tr>
<td>1973 .38</td>
<td>3.65</td>
<td>10.13</td>
<td>24.48</td>
</tr>
<tr>
<td>1974 .51</td>
<td>4.98</td>
<td>12.13</td>
<td>34.19</td>
</tr>
<tr>
<td>1975 .32</td>
<td>3.02</td>
<td>8.31</td>
<td>22.58</td>
</tr>
<tr>
<td>1976 .25</td>
<td>2.35</td>
<td>5.24</td>
<td>16.30</td>
</tr>
<tr>
<td>1977 .23</td>
<td>2.14</td>
<td>4.73</td>
<td>18.39</td>
</tr>
<tr>
<td>1978 .30</td>
<td>3.17</td>
<td>5.53</td>
<td>20.27</td>
</tr>
<tr>
<td>1979 .46</td>
<td>4.21</td>
<td>8.00</td>
<td>22.14</td>
</tr>
<tr>
<td>1980 .52</td>
<td>4.64</td>
<td>8.91</td>
<td>24.86</td>
</tr>
</tbody>
</table>

* Expressed as percentages.

Sources: Federal Reserve Bulletin, FDIC annual reports and Banking and Monetary Statistics.
rate as a measure of \( d \). I have taken the difference between the prime lending rate and the time deposit rate to calculate the average interest rate spread between the deposit and the lending rates. The estimates of ITXI are shown in Table 5.3. The range of ITXI is from 4.73 per cent (in 1977) to 12.50 per cent (in 1969) and the variance is .0005.

3. Rates of taxation per dollar of net income (ITXY) are obtained by dividing \( C' \) by net income.\(^1\) These are shown in Table 5.3. ITXY ranges in value between 16.30 per cent (in 1976) to 34.19 per cent (in 1974) and the variance is 15.93.

4. Finally, the rates of taxation per dollar of equity capital (ITXK) are shown in Table 5.3. These rates are obtained by dividing \( C' \) by total equity capital.\(^2\) The range of ITXK is between 2.14 per cent (in 1977) to 4.98 per cent (in 1974) and the variance is 6.06\( \times 10^{-5} \).

In order to show the comparison between the magnitude of implicit taxes with that of 'regular' taxes paid by banks during this period, the loss of earnings from reserve requirements has been expressed as a ratio of total income tax paid by U.S. banks. These ratios are shown in Table 5.4. Column (a) of Table 5.4 shows the tax paid by banks during the period expressed in

\(^{1}\) Net income is defined as income net of operating expenses and income taxes. Data on net income are obtained from the annual reports of the Federal Deposit Insurance Corporation.

\(^{2}\) Data on equity capital are obtained from Banking and Monetary Statistics, Annual Statistical Digest, and annual reports of Federal Deposit Insurance Corporation.
Table 5.4

A Comparison of Income Tax with the Cost of Required Reserves (1960-1980)

(In millions of dollars)

<table>
<thead>
<tr>
<th>Year</th>
<th>TAXB</th>
<th>COST</th>
<th>TTAX*</th>
<th>TTAX/TAX</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960</td>
<td>1240.6</td>
<td>636.52</td>
<td>1877.04</td>
<td>151.30</td>
</tr>
<tr>
<td>1961</td>
<td>1250.5</td>
<td>610.82</td>
<td>1860.93</td>
<td>148.81</td>
</tr>
<tr>
<td>1962</td>
<td>1109.8</td>
<td>624.46</td>
<td>1734.22</td>
<td>156.26</td>
</tr>
<tr>
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<td>156.50</td>
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<td>1534.87</td>
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<td>1892.90</td>
<td>187.94</td>
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<td>2135.27</td>
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<td>1969</td>
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<td>1460.48</td>
<td>3477.84</td>
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<td>3408.15</td>
<td>179.62</td>
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<tr>
<td>1971</td>
<td>1207.8</td>
<td>1138.62</td>
<td>2345.79</td>
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</tr>
<tr>
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<td>1295.7</td>
<td>1095.21</td>
<td>2391.27</td>
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<tr>
<td>1973</td>
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<td>3304.22</td>
<td>197.98</td>
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</tr>
<tr>
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<td>1412.0</td>
<td>1574.39</td>
<td>2983.06</td>
<td>211.26</td>
</tr>
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<td>3210.29</td>
<td>166.23</td>
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<td>1267.73</td>
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<td>1810.78</td>
<td>5036.02</td>
<td>166.51</td>
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<td>1979</td>
<td>3644.3</td>
<td>2851.37</td>
<td>6494.52</td>
<td>178.21</td>
</tr>
<tr>
<td>1980</td>
<td>3864.2</td>
<td>3426.66</td>
<td>7288.05</td>
<td>188.60</td>
</tr>
</tbody>
</table>

*(c) = (a) + (b)

Sources: Federal Reserve Bulletin, FDIC annual reports and Banking and Monetary Statistics.
millions of dollars. Column (b) shows the cost of required reserves in millions of dollars. Column (c) shows the effective total tax, that is the sum of tax and the cost of required reserves. Column (d) shows how much the effective total tax has been raised because of the implicit tax of required reserves. For example, in the year 1970, the effective cost of tax is 79 per cent higher than the income tax paid by banks. The range of the increase in the effective cost is from 48 per cent (in 1961) to 144 per cent (in 1974).

Table 5.5 shows both the tax and the 'effective' tax expressed as percentages of net income of banks. For example, the tax ratio (ratio of tax to net income before taxes) in 1965 was 29.5 per cent whereas the effective tax ratio (ratio of effective total tax to net income before taxes) was 51.45 per cent in 1965, a difference of approximately 22 per cent.

5.5 Summary and conclusions

In this chapter, I have computed various implicit tax rates of reserve requirements, using alternative definitions of bank output. I will use these rates in testing hypotheses about innovations in the U.S. money market. It is evident from this empirical study that although the loss of earnings has increased significantly during the entire period, these losses expressed as percentage of alternative bases of bank output and earnings remained fairly stable. We do not observe any definite trend in
Table 5.5

<table>
<thead>
<tr>
<th>Year</th>
<th>TAXB*100/NIBT**</th>
<th>TTAX*100/NIBT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(a)</td>
<td>(b)</td>
</tr>
<tr>
<td>1960</td>
<td>42.35</td>
<td>64.07</td>
</tr>
<tr>
<td>1961</td>
<td>42.21</td>
<td>62.81</td>
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<tr>
<td>1962</td>
<td>39.56</td>
<td>61.83</td>
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<tr>
<td>1963</td>
<td>37.07</td>
<td>58.02</td>
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<td>1964</td>
<td>34.16</td>
<td>55.64</td>
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<tr>
<td>1965</td>
<td>29.50</td>
<td>51.45</td>
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<tr>
<td>1966</td>
<td>28.40</td>
<td>55.98</td>
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<tr>
<td>1967</td>
<td>27.85</td>
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<td>27.31</td>
<td>55.33</td>
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<td>1969</td>
<td>36.89</td>
<td>63.61</td>
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<td>1970</td>
<td>33.17</td>
<td>59.58</td>
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<tr>
<td>1971</td>
<td>22.68</td>
<td>44.05</td>
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<tr>
<td>1972</td>
<td>22.74</td>
<td>41.98</td>
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<tr>
<td>1973</td>
<td>24.98</td>
<td>49.45</td>
</tr>
<tr>
<td>1974</td>
<td>23.60</td>
<td>57.79</td>
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<tr>
<td>1975</td>
<td>20.29</td>
<td>42.87</td>
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<tr>
<td>1976</td>
<td>24.60</td>
<td>40.90</td>
</tr>
<tr>
<td>1977</td>
<td>33.55</td>
<td>51.95</td>
</tr>
<tr>
<td>1978</td>
<td>30.92</td>
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<tr>
<td>1979</td>
<td>28.31</td>
<td>50.45</td>
</tr>
<tr>
<td>1980</td>
<td>28.06</td>
<td>52.92</td>
</tr>
</tbody>
</table>

** Net income before taxes (NIBT) is gross operating income minus total operating costs.

Sources: Federal Reserve Bulletin, FDIC annual reports and Banking and Monetary Statistics.
any of the measures of implicit tax rates (see Table 5.3)).

One limitation of the above study is that the benefits from membership of the Federal Reserve System\(^{13}\) are not considered while calculating the total cost of required reserves. The primary justification for this omission is that these benefits ought to be considered in calculating the net cost of membership of the Federal Reserve System. The net cost of membership plays a significant role in the decision to remain in or exit from the Federal Reserve System. But since the benefits from the Federal Reserve System are enjoyed by banks whether they engage in liability substitution or not, these benefits should not affect the inter-liability substitution or growth of new liabilities and therefore should not be a factor in innovations that will be studied in the following chapter.

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\(^{13}\)These benefits such as float, clearing facilities etc. were measured by Frodin (1976), and Benston (1982), among others.
Appendix to Chapter Five

Table 5.A.1

Decomposition of Loss of Earnings from Reserve Requirements into Reserve Ratios, Interest rates and Deposits Changes (1960-1980)*

<table>
<thead>
<tr>
<th></th>
<th>( \Delta \log C' )**</th>
<th>( \Delta \log \rho )</th>
<th>( \Delta \log r )</th>
<th>( \Delta \log D )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960</td>
<td>-.92</td>
<td>-.20</td>
<td>-.88</td>
<td>.23</td>
</tr>
<tr>
<td>1961</td>
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<tr>
<td>1962</td>
<td>-.27</td>
<td>-.64</td>
<td>0</td>
<td>.63</td>
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<tr>
<td>1963</td>
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<td>-.30</td>
<td>0</td>
<td>.62</td>
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<tr>
<td>1964</td>
<td>.30</td>
<td>-.21</td>
<td>0</td>
<td>.61</td>
</tr>
<tr>
<td>1965</td>
<td>1.00</td>
<td>-.31</td>
<td>.74</td>
<td>.73</td>
</tr>
<tr>
<td>1966</td>
<td>2.15</td>
<td>.15</td>
<td>1.65</td>
<td>.27</td>
</tr>
<tr>
<td>1967</td>
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<td>.94</td>
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<tr>
<td>1968</td>
<td>1.53</td>
<td>.02</td>
<td>.79</td>
<td>.70</td>
</tr>
<tr>
<td>1969</td>
<td>2.74</td>
<td>.67</td>
<td>2.11</td>
<td>-.35</td>
</tr>
<tr>
<td>1970</td>
<td>-1.63</td>
<td>-.57</td>
<td>-1.71</td>
<td>.92</td>
</tr>
<tr>
<td>1971</td>
<td>-1.53</td>
<td>-.37</td>
<td>-1.93</td>
<td>.96</td>
</tr>
<tr>
<td>1972</td>
<td>-.08</td>
<td>-.91</td>
<td>.44</td>
<td>.91</td>
</tr>
<tr>
<td>1973</td>
<td>5.31</td>
<td>.10</td>
<td>4.34</td>
<td>.80</td>
</tr>
<tr>
<td>1974</td>
<td>.78</td>
<td>-.38</td>
<td>.62</td>
<td>.79</td>
</tr>
<tr>
<td>1975</td>
<td>-4.11</td>
<td>-.77</td>
<td>-3.07</td>
<td>.30</td>
</tr>
<tr>
<td>1976</td>
<td>-1.32</td>
<td>-.32</td>
<td>-1.12</td>
<td>.38</td>
</tr>
<tr>
<td>1977</td>
<td>1.66</td>
<td>-.32</td>
<td>1.66</td>
<td>.60</td>
</tr>
<tr>
<td>1978</td>
<td>4.81</td>
<td>.43</td>
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<td>.68</td>
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<td>1979</td>
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<td>.06</td>
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</tr>
<tr>
<td>1980</td>
<td>.29</td>
<td>-1.43</td>
<td>2.37</td>
<td>.71</td>
</tr>
</tbody>
</table>

* Expressed as percentages.

** \( \Delta \log C' = \log C'_t - \log C'_{t-1} \)
CHAPTER SIX
AN EMPIRICAL ANALYSIS OF THE ROLE OF RESERVE REQUIREMENTS IN
U.S. BANK INNOVATIONS (1965-1980)

6.1 Introduction

The main focus of this chapter is to evaluate the effects of reserve requirements as an implicit tax on bank innovations in the United States in the period from 1965 to 1980. This chapter is linked with Chapters Two and Five. In those chapters, I provided a theoretical framework for evaluating the effects of reserve requirements as an implicit tax on the various decision variables confronting the banking firm. There I showed that an implicit tax of reserve requirements on some types of liabilities leads to a substitution of liabilities with higher reserve requirements for liabilities with lower or no such requirements. In this chapter I have tried to gather empirical evidence of this substitution in the case of a major innovation in the U.S. financial market: the use of eurodollar funds by U.S. banks.

In Chapter Five, I computed various measures of implicit tax rates of cash reserve requirements of the U.S. banking sector. In the following sections I will try to relate these tax rates to the eurodollar market.

This chapter is organized as follows. An overview of innovations in the U.S. money market during the period from 1960
to 1980 is presented in section 6.2. Section 6.3 provides an outline of the study of the involvement of U.S. banks in the eurodollar market. Section 6.4 presents a graphical analysis of the relation between the implicit tax rate of reserve requirements and the growth of eurodollar business by the foreign branches of U.S. banks. Section 6.5 provides a brief survey of some of the empirical work on the eurodollar market. In section 6.6, I construct and test a single equation model to investigate the role of reserve requirements in the development of the eurodollar market. The contribution of the reserve requirements tax is estimated using the results of this model. Section 6.7 is the concluding section.

6.2 An overview of innovations in the U.S. money market (1960-1980)

The primary objective of this section is to present an overview of various innovations that have taken place in the U.S. money market in the period from 1960 to 1980, with special emphasis on those innovations that have been motivated by attempts to minimize the burden of reserve requirements.

Since the early 1960's U.S. banks, especially the large ones, have engaged in aggressive liability management, forsaking their traditional role as repositories of depositors' funds. The traditional approach of passively accepting deposits and investing them was replaced by the approach of targeting the total amount of funds the banks would attempt to obtain on the
basis of profitable levels of loans and investments.

The most remarkable feature of the new trend in liability management was the growth of non-traditional or interest sensitive sources of funds as compared to traditional deposits. Liability management reduced the role of conventional deposits while simultaneously increasing the role of 'purchased' funds in funding activities of banks and the growth of financial markets.¹ Tables 6.1.1 and 6.1.2 summarize the relative growth of different types of assets and liabilities during the period from 1960 to 1980.

We can identify at least four factors which are responsible for the new direction of thought by bank management: government regulations, growing competition from near-banks and other financial intermediaries, technology,² and high and variable inflation rates. Since the primary focus of my thesis is to discuss the effects of bank regulations on innovations, I do not plan to discuss the other causes of innovations. See Silber...

---

¹This growth can imply any one or all of the following: 1) significant expansion or deepening of already existing instruments 2) emergence of new financial markets and 3) development of secondary markets for new instruments. See Akther (1973). The other innovations in liability management during this period were: a) variable or floating rate debt and maturity shortening b) changes in retail banking c) diversification of sources of financial services. See Akther (1973) for a detailed description of these innovations.

²Technology, particularly development of telegraphic transfer and computer technology, facilitated the search for non-traditional markets. In other words, technology proved to be a strong ally to the bankers in devising escape valves from the regulations-induced constraints. At the same time, innovations were taking place which were purely technology-oriented.
### Table 6.1.1

#### Aggregate Balance Sheet Liabilities of U.S. Banks*
(Percentage of total Liabilities)

<table>
<thead>
<tr>
<th></th>
<th>1960</th>
<th>1980</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demand deposits</td>
<td>51.2</td>
<td>22.1</td>
</tr>
<tr>
<td>Private and foreign</td>
<td>.8</td>
<td>1.7</td>
</tr>
<tr>
<td>U.S. Govt.</td>
<td>2.6</td>
<td>.9</td>
</tr>
<tr>
<td>Savings and Small time deposits</td>
<td>27.0</td>
<td>33.3</td>
</tr>
<tr>
<td>Large time deposits</td>
<td>4.9</td>
<td>20.4</td>
</tr>
<tr>
<td>Federal funds and repurchase agreements</td>
<td>-</td>
<td>7.6</td>
</tr>
<tr>
<td>Long-term bonds</td>
<td>13.5</td>
<td>12.3</td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>


### Table 6.1.2

#### Aggregate Balance Sheet Assets*
(Percentage of total assets)

<table>
<thead>
<tr>
<th></th>
<th>1960</th>
<th>1980</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cash assets</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vault cash</td>
<td>1.4</td>
<td>1.4</td>
</tr>
<tr>
<td>Deposits at Federal Reserve</td>
<td>7.5</td>
<td>2</td>
</tr>
<tr>
<td><strong>Loans</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Securities</td>
<td>42.0</td>
<td>31.9</td>
</tr>
<tr>
<td>Mortgages</td>
<td>12.6</td>
<td>19.1</td>
</tr>
<tr>
<td>Consumer loans</td>
<td>11.6</td>
<td>12.7</td>
</tr>
<tr>
<td>Other</td>
<td>24.9</td>
<td>32.7</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

(1975) for a discussion of various theories of innovation.

Of all the government regulations, Regulation Q, limiting interest earnings on bank time deposits, and Regulation D, requiring banks to keep legal reserves, played key roles in motivating banks to engage in innovative activities. As a result of the growth of non-traditional liabilities, the percentage of required reserves in the form of balances with the Federal Reserve fell from 7.5 per cent to 2.0 per cent, as is evident from Table 6.1.2. The amount of vault cash as a proportion of total costs remained same. The significant fall in commercial banks' balances with the Federal Reserve can be attributed to the following three factors:

1. the steady decline of reserve requirements on given classes of deposits.
2. withdrawal of many banks from the Federal Reserve System.
3. growth of non-traditional liabilities requiring less legal reserves than the traditional ones.

We can trace innovations of at least three types of non-traditional liabilities by U.S. banks which were related to the attempt to minimize the burden of legal reserves.

1. The eurodollar market

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3 Table 2-1 (page 72) in Silber (1975) illustrates the role of various regulations in the development of innovative activities in the financial sector.

4 See Table 5.1.1.

5 This has been discussed in the previous chapter.

6 See Hester (1982).
2. Repurchase agreements
3. Federal funds market

In this chapter I test whether the growth of eurodollar business by U.S. banks is an increasing function of the cost of required reserves.

6.3 An outline of the study of U.S. involvement in the eurodollar market

The participation by U.S. banks in the eurodollar market is an important form of liability management partly motivated by regulatory considerations. The absence of legal reserve requirements and deposit insurance on their deposits as well as freedom from regulation Q enabled U.S. banks to offer better terms and conditions than banks doing business in local currencies. The U.S. banks got involved in the eurodollar market mainly through their foreign branches. Since it is mainly foreign branches of U.S. banks which can escape U.S. monetary regulations by participating in the eurodollar market, the activities of foreign branches of U.S. banks should be the focal

7 Eurodollar funds collected through the offshore branches of U.S. banks provide an alternative source of dollar deposits for U.S. banks.

8 In fact, the principal agents of the offshore market for dollars are the foreign branches and the subsidiaries of U.S. banks.

9 Banks of non-U.S. nationalities can escape U.S. regulations by offering eurodollars in London rather than in New York. Data on the diversion of business by these banks are not easily available and I leave out analysis of their operations.
point in any analysis of effects of domestic regulations on the involvement of U.S. banks in the eurodollar market.

There are two ways to analyze the effects of reserve requirements on the involvement of U.S. banks in the eurodollar market through their foreign branches: 1) effects on the growth of dollar-denominated liabilities of those branches and the 2) effects on the borrowings by U.S. banks from their overseas branches. In the following sections, I analyze the growth of dollar-denominated liabilities of overseas branches of U.S. banks from a regulatory perspective. Since the overseas branches have a comparative advantage in offering liabilities as compared to domestic banks, I chose the liability side instead of the asset side to test the hypotheses concerning the effects of regulations.

I focus on the activities of foreign branches of U.S. banks located in London. London is chosen primarily because of the pre-eminence of London in the eurodollar market. The other reason for choosing London is the relatively unregulated nature of the London money market. Thus U.S. banks can escape the onus of domestic monetary regulations, especially in times of tight monetary conditions, and at the same time they can enjoy the advantages offered to all overseas banks located in London.

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10 Until the imposition of marginal reserve requirements on borrowings in October of 1969, these borrowings had a decisive advantage over domestic sources of funds.

11 As mentioned above, this is mainly because of exemption of legal reserve requirements and Federal Deposit Insurance fees on their deposit liabilities.
6.4 A graphical analysis of the involvement of U.S. banks in the eurodollar market

During the last two decades, the offshore market for dollars has grown faster than the parallel domestic market for dollars. Table 6.2 shows the liabilities of foreign branches located in all countries and the United Kingdom. The liabilities of foreign branches are expressed as percentages of various types of domestic deposits in Table 6.3. The phenomenal growth of the size of the eurodollar market is obvious from these tables. The amount of dollar-denominated liabilities of foreign branches grew from $4,510.14 million in 1965 to $285,777 million in 1980 - a staggering growth of 6300 per cent. The comparative growth between domestic monetary aggregates and the liabilities of foreign branches is shown in Table 6.3. These liabilities, expressed as ratios to total deposits, time deposits and demand deposits at commercial banks grew from 2.1 to 31.1 percent, from 4.2 to 43.0 percent and from 4.7 to 108.3 percent respectively.

Figures 6.1 thru 6.4 show the various measures of the growth of dollar-denominated liabilities of the foreign branches of U.S. banks (referred to as eurodollar deposits in this section) and the implicit tax of reserve requirements per dollar deposit (ITXD). To examine the growth of eurodollar deposits, the following series are plotted:

1. EDDL = dollar-denominated liabilities of foreign branches of U.S. banks located in London,
2. EDAD = EDDL divided by the total domestic deposits of U.S.
Table 6.2*

<table>
<thead>
<tr>
<th>Year</th>
<th>All countries (a)</th>
<th>UK (b)</th>
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<td>4510.14</td>
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<td>1966</td>
<td>6294.41</td>
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<td>1967</td>
<td>8530.50</td>
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<td>1970</td>
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<td>21424.70</td>
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<td>1971</td>
<td>38307.70</td>
<td>23753.10</td>
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<td>1972</td>
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<td>119282.00</td>
<td>52068.70</td>
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<td>1978</td>
<td>207119.00</td>
<td>67381.00</td>
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<td>1979</td>
<td>246669.00</td>
<td>81992.80</td>
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<tr>
<td>1980</td>
<td>285777.00</td>
<td>98346.90</td>
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</table>


** The figures are annual averages of monthly figures.
### Table 6.3

<table>
<thead>
<tr>
<th>Year</th>
<th>EDDA/ADUS</th>
<th>EDDA/TDUS</th>
<th>EDDA/DDUS</th>
</tr>
</thead>
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* expressed as percentages

EDDA = Dollar-denominated deposits at the foreign branches of U.S. banks.
ADUS = Aggregate deposits at commercial banks
DDUS = Total demand deposits at commercial banks
TDUS = Total time and savings deposits at commercial banks.

Source: see sources in Table 6.3.
banks,
3. \( EDDD = EDDL \) divided by the total demand deposits of U.S. banks,
4. \( EDTD = EDDL \) divided by the total time deposits of U.S. banks.

These series and ITXD are plotted for the time period from June 1965 to November, 1980. In all these Figures deposits increased steadily over time with some minor fluctuations during the period under study. The series ITXD is characterized by much more variability than any of the series for deposits. Although we fail to establish any general pattern of the relationship between the growth of eurodollar deposits and the implicit tax of reserve requirements over the entire period, we observe some common trends between these two if we divide the period under study into the following four sub-periods:

\textit{June, 1965 to January, 1970}

During this period the eurodollar deposits (EDDL) grew at an increasing rate\(^ {12} \) with very minor fluctuations. Eurodollar deposits increased from $2,175 million to $20,712 million during this sub-period and the implicit tax rate (ITXD) increased from $.28 to $.57. The series ITXD had two major peaks, one in late 1967, the other in mid-1968. Looking at Figures 6.3 and 6.4, we find a close association between the eurodollar deposit series and ITXD. The series ITXD is highly correlated with EDAD and

\(^{12}\)If we draw a smooth curve for eurodollar deposits for this period, it will be an exponential function convex to x-axis.
Eurodollar Deposits (EDDL) and the Implicit Tax of Reserve Requirements (ITXD)
Ratio of Eurodollar Deposits to Domestic Demand deposits (EDDD) and the Implicit Tax of Reserve Requirements (ITXD)
FIGURE 6.3

Ratio of Eurodollar Deposits to Domestic Time Deposits (EDTD) and the Implicit Tax of Reserve Requirements (ITXD)

LEGEND

△ EDTD

□ ITXD

PERIOD

EDTD

ITXD (ln per cent)
FIGURE 6.4

Ratio of Eurodollar Deposits to Total Domestic Deposits (EDAD) and the Implicit Tax of Reserve Requirements (ITXD)
EDTD. Intuitively, eurodollar deposits are similar to time deposits and therefore are better substitutes for domestic time deposits than for demand deposits.

*February 1970 to September, 1974*

During this sub-period, ITXD generally declined and reached the lowest point of the cycle in March of 1972 and then increased to the peak of the cycle in September of 1974. During this period, EDDL and EDDD increased at an increasing rate during the entire sub-period, again with some minor fluctuations. As in the previous sub-period, both EDTD and EDAD show a closer relationship with ITXD than either of the other two series of eurodollar deposit growth, EDDL and EDDD. The cycles in EDAD and EDTD follow those of ITXD. However, the eurodollar deposit series shows much less variability than ITXD.

*October, 1974 to November 1980*

During this sub-period, ITXD had a declining trend until March 1977, then it rose to the peak of the cycle in April of 1980. During this period, both EDDL and EDDD showed an increasing trend. EDAD and EDTD fluctuated around a slightly increasing trend until mid-1978 and then increased steadily. Both ITXD and all the deposit series showed a declining trend for the rest of the period.

This sub-period gives some evidence contrary to our hypothesis that an increase in the implicit tax rate is
associated with an increase in the size of eurodollar market. Eurodollar deposits continued to grow during that period even though the implicit tax was declining. This can be explained by the following factors.

In January 1974 the U.S. government removed the series of capital controls it had imposed in the 1960's. The lifting of controls, by increasing the interest rate linkage between the U.S. domestic and eurodollar markets, stimulated movement of funds to the eurodollar market.

The marginal reserve requirements on borrowings by U.S. banks from their overseas branches that were imposed in October of 1969 were abolished in 1974. This also gave an incentive for borrowings from overseas branches by U.S. banks which in turn gave an impetus to the growth of eurodollar deposits. This is the period when the first OPEC oil crisis began. The succession of oil price rises created an unprecedented surplus in the balance of payments of oil-exporting countries. A large part of this surplus was absorbed by the international banking system including the foreign branches of U.S. banks. This accounts for the high growth of eurodollar deposits during this period even though the cost advantage of these deposits over domestic dollar deposits due to differential reserve requirements was negligible.

A brief survey of the empirical studies on the eurodollar market is presented in the following section.
6.5 A survey of empirical work on the eurodollar market

There have been numerous studies dealing with the causes of expansion of U.S. banks overseas. So far, three types of econometric models have been estimated: a) a single equation model used by Goldberg and Saunders (1980), among others; b) demand and supply models by Black (1971), Makin (1972) and Mastrapasqua (1973) and c) a general equilibrium model by Hewson and Sakakibara (1975). None of these studies considered the actual opportunity cost of legal reserve requirements on U.S. banks as a determinant of the expansion of foreign branches of U.S. banks. A brief review of some of the above models is presented here.

Goldberg and Saunders (1980) studied the expansion of U.S. banking in the United Kingdom. Their model was as follows,

\[ OV = f(RED, RDIFF, T, X, EXCH, DUS, DGB); \]

where \( OV \) = deposits of U.S. banks in Great Britain in all currencies expressed in dollars, \( RED \) = 90-day eurodollar interest rate, \( RDIFF \) = difference between 90-day U.S. treasury bill rate and the interest ceiling for a 90-day U.S. time deposit, \( T \) = total U.S. commercial bank deposits, \( X \) = total exports, \( EXCH \) = exchange rate between dollars and pounds, \( DUS \) = a dummy variable for U.S. capital restrictions, \( DGB \) = dummy variable for British regulation of foreign banks.

The expected signs are as follows:

\[ f_1 > 0, \ f_2 > 0, \ f_3 > 0, \ f_4 > 0, \ f_5 ?, \ f_6 < 0, \ f_7 ?; \]
According to their results, the principal determinants of overseas bank growth were the eurodollar rate, the exchange rate and the level of domestic deposits and exports. Their results also indicate that for the period as a whole (1961-I to 1978-II), overseas banking and domestic banking were 'complements' or joint products rather than substitutes.

Black (1971) estimated supply and demand functions for the eurodollar deposits borrowed by the New York banks from their foreign branches. His model for eurodollar borrowing was as follows,

\[
\begin{align*}
ED & = f(CD, RE, RFF, RTB) \quad \text{Demand function;} \\
ES & = g(RE, RTB, FL, BPR, UKBR) \quad \text{Supply function;}
\end{align*}
\]

where CD = certificates of deposits, RE = rate paid for eurodollars, RFF = rate paid for federal funds, RTB = rate for treasury bills, FL = discount on the forward pound sterling, BPR = variable measuring the tightness of the U.S. voluntary credit restriction programme, UKBR = UK bank rate.

The expected signs are as follows:

\[
\begin{align*}
f_1 & < 0, f_2 < 0, f_3 > 0, f_4 > 0 \\
g_1 & > 0, g_2 < 0, g_3 < 0, g_4 ?, g_5 < 0
\end{align*}
\]

Black derived two reduced form equations, one for the quantity of borrowings and the other for the rate on eurodollar deposits. All the variables except the U.K. bank rate and the U.S. voluntary foreign credit restriction variables entered significantly in the quantity equation and had expected signs.
The variables in the rate equation were found to be significant and had anticipated signs. The author noted that the UK bank rate and the level of CD's have only transitory effects on the euro-dollar deposit rate and the effect of CD losses dissappears as soon as the losses stop.

Makin's (1972) model is a structural model designed to explain the size of the eurodollar market in terms of the multiplier framework. His model consists of the following four equations:

$$\frac{\text{EDD}}{t} = f(I_t; r^e_t; r_{\text{cdt}}; g_t; \text{DM}_t)$$

$$\frac{\text{EDS}}{t} = h(\text{EBR}^*/t)$$

$$\frac{\text{EBR}}{\text{EDS}_t} = j(r^e_t; r_{\text{cdt}}; S_{A_t^2}; \text{EDS}^*/t)$$

$$\frac{\text{EDD}}{t} = \frac{\text{EDS}}{t}$$

where \(\text{EDD}\) = stock of eurodollars demanded, \(\text{EDS}\) = stock of eurodollars supplied, (both \(\text{EDD}\) and \(\text{EDS}\) are measured by total claims on eurobanks held by units outside the United States), \(I\) = imports of industrial countries, \(r^e\) = 90-day rate on eurodollars and \(r_{\text{cd}}\) = 90-day rate on CD's, \(g\) = expected return on gold, \(\text{DM}\) = forward premium on Deutschemarks, \(\text{EBR}\) = eurobank reserves measured by demand deposits of private, foreign banks at U.S. commercial banks, exclusive of claims on home offices of branch banks, \(S_{A_t^2}\) = variance of past four quarterly changes of eurobanks's assets, taken as a measure of the variance of net receipts and disbursements.

\(^{13}\)A slash, /, following a variable indicates that it is expressed in real terms. Endogenous variables are indicated by asterisks. t subscripts indicate time period t.
The expected signs of their model are as follows:
\[ f_1 > 0, f_2 > 0, f_3 < 0, f_4 < 0, f_5 > 0; \]
\[ h > 0; \]
\[ j_1 < 0, j_2 > 0, j_3 > 0, j_4 < 0; \]

Makin's results suggest that holdings of eurodollars have risen significantly with an index of trade flows among industrial countries. The results also indicate a high degree of substitutability between eurodollar deposits and negotiable certificates of deposit and to a lesser extent, between eurodollar deposits and gold. In addition, the results of Makin's model suggest that about 40 per cent of the growth of eurodollar deposits in the 1964-III to 1970-IV period was due to the multiple deposit expansion process.

Mastrapasqua (1973) tried to explain the dollar deposits in London branches of U.S. banks. His functions were as follows:

\[
\text{LOND} = f(VDI, Ieu-Icd, Ieu-Iusb) \quad \text{Demand function.}
\]

\[
\text{LONS} = g(LNNY, Iusb-Icd, RU-RU(-1)/RU(-1)) \quad \text{Supply function}
\]

where LOND, LONS = demand for and supply of dollar deposits in London branches of U.S. banks, respectively, LNNY = loans at the New York city banks, Ieu = the three month eurodollar rate, VDI = value of U.S. direct investment, Icd = the three month rate on primary certificates of deposit of $100,000 or more, Iusb = the three month U.S. treasury bill rate, RU = unborrowed reserves.

---

14 These countries were the major holders of eurodollar deposits in the period under consideration.
The expected signs of their model are as follows:
\[ f_1 > 0, f_2 > 0, f_3 > 0; \]
\[ g_1 > 0, g_2 > 0, g_3 < 0; \]

All the coefficients in the demand and supply equations were found to have expected signs and were statistically significant. Mastrapasqua found evidence that eurodollar deposits and certificates of deposits were substitutes for each other and eurodollar deposits and treasury bills were complementary financial assets.

6.6 An econometric model of deposits at the overseas branches of U.S. banks

The role of regulations and other factors are first investigated using a single, linear equation model. The following specification (linear form) has been estimated:

\begin{align*}
(6.1) \quad & \text{EDDL} \\
(6.2) \quad & \text{EDAD} = f(\text{ITXD}, \text{REGQ}, \text{RDIF}, \text{LOAN}, \text{EXPO}, \text{UBRE}, \text{ADUS}) \\
(6.3) \quad & \text{EDDD} = \text{DRED}, \text{DU74}, \text{DCCC}, \text{TRND}) \\
(6.4) \quad & \text{EDTD} \\
\end{align*}

In arriving at the above specifications of equations, I have made an extensive experimentation with both alternative forms of equations (such as log-linear, translog functions etc.) and possible sets of explanatory variables and their proxies. Some variables which should have been included on theoretical grounds were omitted for lack of statistical significance. The explanatory variables listed in the above equations have hypotheses attached to them as described below.

6.6.1 Independent variables and expected signs

Regulation variables

ITXD = Implicit tax rate of reserve requirements per dollar deposit as calculated in chapter six.\(^{15}\)

The absence of reserve requirements on deposits at the offshore branches induces the banks to book deposits through their offshore branches rather than through their domestic branches since the effective cost of funding is lower. Therefore, the variable is expected to have positive coefficients.

REGQ = The differential between a U.S. market interest rate and the regulation Q ceiling rate for time deposits (TDRA).

\(^{15}\)This variable was found to be the most satisfactory variable among all the implicit tax variables in terms of the expected sign and statistical significance.
This variable is used to capture the impact of the interest
differential between the domestic loan rate and the ceiling rate
on domestic time deposits. It is hypothesized that as this
differential increases, the overseas branches will be able to
attract more deposits relative to their domestic branches. From
the banks' standpoint, as the market rate rises over the
regulation Q ceiling rate, some disintermediation will occur,
domestic sources of funds shrink and banks can recapture part of
their deposits through their overseas branches.

From the depositors' viewpoint, as the differential between
the regulation Q ceiling and the market rate of interest
increases, the depositors will try to substitute eurodollar
deposits for deposits of domestic banks. Therefore the supply of
eurodollar deposits is expected to rise.

I have used the U.S. treasury bill rate (TBRA) and the
primary lending rate (PLRA) as measures of the market interest
rates. The following alternative measures of a regulation Q
variable are considered:

1. REGQ1 = PLRA - TDRA; 2. REGQ2 = PLRA / TDRA; 3. REGQ3 =
   TBRA - TDRA; 4. REGQ4 = TBRA / TDRA;
where TDRA= U.S. three month time deposit rate.
It is expected that deposits will be directly related to the
level of this variable.

*Interest differential variable*
RDIF = The differential between a domestic deposit rate and the eurodollar deposit rate.

This variable is used to capture the impact of the differential between the return on deposits in the domestic market vis-a-vis the return on funds in the eurodollar market. The domestic return on funds is represented by the three-month CD rate, CDRA, and the return on eurodollar deposits is measured by the three-month eurodollar rate in London, EDRA. As the eurodollar rate increases over the CD rate, depositors will have an incentive to hold more eurodollar deposits and less domestic deposits.

However, it should be noted that as the eurodollar rate increases over the domestic deposit rate, banks' cost of funds in the eurodollar market increases. But since banks are concerned with the effective cost of deposits\textsuperscript{16} in both the domestic and the eurodollar market, this variable may not play a significant role in bank's decision. I considered the difference between the eurodollar rate and the U.S. treasury bill rate (TBRA) and also the difference between the eurodollar rate and UK short term government bonds (UKRA) as alternative measures of RDIF.

\textit{Constraint variables}

\textsuperscript{16}The effective cost of deposits is the costs of deposit funding adjusted for reserve requirements, deposit insurance fees etc.
LOAN = loans of all U.S. commercial banks.

It is expected that U.S. banks will increase borrowing from the eurodollar market as loans by them increase. Overseas branches will have more incentive to collect funds in the eurodollar market. It is therefore expected that the sign of the coefficient will be positive for this variable.

UBRE = unborrowed reserves of all U.S. commercial banks.

The direction and the stance of Federal Reserve policies can often be judged by the level and the growth of unborrowed reserves. When a restrictive monetary policy is being pursued, as indicated by the decline in the level or growth of unborrowed reserves, commercial banks would increase their supply of dollars through their overseas branches and engage in eurodollar borrowings. Therefore, the sign of this coefficient is expected to be negative.

ADUS = total deposits of commercial banks.

It is expected that as the size of banking activities increases, all aspects of banking activities will increase including the eurodollar market. Also, this provides a means of testing whether the eurodollar market is substituting for the domestic market or supplementing it.

EXPO = total U.S. exports, including military aid.
Exports are taken as a proxy for international trade and U.S. foreign direct investment abroad. It is hypothesized that as exports increase, dollar-based transactions increase and therefore the supply of eurodollar deposits increase.

*Regulation dummies*

The following dummies were used to capture the impact of regulatory changes:

\[
DREG = \text{Regulation M variable representing reserve requirements on borrowing (in percent) from the overseas branches; it takes the following values: DREG} = 0 \text{ from 1964:1 to 1969:8 and from 1974:5 to 1980:11; DREG} = 10 \text{ from 1969:9 to 1970:11 DREG} = 20 \text{ from 1970:12 to 1973:4 DREG} = 8 \text{ from 1973:5 to 1974:4}
\]

The expected sign of this coefficient is negative since higher reserve requirements discourage borrowings from the overseas branches and therefore lessen the incentive of overseas banks to expand their deposit base.

\[
DU74 = \text{Dummy variable for withdrawal of restrictions on dollar deposits by commercial banks and private companies in banks outside U.S.. Therefore, deposits are expected to rise after January of 1974. This variable is defined as: DU74} = 0, \text{ from 1965:6 to 1974:1; DU74} = 1, \text{ otherwise. It is expected that the sign of this coefficient will be positive.}
\]

138
DCCC = Dummy variable for introduction of the competition and credit control reforms in the United Kingdom in September, 1971. This variable is defined as: DCCC = 0, from 1965:6 to 1971:9; DCCC = 1, otherwise. During the introduction of credit and control system, marginal reserve requirements were imposed for the first time on sterling liabilities of all overseas banks including U.S. banks. Therefore dollar-denominated liabilities are expected to rise.

Lastly, a monthly time trend variable (TRND) has been added to see whether there was a significant trend in the growth of external liabilities.

6.6.2 Data, Method of Analysis and Results:

Monthly data on the variables have been collected from various issues of International Financial Statistics, Federal Reserve Bulletin and citibase tapes. The period chosen for this regression model is from June, 1965 to November, 1980.

I experimented with various functional forms with different lag specifications. Of all the forms tested, the linear regression model seems to fit the data best in terms of the expected signs and the statistical significance of the coefficients. Initially the parameters of the regression model were estimated using ordinary least squares. But since a significant degree of first order autocorrelation was detected by the very low value of the Durbin-Watson statistic, the equations were re-estimated using generalized least squares to
achieve increased efficiency.

The variance of the residual in equation (6-1) was found to be increasing with the scale variables, LOAN and EXPO, violating the assumption of homoscedasticity in the classical linear regression model. To test for heteroscedasticity, I regressed the square of the residual of estimated equation (6-1) on a scale variable.\(^{17}\) The coefficient of the scale variable was found to be highly significant implying the presence of heteroscedasticity. To correct for heteroscedasticity, equation (6-1) was re-estimated by dividing all the variables by LOAN. The results are reported in Tables 6.4 and 6.5. In preliminary estimation of the equations, the dummy variable DU74 was found to be insignificant and was dropped from all the equations estimated.

ALL the variables seem to have a contemporaneous effect on the dependent variables. The variables ITXD, RDIF, UBRE and EXPO have expected signs and are found to be statistically significant in all the equations. The variables TRND is found to be highly significant in all the ratio equations, that is, in equations (6-2) through (6-4). The dummy variable for regulation M is found to be significant only in equation (6-1) at the 10 per cent level. The variable ADUS and LOAN are found to be highly significant in equation (6-1). In none of the equations

\(^{17}\)That is, I estimated the equation, \(\text{res}^2 = a + bX\) where \(X\) is any scale variable. LOAN is chosen as the scale variable. This is a modified form of the Park-Glejser test. See Pindyck and Rubinfeld (1981).
Table 6.4

Estimates of the Single Equation Model
(GLS estimates)

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* times 10^-5
** degrees of freedom
Table 6.5

Estimates of the Single Equation Model
GLS estimates

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* times 10^-5

** degrees of freedom
estimated, is the dummy variable, DCCC, found to be significant. A detailed analysis of the results is given below.

The coefficient of ITXD is found to be positive as predicted and statistically significant at the 1 per cent level in all the equations estimated. The results of equation (6-1) indicate that an increase in the implicit tax rate of reserve requirements by one basis point raises deposits by $103.58 million dollars. An increase in the implicit tax rate by one basis point raises the ratio of eurodollar deposits to total deposits by 2 percentage points, raises the ratio of eurodollar deposits to time deposits by 2 percentage points, and raises the ratio of eurodollar deposits to demand deposits by 7 percentage points. This gives evidence in favour of a higher degree of substitutability between demand deposits and eurodollar deposits than between time/aggregate deposits and eurodollar deposits. The results confirm the role of the implicit tax of reserve requirements in the development of eurodollar business by U.S. banks in the United Kingdom.

None of the various proxies of regulation Q variables was found to be statistically significant.

The variable RDIF, as defined by the difference between the eurodollar rate and the rate on three month certificates of deposits, is found to be statistically significant in all the equations. An increase in RDIF by one basis point raises eurodollar deposits by 4.26 million dollars.
The proxy variable for the size of the domestic banking business, ADUS, has a positive sign and is statistically significant in equation (6-1). This shows that the size of international activities of U.S. banks varies directly with the size of domestic banking. An increase in ADUS by one million dollars raises ADUS by .10 million dollars.

The variable LOAN has the expected sign, but is found to be statistically significant only in equation (6-1). An increase in loans of one dollar raises eurodollar deposits by $12.95.

The variable EXPO has the expected sign and is statistically significant in all the equations. An increase in EXPO by one million dollars raises EDDL by .49 million dollars.

The variable UBRE is found to be highly significant. A marginal increase in unborrowed reserves by 1 million dollar lowers eurodollar deposits by .28 million dollars.

None of the dummy regulation variables, DREG or DCCC is found to be statistically significant. The trend variable TRND was found to be statistically significant in all the equations except (6-1).

6.6.3 Estimates of elasticities

I computed elasticities of the growth of eurodollar liabilities of U.S. banks with respect to each explanatory variable measured at their mean values. These are reported in
Table 6.6. Although the t-statistic indicates that the implicit tax variable, ITXD is an important explanatory variable, the elasticity of EDDL with respect to ITXD is very small, only .15. I computed this elasticity separately for each of the periods, January, 1965 to December, 1970 and January, 1970 to November 1980. The elasticity for the period from 1965 to 1970 was found to be .37. It was only .06 for the period from 1970 to 1980. The size of domestic deposits at U.S. banks is found to have the highest elasticity (1.88) among all the explanatory variables.

I computed elasticities of EDAD, EDDD and EDTD with respect to ITXD in equations, (6-2), (6-3) and (6-4) (not shown in the table). They are .11, .11 and .12 respectively. To conclude, all the measures of eurodollar deposits are found to be inelastic with respect to the implicit tax rate of reserve requirements.

6.6.4 The contribution of the reserve requirements tax to the growth of the offshore market for dollars

The statistical evidence seems to indicate that there is a direct association between the reserve requirements tax and the growth of dollar-denominated deposits at the foreign branches of U.S. banks. It is an interesting exercise to estimate what the growth of eurodollar deposits would have been in the absence of this tax.

I measured the annual contribution of the implicit tax of reserve requirements to the growth of deposits (CTAX) in the following way:
Table 6.6

Estimates of Elasticities*  
(GLS estimates)

<table>
<thead>
<tr>
<th>ITXD</th>
<th>RDIF</th>
<th>LOAN</th>
<th>ADUS</th>
<th>UBRE</th>
<th>REGQ</th>
<th>DREG</th>
<th>DCCC</th>
<th>EXPO</th>
</tr>
</thead>
<tbody>
<tr>
<td>.15</td>
<td>.01</td>
<td>.16</td>
<td>1.88</td>
<td>-.32</td>
<td>.007</td>
<td>.01</td>
<td>.03</td>
<td>.10</td>
</tr>
</tbody>
</table>

* estimated at the mean values of dependent and independent variables.

CTAX = ITXD*103.58

The estimated coefficient of ITXD in equation (6-1) is 103.58. Column a in Table 6.7 shows CTAX. Thus CTAX indicates how much lower the deposits in the foreign branches would have been in the absence of reserve requirements on domestic deposits. For example, in the year 1975, the amount of liabilities in the foreign branches would have been lower by $3277.52 million dollars in the absence of the reserve requirements tax. The absolute contribution of reserve requirements remained fairly stable during the period considered. The range of this contribution is only $2922.33 (from $2394.97 million in 1977 to $5317.30 in 1980).

To find the contribution of ITXD relative to the total size of eurodollar deposits of foreign branches, I divided CTAX by both EDDL and the estimated values of EDDL. The percentage contributions of the reserve requirements tax are shown in
Table 6.7

Contribution of the Reserve Requirements Tax to the Growth of International Banking Carried Out by U.S. Banks

<table>
<thead>
<tr>
<th>Year</th>
<th>CTAX* (In millions of dollars)</th>
<th>CTAX/EDDL** (times 100)</th>
<th>CTAX/EDDL (times 100)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1965</td>
<td>2954.69</td>
<td>72.4</td>
<td>82.3</td>
</tr>
<tr>
<td>1966</td>
<td>3595.24</td>
<td>58.3</td>
<td>79.9</td>
</tr>
<tr>
<td>1967</td>
<td>3477.17</td>
<td>43.1</td>
<td>62.0</td>
</tr>
<tr>
<td>1968</td>
<td>3945.37</td>
<td>33.1</td>
<td>41.9</td>
</tr>
<tr>
<td>1969</td>
<td>5176.96</td>
<td>32.2</td>
<td>29.0</td>
</tr>
<tr>
<td>1970</td>
<td>5221.30</td>
<td>29.8</td>
<td>24.4</td>
</tr>
<tr>
<td>1971</td>
<td>3421.82</td>
<td>15.2</td>
<td>14.4</td>
</tr>
<tr>
<td>1972</td>
<td>2964.65</td>
<td>10.4</td>
<td>10.9</td>
</tr>
<tr>
<td>1973</td>
<td>3937.59</td>
<td>10.3</td>
<td>11.4</td>
</tr>
<tr>
<td>1974</td>
<td>5291.95</td>
<td>11.2</td>
<td>11.2</td>
</tr>
<tr>
<td>1975</td>
<td>3277.52</td>
<td>6.7</td>
<td>6.3</td>
</tr>
<tr>
<td>1976</td>
<td>2578.20</td>
<td>4.9</td>
<td>4.5</td>
</tr>
<tr>
<td>1977</td>
<td>2394.97</td>
<td>4.1</td>
<td>4.5</td>
</tr>
<tr>
<td>1978</td>
<td>3132.78</td>
<td>4.1</td>
<td>3.7</td>
</tr>
<tr>
<td>1979</td>
<td>4713.08</td>
<td>5.8</td>
<td>4.6</td>
</tr>
<tr>
<td>1980</td>
<td>5317.30</td>
<td>5.8</td>
<td>5.7</td>
</tr>
</tbody>
</table>

* CTAX = contribution of reserve requirements tax to the growth of eurodollar business.

** estimated value of EDDL
columns (b) and (c) of Table 6.7. The range of the ratios is between 4 and 58 per cent in Column (b) and between 4 and 80 percent in column (c). These columns present a strikingly different picture from that of column (a) in Table 6.7. A sharply declining percentage contribution of this tax is observed during the period, particularly after 1971. These ratios declined over time because of the high growth of the eurodollar market and the relatively stable implicit tax rates of reserve requirements. Therefore, although the contribution of the reserve requirements tax to the growth of the offshore market for dollars runs in millions of dollars, when expressed as a percentage of the total size of the market, it is small in recent years.

In order to have a better look at the role of reserve requirements in the growth of the eurodollar market, the entire period under study can be divided into 3 phases: phase I (high contribution), from 1965 to 1970, when the contribution exceeded 25 per cent; phase II (medium contribution), from 1971 to 1974, when the contribution was between 10 and 25 per cent and phase III (low contribution), from 1975 to 1980, when the contribution was less than 10 per cent. It should be noted here that these three phases correspond to the three sub-periods considered in the graphical analysis done at the beginning of this chapter.

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18 The main reason for the stable reserve requirements tax is that the higher market interest rate was offset by the declining effective reserve ratio on traditional liabilities.
During the transition from phase I to phase II, we observe that the contribution of reserve requirements in 1971 was reduced to one-half of what it was in the preceding year. During this transition, the implicit tax of reserve requirements per dollar of deposit (ITXD) has fell from $.50 in 1970 to $.33 in 1971. During the transition from phase II to phase III, there was a drastic fall in the contribution of the reserve requirements tax, from 11.2 per cent in 1974 to 6.7 per cent in 1975. During this period, the implicit tax of reserve requirements fell from $.51 in 1974 to $.32 in 1975.

In order to find out what accounted for the high growth of the eurodollar market after 1970, when the importance of reserve requirements sharply declined, I computed the absolute and percentage contributions of all the explanatory variables during the period from 1970 to 1980.\footnote{The absolute contributions were computed by multiplying the estimated values of the coefficients (from equation 6.1) by the values of respective explanatory variables over the period from 1970 to 1980. See the calculation of CTAX above. The percentage contributions were computed by dividing the absolute contributions by the estimated size of the eurodollar market, EDDL.} As the last row of Table 6.9 shows, the variables which contributed most to the growth of the eurodollar market in London during this period are ADUS (151 per cent), EXPO (407 per cent), RDIF (23 per cent), REGQ (100 per cent). During this period, the contribution of ITXD increased only 2 per cent.

From the evidence presented above, there can be no doubt that at the initial stage of the growth of the eurodollar
Table 6.9

Partitioning of the Contributions of Explanatory Variables to the Growth of the Eurodollar Market

<table>
<thead>
<tr>
<th>YEAR</th>
<th>CONST</th>
<th>ITKD</th>
<th>LOAN</th>
<th>ADUS</th>
<th>EXPO</th>
<th>RDIF</th>
<th>REGQ</th>
<th>UBRE</th>
<th>REGD</th>
<th>CCCR</th>
<th>EDDL*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td>2588.20</td>
<td>5221.3</td>
<td>3654.1</td>
<td>39748.4</td>
<td>1801.04</td>
<td>397.32</td>
<td>316.02</td>
<td>-7896.11</td>
<td>10.8</td>
<td>0</td>
<td>17492.7</td>
</tr>
<tr>
<td></td>
<td>(-147%)</td>
<td>(10%)</td>
<td>(20.9%)</td>
<td>(227.2%)</td>
<td>(10.3%)</td>
<td>(2.27%)</td>
<td>(1.80%)</td>
<td>(-45%)</td>
<td>(0.06%)</td>
<td>(0%)</td>
<td>(100%)</td>
</tr>
<tr>
<td>1971</td>
<td>3142.0</td>
<td>3964.1</td>
<td>46084.4</td>
<td>1838.7</td>
<td>665.8</td>
<td>78.4</td>
<td>-8619.1</td>
<td>20</td>
<td>3.35</td>
<td>22524.4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(-114%)</td>
<td>(15.3%)</td>
<td>(17.6%)</td>
<td>(204.6%)</td>
<td>(8.2%)</td>
<td>(3.0%)</td>
<td>(.35%)</td>
<td>(-38.8%)</td>
<td>(.07%)</td>
<td>(0.003%)</td>
<td>(100%)</td>
</tr>
<tr>
<td>1972</td>
<td>2964.7</td>
<td>4526.7</td>
<td>51651.4</td>
<td>2073.3</td>
<td>328.3</td>
<td>27</td>
<td>-9258.0</td>
<td>20</td>
<td>3.35</td>
<td>28420.8</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(-91%)</td>
<td>(10.5%)</td>
<td>(15.9%)</td>
<td>(181.8%)</td>
<td>(7.3%)</td>
<td>(1.2%)</td>
<td>(.09%)</td>
<td>(-32.6%)</td>
<td>(.03%)</td>
<td>(0.003%)</td>
<td>(100%)</td>
</tr>
<tr>
<td>1973</td>
<td>3937.6</td>
<td>5177.5</td>
<td>58435.6</td>
<td>2972.4</td>
<td>780.2</td>
<td>301.0</td>
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<td>12</td>
<td>3.35</td>
<td>38257.0</td>
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<tr>
<td></td>
<td>(-67.6%)</td>
<td>(10.2%)</td>
<td>(14.3%)</td>
<td>(152.7%)</td>
<td>(7.8%)</td>
<td>(1.1%)</td>
<td>(.79%)</td>
<td>(-23.7%)</td>
<td>(.03%)</td>
<td>(0.003%)</td>
<td>(100%)</td>
</tr>
<tr>
<td>1974</td>
<td>5292.0</td>
<td>6378.3</td>
<td>64601.1</td>
<td>4104.5</td>
<td>332.3</td>
<td>575.4</td>
<td>-9879.5</td>
<td>8</td>
<td>3.35</td>
<td>47445.3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(-55%)</td>
<td>(11.2%)</td>
<td>(13.5%)</td>
<td>(137.0%)</td>
<td>(8.7%)</td>
<td>(.7%)</td>
<td>(.22%)</td>
<td>(-21%)</td>
<td>(.02%)</td>
<td>(0.003%)</td>
<td>(100%)</td>
</tr>
<tr>
<td>1975</td>
<td>3277.5</td>
<td>6400.4</td>
<td>68560.2</td>
<td>4483.0</td>
<td>246.2</td>
<td>256.6</td>
<td>-10004.9</td>
<td>5</td>
<td>3.35</td>
<td>48610.6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(-53%)</td>
<td>(6.7%)</td>
<td>(13.2%)</td>
<td>(141.0%)</td>
<td>(9.2%)</td>
<td>(.5%)</td>
<td>(.53%)</td>
<td>(-20.5%)</td>
<td>(.003%)</td>
<td>(100%)</td>
<td></td>
</tr>
<tr>
<td>1976</td>
<td>2578.2</td>
<td>6569.6</td>
<td>73135.2</td>
<td>4805.4</td>
<td>135.4</td>
<td>145.5</td>
<td>-9833.7</td>
<td>4</td>
<td>3.35</td>
<td>52804.1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(-49%)</td>
<td>(4.9%)</td>
<td>(12.5%)</td>
<td>(138.5%)</td>
<td>(9.1%)</td>
<td>(.7%)</td>
<td>(.28%)</td>
<td>(-18.6%)</td>
<td>(.007%)</td>
<td>(0.003%)</td>
<td>(100%)</td>
</tr>
<tr>
<td>1977</td>
<td>2395.0</td>
<td>7529.4</td>
<td>80112.9</td>
<td>5050.5</td>
<td>161.7</td>
<td>144.1</td>
<td>-9969.5</td>
<td>4</td>
<td>3.35</td>
<td>60914.7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(-62%)</td>
<td>(3.9%)</td>
<td>(12.4%)</td>
<td>(131.5%)</td>
<td>(8.3%)</td>
<td>(.27%)</td>
<td>(.24%)</td>
<td>(-16.5%)</td>
<td>(.006%)</td>
<td>(0.003%)</td>
<td>(100%)</td>
</tr>
<tr>
<td>1978</td>
<td>3132.8</td>
<td>8665.1</td>
<td>88432.6</td>
<td>5986.0</td>
<td>222.5</td>
<td>386.3</td>
<td>-10653.9</td>
<td>2.7</td>
<td>3.35</td>
<td>71707.1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(-36%)</td>
<td>(4.4%)</td>
<td>(12.1%)</td>
<td>(123.3%)</td>
<td>(8.3%)</td>
<td>(.31%)</td>
<td>(.54%)</td>
<td>(-14.3%)</td>
<td>(.003%)</td>
<td>(0.003%)</td>
<td>(100%)</td>
</tr>
<tr>
<td>1979</td>
<td>4713.1</td>
<td>10259.1</td>
<td>94072.8</td>
<td>7575.0</td>
<td>320.3</td>
<td>778.2</td>
<td>-11503.6</td>
<td>0</td>
<td>3.35</td>
<td>81698.4</td>
<td></td>
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<tr>
<td></td>
<td>(-31%)</td>
<td>(5.8%)</td>
<td>(12.5%)</td>
<td>(115.1%)</td>
<td>(9.3%)</td>
<td>(.39%)</td>
<td>(.95%)</td>
<td>(-14.0%)</td>
<td>(0%)</td>
<td>(0.003%)</td>
<td>(100%)</td>
</tr>
<tr>
<td>1980</td>
<td>5317.3</td>
<td>11224.5</td>
<td>99947.2</td>
<td>9143.7</td>
<td>492.6</td>
<td>983.2</td>
<td>-11895.25</td>
<td>0</td>
<td>3.35</td>
<td>90937.6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(-28%)</td>
<td>(5.8%)</td>
<td>(12.3%)</td>
<td>(109.9%)</td>
<td>(10.5%)</td>
<td>(.54%)</td>
<td>(1.08%)</td>
<td>(-13.07%)</td>
<td>(0%)</td>
<td>(0.003%)</td>
<td>(100%)</td>
</tr>
</tbody>
</table>

Percentage changes (1971-1980) .02% 207% 15% 407% 24.01% 21% 50% 420%
market, reserve requirements played a crucial role in this growth, but over time its importance declined. The cost advantage from a system of differential reserve requirements motivated banks to seek the relatively unregulated funds of the eurodollar market. But once the market was established, it gained its own momentum as the marginal cost of further expansion was getting lower because of the technological and informational economies and as banks became familiar with the use of the overseas market.

6.7 Conclusion

In this chapter, I examined the role of the implicit tax of reserve requirements and other factors in the development of perhaps one of the most striking innovations of recent times - the offshore market for dollars. I applied a single equation model to determine the effects of regulations on the involvement of U.S. banks in the offshore dollar market (located in London) through their foreign branches. The implicit tax variable (implicit tax of reserve requirements per dollar deposit) is found to be statistically significant in all the equations formulated to explain the growth of eurodollar market. However, although it played a very important role in the growth of eurodollar market, its importance declined over time. The variables that accounted for the high growth of the eurodollar market are U.S. exports, aggregate deposits of the U.S. banking sector, total domestic loans of U.S. banks and the less
restrictive stance of U.S. monetary policy (captured by the growth of unborrowed reserves in this model).

Statistical evidence from results of the single equation model seems to support the hypothesis postulated in the theoretical part of the thesis. That is, banks engage in innovative activities to avoid or minimize the burden of regulations. These innovations are not, however, without costs. For instance, the development of offshore banking may lead to instability of monetary aggregates\textsuperscript{20}, loss of domestic employment opportunities\textsuperscript{21}, etc. These and other welfare consequences of banking innovations designed to circumvent regulations will be discussed in detail in the concluding chapter of the thesis.

\textsuperscript{20}The definition of monetary aggregates changes when the offshore market for some currency develops.

\textsuperscript{21}See Grubel (1983). Grubel calls this 'employment diversion'.
7.1 Introduction

This chapter discusses bank regulations pertaining to the structure of the reserve requirements system in the United Kingdom and their effects on the British banking system. It is organized as follows: Section 7.2 discusses the main balance-sheet controlling ratios related to the reserve requirements system during this period. In section 7.3, I survey the opinions of various authors about the 'implicit tax' aspects of the reserve requirements system in the United Kingdom. In section 7.4, I try to quantify the losses of earnings for clearing banks for having to maintain various types of reserves including special deposits and estimate the implicit tax rates of these reserves using the definitions derived in Chapter One. Section 7.5 is the concluding section.

7.2 Balance sheet regulations of the banking sector

British monetary policy from the 50's to the late 60's was exercised with a view to influencing the cost and availability of credit to the various sectors of the economy. Considerable reliance was placed on the control of bank lending through quantitative and qualitative restraints. The main quantitative controls on the bank's balance sheet in the 60's were: 1) cash
ratio, 2) liquidity ratio, 3) special deposits, 4) restrictions on lending, and 5) the cash deposits scheme. With the exception of 4), all the other ratios are the variants of a reserve requirements system. Therefore, I shall limit my discussion to these four ratios.

7.2.1 Cash ratio

Since the beginning of this century, large banks of the United Kingdom published their monthly statements of cash holdings. One of the reasons for this practice was that it enabled the monetary authorities to watch banks' cash holdings more closely. Gradually the cash ratio came to be regarded not only as an indicator of liquidity but also as an indicator of monetary policy.

From 1960 until the introduction of the credit and control system in September of 1971, British clearing banks were mandated by the Bank of England to keep 8% of their gross deposit liabilities as cash reserves.¹ The cash reserves comprised holdings of coins and notes, and balances with the Bank of England. It was expressed as a percentage of gross deposits. Since the cash ratio applied solely to the clearing banks, the absence of interest payments on the cash reserves reduced the profitability of clearing banks and left them at a competitive disadvantage compared to the non-clearing banks. In September, 1971, the cash ratio was reduced to 1.5%.

¹The same cash ratio applied to both current (demand) and deposit (time) accounts, unlike the United States.
7.2.2 Liquidity ratio

The liquidity ratio is the ratio of cash and various other liquid assets to gross deposits. The liquid assets comprise the money at call, lent mostly to the discount market, treasury bills and commercial bills.

When the authorities realized that the cash ratio was rather an ineffective instrument of regulation, they became serious about establishing the liquidity ratio. In 1951, the Governor of the Bank of England instructed the clearing banks not to allow their liquidity ratio to fall below 30 per cent. However, when the banks faced strong pressure on liquidity, the Bank of England took a flexible stand indicating that a liquidity ratio of not less than 28 per cent was acceptable. The 28 percent continued to be the acceptable minimum until the credit reform of 1971. The liquidity ratio was reduced to 12.5 percent during the reforms of 1971 for the clearing banks and extended to other banks in the system as well.

7.2.3 Special deposits

The call for special deposits is a relatively new instrument of monetary regulation. The clearing banks (except Northern Ireland) and finance houses are required to place a certain percentage of their gross deposit liabilities with the Bank of England until they are released by further order. The rate paid on special deposits is adjusted weekly to the nearest 1/16% per annum to the average rate of discount for treasury bills. The
special deposit scheme was extended to all banks in September, 1971.

The purpose of special deposits is to impose pressure on the bank's reserve position by forcing them to dispose of their eligible reserve assets. From the perspective of monetary and credit policy, a call for special deposits reduced the freely saleable liquid assets of the deposit banks and was intended to influence their lending policy. But from the perspective of banks, special deposits represented a tax on financial intermediation to the extent that the rate on special deposits differs from the rates on banks' earning assets.  

7.2.4 Supplementary special deposits scheme

This regulation, also known as the 'corset' was first introduced in December of 1973. It required banks to place a fraction of the excess of eligible interest-bearing liabilities over the officially determined permitted level as non-interest bearing supplementary deposits.

The penal aspect of the scheme is that these deposits are to be held with the Bank of England, and they earn no interest. Thus, by this scheme, the monetary authorities penalize those banks and finance houses that allow their interest-bearing

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3The effects of special deposits on the short-run equilibrium for a banking firm are analyzed in Artis and Lewis (1981).
liabilities to exceed a certain officially determined rate. The magnitude of the fraction of excess interest bearing liabilities that must be deposited is called the rate of supplementary special deposits. This rate is progressive in nature, i.e., the greater the excess of interest bearing liabilities, the heavier the penalty.\(^5\)

7.3 **Survey of the literature on the implicit taxation aspect of balance sheet regulations of the UK banking sector**

The implicit 'tax' aspect of reserve requirements and the consequent effects on bank intermediation have been recognized from time to time by different analysts of the British banking system. As early as 1959, the Radcliffe Committee was aware of the discriminatory effects of banking regulations on the financial sector and the consequent diversion of business from banks to non-banks (Wadsworth, 1973). This Committee, which first identified the important growth in non-banking activity, concluded that monetary policy should seek to control the money supply and the liquidity of non-banks.

It was argued by the Radcliffe Committee that monetary policy should operate on two closely related goals: first, that the money creation by banks should be controlled and second, that the liquidity and therefore credit creation ability of

\(^4\)See Zawadazki (1973).

\(^5\)The effects of the 'corset' are analyzed theoretically in Artis and Lewis (1981).
Griffiths (1970) noted that the clearing banks are subject to a system of implicit taxation resulting from the Bank of England's techniques of implementing monetary policy. In his own words,

"The forced holding of cash reserves via the 8 percent cash-to-deposits ratio involves an interest-free loan from the banks to the Bank (depending on the amount of bankers' deposits) and to the Treasury (depending on the holding of notes and coins)." (Griffiths, 1970, p 31)

Griffiths estimated the transfer of funds from the clearing banks to the Bank of England and the treasury. The annual transfer was estimated to be 85 million pounds sterling in 1969, using the treasury bill rate as an approximation of the cost of funds, of which approximately 20 per cent went to the Bank of England and 80 percent went to the treasury.

In the opinion of Artis and Lewis (1981), reserve requirements can 'tax' bank intermediation. Using a simple model, they showed how the constraint upon the bank's acquisition of non-reserve assets inherent in reserve requirements can impose pecuniary costs that can influence the scale of intermediation.

According to Wills (1982), the government has two basic types of control over the banking system. The first is the ability to influence the financial markets as a result of its activities as a borrower. Second, there are specific controls on

---

bank operations which have direct effects on bank customers and which discriminate against financial transactions intermediated through banks. Wills noted that bank regulations are of the second type. According to him, regulations can reduce bank assets substantially while having almost no effect on the quantity or configuration of final lending. Credit would simply be rechannelled through parallel markets to avoid the banking system and the discriminatory tax.

Wilson (1983) noted that clearing banks, as distinct from other listed banks, are required to deposit a percentage of their total deposits with the bank of England. They carry no interest and act as a control device upon the lending activity of the clearers quite separately from the minimum reserve asset ratio which is applicable to all listed banks. Wilson also pointed out that the regulations merely direct business away from banks into the hands of the non-banks.

To conclude, it was recognized by various authors that the imposition of cash, liquidity and special deposits on clearing banks was not appropriate. There seems to a fair degree of agreement among economists that the Bank of England seemed to concentrate its controls upon the clearing banks to achieve its monetary objectives. The depository banks other than clearing banks were less subject to traditional bank controls than the clearing banks throughout British monetary history. However, no systematic effort has been made to assess the quantitative significance of these regulations or determine their effects on
the various innovations in the UK financial sector. The objective of this and the next chapter is to fill this gap.

7.4 Computation of the burden of various types of reserve requirements

The total loss of earnings \( L \) from various types of reserve requirements can be estimated as follows:

\[
L = (\rho_1 + \rho_2 + \rho_3)D\Sigma \alpha_i r_i - \rho_2 D\Sigma \beta_j d_j - t\rho_3 D; \quad \Sigma \alpha_i = 1, \quad \Sigma \beta_j = 1
\]  

(7-1)

where,

\( \rho_1 \) = cash reserve ratio
\( \rho_2 \) = liquidity ratio
\( \rho_3 \) = special deposits ratio
\( \alpha_i \) = proportion of total deposit liabilities in the \( i \)th type of asset
\( \beta_j \) = proportion of total deposit liabilities in the \( j \)th type liquid asset (as required by liquidity ratio)
\( D \) = deposits of London, Scottish and Irish clearing banks.
\( r_i \) = interest rate on the \( i \)th type of earning asset that the bank would have purchased in the absence of reserve requirements.
\( d_j \) = interest rate earned on the \( j \)th type of liquid asset.
\( t \) = three-month treasury bill rate paid on special deposits.

\( L \) has three components: loss from cash reserves, \( L_1 = \rho_1 D\Sigma \alpha_i r_i \); loss from secondary reserves, \( L_2 = \rho_2 D\Sigma \alpha_i r_i - \rho_2 D\Sigma \beta_j d_j \); and loss from special deposits, \( L_3 = \rho_3 D\Sigma \alpha_i r_i - t\rho_3 D \).

The method for deriving (7-1) is described in Chapter Two.
Since the structure of interest rates on bank advances and investments that banks would have made in the absence of reserve requirements is unknown, I assume a unique interest rate, the long term government bond rate, to represent the structure of bank lending rates. Therefore, $r_i = r$ for all $i$ and $\Sigma r_i = r$ where $r$ = the long term government bond rate. Since the historical breakdown of the components of liquid assets is not available, I assume the treasury bill rate represents the interest earnings on banks' liquid assets.

With the above simplifications, (7-1) is reduced to

$$L = [r\rho_1 + (r-t)\rho_2 + (r-t)\rho_3]D$$

(7-2)

In the computations of the loss and implicit tax rates of reserve requirements, I use quarterly data. The annual averages are reported in the Tables of this chapter. The quarterly values are used in the regression results of chapter eight. The different money market rates used in the calculations of loss of earnings and implicit tax rates are reported in Table 7.1.

---

8I considered the highest money market rates available to compute the opportunity cost of reserve requirements. This is done in order to avoid some negative figures for estimates of earning losses of U.K. banks. During some years in the period under study, the treasury bill rate on secondary reserves was high and exceeded most other short term money market rates including the inter-bank lending rate.

9The monthly data were not available for most of the variables used in the regression analysis for the UK banking sector.
Table 7.1.

Interest Rates Used in Calculating Loss of Earnings from Reserve Requirements
(1960 - 1980)
(In per cent)

<table>
<thead>
<tr>
<th>Year</th>
<th>Long term government bond yield (a)</th>
<th>Interest rate on clearing bank deposits (b)</th>
<th>3-month treasury bill rate (c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960</td>
<td>5.77</td>
<td>3.00</td>
<td>4.88</td>
</tr>
<tr>
<td>1961</td>
<td>6.28</td>
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<td>5.13</td>
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<tr>
<td>1962</td>
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<td>2.50</td>
<td>4.18</td>
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<td>1963</td>
<td>5.43</td>
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<td>3.66</td>
</tr>
<tr>
<td>1964</td>
<td>5.98</td>
<td>5.00</td>
<td>4.61</td>
</tr>
<tr>
<td>1965</td>
<td>6.56</td>
<td>4.00</td>
<td>5.91</td>
</tr>
<tr>
<td>1966</td>
<td>6.94</td>
<td>5.00</td>
<td>6.10</td>
</tr>
<tr>
<td>1967</td>
<td>6.80</td>
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</tr>
<tr>
<td>1968</td>
<td>7.55</td>
<td>5.00</td>
<td>7.09</td>
</tr>
<tr>
<td>1969</td>
<td>9.04</td>
<td>6.00</td>
<td>7.64</td>
</tr>
<tr>
<td>1970</td>
<td>9.22</td>
<td>5.00</td>
<td>7.01</td>
</tr>
<tr>
<td>1971</td>
<td>8.90</td>
<td>2.50</td>
<td>5.57</td>
</tr>
<tr>
<td>1972</td>
<td>8.91</td>
<td>5.75</td>
<td>5.54</td>
</tr>
<tr>
<td>1973</td>
<td>10.72</td>
<td>9.50</td>
<td>9.34</td>
</tr>
<tr>
<td>1974</td>
<td>14.77</td>
<td>9.50</td>
<td>11.37</td>
</tr>
<tr>
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<td>14.39</td>
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<td>10.18</td>
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<td>1976</td>
<td>14.43</td>
<td>11.00</td>
<td>11.12</td>
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<td>1977</td>
<td>12.73</td>
<td>4.00</td>
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</tr>
<tr>
<td>1979</td>
<td>12.99</td>
<td>15.00</td>
<td>12.98</td>
</tr>
<tr>
<td>1980</td>
<td>13.79</td>
<td>11.75</td>
<td>15.11</td>
</tr>
</tbody>
</table>

Data Source: Central Statistical Office, Financial Statistics.
7.4.1 Estimation of loss from the cash reserve ratio

The loss from cash reserves, \( L_1 \) is given by,

\[
L_1 = r \times \rho_1 \times D
\]  

(7-3)

where \( r \) = long term government bond-yield.

\( \rho_1 \) = cash ratio for the clearing banks.

= .08 (from 1960-I to 1971-II)

= .015 (from 1971-III to 1980-II)

\( D \) = total deposits of London, Scottish and Irish clearing banks.

The loss of earnings from cash reserves is shown by column (a) in Table 7.2. Table 7.A.1 in the appendix to Chapter Seven shows the decomposition of the change in the loss of earnings from cash reserves into interest rates and deposits changes.

7.4.2 Implicit tax rate of reserve requirements

Different tax rates are computed dividing the loss, \( L_1 \) derived above by an appropriate base. The implicit tax rate per dollar of cash reserves (ITAXC) is calculated by dividing \( L \) by \( D \), the total amount of clearing bank deposits. With the assumption of a unique return on bank investments, this rate is reduced to

\[
ITAXC = r \times \rho_1 = f(r, \rho_1)
\]  

(7-4)

Table 7.3 column (a) shows the annual implicit tax rates for the period from 1960 to 1980.
### Table 7.2

Estimates of Loss of Earnings* from Various Types of Reserve Requirements for all Clearing Banks in the United Kingdom.**

(1960 - 1980)

(In millions of pound sterling)

<table>
<thead>
<tr>
<th>Year</th>
<th>cash reserves</th>
<th>secondary reserves</th>
<th>special deposits</th>
<th>Total (adjusted)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(a)</td>
<td>(b)</td>
<td>(c)</td>
<td>(d)</td>
</tr>
<tr>
<td>1960</td>
<td>37.03</td>
<td>21.38</td>
<td>.62</td>
<td>45.16</td>
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<tr>
<td>1961</td>
<td>41.30</td>
<td>28.31</td>
<td>1.97</td>
<td>56.10</td>
</tr>
<tr>
<td>1962</td>
<td>39.70</td>
<td>43.40</td>
<td>2.77</td>
<td>70.99</td>
</tr>
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<td>1963</td>
<td>38.71</td>
<td>45.02</td>
<td>0</td>
<td>69.22</td>
</tr>
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<td>1964</td>
<td>45.36</td>
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<td>0</td>
<td>64.51</td>
</tr>
<tr>
<td>1965</td>
<td>52.24</td>
<td>17.28</td>
<td>.55</td>
<td>51.48</td>
</tr>
<tr>
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<td>57.55</td>
<td>24.10</td>
<td>1.03</td>
<td>61.11</td>
</tr>
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<td>59.16</td>
<td>29.66</td>
<td>1.98</td>
<td>68.63</td>
</tr>
<tr>
<td>1968</td>
<td>69.94</td>
<td>16.97</td>
<td>1.14</td>
<td>61.82</td>
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<td>1969</td>
<td>84.51</td>
<td>45.95</td>
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<td>1970</td>
<td>83.28</td>
<td>70.21</td>
<td>6.13</td>
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</tr>
<tr>
<td>1971</td>
<td>65.50</td>
<td>98.29</td>
<td>8.57</td>
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</tr>
<tr>
<td>1972</td>
<td>20.64</td>
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<td>44.99</td>
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<td>1973</td>
<td>51.67</td>
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<td>11.05</td>
<td>29.01</td>
</tr>
<tr>
<td>1974</td>
<td>58.65</td>
<td>115.45</td>
<td>32.69</td>
<td>88.08</td>
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<tr>
<td>1975</td>
<td>62.42</td>
<td>152.49</td>
<td>40.48</td>
<td>130.33</td>
</tr>
<tr>
<td>1976</td>
<td>67.14</td>
<td>127.62</td>
<td>35.76</td>
<td>95.46</td>
</tr>
<tr>
<td>1977</td>
<td>64.10</td>
<td>216.27</td>
<td>54.08</td>
<td>205.03</td>
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<tr>
<td>1978</td>
<td>73.32</td>
<td>193.13</td>
<td>39.88</td>
<td>158.25</td>
</tr>
<tr>
<td>1979</td>
<td>87.19</td>
<td>248.27</td>
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</tr>
<tr>
<td>1980</td>
<td>114.37</td>
<td>306.70</td>
<td>195.91</td>
<td>210.49</td>
</tr>
</tbody>
</table>

* Using the formulae (7-3), (7-5), (7-7) and (7-10)

** Using the long-term government bond yield as representative of bank returns on loans and investments.

Data Sources: Central Statistical Office, Financial Statistics
Table 7.3

Estimates of Implicit Tax Rates for Clearing Banks*
(times 100 )

<table>
<thead>
<tr>
<th>Year</th>
<th>cash reserves (a)</th>
<th>secondary reserves (b)</th>
<th>special deposits (c)</th>
<th>total reserves (adjusted) (d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>60</td>
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<td>.26</td>
<td>.007</td>
<td>.56</td>
</tr>
<tr>
<td>61</td>
<td>.50</td>
<td>.34</td>
<td>.02</td>
<td>.68</td>
</tr>
<tr>
<td>62</td>
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<td>.68</td>
</tr>
<tr>
<td>65</td>
<td>.52</td>
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<td>.005</td>
<td>.51</td>
</tr>
<tr>
<td>66</td>
<td>.55</td>
<td>.23</td>
<td>.01</td>
<td>.59</td>
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<tr>
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<td>.27</td>
<td>.02</td>
<td>.63</td>
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<td>.01</td>
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<td>.10</td>
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<td>.01</td>
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<td>.41</td>
<td>.02</td>
<td>.31</td>
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<tr>
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<td>.41</td>
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<td>79</td>
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<td>.01</td>
<td>.02</td>
<td>.20</td>
</tr>
<tr>
<td>80</td>
<td>.20</td>
<td>.02</td>
<td>.007</td>
<td>.37</td>
</tr>
</tbody>
</table>

* Using the long-term government bond yield as representative of bank returns on loans and investments.

Data Sources: Central Statistical Office, Financial Statistics.
The rate of implicit taxation per dollar of interest earnings (ITIB) is computed by dividing the loss by the interest earnings on deposits.

\[
\text{ITIB}_1 = \frac{L_1}{(r-i)*D},
\]

where \( L_1 \) is defined in (7-3), \( r \) is defined above and \( i \) = interest rate on clearing bank deposits. These rates, expressed as percentages, are shown by column (a) in Table 7.4.

7.4.3 Loss of earnings from secondary reserves

Again, employing the assumption that the long term government bond rate represents the earnings on the secondary reserves, the following formula is used to calculate the opportunity cost of earnings from cash reserves, \( L_2 \), for the British clearing banks.

\[
L_2 = (r-t) \times \rho_2 \times D
\]

where \( r \) = long term government bond-yield.

\( t \) = three month treasury bill rate.

\( \rho_2 \) = secondary reserves ratio for clearing banks.

\( = .30 \) (from 1960 to 1963)

\( = .28 \) (from 1964 to 1970)

\( = .125 \) (from 1964 to 1970)

\( D \) is defined above.

Different tax rates are computed dividing the loss, \( L_2 \) derived above by an appropriate base.
### Table 7.4

Estimates of Implicit Rates of Taxation per Dollar of Interest Earnings (ITIB)*
(per pound sterling)

<table>
<thead>
<tr>
<th></th>
<th>ITIB1 (a)</th>
<th>ITIB2 (b)</th>
<th>ITIB3 (c)</th>
<th>ITIB (d)</th>
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</thead>
<tbody>
<tr>
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<td>.01</td>
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<td>.15</td>
<td>.02</td>
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<tr>
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<tr>
<td>80</td>
<td>.41</td>
<td>.33</td>
<td>.007</td>
<td>.77</td>
</tr>
</tbody>
</table>

4 Using the long term government bond yield as the representative of bank returns on loans and investments.

Data Sources: Central Statistical Office, Financial Statistics.
Column (b) in Table 7.2 represents L2. The implicit tax rate per dollar of secondary reserves (ITAXR) is calculated by dividing L2 by D, the total amount of clearing bank deposits.

\[ ITAXR = (r-t) \times p2 = f(r, t, p2) \]  \hspace{1cm} (7-6)

Column (b) in Table 7.3 shows the annual implicit tax rates for the period from 1960 to 1980.

The rate of implicit taxation per dollar of interest earnings (ITIB) is computed by dividing the loss by the interest earnings on the deposits.

\[ ITIB2 = L2/[(r-i) \times D], \]

where \( L2 \) is defined in (7-5), \( r \) and \( i \) are defined above. These rates, expressed as percentages, are shown in Table 7.4.

7.4.4 Opportunity cost of special deposits

The opportunity costs of special deposits is computed using the long-term government bond yield.

\[ L3 = (r - t) \times p3 \times SD, \]  \hspace{1cm} (7-7)

where \( L3 \) = loss of earnings from special deposits, and \( r \) and \( t \) are as defined above.

\( SD = \) special deposits.

Data on special deposits are taken from various issues of International Financial Statistics. The period considered is from 1960 to 1980. Table 7.2 shows the estimates of the loss in million pound sterling.
The implicit tax rates for special deposits (ITAXS), are calculated dividing L3 in (7-5) by the aggregate deposits of all the clearing banks. These rates, expressed per pound sterling of clearing bank deposits are shown by column (c) in Table 7.3.

The implicit tax rates per dollar of interest earnings (ITIB3) shows the loss of earnings as a percentage of interest earnings for all clearing banks. These are calculated by dividing L3 by the interest earnings on aggregate deposits:

\[ ITIB3 = \frac{L3}{(r-d)D} \]  

(7-6)

where L3, r, d and D are defined above.

These tax rates are shown in Table 7.4. The total loss of earnings (L) from various types is \( L = L1 + L2 + L3 \).  

(7-9)

Since banks keep a certain percent of their deposit liabilities as cash reserves to meet unforeseen demand for cash even in the absence of legal requirements, the estimates provided by equation (7-7) overestimate the actual losses that banks incur. Assuming banks keep 3 per cent of their deposit liabilities as voluntary reserves, the amount of loss can be estimated by

\[ L' = L - .03rD \]  

(7-10)

where L is given by (7-7).

Column d in Table 7.2 represents L'.

The total implicit tax rates per dollar of deposit (ITAXT) and per dollar of interest earnings can be obtained dividing L'.
by $D$ and $(r-i)D$. These are shown by column (d) of Tables 7.3 and 7.4.

7.5 Conclusion

In this chapter, I have discussed the structure and the costs of reserve requirements in the United Kingdom. The clearing banks are subject to three types of reserve requirements, namely, cash reserves, liquid asset requirements and special deposits. Using the definitions of chapter one, I calculated the costs of these requirements for the clearing banks. Although the loss of earnings runs in millions of pounds, they are not substantial when expressed as percentages of deposits or interest earnings on deposits. Even though the measures are based on simplified assumptions about bank behaviour, they provide an approximation of the actual losses incurred by banks in holding reserves. In the next chapter, I will investigate the role of the various types of reserve requirements in the growth of international banking in the United Kingdom.
Appendix to Chapter Seven

Table 7.A.1

Decomposition of Losses of Earnings from Reserve Requirements into Interest Rates and Deposits Changes (1960-1980)*

<table>
<thead>
<tr>
<th></th>
<th>AlogL1**</th>
<th>Alogr</th>
<th>AlogD</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)</td>
<td>(b)</td>
<td>(c)</td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>4.37</td>
<td>3.97</td>
<td>.40</td>
</tr>
<tr>
<td>61</td>
<td>2.07</td>
<td>1.54</td>
<td>.54</td>
</tr>
<tr>
<td>62</td>
<td>-3.28</td>
<td>-4.18</td>
<td>.88</td>
</tr>
<tr>
<td>63</td>
<td>2.38</td>
<td>.41</td>
<td>1.98</td>
</tr>
<tr>
<td>64</td>
<td>4.78</td>
<td>3.25</td>
<td>1.50</td>
</tr>
<tr>
<td>65</td>
<td>2.10</td>
<td>.88</td>
<td>1.23</td>
</tr>
<tr>
<td>66</td>
<td>2.13</td>
<td>1.69</td>
<td>.44</td>
</tr>
<tr>
<td>67</td>
<td>2.74</td>
<td>.82</td>
<td>1.91</td>
</tr>
<tr>
<td>68</td>
<td>3.66</td>
<td>2.44</td>
<td>1.23</td>
</tr>
<tr>
<td>69</td>
<td>3.02</td>
<td>3.66</td>
<td>-.64</td>
</tr>
<tr>
<td>70</td>
<td>1.25</td>
<td>.89</td>
<td>.36</td>
</tr>
<tr>
<td>71</td>
<td>-.61</td>
<td>-3.71</td>
<td>3.10</td>
</tr>
<tr>
<td>72</td>
<td>10.66</td>
<td>3.92</td>
<td>7.26</td>
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<tr>
<td>73</td>
<td>13.50</td>
<td>5.67</td>
<td>7.23</td>
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<td>74</td>
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<td>8.17</td>
<td>4.26</td>
</tr>
<tr>
<td>75</td>
<td>-1.62</td>
<td>-2.86</td>
<td>.99</td>
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<tr>
<td>76</td>
<td>4.34</td>
<td>1.67</td>
<td>2.57</td>
</tr>
<tr>
<td>77</td>
<td>-6.27</td>
<td>-8.69</td>
<td>2.65</td>
</tr>
<tr>
<td>78</td>
<td>7.41</td>
<td>4.05</td>
<td>3.37</td>
</tr>
<tr>
<td>79</td>
<td>6.81</td>
<td>1.90</td>
<td>5.11</td>
</tr>
<tr>
<td>80</td>
<td>2.72</td>
<td>-1.45</td>
<td>4.32</td>
</tr>
</tbody>
</table>

*Expressed as percentages ** AlogL1 = logL1_t-logL1_{t-1}

Data Sources: Central Statistical Office, Financial Statistics.
8.1 Introduction

In this chapter, I use various models to explain the growth of international banking in the United Kingdom. The main objective is to investigate whether discriminatory regulations between the clearing banks and other banks played any role in the development of international banking during the period 1964 to 1980.

Historically London was always an important centre for international banking activities. This role can be attributed to the vast colonial empire that the United Kingdom once possessed and the predominance of sterling as the most important currency until the second World War. Even today London is the biggest international banking centre within the OECD area.

The continued role of the United Kingdom as a center of international banking activities was partly made possible by the presence of a large number of overseas banks. These banks flourished in the relatively relaxed environment of the UK money market. The UK banking laws were not as strict on its foreign banks as they were on its clearing banks. The main task of this section is to test the role of various implicit tax rates of reserve requirements in the growth of international banking activities in the United Kingdom. While doing this, I consider
statistical tests on other relevant explanatory factors as well.

International banking is defined as lending and borrowing denominated in foreign currencies. Thus I exclude transactions with non-residents denominated in local currencies from the definition of international banking.¹ This definition is used because British banking regulations treat local and foreign currency denominated deposits differently. The currency denomination of deposits is sometimes considered to be a relevant criterion from a regulatory perspective.

There has been a phenomenal growth of international banking activities in the United Kingdom in the sense of the term defined above, during the last two decades. From 1963 to 1981, external liabilities of the UK banking sector² grew from 1280 million pounds sterling in 1963 to 2,16,413 million pounds sterling in 1981--- a growth of about 169 times during the period. The asset side also demonstrated a similar growth, about 165 times. Even allowing for the fact that the figures after 1974 are slightly overestimated because of the inclusion of other financial institutions, this growth was phenomenal, by all standards.

¹See OECD (1978) for a detailed scrutiny of the operations that should be covered by a strict definition of international banking.

²The banking sector is defined as comprising all banks in the United Kingdom together with National Zero, the discount market and the Bank of England banking department.
Comparative figures on the growth of total liabilities of the banking sector and the liabilities of clearing banks provide a more revealing picture of the growth in international banking activities of UK banks. These are shown in Table 8.1. During the same period, total liabilities of the banking sector increased 25 times from 12,404 million pounds sterling to 317,675 million pounds sterling. The deposit liabilities increased 9 times from 8640 million pounds sterling to 84,880 million pounds sterling. Foreign currency denominated liabilities as a percentage of total liabilities was only 10 percent in 1963, and rose to 68 percent in 1981. These liabilities expressed as a percentage of clearing banks' deposits rose from 13 percent to 317 percent.

We can identify several regulatory advantages that the UK banks enjoyed with respect to their foreign currency denominated liabilities as compared to their sterling denominated liabilities.

1. Banks domiciled in the United Kingdom may and do borrow freely in the euro-currency market to relend in foreign currencies. The monetary authorities have never prescribed a limit for foreign currency denominated loans as they have with sterling loans.

2. The authorities did not specify cash or liquid asset reserves for foreign currency deposits as they did with sterling deposits. Even during the reforms of 1971, when the foreign banks were put on a competitive footing with domestic banks, foreign currency liabilities were exempted
Table 8.1

A Comparison of Total Liabilities, External Liabilities in Foreign Currency and Deposit Liabilities of Clearing Banks.*
(In million pound sterling)

<table>
<thead>
<tr>
<th>Year</th>
<th>External Liabilities</th>
<th>Total Liabilities</th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(1/2)*100</th>
<th>(1/3)*100</th>
</tr>
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<tbody>
<tr>
<td>1963</td>
<td>1280</td>
<td>12404</td>
<td></td>
<td></td>
<td></td>
<td>9215.7</td>
<td>10</td>
</tr>
<tr>
<td>1964</td>
<td>1786</td>
<td>13437</td>
<td></td>
<td></td>
<td></td>
<td>9441</td>
<td>13</td>
</tr>
<tr>
<td>1965</td>
<td>2122</td>
<td>14725</td>
<td></td>
<td></td>
<td></td>
<td>9920.91</td>
<td>14</td>
</tr>
<tr>
<td>1966</td>
<td>3002</td>
<td>15739</td>
<td></td>
<td></td>
<td></td>
<td>10353.2</td>
<td>19</td>
</tr>
<tr>
<td>1967</td>
<td>4488</td>
<td>18493</td>
<td></td>
<td></td>
<td></td>
<td>10796.5</td>
<td>24</td>
</tr>
<tr>
<td>1968</td>
<td>7223</td>
<td>22221</td>
<td></td>
<td></td>
<td></td>
<td>11537.2</td>
<td>33</td>
</tr>
<tr>
<td>1969</td>
<td>12083</td>
<td>27493</td>
<td></td>
<td></td>
<td></td>
<td>11752.2</td>
<td>44</td>
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<tr>
<td>1970</td>
<td>15283</td>
<td>33727</td>
<td></td>
<td></td>
<td></td>
<td>11219.2</td>
<td>45</td>
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<tr>
<td>1971</td>
<td>17605</td>
<td>39623</td>
<td></td>
<td></td>
<td></td>
<td>12384.3</td>
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<tr>
<td>1972</td>
<td>25460</td>
<td>53234</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>1973</td>
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<td>74693</td>
<td></td>
<td></td>
<td></td>
<td>33349.3</td>
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<td>1974</td>
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<td>88153</td>
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<td></td>
<td></td>
<td>26386.7</td>
<td>54</td>
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<tr>
<td>1975</td>
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<tr>
<td>1976</td>
<td>87319</td>
<td>136274</td>
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<td></td>
<td></td>
<td>30959.7</td>
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<tr>
<td>1977</td>
<td>89338</td>
<td>148489</td>
<td></td>
<td></td>
<td></td>
<td>33702.7</td>
<td>62</td>
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<tr>
<td>1978</td>
<td>104566</td>
<td>167407</td>
<td></td>
<td></td>
<td></td>
<td>39123.3</td>
<td>62</td>
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<tr>
<td>1979</td>
<td>126756</td>
<td>199590</td>
<td></td>
<td></td>
<td></td>
<td>45687.5</td>
<td>64</td>
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<tr>
<td>1980</td>
<td>144954</td>
<td>233392</td>
<td></td>
<td></td>
<td></td>
<td>55391.7</td>
<td>62</td>
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<tr>
<td>1980</td>
<td>216413</td>
<td>317675</td>
<td></td>
<td></td>
<td></td>
<td>84880.4</td>
<td>68</td>
</tr>
</tbody>
</table>

from reserve requirements.

All the liability operations of banks in foreign currencies with residents as well as non-residents were free from reserve requirements. Only the liability operations of banks in domestic currency with non-residents were subject to reserve requirements.³

3. The interest rate differential between the traditional deposits like clearing bank's sterling deposits and the foreign currency liabilities increased the growth of foreign currency denominated liabilities. The rate on clearing bank deposits continued to be closely related to the bank rate until 1971. On the other hand, the operations of Bank of England had only limited effects on complementary markets, especially the foreign currency deposits of the banking sector. In the market for foreign currency deposits, the rates have been determined in the international markets.

Of all the rates on foreign currency deposits, the eurodollar rate is the most important rate, because of the predominance of eurodollar deposits among all the foreign currency deposits. The eurodollar rate remained below the UK bank rate up to 1969, but after that the position was reversed. It has risen above most of the prevailing short-term money market rates.

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³See OECD (1978), Table III (page 74) for a summary view of those international banking operations which were covered by the minimum reserve requirements regulations.
8.2 A graphical analysis

The major hypothesis to be tested in this chapter is that the growth of external liabilities denominated in foreign currencies is directly related to the implicit tax of reserve requirements on the sterling liabilities of clearing banks as computed in the previous chapter. In the following section I plot several graphs to show the relationship between the development of international banking (as defined above) and the implicit tax of reserve requirements. The objective is to see whether we can observe any direct association between these two variables as hypothesized above, from the visual inspection of the series. The following variables are plotted:

1. EXUK = liabilities denominated in foreign currencies of British banking sector,
2. EXCB = ratio of EXUK to sterling-denominated liabilities of UK banks,
3. ITAXC = implicit tax of cash reserve requirements,
4. ITAXT = implicit tax of total reserve requirements.

Figures 8.1 and 8.2 show EXUK, ITAXC and ITAXT. The series EXUK shows a steadily increasing trend. Although both ITAXT and ITAXC show cyclical variability, ITAXC shows less variability than ITAX. It is difficult to establish any general pattern consistent with our hypothesis, over the entire period. However, some patterns can be observed if we divide the period into four sub-periods.
Foreign Currency Liabilities of UK Banks (EXUK) and the Implicit Tax of Cash Reserves (ITAXC)

LEGEND

- EXUK
- ITAXC
Foreign Currency Liabilities of UK Banks (EXUK) and the Implicit Tax of Total Reserves (ITAXT)

LEGEND

EXUK

ITAXT

EXUK (in billions of dollars)

PERIOD

64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

0 0.2 0.4 0.6 0.8 1 1.2 1.4 1.6
Ratio of Foreign Currency to Sterling Liabilities of UK Banks (EXCB) and the Implicit Tax of Cash Reserves (ITAXC)
Ratio of Foreign Currency to Sterling Liabilities of UK Banks (EXCB) and the Implicit Tax of Total Reserves (ITAXT)
1964-I to 1971-II

This is the period when both ITAX and ITAXC vary cyclically around a rising trend but ITAX shows more variability than ITAXC. Both EXUK and EXCB follow a steadily increasing path. Therefore this sub-period confirms our hypothesis.

1971-III to 1974-II

During this period both EXUK and EXCB maintain their steady, upward trends. EXCB shows some minor fluctuations. The implicit tax falls sharply at the beginning of the period because of reduction in the reserve ratio from 8 per cent to 1.5 percent. The drastic fall in the implicit tax has slowed down the growth of foreign currency liabilities relative to sterling liabilities during this period as is evident from Figures 8.3 and 8.4. This supports my hypothesis that the fall in the implicit tax reduces the advantage of supplying foreign currency liabilities vis-a-vis sterling liabilities. Except for a very small period, EXUK and ITAXC seems to be highly correlated (Figure 8-1). Since ITAXT fluctuated very widely during this period, no clear pattern is observed between ITAX and international banking series. (Figures 8-2 and 8-4) This supports my hypothesis of a relationship between ITAXC and the growth of international banking during this sub-period.

1974-III to 1984-II

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During this period while both EXUK and EXCB show increasing trends, ITAXC shows a slightly declining trend. ITAXT fluctuated very widely and we notice no clear pattern between ITAXT and international banking. The oil price crisis might explain the divergence of the international banking and the implicit tax series during this period. Even though regulations on domestic liabilities were relaxed, the oil-price induced surplus was deposited in foreign currencies in British banks and thus provided momentum to the growth of international banking. EXCB follows ITAXC more closely. See Figure 8.3 during the period. We do not see the steadily increasing trend in EXCB as was the characteristic of the series in earlier periods. The cycles in EXCB follow to some extent the cycles in ITAXC with some lag. To conclude, except in the last sub-period, we have some confirmation of the hypothesis as postulated above.

8.3 An econometric model

The following model is set up to test the role of reserve requirements and other regulatory and non-regulatory factors in the development of international banking activities of the United Kingdom.  

\[ y = A(1-x)^\alpha z^\beta e^u \]  

(8-1)

where \( x \) represents various implicit tax rates of reserve requirements, \( z \) represents variables other than the reserve requirements. Unlike the US model, the double-logarithmic form yields better results than the linear form in terms of the expected signs and statistical significance of the coefficients of the estimated equation.
requirements tax, and \( u \) is the error term. The error term is assumed to satisfy all the assumptions of the classical log-linear regression model. In the absence of any type of reserve requirements \( x = 0 \), and (8-1) is reduced to:

\[
y' = A \beta e^u \quad (8-2)
\]

The contribution of reserve requirements to the development of international banking can be measured by taking the differential between \( y \) and \( y' \). Since the size of external liabilities of the U.K. banking sector in the absence of reserve requirements on the sterling liabilities of clearing banks is not known,\(^5\) I have used the estimates of coefficients of (8-1) to estimate \( y' \). By this method, the estimate of \( y' \) is given by \( A^\ast z^\beta^\ast \) where \( A^\ast \) and \( \beta^\ast \) are estimates of \( A \) and \( \beta \) respectively in equation (8-1).

Taking logarithms of both sides of equation (8-1),

\[
\log y = \log A + a \log(1-x) + \beta \log z + u \quad (8-3)
\]

The basic double-logarithmic equation (8-3) is written in the following two forms, listing all the explanatory variables.

\[
\begin{align*}
\text{LEXB} &= f(\text{LRDD}, \text{LRDI}, \text{LTAX}, \text{LGNP}, \text{LBRU}, \text{DPRE}, \text{DADJ}, \text{DCOR}, \text{DCCC}) \\
\text{LEXC} &= \text{DCOR}, \text{DCCC}
\end{align*}
\]

\[
(8-4)-(8-5)
\]

where

\[
\begin{align*}
\text{LEXB} &= \log(\text{EXUK}), \text{LEXC} = \log(\text{EXCB}), \text{LRDD} = \log(\text{RDID}), \text{LRDI} = \\
&\log(\text{RDII}), \text{LTAX} = \log(1-\text{ITAXi})^6, \text{LGNP} = \log(\text{GNPB}), \text{LBRU} = \\
&\log(\text{BRUK}).
\end{align*}
\]

\[
^5\text{Running a regression of } y' \text{ on just } z, \text{ ignoring } x \text{ would produce biased estimates of coefficients of (8-2) and therefore of } y'.
\]

\[
^6\text{ITAXi=ITAXC, ITAXS, ITAXR or ITAXT.}
\]
The variables are described in detail below.

*Interest differential variables*

RDID = Difference between a domestic representative rate of the rates paid on foreign currency deposits and the clearing bank deposit rate. Three different measures of RDID are considered.

RDID1 = Difference between the eurodollar rate and the clearing bank deposit rate.

RDID2 = Difference between local authority deposit rate and the clearing bank deposit rate.

RDID3 = Difference between short-run government bond yield and the clearing bank deposit rate.

RDII= Difference between a foreign representative interest rate and one of the domestic representative rates as mentioned above.

I used the US three-month certificate deposit rate and the German three-month time deposit rate to represent the foreign representative interest rate.

*Implicit tax variables*

ITAXC = Implicit tax rate of cash reserves of clearing banks calculated above.
\[ \text{ITAXS} = \text{Implicit tax rate of special deposits calculated above.} \]

\[ \text{ITAXR} = \text{Implicit tax rate of secondary reserves.} \]

\[ \text{ITAXT} = \text{Implicit tax rate of total required reserves.} \]

**Supplementary special deposits variables**

\[ \text{DPRE} = \text{Dummy variable for the pre-activation period, taking the following values.} \]

\[ = 1, 1973 2 \text{ to } 1973 4, 1976 2 \text{ to } 1976 4, 1977 4 \text{ to } 1978 2; \]

\[ = 0, \text{otherwise.} \]

\[ \text{DADJ} = \text{Dummy variable for the adjustment period.} \]

\[ = 1, 1974 1 \text{ to } 1974 2, 1976 4 \text{ to } 1977 1, 1978 3 \text{ to } 1978 4; \]

\[ = 0, \text{otherwise.} \]

\[ \text{DCOR} = \text{Dummy variable for the "corset" period.} \]

\[ = 1, 1974 3 \text{ to } 1975 2, 1977 2 \text{ to } 1977 3, 1978 4 \text{ to } 1980 2; \]

\[ = 0, \text{otherwise.} \]

\[ \text{DCCC} = \text{Dummy variable for the competition and credit control system in September, 1971.} \]

\[ = 0, 1963 1 \text{ to } 1971 3; \]
\[ = 1, 1971 \text{ to } 1980 \]

Scale variables

\[ \text{GNPB} = \text{Gross national income at market prices.} \]

\[ \text{BRUK} = \text{UK bank rate} . \]

8.4 Data and hypotheses

The period selected for testing the hypotheses ran from the first quarter of 1963 to the second quarter of 1980. The dependent variable, EXUK was measured by taking quarterly observations on the foreign-currency denominated liabilities of the UK banking sector. Data were collected from the various issues of 'Financial Statistics' published by the Central statistical Office (hereafter referred as CSO-FS). Each of the independent variables in the model is designed to test a particular hypothesis about the determination of the dependent variable.

Since there is no unique rate for foreign currency deposits, I have considered several proxies to represent this rate and investigated each of them to determine which performs best statistically. These are the eurodollar rate in London, the local authority deposit rate and the short-term government bond yield. Two types of interest differential variables are considered:

1. RDID represents domestic money market conditions. RDID is
the difference between one of the proxy rates for foreign currency denominated liabilities and the rate on clearing bank deposits. As RDID increases in favour of the rates on foreign currency liabilities, some depositors will switch funds out of their domestic currencies and put them into foreign currencies. Consequently the supply of foreign currency liabilities is expected to increase. Therefore I expect the sign of RDID to be positive.

2. The other interest differential variable, RDII represents the international market conditions. RDII is computed by taking the difference between one of the proxy rates and the three month time deposit rate in the USA and Germany. As for the sign of RDII, an increase in the eurodollar rate in London relative to the rate on similar deposits in the United States should encourage some depositors to keep eurodollar deposits in London rather than keep dollar deposits in domestic banks. The same is true for the euromark deposits in London. Therefore, the expected sign for this variable is positive.

I have considered four different types of implicit tax variables for different types of reserve requirements.

1. Implicit tax of cash reserves (ITAXC)
2. Implicit tax of secondary reserves (ITAXR)
3. Implicit tax of special deposits (ITAXS)
4. Implicit tax of total reserve requirements (ITAXT)

Using the method described in Chapter Seven, I have computed
these rates using quarterly data.

It is hypothesized that the growth of foreign currency liabilities will be directly related to each of the above three implicit rates of taxation. The absence of cash reserve requirements on the external liabilities induces the clearing banks to offer them through their subsidiaries. Also, the overseas banks, which mostly deal in foreign currencies, can escape domestic reserve requirements by offering these liabilities. This provides stimulus to the growth of these liabilities. Since I have used \( \log(1-\text{ITAX}_i) \) as the independent variable, I expect the sign of the coefficient to be negative.

Data on GNPB are taken from various issues of International Financial Statistics. A significant portion of foreign currency liabilities are also owned by United Kingdom residents. Therefore, foreign currency liabilities are expected to increase with an increase in GNPB.

When the UK bank rate rises, the pound sterling is expected to get stronger and the speculative demand for pound sterling will rise against all other currencies. As a result, the supply of foreign currencies will rise as investors try to switch from other currencies into sterling. Therefore, the expected sign of the coefficient is positive.

To capture the impact of the supplementary special deposits scheme, I have included three dummies in the set of explanatory variables. DPRE is the dummy for the pre-activation period. This
is the period six months preceding the activation of the scheme. The dummy variable, DADJ, is used for the adjustment period. This is the period between the activation of the scheme and the time when the obligation to place supplementary special deposits becomes operative. Lastly, the dummy variable, DCOR, represents the 'corset' period.

During the pre-activation and adjustment periods, banks may build up their liabilities in order to start with a high 'base' to avoid the penalty during the 'corset' period. Therefore, I would expect positive coefficients for the variables 'pre' and 'adjust'. During the 'corset' period, supplementary special deposits must be placed if the growth of interest-bearing liabilities exceed the permitted level. Whether there has been a decline in the growth of external liabilities during the three 'corset' periods is an empirical issue. The supplementary special deposits scheme was applicable to bank liabilities including foreign currency deposits. Therefore, one can expect a relatively slower growth of these liabilities during the 'corset' period than during the other periods.

After the introduction of competition and credit control reforms in October of 1971, foreign banks were put on the same footing as the clearing banks. But reserve requirements were imposed only on the sterling liabilities leaving the foreign currency liabilities free from regulatory controls. Therefore the coefficients of DCCC in both the equations (8-4) and (8-5) are expected to be positive.
8.4.1 Methodology and analysis of results

Equations (8-4) and (8-5) have been estimated using ordinary least-squares. The results are shown in Table 8.2. The Durbin-Watson test did not indicate any strong auto-correlation of the residuals of the two estimated equations. All the variables have expected signs as hypothesized and with the exception of DADJ, all are statistically significant.

The variable $\log(1-\text{ITAXC})$ has a negative sign as expected and is found to be statistically significant at the 1 per cent level of significance in both the equations. The other implicit tax variables, $\log(1-\text{ITAXT})$, $\log(1-\text{ITAXR})$ and $\log(1-\text{ITAXS})$ were found to be insignificant and were dropped from the equation. The estimate of elasticity with respect to ITAXC can be derived from the estimate of the coefficient of $\log(1-\text{ITAXC})$. This elasticity is estimated to be .70.

I experimented with various measures of RDID. Of all the measures of RDID, only the one measured by the difference between the local authority deposit rate and the clearing bank deposit rate is found to be statistically significant. This indicates that the local authority deposit rate is a better representation of the rate on foreign currency liabilities than the other short-term interest rates. The results indicate that

$I$ used the formula, $e=\alpha X/(1-X)$ to estimate elasticity of EXUK with respect to ITAXC.

$^8$Rates on foreign currency deposits in London are generally close to rates on local authority temporary money and rates on
Table 8.2

Determinants of External Liabilities of UK Banking Sector

Log-linear model

OLS estimates

<table>
<thead>
<tr>
<th>DEPENDENT VARIABLES: LEXB</th>
<th>LEXC</th>
</tr>
</thead>
<tbody>
<tr>
<td>EQUATION # 8-4</td>
<td>EQUATION # 8-5</td>
</tr>
<tr>
<td>INDEPENDENT VARIABLES</td>
<td>ESTIMATED COEFFICIENT</td>
</tr>
<tr>
<td>INTERCEPT</td>
<td>1.88</td>
</tr>
<tr>
<td>LRDD</td>
<td>.37</td>
</tr>
<tr>
<td>LRD1</td>
<td>1.01</td>
</tr>
<tr>
<td>LTAX</td>
<td>-112.03</td>
</tr>
<tr>
<td>LGNP</td>
<td>1.28</td>
</tr>
<tr>
<td>LBRU</td>
<td>1.17</td>
</tr>
<tr>
<td>DCCC</td>
<td>1.57</td>
</tr>
<tr>
<td>DPRE</td>
<td>-.38</td>
</tr>
<tr>
<td>DADJ</td>
<td>-.12</td>
</tr>
<tr>
<td>DCOR</td>
<td>-.66</td>
</tr>
<tr>
<td>d.f.*</td>
<td>56</td>
</tr>
<tr>
<td>R²</td>
<td>.95</td>
</tr>
<tr>
<td>D.W</td>
<td>2.01</td>
</tr>
<tr>
<td>F</td>
<td>112.79</td>
</tr>
</tbody>
</table>

* degrees of freedom
EXUK is fairly elastic (1.17) with respect to RDID. The variable is statistically significant at the 1 per cent level in both the equations.

The variable LRDI, measured by the log of the ratio of the eurodollar rate in London to the three month time deposit rate in the United States, has the expected sign and found to be statistically significant at the 10 per cent level in both the equations.

All the 'corset' dummies have negative signs and with the exception of the dummy for the adjustment period all are statistically significant at the 5 per cent level. The dummy variable for competition and credit control, DCCC, has the expected sign and is found to be highly significant in both equations with t-values over 5. This gives evidence of the growth of foreign currency liabilities and substitution for clearing bank liabilities after the introduction of credit control reforms in 1971.

The GNP variable, LGNP has a positive sign as expected and is statistically significant at the 1% level in both equations and therefore, indicates an elastic supply of external liabilities with respect to GNP.

The coefficient of the variable BRUK is found to be positive and statistically significant. The estimate of the coefficient

---

(cont'd) deposits with finance houses, after allowing for the cost of forward cover. See Gibson (1970).
of LBRUK indicates that EXUK is elastic with respect to BRUK.

8.4.2 Contribution of the reserve requirements tax to the growth of international banking in the United Kingdom

From the regression results, it is evident that the implicit tax of reserve requirements has played a positive role in the growth of international banking in the United Kingdom. To quantify the size of international banking in the absence of reserve requirements, I put \( ITXD = 0 \) in the estimated equation (8-4) to compute an estimated value of EXUK, \( EXUK^{**} \). The difference between \( EXUK^* \) (estimated value of EXUK in the presence of reserve requirements) and \( EXUK^{**} \) gives the size of contribution of reserve requirements to the growth of international banking (CTXU). In Table 8.2 column (a) shows the annual averages of quarterly values of this contribution. Column (b) shows the contribution expressed as a percentage of EXUK (that is, \( CTXU*100/EXUK \)). The range of this series is between 20 to 70 per cent. Column (c) shows the contribution expressed as a percentage of EXUK (that is, \( CTXU*100/EXUK^* \)). The range of this series is between 22 per cent to 75 per cent.

8.5 Conclusion

The inequitable treatment of clearing banks and non-clearing banks by U.K. banking laws is an example of regulatory imperfections that created an incentive for the development of 'parallel markets' in the British banking sector. International
<table>
<thead>
<tr>
<th>Year</th>
<th>CITU* (In millions of dollars)</th>
<th>CITU/EXUK (times 100)</th>
<th>CITU/EXUK** (times 100)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1964</td>
<td>966.14</td>
<td>67.84</td>
<td>54.90</td>
</tr>
<tr>
<td>1965</td>
<td>1353.78</td>
<td>70.51</td>
<td>46.44</td>
</tr>
<tr>
<td>1966</td>
<td>1588.95</td>
<td>61.49</td>
<td>50.67</td>
</tr>
<tr>
<td>1967</td>
<td>1825.60</td>
<td>48.87</td>
<td>53.23</td>
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<tr>
<td>1968</td>
<td>2079.40</td>
<td>34.41</td>
<td>48.79</td>
</tr>
<tr>
<td>1969</td>
<td>6147.53</td>
<td>58.12</td>
<td>65.51</td>
</tr>
<tr>
<td>1970</td>
<td>9048.31</td>
<td>65.80</td>
<td>75.16</td>
</tr>
<tr>
<td>1971</td>
<td>10373.30</td>
<td>62.60</td>
<td>67.75</td>
</tr>
<tr>
<td>1972</td>
<td>5103.59</td>
<td>23.52</td>
<td>25.37</td>
</tr>
<tr>
<td>1973</td>
<td>7694.55</td>
<td>23.89</td>
<td>22.67</td>
</tr>
<tr>
<td>1974</td>
<td>14236.60</td>
<td>33.81</td>
<td>33.35</td>
</tr>
<tr>
<td>1975</td>
<td>39321.70</td>
<td>20.34</td>
<td>41.11</td>
</tr>
<tr>
<td>1976</td>
<td>25133.30</td>
<td>32.53</td>
<td>30.17</td>
</tr>
<tr>
<td>1977</td>
<td>35956.60</td>
<td>39.98</td>
<td>50.29</td>
</tr>
<tr>
<td>1978</td>
<td>43462.40</td>
<td>44.05</td>
<td>35.63</td>
</tr>
<tr>
<td>1979</td>
<td>29382.70</td>
<td>25.53</td>
<td>24.56</td>
</tr>
<tr>
<td>1980</td>
<td>83075.40</td>
<td>41.77</td>
<td>60.00</td>
</tr>
</tbody>
</table>

* CITU = contribution of reserve requirements tax to the growth of international banking
** estimated value of EXUK
banking is just one kind of parallel market that exists side by side with the traditional markets.

In this chapter, I tested the hypothesis that discriminatory regulations between the sterling and non-sterling liabilities that existed during the period under study provided an incentive for the growth of the external currency market in the United Kingdom. Evidence indicates that of all the implicit tax variables, only the implicit tax of cash reserve requirements seemed to play a significant role. Regression results also indicate that the contribution of reserve requirements to the growth of international banking in the United Kingdom has declined over time, but it remained fairly significant during the period under study.
CHAPTER NINE

SUMMARY, POLICY IMPLICATIONS AND AN AGENDA FOR FURTHER RESEARCH

The concluding chapter is divided into 3 sections. In section 9.1, I present a summary of the thesis. In section 9.2, the welfare and policy implications of the study are discussed. In section 9.3, the limitations of the study are reviewed and suggestions are made for future research in the area.

9.1 A summary of the thesis

The economic functions of reserve requirements have changed gradually over time. Since the very inception of reserve requirements as a policy tool, there has always been a discrepancy between those objectives that are explicitly stated and those objectives that are implicitly assumed by the monetary authorities. Some of the explicitly stated objectives are the preservation of adequate bank liquidity and monetary and credit control.

There are other 'hidden' functions of reserve requirements which are not usually mentioned in discussions. These are: 1) reserve requirements contribute significantly to the revenue of the treasury, (Goodfriend and Hargreaves, 1980), 2) reserve requirements act as a seigniorage sharing rule between the Central Bank and other banks (Greenbaum, 1983), 3) the imposition of reserve requirements provides a guarantee against the exploitation of the discount mechanism by banks (Greenbaum,
reserve requirements function as an excise tax on bank financial intermediation (Black, 1975; Johnson, 1976; and Grubel, 1983). From the banks' standpoint the last function is very important since this has implications for their income and their decision parameters.

In the theoretical part of the thesis the effects of reserve requirements were studied using alternative models of bank behaviour. Measures of the implicit tax of reserve requirements were developed in alternative models to compute the burden of reserve requirements using different proxies for bank size and income. Although the measures of the simple model of Chapter Two were used in the testing of the empirical hypotheses, the measures developed in the extended models of bank behaviour presented in Chapters Three and Four provide additional insights into the nature and measurement of this burden.

It was shown that reserve requirements have mainly two types of effects on bank portfolio behaviour. The primary effects are generated by the profit-maximizing response of the banking firm to the imposition of the reserve requirements constraint on its balance sheet and the consequent effects on the decision variables such as the level of deposits, loans and interest rates. I discussed the primary effects of reserve requirements in detail in the theoretical part of the thesis using alternative models of bank behaviour.
The conclusions of the theoretical models are that a system of differential reserve requirements lowers the relative supply of deposits on which higher level of reserve requirements are imposed (Chapter Two) and reserve requirements lower bank profits, the level of deposits and the interest paid on them (Chapter Three). A general conclusion that can be drawn from the model in Chapter Three is that the reserve requirements tax, depending on the market structure of loans and deposits, can entirely be borne by the bank itself or it can be passed on to the depositors or to the borrowers from the bank. Chapter Four underscores the importance of incorporating uncertainty in models of bank behaviour. By analyzing the uncertainty in deposit flows that a bank may face, this chapter derives deposits and reserves demand functions and uses these to investigate the role of reserve requirements.

The secondary effects result from the banking firms's creative response to close the gap between the profit when there is a legal reserve requirements constraint and when there is no such constraint. In other words, since reserve requirements represent a tax on some of its liabilities, banks have an incentive for developing reserves-minimizing substitutes in order to lower the opportunity cost of non-interest-bearing required reserves. Some innovations such as the growth of the market for repurchase agreements in the United States are manifestations of this process.
Taxing the domestic banking sector through a system of non-interest-bearing legal reserves causes financial transactions to be disintermediated to the unregulated market and consequently, the unregulated market expands at the expense of the regulated market. The international banking markets provide an attractive outlet for escaping domestic regulations as long these markets are unregulated. The growth of the offshore market for dollars by US banks and the development of foreign currency markets in the United Kingdom are good examples of domestic bank disintermediation caused by regulations.

The primary objectives of the empirical part are 1) to compute the burden of reserve requirements for the banking sectors in the United States and the United Kingdom and 2) assess its role in the relatively faster growth of international financial intermediation as compared with domestic financial intermediation. In the case of US banks, I chose the international banking market consisting of offshore dollars because in the US national banking markets, US regulations did not treat domestic and foreign banks differently during the period under study. This is not true in the case of UK banking sector. Foreign banks and foreign currency denominated liabilities are usually treated favourably by British banking laws. This explains why I investigated the role of differential regulations including reserve requirements in the growth of foreign-currency denominated liabilities in the United Kingdom.

\*these are sometimes called the supra-national markets. See Gray and Gray (1981).
The major finding of the empirical study is that the implicit tax of reserve requirements has played a significant role in the development of offshore banking for dollars by US banks and international banking activities in the United Kingdom.

9.2 Welfare implications of the study

Reserve requirements, like any excise tax, have efficiency, neutrality and equity implications. For some time banks, economists and the members of the public have expressed concerns about these and other welfare effects of the reserve requirements tax. The efficiency effects are generated in the following way. Since reserve requirements can be thought of as a selective tax on deposits offered by depository institutions, they have the effect of artificially raising the 'cost' of these deposits (by raising the appropriate cost of holding them). This drives a wedge between the marginal cost and the marginal earnings from deposit production. As a result, the price system directs resources away from what might have been the most productive use.

A system of subjecting a certain class of depository institutions to reserve requirements is not consistent with the principles of equity. The customers of banks subject to reserve requirements were taxed while the customers of other financial institutions were not. Historically the commercial banks were discriminatated against to the extent that only they were
subject to higher reserve requirements than other financial intermediaries performing similar functions.

There are also welfare consequences of bank innovations and disintermediation. The welfare consequences may arise because of the shrinkage of deposits below the socially optimal level and the consequent loss of the welfare triangle. Some of this may be offset by welfare gains from the development of substitutes for the traditional deposits.

The growth of international banking, to the extent that it has been induced by the implicit taxation of domestic banking, has the following welfare consequences:

1. Banks shift their banking business to offshore jurisdictions even though the social costs of intermediation in the offshore market exceed the social costs of intermediation in the domestic market. This is because financial intermediaries are not concerned with social costs. They compare private costs with private benefits. (Aliber, 1980).

2. If banks are forced to move abroad because of the reserve requirements tax, there may be a welfare loss through locational and currency diversions (Grubel, 1983). The incurring of extra costs of travel and communication and loss of employment opportunities at home are examples of locational costs. The currency diversion costs arise through additional exchange risk as lenders and borrowers are induced to denominate their business in foreign currencies.

3. There are additional costs due to induced instability and
growth of substitutes for traditional deposits. Sudden shifts of funds between offshore and domestic deposits might have a significant impact on the volume of credit because of the change in the effective reserve ratio. The relatively faster growth of international financial intermediation as compared to domestic financial intermediation has also given rise to fears of a worldwide 'credit explosion'. (Swoboda, 1982)

All these arguments and fears (some of them may be unfounded) have called for the imposition of controls on international banking. One way of approaching this problem is to reduce the cost advantages enjoyed by banks engaged in international banking. This implies, in other words, an harmonization of the implicit and explicit taxes affecting domestic and offshore activities of banks. Several recommendations have been suggested by economists to attain this objective. These are lower or zero reserve requirements, uniform reserve requirements on all depository institutions, interest payments on required reserves, interest payments on third party payments balances, and explicit charges for Federal Reserve Services. Benston (1982) discussed in detail the merits and demerits of these alternative measures. Of these the proposal of interest payments on bank reserves seems to be preferred by many economists and politicians for its associated advantages.

Interest payments on reserves have been defended on both efficiency and equity grounds. This would restore allocative
efficiency by narrowing or even eliminating the discrepancy between the marginal return and the marginal cost of deposit production. It would reduce the artificial wedge between the private and social profitability of offshore banking. It has the added advantage of contributing to the removal of the discrimination against domestic borrowers and lenders. It would also remove the discrimination against the commercial banks vis-a-vis other financial intermediaries. Since treasury revenue would fall by the amount of interest payment on reserves, the government would have to increase taxes. Thus one consequence of the payment of interest on reserves is that the burden of the tax will shift from the bank customers to the public.

9.3 Limitations of this study and suggestions for further research

First, the implicit taxes are measured and the empirical hypotheses are tested at the industry (sectoral) level rather than at the individual firm (bank) level. The reasons for this were explained in the introductory chapter. The decision to innovate is usually undertaken at the firm level. Therefore an interesting extension of the study would be to measure the tax burden of reserve requirements at the individual bank level using micro data.

Second, this study uses the simple model presented in Chapter Two to compute the tax burden of reserve requirements. This study does not use the more realistic models of bank
behaviour of Chapters Three and Four. The application of models of Chapters Three and Four require estimation of the industry supply function and the deposit withdrawal function. Further research can be done in these directions.

Third, this study does not estimate the demand functions for voluntary reserves that the banks would keep even if there are no reserve requirements. Rather it has taken an ad-hoc measure of the voluntary reserve holdings.

Fourth, no effort has been made to quantify the welfare loss of reserve requirements tax. This is not an easy task because the welfare loss depends on the development of substitutes for traditional bank liabilities. Development of each type of substitute has its own welfare implications. For example the growth of domestic substitutes may not have the same welfare implications as the growth of offshore banking. Also the costs and benefits of alternative policy recommendations should be measured to determine the appropriate set of policies.
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