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TIME SERIES ANALYSIS OF MORTGAGE CHOICE:
HISTORY. THEORY. AND METHODS

DISSERTATION

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

By

Mulya E. Siregar. M.S., M.S.

* * * * *

The Ohio State University
1998

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ABSTRACT

The main goal of this study is to have a better understanding of the factors that influence a borrower to choose a particular type of mortgage loan. This study incorporates history and theory with newer econometric methods in the time series analysis of mortgage choice. The Brueckner (1986) theoretical model of ARM-FRM choice provides the basic theoretical structure. This study shows that certain historical events profoundly impact Brueckner theoretical predictions.

The choice of mortgage loans is investigated from both the borrower's and lender's points of view. This study is based upon the fixed-adjustable interest rate spread influencing mortgage-choice model, the spread and other factors influencing mortgage-choice model, and interest-rate expectations influencing the fixed-adjustable interest rate spread model. Moreover, this study employs the switching-regression technique of Goldfeld and Quandt (1973) to examine whether there are any regime shifts or partitions in each of the three models. Then, unit-root tests are conducted on the series in each partition of a model. If the series are integrated of order one, co-integration tests are conducted in each partition of the model. Finally, when the series in each partition have long-run relationships, Granger causality tests are conducted.

Several conclusions were reached:
1. The spread positively influences the borrower to choose an ARM loan. However, the borrower does not always consider the spread in choosing an ARM loan, because certain historical events may lead the consumer to ignore the spread.

2. The empirical results show that the consumer confidence index and income growth positively influence the borrower to choose an ARM loan, while the affordability index has a negative impact on the choice of an ARM loan. However, these three factors, together with the spread, seem not to play a role in the choice of an ARM loan, when the U.S. economy is in recession.

3. The lender does not make any spread adjustments when interest-rate expectations change. In addition, neither the lender makes any spread adjustments when he or she observes changes in consumer choice.

4. The demand side appears to dominate the supply side of the mortgage market, as the borrower is responding to changes in spread and other factors, and the lender is not responding to changes in consumer choice and interest-rate expectations.
To My Mother. Father-in-law
Wife. Daughter. Son. and

to the Memory of My Father and Mother-in-law
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I am grateful to my Muslim and Indonesian friends with whom I developed a better understanding about my religion and a very close relationship during my stay in this nice city, Columbus. They are always very helpful for my family and me.

I would like thank my family, for their constant support during all this time. Special thanks to my mother, who motivated me to continue struggling to fulfill a commendable goal. Thanks also to my brothers and sisters for their confidence in me. My wife, Ratna, who has always been there for me, has been very supportive through the course of my Ph.D. program. All her strength during my uncertain steps and her endless support made
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Finally, thanks to Allah, the greatest and most merciful, without Allah’s permission this study could not have been completed. May Allah bless me to use this knowledge for a better world. Amen.
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# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABSTRACT</td>
<td>ii</td>
</tr>
<tr>
<td>DEDICATION</td>
<td>iv</td>
</tr>
<tr>
<td>ACKNOWLEDGMENTS</td>
<td>v</td>
</tr>
<tr>
<td>VITA</td>
<td>vii</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>xi</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>xii</td>
</tr>
<tr>
<td><strong>CHAPTERS:</strong></td>
<td></td>
</tr>
<tr>
<td>1. INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>1.1. Historical Development of Housing Finance</td>
<td>2</td>
</tr>
<tr>
<td>1.2. Dissertation Overview</td>
<td>19</td>
</tr>
<tr>
<td>2. REVIEW OF THEORETICAL AND EMPIRICAL LITERATURE</td>
<td>27</td>
</tr>
<tr>
<td>2.1. Theoretical Studies and the Framework for Mortgage Decisions</td>
<td>27</td>
</tr>
<tr>
<td>2.2. Cross Section Studies</td>
<td>53</td>
</tr>
<tr>
<td>2.3. Time Series Studies</td>
<td>63</td>
</tr>
<tr>
<td>2.4. Survey Studies</td>
<td>67</td>
</tr>
<tr>
<td>2.5. Other Studies</td>
<td>73</td>
</tr>
<tr>
<td>2.6. Summary</td>
<td>75</td>
</tr>
<tr>
<td>3. EMPIRICAL METHODS TO STUDY THE HISTORY OF MORTGAGE DECISIONS</td>
<td>81</td>
</tr>
<tr>
<td>3.1. Stationary Series</td>
<td>84</td>
</tr>
<tr>
<td>3.1.1. Hypothesis</td>
<td>84</td>
</tr>
<tr>
<td>3.1.2. Unit Root Tests</td>
<td>87</td>
</tr>
<tr>
<td>3.2. Long-run Relationship</td>
<td>92</td>
</tr>
<tr>
<td>3.2.1. Hypothesis</td>
<td>92</td>
</tr>
</tbody>
</table>
3.2.2. Co-integration Tests ................................................................. 93
3.3. Causality Relationship ................................................................. 96
  3.3.1. Hypothesis ............................................................................... 96
  3.3.2. Granger Causality Tests ......................................................... 97
3.4. Data .......................................................................................... 100

4. EMPIRICAL RESULTS .................................................................. 104
  4.1. Graphical Analysis of Mortgage Choice .................................... 106
  4.2. Spread Influencing Mortgage Choice ....................................... 111
  4.3. Spread and Other Factors Influencing Mortgage Choice .......... 119
  4.4. Interest Rate Expectation Influencing Spread Adjustment ........ 128

5. SUMMARY. IMPLICATIONS AND CONCLUSIONS ..................... 133
  5.1. Summary ................................................................................ 133
  5.2. Implications and Limitations .................................................. 139
  5.3. Conclusions ........................................................................... 143

APPENDICES
  A. Partition Months & Significance of Regime Shifts ...................... 145
  B. Critical Values .......................................................................... 154

LIST OF REFERENCE ................................................................. 157
## LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1 Summary of Previous Studies</td>
<td>78</td>
</tr>
<tr>
<td>3.1 Descriptive Statistics of Data, 1984-1996</td>
<td>102</td>
</tr>
<tr>
<td>4.1 Tests for Unit Root in ARM Share (AS) &amp; Fixed-Adjustable Interest Rate Spread (S)</td>
<td>115</td>
</tr>
<tr>
<td>4.2 Tests for Co-integration between ARM Share (AS) &amp; Fixed-Adjustable Interest Rate Spread (S)</td>
<td>116</td>
</tr>
<tr>
<td>4.3 Granger Causality Tests (based on first differences) between ARM Share (AS) &amp; Fixed-Adjustable Interest Rate Spread (S)</td>
<td>118</td>
</tr>
<tr>
<td>4.4 Tests for Unit Root in ARM Share (AS) &amp; Fixed-Adjustable Interest Rate Spread (S), Consumer Confidence Index (CCI), Affordability Index (AI) and Income Growth (IG)</td>
<td>122</td>
</tr>
<tr>
<td>4.5 Tests for Co-integration between ARM Share (AS) &amp; Fixed-Adjustable Interest Rate Spread (S), Consumer Confidence Index (CCI), Affordability Index (AI) and Income Growth (IG)</td>
<td>123</td>
</tr>
<tr>
<td>4.6 Granger Causality Tests (based on first differences) between ARM Share (AS) &amp; Fixed-Adjustable Interest Rate Spread (S), Consumer Confidence Index (CCI), Affordability Index (AI) and Income Growth (IG)</td>
<td>126</td>
</tr>
<tr>
<td>4.7 Tests for Unit Root in Fixed-Adjustable Interest Rate Spread (S) &amp; Interest Rate Expectation (IRE)</td>
<td>130</td>
</tr>
<tr>
<td>4.8 Tests for Co-integration between Fixed-Adjustable Interest Rate Spread (S) &amp; Interest Rate Expectation (IRE)</td>
<td>131</td>
</tr>
<tr>
<td>B.1 Dickey-Fuller Critical Values for Unit Root Tests</td>
<td>155</td>
</tr>
<tr>
<td>B.2 Engel-Granger Critical Values for Co-integration Tests</td>
<td>156</td>
</tr>
</tbody>
</table>
LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>FRM &amp; ARM Rates, 1949-1996</td>
<td>7</td>
</tr>
<tr>
<td>1.2</td>
<td>Monthly Share of ARM Origination, 1984-1996</td>
<td>20</td>
</tr>
<tr>
<td>1.3</td>
<td>Monthly Fixed-Adjustable Interest Rate Spread, 1984-1996</td>
<td>21</td>
</tr>
<tr>
<td>1.4</td>
<td>Monthly Interest Rate Expectation, 1984-1996</td>
<td>21</td>
</tr>
<tr>
<td>1.5</td>
<td>Monthly Fixed-Adjustable Interest Rate Spread &amp; ARM Share, 1984-1996</td>
<td>23</td>
</tr>
<tr>
<td>1.6</td>
<td>Monthly Interest Rate Expectation &amp; Fixed-Adjustable Interest Rate Spread, 1984-1996</td>
<td>24</td>
</tr>
<tr>
<td>2.1</td>
<td>The Impact of Increase in Discount Rate on Mortgage Choice</td>
<td>47</td>
</tr>
<tr>
<td>2.2</td>
<td>The Impact of Increase in Income Growth on Mortgage Choice</td>
<td>48</td>
</tr>
<tr>
<td>2.3</td>
<td>The Impact of Increase in Interest Rate Expectation on Mortgage Choice</td>
<td>52</td>
</tr>
<tr>
<td>3.1</td>
<td>Level Form &amp; First Difference of Monthly ARM Share, 1984-1996</td>
<td>85</td>
</tr>
<tr>
<td>3.2</td>
<td>Level Form &amp; First Difference of Monthly Fixed-Adjustable Interest Rate Spread, 1984-1996</td>
<td>85</td>
</tr>
<tr>
<td>3.3</td>
<td>Level Form &amp; First Difference of Monthly Consumer Confidence Index, 1984-1996</td>
<td>86</td>
</tr>
<tr>
<td>3.4</td>
<td>Level Form &amp; First Difference of Monthly Affordability Index, 1984-1996</td>
<td>86</td>
</tr>
<tr>
<td>3.5</td>
<td>Level Form &amp; First Difference of Monthly Income Growth, 1984-1996</td>
<td>87</td>
</tr>
<tr>
<td>3.6</td>
<td>Level Form &amp; First Difference of Monthly Interest Rate Expectation, 1984-1996</td>
<td>87</td>
</tr>
</tbody>
</table>
4.1 Monthly Consumer Confidence Index & ARM Share, 1984-1996 ..................... 108
4.2 Monthly Income Growth & ARM Share, 1984-1996 ................................. 109
4.3 Monthly Affordability Index & ARM Share, 1984-1996 .............................. 110
A.1 Total SSE to Locate Partition Month of AS & S Relationship and F-value to Verify Significance of Regime Shift in January 1984 - December 1996 .......... 146
A.2 Total SSE to Locate Partition Month of AS & S Relationship and F-value to Verify Significance of Regime Shift in January 1984 - July 1987 ..................... 147
A.3 Total SSE to Locate Partition Month of AS & S Relationship and F-value to Verify Significance of Regime Shift in August 1987 - December 1996 ............... 148
A.4 Total SSE to Locate Partition Month of AS & S, CCI, AI and IG Relationship and F-value to Verify Significance of Regime Shift in January 1984 - December 1996 ................................................................. 149
A.5 Total SSE to Locate Partition Month of S & IRE Relationship and F-value to Verify Significance of Regime Shift in January 1984 - December 1996 .............. 150
A.6 Total SSE to Locate Partition Month of S & IRE Relationship and F-value to Verify Significance of Regime Shift in January 1984 - May 1995 ......................... 151
A.7 Total SSE to Locate Partition Month of S & IRE Relationship and F-value to Verify Significance of Regime Shift in June 1987 - May 1995 ......................... 152
A.8 Total SSE to Locate Partition Month of S & IRE Relationship and F-value to Verify Significance of Regime Shift in June 1989 - May 1995 .......................... 153
CHAPTER 1

INTRODUCTION

Homeownership is a common financial goal of households (Kapoor, Dlabay and Hughes, 1996) and it is a part of the American Dream. Based on a 1994 Federal National Mortgage Association (FNMA) survey, most Americans (86%) believe that they will be better off if they own a home. About 74% believe that one should buy a home as soon as one can afford it whether or not one is married or has children. To reach this dream, most rely on external funds from lenders such as thrift institutions, commercial banks, and mortgage companies. In addition, housing expenditure is about 40 percent of disposable income, and is an extremely important component of personal finance (Garman and Forge, 1997).

A household’s decision on how much income to allocate for housing and other consumption expenditures is influenced by the type of mortgage loans, interest rates, and non-price terms such as loan size, payment to loan value ratio and some household characteristics and resources. The decision to choose a fixed rate mortgage (FRM) or adjustable rate mortgage (ARM) loans has an important effect on a household’s financial health. For many households, this decision impacts their largest financial transaction (Lino, 1987).
Many studies have been conducted to identify the factors affecting consumers' choice of a mortgage loan type. This study will examine the factors that influence the borrowers' decision when choosing a mortgage loan. Unlike most previous studies, this study examines factors from both the borrower and lender perspectives. Before examining these factors, it is important to know the historical development of housing finance, as housing finance has a rich history with many changes in market structure, economic trends, demographics and consumer policy / banking regulations. Therefore, this chapter is divided into two sections. Section 1 briefly describes the historical background of housing finance in America. The second section overviews and discusses the objective of the dissertation.

1.1. Historical Development of Housing Finance

This section describes the background of government involvement in housing and mortgage markets, the introduction of adjustable rate mortgage (ARM) loans and the volatility of mortgage choice. Moreover, this section shows that the changes in government policy, economic trends, demographic structure and certain historical events may influence the housing and mortgage markets. The historical background of housing finance spans from 1880 to 1996. Before the 1930s, the U.S. government was not really involved in housing and mortgage markets. Public intervention in the housing sector was limited to selling surplus government land, regulating building location and design, and maintaining minimum standards of safety and health.

The average housing production rate, which is the percentage of housing starts plus mobile home shipments or placements to estimated housing stock, was relatively high at
3.06% from 1880 to 1928. Except for World War I, when the rates only reached from 0.67 percentage to 1.38%. After the war, the rate of housing production increased again to reach a peak at 4.51% in 1923. Until 1928 the rates never dropped below 3%.

Therefore, estimated housing stock grew from 6.2 million units in 1880 to 24.8 million units in 1928. On the other hand, mortgage debt increased from $2.0 billion in 1880 to $27.2 billion in 1928. The rise of mortgage debt particularly happened after World War I, as mortgage debt increased almost three fold from $9.4 billion in 1920 to $27.2 billion in 1928. After the war, real income increased so that borrowers were more willing to take the burden of a mortgage loan. Then, the average annual increase of housing stock reached a high level at 839 thousand units in the period from 1920 to 1928. In addition, the home ownership ratio increased from 40.9% in 1920 to 45% in 1928.

From 1921 to 1928, the increase in housing stock (6.7 million units) was more than household formation (4.7 million units); consequently, the housing market was oversupplied. One of the factors that caused the stock market crash in 1929 was the collapse of the real estate market (Mitchell, 1985). Oversupply in the housing market in the years preceding the crash led to the collapse of the real estate industry as investment in the housing sector quickly decreased. Lower investment in the housing sector can be observed in declining housing starts and lower production rates. Housing starts and the

---

1 All the data up to 1990 including production rate, housing stock, housing starts, mortgage debt, non-farm disposable income, population growth, number of households and home ownership ratio are calculated from or based on Table A, B, C and E. In Mason C. Doan (1997), American Housing Production 1880-2000: A Concise History (pp. 182-188). Lanham, MD: University Press of America.
production rate were 937 thousand units and 4.4% in 1925, then decreased to 509 thousand units and 2.0% in 1929.

The real estate industry bottomed out in 1933 with housing starts and production rate at 93 thousand units and 0.34 percentage, respectively. The great depression brought down total disposable personal income of non-farm households from $74.9 billion in 1928 to $45.1 billion in 1932 and raised the unemployment rate\(^2\) from 2% in 1926 to nearly 30% in 1932. Since the disposable personal income of non-farm households decreased, the burden of mortgage debt increased from 36.3% in 1928 to 60.8% in 1932. Thus, many borrowers experienced loan default, and home ownership decreased to 40% in 1932. These situations became worse as savers withdrew their deposits from financial institutions, especially from savings and loan institutions. Consequently, many financial institutions failed. These situations led the federal government to become involved in the housing and mortgage markets. The involvement of the federal government in the housing and mortgage markets was known as the New Deal of the housing system.

The major characteristics of the New Deal of the housing system in the United States can be summarized as follows:

1. The Federal Home Loan Bank Act was introduced to establish the Federal Home Loan Bank Board (FHLBB) in 1932. This Act separated housing finance from commercial and other business banking. Moreover, this act authorized FHLBB to supervise and support home lending institutions, such as federally chartered savings

and loan associations (S&Ls) and mutual savings banks (MSBs), commonly known as thrift institutions. This act was the first clear sign that the government was willing to become involved in housing through mortgage markets.

2. The Home Owners’ Loan Act was passed to create the Home Owners’ Loan Corporation (HOLC) in 1933 to lend directly to homeowners who faced difficulty to fulfill their obligation and refinance their mortgage debts. The HOLC loans were the foundation of modern mortgage loans as the terms of loans consisted of a fixed-interest rate, level payment, and self-amortizing mortgages that required an 80% loan-to-value ratio.

3. The National Housing Act introduced the Federal Housing Administration (FHA), the Federal Savings and Loan Insurance Corporation (FSLIC) and a secondary market in 1934. The FHA provided warranty to insure lenders against mortgage loan default so that the lender was encouraged to provide loans to the borrowers. The FSLIC insured deposits in S&Ls to encourage savers to provide funds for housing finance. Finally, nationally chartered mortgage associations were authorized to purchase FHA insured mortgages in the secondary market. Later in 1938, the federal government created the Federal National Mortgage Association (FNMA) to promote secondary mortgage markets.

This New Deal of the housing system helped the housing industry to recover as the production rate started to increase from the lowest rate of 0.34 percent in 1933 to 0.46 percent in 1934, continuously increasing up to 2.18% in 1941. Moreover home ownership increased to 41% and as disposable income increased, the burden of mortgage debt decreased to 27.8% in 1941. In the period of World War II from 1942 to 1945, the
production rate decreased to the range between 0.43 percentage and 1.12%. Housing production decreased during the war because construction materials, financial capital, and skilled labor were allocated to the war effort (Pozdena, 1988). During the war period, income increased and migration from rural to urban areas increased; consequently, demand for housing increased. As the burden of mortgage debt decreased to 17.6% due to higher income, home ownership increased to 50.8% in 1945.

After the war, the New Deal worked well until the mid-1960s. Mortgage debt increased more than ten-fold from $24.3 billion in 1945 to $257.7 billion in 1965. The average annual increase of housing stock, production rate and housing starts were 1.4 million units, 3.44% and 1.6 million units, respectively. Then, housing stock increased by 28.1 million units and homeownership ratio increased from 50.8% in 1945 to 61% in 1965. The period from 1946 to 1965 was known as the period of high housing demand as most of the time unemployment rates were below 5% and economic growth per capita was around 3% per year. Moreover, the FRM interest rates were relatively stable in the range of 4% to 6.2% from 1949 to 1965, as can be seen in Figure 1.1. In addition, demographic factors also played a role on this high housing demand. During this period, the average population growth was high, above 2% per year. On the other hand, household size declined from 3.62 in 1945 to 3.34 in 1965 and migration from farm areas increased during this period of stability and prosperity of the economy.

Because of the credit crunch of 1966, however, the increase of housing stock, production rate and housing starts decreased to 1.1 million units, 2.24%, and 1.4 million units, respectively. Two factors were important in the credit crunch of 1966. Firstly, since 1952, the share of mortgage loans by other financial institutions such as commercial
banks and life insurance companies reduced as they shifted their investment to other more attractive assets. Secondly, Regulation Q was also applied to thrift institutions since FHLBB set the interest rate ceiling on deposits in 1966.

![Graph of FRM and ARM Rates, 1949-1996](image)

**Sources:**
3. 1984-96 ARM from Federal Housing Finance Board.

**Figure 1.1: FRM and ARM Rates, 1949-1996**
The share of mortgage loans by commercial banks and life insurance companies decreased from 41.3% in 1951 to 40.7% in 1952 and continuously decreased to 32.3% in 1966. Meanwhile, thrift institutions' share of mortgage loans increased from 31% in 1952 to 45.4% in 1966. This situation occurred because commercial banks and life insurance companies shifted their investments to other investment alternatives as the yield of other investment alternatives, such as corporate bonds and treasury securities, started to increase in 1951. On the other hand, the thrift institutions did not face the same alternatives. The situation became worse for thrift institutions, as in late 1965, the Federal Reserve administered tight money policy to fight the rising inflation rate due to larger federal spending to finance the Vietnam War and many domestic programs. As the tight money policy pushed interest rates higher, other financial assets became more attractive than fixed rate mortgage loans. Then, other financial institutions abandoned the mortgage market; consequently, the average growth of outstanding residential mortgage debts decreased from 10.7% during the 1951-1965 period to only 6.7% in 1966.

Because of the deposit rate ceiling, the interest rate of deposits did not reflect the market rate; thus, depositors withdrew their deposits from thrift institutions. Thrift institutions could not have any saving deposit options, but other financial institutions had more deposit instruments to offer. Then, depositors put their savings in other financial institutions. Consequently, the share of S&L associations on household saving deposits decreased from 46% during the 1951-1955 period to 11% in 1966.5

5 Calculated from Table B-76. Mortgage debt outstanding by holder, 1945-1997. in Economic Report of the President. 1998. This source is also used for other years. 
Therefore, housing finance was more dependent on thrift institutions, but thrift institutions had less ability to attract funds. As a result of the credit crunch of 1966, thrift institutions could not function as a financial intermediary and housing finance experienced the disintermediation (the process whereby financial institutions fail to mobilize funds from savers and lend these funds to borrowers). Hence, this condition drove housing production into a more unstable condition.

Because of the credit crunch, thrift institutions had limited funds for housing finance. Since 1966, the FRM interest rate started to increase from 5.46% in 1965 to 6.29% in 1966 and continued up to 8.45% in 1970, particularly because thrift institutions cannot compete based on price. Thrifts applied non-price competition by offering better service, longer office hours, and larger offices and gifts for customers; consequently, the cost of funds increased. However, the average annual increase of housing stock, production rate and housing starts still reached high levels at 1.6 million units, 3.22% and 2.2 million units during the 1967-1973 period. Then, the homeownership ratio increased to 62% in 1973. The government involvement was the most important factor to influence this high production. Based on the Housing and the Urban Development Act of 1968, the government subsidized housing finance for low and moderate-income households. Moreover, the government promoted the secondary mortgage market by introducing the Government National Mortgage Association (GNMA) to carry out functions and operations of the former FNMA and modifying FNMA as a quasi-private corporation to conduct secondary market operations.

Later in 1970, the government introduced the Federal Home Loan Mortgage Corporation (FHLMC) as a quasi-private corporation to conduct secondary market
operations for conventional loans. Therefore, government subsidies and funds from secondary markets, which financed housing activities, boosted housing production during the 1967-1973 period and brought down FRM interest rates to 7.74% and 7.60% in 1971 and 1972, respectively.

Although mortgage debts increased from $501 billion in 1973 to $1.107 billion in 1980, this increase did not match the rising demand for housing and mortgage loans. The rising demand for mortgage loans along with disintermediation of housing finance caused the FRM interest rates to reach double digits (10.78%) for the first time in 1979 and 12.66% in 1980. Three things caused the high demand for mortgages during this period. First, household formation was greater than the increase of housing stock during the 1974-80 period. Secondly, baby boomers started entering the mortgage market in this period as the 25- to 34-year old group composed 39.4% of household formation and the 35- to 44-year old group composed 18.1% of household formation. Thus, 57.5% of household formation was composed of 25 through 44 year olds during this period. Finally, another factor that influenced a higher demand in this period was that housing investment became more attractive than fixed-return financial assets during the period of high inflation. All these factors led more households to purchase houses and consequently, homeownership reached 64% in 1980.

Furthermore, the annual average increase of housing stock climbed from 1.6 million units during the 1967-1973 period to 1.7 million units during the 1974-1980 period, while average housing starts decreased from 2.2 million units to 1.8 million units. Therefore, 

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5 Calculated from Table HH-3. Households, by Age of Householder: 1960 to Present. U.S. Bureau of the Census, Internet release date: July 3, 1997. This source is also used for other years.
the average production rate decreased from 3.22% to 2.30%. The decrease of housing starts was particularly due to declining mobile home placements and multifamily housing starts during the 1974-1980 period.

A factor that might have decreased multifamily housing starts was the declining government subsidy for this type of housing unit. At the same time, the disintermediation in mortgage markets continued as the inflation rate continuously increased and there were no major changes in the housing finance system until March 1980, when the Depository Institutions Deregulation and Monetary Control Act (DIDMCA) was enacted. Before Congress passed DIDMCA, financial institutions, especially thrift institutions, tried to introduce new deposit instruments such as money market mutual funds and money market certificates to circumvent interest rate controls. On the portfolio side, several thrift institutions in California introduced the variable rate mortgage (VRM) loan, which later became known as the adjustable rate mortgage (ARM) loan, to overcome the impact and risk of rising inflation rates. The introduction of these innovations was known as a "silent revolution" because thrift institutions introduced those instruments before new legislation was issued. Furthermore, thrift institutions paid higher rates on new deposit instruments. While the fixed-return of thrift institutions from existing mortgage loans was often lower than the deposit rate, profitability decreased and they started facing financial problems.

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In the early 1980s, several policies changed the housing finance system that had prevailed since the 1930s. In 1980, Congress enacted DIDMCA to de-regulate the housing finance system. The major features of DIDMCA can be summarized as follows:

1. Ceilings on deposit rates were removed on a gradual basis that stretched out to March 31, 1986.

2. Thrift institutions had more portfolio options.

3. Thrift institutions had more liability powers, as they had new sources of money.

4. Financial institutions could expand the number of alternative mortgage instruments.

Moreover, in March 1981, the Comptroller of the Currency (COC) set specific guidelines for national banks to provide ARM loans. A month after that in April 1981, FHLBB also approved federally chartered thrift institutions to offer ARM loans. Then, in 1982, the Garn-St. Germain Depository Institutions Act was enacted to authorize thrift institutions to have more banking powers / portfolio options, allowing thrifts to offer a competitive money market deposit account. All these policies de-regulated the housing finance system so that thrift institutions had more power to compete.

However, de-regulation did not improve housing and mortgage market conditions as the Federal Reserve again applied tight monetary policy in 1981 and 1982 to attack the rising inflation that continued from the preceding period. A higher prime rate caused a higher deposit rate, economic slow downs, rising unemployment rates, and declining median real household incomes. Moreover, money market mutual funds were more attractive than saving deposits. Then, before the Depository Institutions Act was enacted in 1982, households moved their savings from thrift institutions to other depository institutions that offered money market mutual funds. Consequently, thrift
institutions had less available funds for mortgage loans and their profitability decreased as they experienced negative net income. In the early 1980s, more than a thousand unhealthy thrifts were merged. At the same time, the Reagan administration started reducing subsidies in the housing sector. As a result, mortgage debt growth decreased from 11.9% per year in the 1970s to 7.5% and 4.9% in 1981 and 1982, respectively, followed by a decreasing production rate to 1.52% and 1.47% in 1981 and 1982.

In 1983, the Federal Reserve started to release its tight money policy as it succeeded in bringing down the inflation rate from 13.5% in 1980 to 3.2% in 1983. Looser monetary policy and the Depository Institution Act of 1982 created a good environment for thrift institutions to compete to mobilize funds and channel mortgage loans. As they were able to mobilize funds, the mortgage interest rate started to decrease from 15.14% in 1982 to 12.57% in 1983 and continued to decrease to 9.19% in 1988. Then, mortgage debt growth increased from 4.9% in 1982 to 11.6% in 1983 and continued to increase up to 13.3% in 1987. During the 1983-1986 period, the average annual increase of housing stock, production rate, and housing starts increased to 1.8 million units, 2.18%, and 2.0 million units, respectively. Furthermore, as mortgage interest rates started to decrease and borrowers had alternative mortgage choices, borrowers displayed a preference for ARM loans. The share of ARM loans increased to high levels at 68% in August 1984. However, the ARM share decreased to 21% in June 1986 although mortgage interest rates continued to decrease.

During the 1987-1990 period, the financial health of thrift institutions became worse because competitive climates drove thrift institutions to engage in risky behavior. As interest rate ceilings on deposits were removed, thrift institutions aggressively offered higher deposit rates; hence, they had a higher cost of funds. On the other side, they did not utilize all portfolio options. Furthermore, as the size of federally insured deposits increased from $40,000 to $100,000, the scale of funding mismatch on thrifts' balance sheets increased (Hu, 1992). On the other hand, thrifts had to screen ARM borrower more accurately given the fact that more risk was being taken by the borrower. However, the way thrifts channeled adjustable-rate mortgage loans was the same as they channeled fixed-rate mortgage loans. Therefore, the ARM share, which may represent borrower preference, increased again to reach its highest level at 69% in December 1987. Besides, mortgage-insurance companies failed to screen qualified borrowers for any specific type of mortgage loans. In short, thrift institutions and mortgage insurance companies did not function as prudent financial institutions. Consequently, they made loans with greater danger of default and thrift institutions faced financial losses as much as $38 billion in this period (Doan, 1997). At the end of 1990, as oil prices climbed, the U.S. entered the recession era, which made things worse.

As inflation started increasing again in early 1987, the Federal Reserve increased the Federal Funds rate from 6.66% in 1987 to 7.57% in 1988 and 9.21% in 1989, then it decreased to 8.10% in 1990. Then, the interest rate of FRM and ARM increased from

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9.19% and 8.51% in 1988 to 10.13% and 9.44% in 1989, then later it decreased to 10.05% and 8.26% in 1990, respectively. With higher interest rates, the growth of mortgage debt started to decrease to 9.9%, 9.2%, and 6.2% in 1988, 1989, and 1990, respectively. The average annual increase of housing stock, production rates, and housing starts decreased to 1.5 million units, 1.65%, and 1.6 million units, respectively.

Overall, between 1981 and 1990, the housing market weakened as the increase in housing stock, which was 16.3 million units, was higher than household formations, which was only 13.0 million units. Another factors that caused a lower demand for housing was that the number of first-time homebuyers decreased from 4.9 million units during the 1974-1980 period to 2.0 million units during the 1981-1990 period. Those between the ages of 25 and 34 composed only 16.0% of household formation. Although the percentage of the 35- to 44-year old group increased to 52.3% of household formation, this group did not have much impact on demand for housing because it had already passed the age of typical first-time homebuyers. However, this group contributed to the increase in housing prices as its members usually were the “housing upgraders” (Hu, 1992). With better income, this group required better quality of houses, which raised the relative price of houses during this period. Another factor that weakened housing demand was the declining median real income in 1981 and 1982 as inflation rates increased, and it never recovered until the end of 1990.10

To restore the housing finance system, Congress passed the Financial Institutions Reform, Recovery, and Enforcement Act (FIRREA) in August 1989. The main objectives of this act were closing and merging insolvent thrift institutions and decreasing the

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number of insolvent institutions in the future. Many agencies were replaced and reorganized to provide capital and organization for closing and merging the thrifts.

First, the Office of Thrift Supervision (OTS), which replaced the FHLBB, charters thrifts and sets capital standards for thrifts to operate. Second, an independent Federal Housing Finance Board (FHFB) was created to supervise the operation of FHLBs in twelve districts. Third, the Resolution Trust Corporation (RTC) replaced the bankrupt FSLIC, would operate to manage assets and liabilities owned by insolvent thrift institutions. Later, the RTC was replaced by the Savings Association Insurance Fund (SAIF) in 1992. In addition, this act determined more restrictive investment regulations that thrift institutions have to follow. Consequently, this act would reduce the number of thrift institutions.

As the recession continued, the average unemployment rate increased from 5.6% during the 1987-1990 period to 7.1% during the 1991-1993 period and average income growth decreased from 4.6% during the 1987-1990 period to 1.5% between 1991 and 1993. Higher unemployment rates and lower income growth led first-time homebuyers to postpone purchasing a house. Although FRM and ARM interest rates decreased from 10.05% and 9.15% in 1990 to 7.20% and 5.74% in 1993, respectively, demand for housing and mortgage loans weakened. Then, average mortgage debt growth decreased from 9.6% during the 1987-1990 period to 3.9% between 1991 and 1993. Moreover, although the government tried to stimulate first-time homebuyers by giving tax breaks and penalty-free use of Individual Retirement Account funds as down payments on homes during this period, the housing industry could not recover. Consequently, the
average annual increase of housing stock, production rate, and housing starts decreased to 1.1 million units, 1.33%, and 1.4 million units in this period, respectively.

In 1994, as the inflation rate started to increase again, the Federal Reserve increased the Federal Funds rate from 3.02% in 1993 to 4.21% in 1994 and up to 5.83% in 1995. Later, it decreased to 5.30% in 1996. Then, the FRM and ARM interest rates increased from 7.20% and 5.74% in 1993 to 7.49% and 6.42% in 1994 and 7.87% and 7.13% in 1995. Finally, the interest rate of FRM and ARM decreased to 7.80% and 7.06% in 1996. Although mortgage interest rates had the tendency to rise, demand for mortgage loans increased as indicated by increasing mortgage debt growth from 3.9% during the 1991-1993 period to 5.6% between 1994 and 1996. This means that the housing industry started to recover during this period. This happened because the economy recovered as the average unemployment rate decreased from 7.1% between 1991 and 1993 to 5.7% between 1994 and 1996 and average income growth increased from 1.48% during the 1991-1993 period to 4.6% during the 1994-1996 period. Lower unemployment and higher income growth increased demand for mortgages. Consequently, the housing industry moved again as the average annual increase of housing stock, production rates, and housing starts increased to 1.5 million units, 1.55%, and 1.7 million units during this period.

Overall, between 1991 and 1996, demand for housing continuously weakened as household formation, which was only 6.3 million units, was lower than the increase in housing stock, which was 7.8 million units. Moreover, first-time homebuyers who were in the 25- to 34-year old bracket did not contribute to household formation in this period.

Instead, household formation was dominated by baby boomers, who were in the range of 35- to 54-year old range. Their contribution to household formation reached its highest percentage at 98.1%. Therefore, the average annual increase of housing stock, production rate, and housing starts decreased to 1.3 million units, 1.44%, and 1.6 million units, respectively. Then, average growth of mortgage debt decreased to only 3.95% per year. Unlike the previous two decades, baby boomers were not the driving force of demand for housing and mortgage loans in the 1990s. In fact, at their age, baby boomers became a surplus unit who would be suppliers of lendable funds. Supply of lendable funds would increase; thus, higher lendable funds would bring down the mortgage interest rate as it went down from 10.05% in 1990 to 7.20% in 1994. Although mortgage interest rates decreased, the ARM share did not increase. In fact, the ARM share decreased to 15% in February 1992. Then later it increased again to 59% in January 1995 and finally decreased to reach its lowest level at 14% in February 1996. Furthermore, for the first time since the 1930s, thrift institutions were less dominant in channeling mortgage loans as the average share of mortgage debt was only 14.3% per year during the 1991-1996 period. During this period, funds from secondary mortgage markets and commercial banks dominated housing finance as their average shares of mortgage debt were 38.9% per year and 22.4% per year, respectively. Finally, this structural change of mortgage debt occurred because the number of thrift institutions decreased due to FIRREA of 1989.

In conclusion, this historical background, shows that the level of housing production was very likely related to housing finance policy, as well as economic and demographic developments. Furthermore, thrift institutions had to be more efficient,
competitive and prudent to constantly support housing programs during the de-regulation
era. The existence of ARM loans reduced the sensitivity of the housing market to interest
rate volatility because both lenders and borrowers now had an option. On the other hand,
it is interesting to observe that the ARM share was volatile and it seems that this volatility
was not only caused by mortgage interest rates. This indicates that factors other than
mortgage interest rates influenced changes in borrower choice of mortgage type. Finally,
as the mortgage market become integrated into the capital market, the sources of funds
for housing finance will not depend only on saving deposit inflows; therefore, housing
finance may be more stable in the years to come.

1.2. Dissertation Overview

Since 1981, ARM loans have been an alternative loan for housing finance. In
August 1984, ARM choice represented by a share of ARM loan (AS) in the mortgage
market reached 68%, then decreased to 21% by June of 1986, and increased again to
reach its highest level at 69% in December of 1987. This share swung down to a low of
15% in February 1992, and rebounded again to 59% in January 1995. Then, it reached its
lowest level at 14% in February of 1996. This volatile series is depicted in Figure 1.2.

The fluctuation of ARM shares indicates the type of mortgage loans that borrowers
have preferred during the last 13 years. Several studies have been conducted to identify
the factors affecting consumers’ decision in choosing a mortgage loan type. These studies
have mainly focused on the impact of borrower, price, and market characteristics on
mortgage choice. The borrower characteristics include age, family size, education level,
race, employment status, length of stay in the home, marital status, risk aversion, income,
wealth, and net worth. Price characteristics include mortgage interest
rates, interest rate expectations, inflation and fixed-adjustable interest rate spreads. Market characteristics refer to property tax rates, housing demand and housing prices.

![Figure 1.2: Monthly Share of ARM Origination, 1984-1996](image)

Price characteristics, which include mortgage interest-rates, and interest rate expectations have been as volatile as the ARM share (AS) series. Figures 1.3 and 1.4 depict the extreme volatility of the spread between fixed and adjustable interest rates (S) and interest rate expectation (IRE) series. The IRE series is substituted by the slope of the yield curve defined as the difference between the yield on thirty-year and one-year Treasury Securities.
Figure 1.3: Monthly Fixed-Adjustable Interest Rate Spread. 1984-1996

A steeply positive yield curve can be an outcome from expectations of rising interest rates or from a higher risk premium for interest rate uncertainty. This yield curve indicates that investors ask a higher premium for longer-term investment. Such a yield curve can be a signal for mortgage lenders to offer attractive ARM loans by setting a
larger premium or spread between fixed and adjustable interest rates because lenders expect interest rates will rise in the future.

Most of the earlier research found that the fixed-adjustable interest rate spread was the most important factor that influenced mortgage choice. In addition, most previous studies examined factors that influence mortgage choice only from the borrower’s side. Therefore, these previous studies treated the spread as an exogenous effect on mortgage choice. These studies did not consider the lender, who in fact may influence the borrower’s decision. However, Devaney (1994) and Jones et al. (1995) considered the spread as a factor that indirectly influences the borrower’s choice; therefore, these two studies used the spread as a dependent variable. They argued that the lender might adjust the interest rate spread to avoid declining returns as the lender observes changes in the interest rate expectation and ARM share. Devaney (1994) focused only on the impact of ARM share on the interest rate spread, while, Jones et al. (1995) considered both the effects of interest rate expectation and ARM share on the interest rate spread. In addition, Jones et al. observed the direct and indirect effects of the spread on mortgage choice by placing the spread as an independent and a dependent variable. In other words, Jones et al. examined the effect of the spread on mortgage choice from both the borrower’s and lender’s sides.

Superimposing Figures 1.2 and 1.3 produces Figure 1.5. The series definitely do not appear to be drifting apart over the 13-year period. The ARM share and fixed-adjustable interest rate spread series appear to be moving in tandem except from January 1984 to early 1985 and the beginning of 1990s to mid 1994. Figure 1.5 shows that the AS and S series had a strong relationship from early 1985 to the end of the 1980s and from
mid 1994 to the end of 1996. Therefore, the borrower's choice of mortgage (represented by the ARM share) and fixed-adjustable interest rate spread appear as though they have a close long-run relationship. Based on Figure 1.6, it seems that the fixed-adjustable interest rate spread and interest rate expectations have a close long-run relationship as well, except from early 1987 to the end of the 1980s and from the early 1990s to early 1995. In many ways, this study can be described as a close investigation of these important economic series, and the testing of any long-run relationship that may exist between them.

Figure 1.5: Monthly Fixed-Adjustable Interest Rate Spread & ARM Share, 1984-1996
Figure 1.6: Monthly Interest Rate Expectation & Fixed-Adjustable Interest Rate Spread, 1984-1996

Since these series appear to have close relationships, this study investigates mortgage choice not only from the borrower's side but also from lender's side. The investigation from the borrower's side, which is designated as a mortgage choice model, is reviewing whether the spread influences the borrower in choosing a mortgage loan. In addition, this study also investigates whether other factors together with the spread have impact on mortgage choice. On the other hand, the investigation from the lender's side, which is specified as a spread adjustment model, is discussing whether interest rate expectation influences lenders in adjusting the spread offered to borrowers.

The main goal of this study is to have a better understanding of mortgage choice. In trying to reach that goal, this study incorporates history, theory and methods in the time series analysis of mortgage choice. By studying history of housing finance, this
study may show that certain historical events may affect a theoretical prediction. Using Brueckner (1986) theoretical model of ARM-FRM choice and understanding certain historical events, this study may show that consumers may not always behave according to expectations based on this theory. Moreover, the method of analysis that best incorporates history and data on mortgage decisions involves unit root and co-integration tests. These methods avoid making any conclusions from non-stationary series and spurious regressions. In addition, Granger causality tests are also used to show whether certain variables have 'causal' relationships. Finally, this study may provide feedback to all sides such as borrowers, lenders, policy makers and researchers.

This study has several purposes to achieve the main goal. Since the strengths of the relationships may not stabilize during the period of observation, and the historical events described in the previous section may affect the stability of the models, the first purpose of this study is to examine the stability of mortgage choice and spread adjustment models. The second purpose is to examine the stationarity of economic series in the models. The third purpose is to investigate whether there is a long-run relationship between mortgage choice and the spread, between mortgage choice and the spread together with other factors, and between spread adjustment and interest rate expectation. The fourth purpose is to investigate whether consumers are more responsive to price and changes in other factors, or if prices are more responsive to consumer choices and change in interest rate expectation.

The remainder of this study consists of four chapters that are organized as follows. Chapter 2 reviews the theoretical and empirical literature of mortgage choice. Chapter 3 describes the empirical methods for the time series analysis. In chapter 4, the
empirical results are shown. Finally, chapter 5 shows the summary, conclusions and implications of this study.
CHAPTER 2

REVIEW OF THEORETICAL AND EMPIRICAL LITERATURE

This chapter reviews previous studies on mortgage choice. These include theoretical pieces as well as empirical work with cross section and time series data sets. Survey and other approaches to the home financing decision are also reviewed. The chapter is divided into six sections. The first section summarizes four theoretical models of mortgage choice from Yohannes (1991), Smith (1987), Alm and Follain (1987), and Brueckner (1986). The second section discusses various cross-section studies of mortgage choice. The third section includes a discussion of time-series studies and the fourth and fifth sections discuss several surveys and other studies, respectively. Finally, section six summarizes the findings in the existing literature.

2.1. Theoretical Studies and the Framework for Mortgage Decisions

Yohannes (1991) used the present value framework and the term structure of interest rates, together with the worst-case scenario approach to simplify the choice between an adjustable-rate mortgage (ARM) and a fixed-rate mortgage (FRM). Smith (1987) used a single-period framework to analyze the impact of various factors on the consumer’s decision to choose either a fixed-rate or an adjustable-rate contract. Using a
two-period uncertainty framework, both Alm & Follain (1987) and Brueckner (1986) developed theoretical models of consumer choice in the market for adjustable-rate and fixed-rate mortgages. They both executed a comparative static analysis to determine the optimal mortgage choice. However, they took different approaches to solve the mortgage choice problem. Alm & Follain treated the mortgage choice problem as a discrete choice, while Brueckner framed it as an ongoing choice. This section reviews these theoretical studies that used a single-period framework, a present-value framework, and a two-period uncertainty framework.

**Yohannes' Model**

Yohannes (1991) modified a model of mortgage choice developed by Chmura (1989), who used the present-value method to form break-even points between ARM and FRM loans and calculated the break-even points for moderate-case and worst-case scenarios. Yohannes used the present-value framework and the term structure of interest rates, together with the worst-case scenario to create break-even points.

In his model, Yohannes compared the present values of the total after-tax costs of the two types of loans. Next, he selected the mortgage loan with the lower total cost. Initially, he argued that the total cost of an ARM loan is presumably lower, compared to the total cost of an FRM loan, as the initial interest rate of an ARM loan has the tendency to be lower than the interest rate of an FRM loan. Nonetheless, FRM may have lower costs than ARM, if interest rates are expected to increase in the next period. Therefore, Yohannes argued that the break-even point is reached at a certain time when the cost of the FRM loan equals that of the ARM loan.
If the net benefit of the ARM loan were positive, a borrower would prefer the ARM loan to the FRM loan. In contrast, if the net benefit was negative, the FRM loan would be preferred to the ARM loan, whereas if the net benefit were zero, that would be the break-even point. The net after-tax benefit was expressed as:

\[
NBA_{AT} = (CCF - CCA) + \sum_{i=1}^{n} \frac{(MPF_{AT} - MPA_{AT})}{(1 + i)^i} + \frac{MBF_n - MBA_n}{(1 + i)^n}
\]

where \(NBA_{AT}\) is the net after-tax benefit of ARM, \(CCF\) refers to the closing costs associated with FRM, \(CCA\) is closing costs associated with ARM, \(MPF_{AT}\) is the after-tax monthly payment of FRM, \(MPA_{AT}\) is the after-tax monthly payment of ARM, \(i\) is the after-tax opportunity discount rate, \(MBF_n\) is a mortgage balance of FRM at the end of month \(n\), and \(MBA_n\) is a mortgage balance of ARM at the end of month \(n\). As the interest rate of the ARM loan is adjustable, the future monthly payments for an ARM cannot be known. Therefore, to know future monthly payments of ARM loans, the future interest rates of ARM loans had to be predicted. Yohannes used two approaches in predicting these future interest rates.

The first approach is based on the term structure of interest rates. It applies the forward-rate formula on the yield on one-year Treasury bills (T-bills). This yield of T-bills is chosen because it is a popular index rate used for adjusting ARM interest rates. However, Yohannes argued that the choice between an ARM loan and an FRM loan not only depends on the index rate, but also on many factors. These factors include the interest rates of the FRM loan, the fixed-adjustable interest-rate spread, the interest rate on alternative investments, the homeowner’s marginal tax rate, the ARM margin, the annual lifetime interest-rate caps, and the expected changes in the index rate. For
illustrative purpose, he used 8.25% for the initial ARM rate and calculated the following eight one-year forward rates from T-securities yield data obtained from the *Wall Street Journal*. Then, after he combined them with illustrative data of other factors, he found that the break-even point is reached at the sixty-first month. This means that if the borrower plans to stay in the house for about five years, he or she ought to choose the ARM loan to save a considerable amount of money. However, Yohannes' illustrative results indicate that the break-even month is not sensitive to changes in the marginal tax rate or the discount rate.

The second approach uses the worst-case scenario, based on the assumption that the ARM loan will reach the maximum rate of the initial rate plus the lifetime cap, since the ARM rate will increase by the annual interest-rate cap each year. The illustrative results show that the break-even point is reached in about 3 to 3.5 years. This means that the ARM loan would be the better choice, if the borrower were planning to stay in the house for less than 3 to 3.5 years. Yohannes also found that break-even points are sensitive to the change in the fixed-adjustable interest-rate spread. Finally, he concluded that homeowners have the tendency to choose the ARM loan, when the interest rates of FRM are high and the fixed-adjustable interest-rate spread is relatively large. However, the choice may not be clear as the interest rates of the FRM loan decrease, and the fixed-adjustable interest-rate spread decreases.

**Smith's Model**

Smith also developed a decision model of mortgage choice, generally based on the models developed by Basel and Biger (1980) and Statman (1982). Baesel and Biger
argued that the optimal mortgage depends on the spread of interest rates between alternative mortgages and on the covariance between inflation and real labor income. Statman expanded the Baselsi-Biger model by inserting the net end-period value of the house financed by the mortgage loan. According to Statman, the covariance between the real value of the house and inflation is a critical factor, which can influence borrowers' decision between a fixed-rate and index-linked contract. Therefore, Smith developed his model using the covariance between the real interest rate and real income and the covariance between the real interest rate and real asset values. However, instead of using the two-period framework, Smith assumed a mean-variance expected utility maximizing borrower in a single-period framework. His analysis focused on the directional impact of various factors on mortgage choice.

Smith developed his model by defining end-of-period wealth ($W$) as follows:

$$W^f = YP^f - FMP^f - XP^f$$ if the borrower chooses a fixed-rate contract and

$$W^a = YP^f - AMP^f - XP^f$$ if the borrower chooses an adjustable-rate contract. In his model, $Y$ is a nominal income, $M$ is an amount of loan, $P$ is a price index at the end of the period, $X$ is a nominal asset financed by the loan, and $F$ and $A$ are the interest rates of the FRM and ARM loan, respectively. The objective of any borrower is to maximize the expected utility of the terminal period real wealth. The expected utility function is a simple function of the expected mean and variance of the real contract for any type of mortgage. This can be expressed mathematically as $EU(W) = E(W) - \lambda Var(W)$, where $\lambda$ is the degree of constant absolute risk aversion. In general, Smith substituted $W^f$ and $W^a$ equations into an expected utility expression and assumed that the adjustable rate
contract is directly tied to the price index such that \( A = \bar{A} P \) (where \( \bar{A} \) is non-stochastic and is known at the beginning of the period). Next, Smith showed that a borrower will choose an ARM loan, be indifferent and choose an FRM loan if \( EU(\bar{W}^f) \) is greater, equal and less than \( EU(W^f) \), respectively, if only if \( EU(W^f) - EU(\bar{W}^f) = 0 \). Using the expression for the variance of sums of random variables, this inequality can be expressed as:

\[
\{E(FP^f) - E(AP^f) + \lambda M F^2 \text{Var}(P^f) - \lambda M \text{Var}(AP^f) + 2 \lambda F \text{Cov}(YP^f, AP^f) - 2 \lambda F \text{Cov}(YP^f, P^f) - 2 \lambda F \text{Cov}(XF^f, AP^f) - 2 \lambda F \text{Cov}(XF^f, P^f)\} = 0.
\]

Then, as he assumed that \( E(P^f) = 1 \) and with the price index-linked adjustable contract \( \text{Var}(AP^f) = \text{Cov}(YP^f, AP^f) = \text{Cov}(XP^f, AP^f) = 0 \), the inequality can be simplified as:

\[
\{F - \bar{A} + \lambda M F^2 \text{Var}(P^f) - 2 \lambda F \text{Cov}(YP^f, P^f) - 2 \lambda F \text{Cov}(XP^f, P^f)\} = 0 \quad (2.1.1).
\]

Special cases of this expression become the Baesel-Biger or Statman model.

If the asset value \( X \) is excluded from equation (2.1.1), Smith Model is the same as Baesel-Biger Model. Then, by assuming that real income is stochastically independent of inflation (in other words \( \text{Cov}(YP^f, P^f) = 0 \)), Smith found that the borrower's decision depends on only the magnitude of \( F - \bar{A} \) (fixed-adjustable interest rate spread). If fixed-adjustable interest rate spread is greater than zero, the price index-linked adjustable contract or the ARM loan is optimal.

Moreover, instead of assuming that real income is constant, Smith assumed that the
nominal income is constant, say at \( \bar{Y} \). Then \( \text{Cov}(\bar{Y}P', P') = \bar{Y} \text{Var}(P') \). Smith showed that equation (2.1.1) could be modified as:

\[
\{F - \bar{A} + \lambda M F^2 \text{Var}(P') - 2 \lambda F \bar{Y} \text{Var}(P')\} = 0
\]

and simplified as:

\[
\{F - \bar{A} - (\lambda F (2 \bar{Y} - M F) \text{Var}(P'))\} = 0. \tag{2.1.2}
\]

Therefore, a borrower chooses an ARM loan if fixed-adjustable interest rate spread is greater than \( (\lambda F (2 \bar{Y} - M F) \text{Var}(P')) \). In contrast, although fixed-adjustable interest rate spread is greater than zero, a borrower chooses an FRM loan if fixed-adjustable interest rate spread is less than \( (\lambda F (2 \bar{Y} - M F) \text{Var}(P')) \).

If the asset value \( X \) is included in equation (2.1.1), Smith Model is the same as Statman Model. Then, by assuming that real income is constant, Smith found that the borrower's decision does not only depend on fixed-adjustable interest rate spread because the magnitude now depends on \( \{F - \bar{A} - (2 \lambda F \text{Cov}(XP', P'))\} \). As a result, the borrower's decision in the Basel-Biger model can be altered by the magnitude of \( \text{Cov}(XP', P') \). If the real value of the asset decreases with inflation or \( \text{Cov}(XP', P') > 0 \), the borrower chooses an ARM loan as long as fixed-adjustable interest rate spread is greater than \( (2 \lambda F \text{Cov}(XP', P')) \). On the other hand, the borrower may choose an FRM loan if fixed-adjustable interest rate spread is less than \( (2 \lambda F \text{Cov}(XP', P')) \). However, if the real asset value rises with inflation or \( \text{Cov}(XP', P') < 0 \), then the magnitude of \( \{F - \bar{A} - (2 \lambda F \text{Cov}(XP', P'))\} \) becomes greater than zero. This means that the borrower prefers an ARM loan to an FRM loan.
Finally, if the nominal income is assumed to be constant, equation (2.1.1) can be modified as:

\[ F - A - (\lambda F (2 \bar{Y} - M F) Var (P^1)) - (2 \lambda F Cov (XP^1, P^1)) = 0 \]  

(2.1.3).

If Cov (XP^1, P^1) is greater than zero, and if fixed-adjustable interest rate spread is less than \( \lambda F (2 \bar{Y} - M F) Var (P^1) \) + \( 2 \lambda F Cov (XP^1, P^1) \), the borrower prefers to choose an FRM loan. Moreover, the borrower still chooses an FRM loan, although fixed-adjustable interest rate spread is greater than \( \lambda F (2 \bar{Y} - M F) Var (P^1) \).

In contrast, if Cov (XP^1, P^1) is less than zero or if the real value of the asset increases with inflation, the borrower chooses an ARM loan, as long as fixed-adjustable interest rate spread is greater than \( \lambda F (2 \bar{Y} - M F) Var (P^1) \).

The discussion above has shown that there are four important factors that influence any borrower's decision. First, the higher the degree of risk aversion, the more likely the borrower is to choose an FRM loan. The spread between fixed- and adjustable-interest rates is the premium paid by risk-averse borrowers who prefer to choose an FRM loan. The risk-averse borrower considers the trade-off between lower expected real cost and the possibility of greater variability in wealth, if the borrower chooses an ARM loan. The amount of premium the borrower is willing to pay and the degree of variability in wealth the borrower can accept indicate that borrower's degree of risk aversion.

Second, the larger the positive fixed-adjustable interest rate spread, the more likely is the borrower to choose an ARM loan, while the smaller spread drives borrowers to choose an FRM loan. Therefore, the spread influences borrower choice of mortgage.
Third, a borrower prefers an ARM to an FRM loan as the variance of real fixed-interest rate is larger than the variance of real adjustable-interest rate. As long as change in price is correlated with change in nominal adjustable rate and in a one-to-one fashion, the variance of real fixed-interest rate is larger than the variance of adjustable-interest rate. However, if there is no change in the price level, the variance of the real fixed-interest rate may be lower than the variance of the real adjustable-interest rate. Consequently, a borrower’s preference shifts toward an FRM loan.

Fourth, if real income and real value of housing assets have positive relationships to inflation and to the real adjustable-interest rate, the variance of wealth decreases. As a result, the borrower chooses an ARM loan, as smaller variance of wealth accompanied by lower expected financing cost leads to higher expected utility.

**Alm and Follain's Model**

Alm and Follain considered some other important factors in developing a theoretical model of consumer mortgage choice. These factors included the uncertainty of income growth, housing prices, inflation, and interest rates. Furthermore, the researchers considered the dual character of housing that covers consumption and investment activities. They also considered the discrete nature of consumer mortgage choice as other significant factors. However, they ignored still other factors that may be relevant for the mortgage choice decision, such as initial ARM rates, caps, and length of stay, which are usually considered by other studies.

Alm and Follain’s model focuses on the demand for the ARM loan against the FRM loan at a certain existing price differential. They assumed that the price differential is
independent of demand; and the supply function is perfectly elastic, which means that mortgage suppliers offer the quantity demanded at the market price differential. They presented two different models of mortgage choice. The first model shows that the consumer chooses the mortgage loan that yields the higher level of utility after the consumer compares the utility levels achieved with an ARM and a FRM loan. They used the additive utility function that depends on non-housing consumption \( C \) and housing consumption \( H \) at the first period and on the mean \( \overline{w} \) and variance \( \nu \) of wealth at the end of the first period.

The second model is different from the first, because instead of comparing attained utility with the ARM and the FRM loans, the consumer makes a decision based on his or her willingness to pay the WTP differential between ARM and FRM. If the WTP differential between ARM and FRM is less than the current market interest differential, the consumer selects the ARM loan instead of the FRM loan. Alm and Follain calculated the interest-rate differential that shows the consumer has the same utility level either with the ARM or the FRM loan, so that the consumer is indifferent between these two types of loans. In essence, Alm and Follain determined a maximum premium that the consumer is willing to pay for choosing FRM over ARM. That is to say, they computed the compensation that the consumer is willing to accept for choosing an ARM over an FRM loan.

Alm and Follain's study focuses on the second model, which shows the theoretical results in comparing the WTP differentials. To show the comparative static of the WTP, the researchers classified three kinds of parameters. They are parameters that affect the
riskiness of the choices (variance and covariance effects), parameters that primarily affect the level of the returns (income, wealth, and interest rate effects) and parameters that reflect the preferences of the household. Accordingly, the increase in the WTP differential implies that the consumer’s preference for FRM increases, while the decrease in WTP implies that consumers prefer to choose ARM.

Using partial derivatives of the WTP differential with respect to those parameters. Alm and Follain make some theoretical predictions with respect to consumer choice in the mortgage market. First, the partial derivatives of the WTP differential with respect to the variance of the ARM mortgage interest rate ($\sigma^2$) are positive, if the amount of the mortgage ($M$) is positive. Mathematically, it can be expressed as

$$\frac{\partial WTP}{\partial \sigma^2} = \left[ (1-t)M \frac{U_v}{U_w} \right]_{\text{eq}} > 0 \text{ if } M > 0.$$  

The notation $U_v$ and $U_w$ are the marginal expected utilities of the variance and the mean of wealth, respectively and their respective signs are negative and positive. The notation $[]_{\text{eq}}$ means that the expression is evaluated at the equal-utility optimal choices for the ARM loan. From this expression, a larger $M$ and a higher $U_v$, which could represent consumer’s risk-averse level, increase the WTP differential. This means that consumer’s preference for FRM increases as the variance of ARM increases. The higher level of risk-aversion indicates that a consumer is more likely to choose a less risky fixed rate mortgage. Meanwhile, lower $U_w$ and lower $t$ (marginal income-tax rate) increase the WTP differential. The consumer who puts less value on expected wealth is not sure about the prospect of higher wealth in the future, therefore consumer prefers the FRM. With a lower marginal income tax rate, the consumer has more disposable income to cover maximum premium, therefore the consumer
would be willing to pay for an FRM over an ARM loan.

Second, an increase in covariance between the interest rate of a mortgage loan and other uncertain variables, such as housing prices, return on the risky asset, growth of income, and inflation, reduce the WTP differential. This means that a consumer prefers ARM to FRM loans. The larger covariance between the mortgage rate and other uncertain variables suggests that a higher mortgage rate must be related to a higher housing price, higher return on the risky asset, higher income growth, and higher inflation. As a result, the consumer chooses an ARM loan to have higher capital gains with higher housing prices. The consumer may compensate higher mortgage rates with higher returns on risky assets. The consumer may also pay higher mortgage rates with higher income growth and have no problem with higher inflation, as housing prices will appreciate.

Third, an increase in initial wealth and actual income growth does not have an impact on the WTP differential, as the sign of this derivative depends on which mortgage loan offers the greater loan amount. The sign of this derivative is positive if the ARM amount is greater than the FRM amount and it is negative if the FRM amount is greater than the ARM amount. However, as an initial discount for an ARM loan may allow the consumer to borrow more with an ARM loan than with a FRM loan, the signs of derivatives of WTP with respect to initial wealth and actual income growth rate may be positive.

Finally, Alm and Follain showed that the numerical results have the same results as their predictions in the theoretical analysis. Basically, they argued that the consumer is more likely to choose an ARM loan 1) if less uncertainty of mortgage rates exists, 2)
if the housing price has a stronger correlation with the mortgage rate, and 3) if there is a lower demand for housing. Meanwhile, the other covariance variables do not seem to have much impact on mortgage choice.

**Brueckner's Model**

Brueckner argued that the borrower faces a trade-off between mortgage cost and interest-rate risk in choosing between ARM and FRM loans. The gain from the low initial interest rate of the ARM loan can be kept if the borrower can tolerate the risk of future interest-rate volatility. Therefore, the borrower's problem is to anticipate the market trade-off between cost and interest-rate risk and to select the best combination of these two basic parameters.

In this model, mortgage cost and interest-rate risk can be represented by $m$ (margin), which is the ARM rate markup over the index interest rate and $k$ (cap), which is the maximum increase between periods in the ARM rate. According to Brueckner, if $k$ is infinite (unlimited increase of interest rate), it corresponds to an uncapped ARM, and if $k$ is zero, it corresponds to FRM. Then, if $k$ has a limited positive value, it indicates a regular capped ARM. Furthermore, this model considers factors not only from the borrower side but also from the lender side. Therefore, first, Brueckner derived the price equation that indicates the relationship between $m$ and $k$ from the lender's point of view. Secondly, Brueckner derived indifference curves that indicate the relationship between $m$ and $k$ from the borrower's point of view. Finally, he set a comparative static analysis of the borrower's choice problem to show the impact of various parametric changes on optimal mortgage choice.
To derive the price equation, Brueckner assumed that no inflation and no default risk in the simple two-period model. The ARM rate at period 0 \((r_0)\) is the summation of cost of funds at period 0 \((i_0)\) and margin \((m)\). The net profit of lender at period 0 equals to \((r_0 - i_0)\). On the other hand, the ARM rate at period 1 has two alternatives as cost of funds at period 1 is a random variable with probability density function \(f(i_1)\). If the cost of funds at period 1 is less than or equal to the cost of funds at period 0 plus cap \((k)\), the ARM rate at period 1 \((r_1)\) equals the cost of funds at period 1 \((i_1)\) plus margin \((m)\). Then, if the cost of funds at period 1 is greater than the cost of funds at period 0 plus cap \((k)\), the ARM rate at period 1 \((r_1)\) equals the ARM rate at period 0 \((r_0)\) plus cap \((k)\). This means that if the cost of funds at period 1 is still low, lenders do not put on a cap, but if the cost of funds at period 1 passes \((i_0 + k)\) lenders start putting cap on mortgage loan rate. Moreover, the net profit at period 1 equals to \((m)\) if \(i_1 \leq (i_0 + k)\) and equals to \((i_0 + m + k - i_1)\) if \(i_1 > (i_0 + k)\). Mathematically, ARM rate and net profit at period 0 and 1 can be expressed as follows:

**ARM rate \((r)\):**

Period 0: \(r_0 = i_0 - m\)  \hspace{1cm} (2.1.4).

Period 1: \(r_1 = i_1 - m\) if \(i_1 \leq i_0 - k\)

\[ r_1 = i_0 + m + k \text{ if } i_1 > i_0 + k \]  \hspace{1cm} (2.1.5).

**Net Profit \((NP)\) per dollar:**

Period 0: \(NP = r_0 - i_0 = m\).

Period 1: \(NP = r_1 - i_1 = m\) if \(i_1 \leq i_0 - k\)

\[ NP = r_1 - i_1 = i_0 + m + k - i_1 \text{ if } i_1 > i_0 + k \]  \hspace{1cm} (2.1.6).
As uncertainty of cost of funds at period 1 exists and the lender is assumed to be a risk neutral agent, who focuses only on the discounted expected value of profit per dollar of lending, expected profit \( EP \) of lender can be expressed as follows:

\[
EP = m + \theta E(r_i - i_i) = m + \theta \int_0^{\infty} mf_i d_i + \theta \int_{-\infty}^{\infty} (i_0 + m + k - i_i) f d_i
\] (2.1.7).

where \( \theta < 1 \) is the lender's discount factor and \( f \) is the density function for \( i_i \).

The important requirement of profitability ARM lending measured by equation (2.1.7) must exactly match the profitability of short term lending at cost of funds \( i_0 \) and \( i_t \). Since profit is identically zero for such lending (the rate earned = the cost of funds in every period). ARM lending must also generate zero expected profit. Therefore, equation (2.1.7) can be modified as an ARM price equation:

\[
m = \frac{\theta}{1 + \theta} \int_a^b [i_i - (i_0 + k)] f d_i
\] (2.1.8).

where \( m > 0 \) as long as \( i_t > i_0 + k \). To be precise, suppose \( f \) (the probability that \( i_t > i_0 + k \)) > 0 on the interval \([a,b]\) and zero outside it. Then, equation (2.1.8) will be positive if \( i_0 + k < b \), which is the maximum value of \( i_t \).

Therefore, \( m > 0 \) if \( k < b - i_0 \) and

\[
m = 0 \text{ if } k \geq b - i_0 , \text{ as } f = 0 \text{ over the range of integration in equation (2.1.8)}.
\]

This means that as long as \( k \) is at least as large as \( b - i_0 \) then \( m = 0 \). Consequently \( k \) goes to infinity, then the ARM is effectively uncapped. This price equation shows a negative relationship that indicates the lenders offering a low interest rate ARM by lowering the ARM margin, but avoiding interest-rate risk by setting a higher cap.

Furthermore, differentiating equation (2.1.8) with respect to \( k \). Brueckner shows the
slop of price equation:

\[
\frac{\partial m}{\partial k} = -\frac{\theta}{1+\theta} \int f d i_1
\] (2.1.9).

The integral part in equation (2.1.9) will be positive as long as \( k < b - i_0 \), then the slope will be negative, which means that higher \( k \) should be accompanied by a lower \( m \). The opposite direction between \( m \) and \( k \) is important to maintain zero expected profit. The price curve is strictly convex over its positive range as derivative of equation (2.1.9):

\[
\frac{\partial^2 m}{\partial k^2} = -\frac{\theta}{1+\theta} f(i_0 + k)
\] (2.1.10)

is positive as long as \( i_0 \geq a \); and \( a < i_0 + k < b \).

Finally, Brueckner shows that increase in cost of funds in period 1 shift the price curve upward. Increase in cost of funds in period 1 may increase the potential losses from the cap. therefore to maintain zero expected profit margin should be higher, as a result price curve shifts upward.

Brueckner also derived the indifference curve that indicates the relationship between margin \( (m) \) and cap \( (k) \) from the borrower’s point of view. He used the additive utility function, which consists of the utility function for current consumption and the expected utility function for future consumption. The utility function for current consumption depends on current non-housing expenditures \( (x_0) \) and the cost of the house purchased at the current period \( (v) \), while the utility function for future consumption depends on future non-housing expenditures \( (x_f) \) and the cost of the house purchased at the current period \( (v) \).

By assuming that tax does not exist, Brueckner derived non-housing expenditure \( (x) \)
as follows:

Period 0: \( x_0 = y_0 - s_0 - \beta v - r_0 (1- \beta) v \) \hspace{1cm} (2.1.11)

Period 1: \( x_1 = y_1 + s_1 - r_1 (1-\beta)v + \beta v + g \) \hspace{1cm} (2.1.12)

where \( g = \) capital gain from sale of the house

\( s_0 = \) income invested at period 0

\( s_1 = \) total investment return at period 1

\( \beta = \) down-payment ratio of the house, \( 0 \leq \beta \leq 1 \)

\( v = \) cost of the house purchased at period 0

\( y_0 = \) income level at period 0

\( y_1 = \) income level at period 1.

The borrower's objective function is assumed to be

\[
\max_{v, s_0, s_1, m, k}[U(x_0, v) + \phi E[U(x_1, v)]]
\] \hspace{1cm} (2.1.13)

where \( \phi < 1 \) is the borrower's discount factor. Brueckner simplifies the non-housing expenditure by setting \( s_0 = 0, \beta = 0, g = 0, v \) to be fixed, and \( y \) to be known. Therefore, non-housing expenditure simplified as:

Period 0: \( x_0 = y_0 - r_0 v \) \hspace{1cm} (2.1.14)

Period 1: \( x_1 = y_1 - r_1 v \) \hspace{1cm} (2.1.15)

Then, the borrower's objective function becomes:

\[
\max_{m, k}[U(x_0) + \phi E[U(x_1)]]
\] \hspace{1cm} (2.1.16)

Therefore, the randomness of period 1 utility will arise only from uncertainty over the mortgage rate \( r_1 \) and consumer has only two choice variables (the mortgage parameters \( m \) and \( k \)) to maximize expected utility. However, to generalize the discussion
Brueckner relaxes some of the assumptions and argues that most results of the analysis are unchanged. For example, \( v \) is treated as a choice variable as a result of changes in income.

Moreover, recalling that \( r_0 \) and \( r_1 \) are defined by equation (2.1.5) and that \( y_1 \) is certain, expected discounted utility becomes:

\[
L = u(y_0 - (i_0 + m)v) + \phi \int_0^t u(y_1 - (i_1 + m)v) f di_1 + \phi \int_{i_k}^z u(y_1 - (i_0 + m + k)v) f di_1 \quad (2.1.17)
\]

To derive slope of indifference curve relating \( m \) and \( k \), two important things should be considered:

1. Higher margin reduces \( x \) in both periods, then expected utility falls as \( m \) increases, \( \frac{\partial L}{\partial m} < 0 \). The higher the margin, the lower the total expected utility, as the higher margin decreases non-housing expenditures in both periods.

2. Higher cap raises the allowable \( r_1 \) (reducing \( x_1 \)) when \( i_1 \) is high, then expected utility falls as \( k \) increases, \( \frac{\partial L}{\partial k} < 0 \). The higher the cap, the lower the total expected utility, as the higher cap could lead to greatly decreased non-housing expenditures in the future period.

Consequently, \( m \) and \( k \) should move in opposite directions to keep expected utility constant, yielding \( \frac{\partial m}{\partial k} < 0 \) along an indifference curve. The total differentiation of equation (2.1.17):
\[ \frac{\partial m}{\partial k} = -\frac{\partial L/\partial k}{\partial L/\partial m} \]

\[ \phi \int_{y_0}^{x} u'(y_1 - (i_0 + m + k)v) fdi_1 \]

\[ = -\frac{\phi \int_{0}^{\infty} u'(y_1 - (i_0 + m)v) fdi_1 + \phi \int_{t_1 - \epsilon}^{\infty} u'(y_1 - (i_0 + m + k)v) fdi_1}{[u'(y_0 - (i_0 + m)v) + \phi \int_{0}^{\infty} u'(y_1 - (i_1 + m)v) fdi_1 + \phi \int_{t_1 - \epsilon}^{\infty} u'(y_1 - (i_0 + m + k)v) fdi_1]} \]

< 0 (2.1.18).

Then, to make comparative static analysis feasible he uses exponential utility function

\[ u(x) = -e^{-\alpha x}, \alpha > 0, \]

which exhibits constant absolute risk aversion. Substituting \( u' = -\alpha e^{-\alpha x} \) into equation (2.1.16), the slope of borrower's indifference curve becomes:

\[ \frac{\partial m}{\partial k} = -\left( \int_{y_0}^{x} fdi_1 \right) \Gamma^{-1} \]

where

\[ \Gamma = \phi^{-1} e^{-\sigma(y_0 - y_1 - kv)} + \int_{0}^{\infty} e^{-\sigma(t_1 - \epsilon - k)v} fdi_1 + \int_{t_1 - \epsilon}^{\infty} fdi_1 \]

(2.1.20)

and \( \sigma \) is a level of risk aversion. The steepness of indifference curve depend on \( \Gamma \): a lower (higher) \( \Gamma \) yields steeper (less steep) indifference curve. Any parametric change in \( \Gamma \) affects the indifference curve of the consumer without altering the price curve can be analyzed using a simple principle (all the above changes except for the shift in \( f \) are of this form). Differentiating equation (2.1.19) with respect to \( k \) yields an expression with an ambiguous sign. Therefore, indifference curves in this problem are not necessarily concave.

Finally, optimal solution occurs at the tangency between an indifference curve and price curve, which requires equality of the slope expressions (2.1.9) and (2.1.19). As a result, optimal solution occurs when:
\[ \Gamma^{-1} = \theta(1 - \theta) \]  

Equation (2.1.21) determines the value of \( k \) associated with the optimal mortgage.

Brueckner made comparative static analysis, which shows that various parametric changes may shift borrower choice of mortgage. He predicted that changes in borrower characteristics (level of risk aversion, income, and income growth), market characteristic (house price at period 0) and price characteristics (discount rate, down-payment ratio, and interest rate expectation) affect the slope of the indifference curve. The change in the slope of indifference curve determines the optimal combination of price characteristics represented by margin and cap. High margin or low cap leads the borrower to choose an FRM loan and low margin or high cap leads the borrower to select an ARM loan. In short, Brueckner showed that borrower, market and price characteristics influence mortgage choice. The main results of the analysis consist of some theoretical predictions with respect to the borrower choice in the mortgage market. Based on equation (2.1.19) and (2.1.20):

1. Change in discount rate or change in valuation of future consumption:

   As \( \frac{\partial(\dot{m}/\dot{k})}{\partial \Gamma} < 0 \) and \( \frac{\partial \Gamma}{\partial \phi} < 0 \), the value of \( \frac{\partial(\dot{m}/\dot{k})}{\partial \phi} > 0 \). This means that as discount rate increases, indifference curve becomes steeper. As no change in price curve, the optimal \( k \) decreases meaning the borrower chooses an FRM loan. When the borrower considers a high discount rate, which means high valuation of future consumption, the optimal cap decreases, urging the borrower to select an FRM loan. Intuitively, as future consumption becomes more expensive, the borrower is better off having a high margin and low cap. Therefore, the borrower selects an FRM loan for the optimal mortgage.
choice. Figure 2.1 depicts the impact of increase in discount rate on mortgage choice.

![Figure 2.1: The Impact of Increase in Discount Rate on Mortgage Choice.](image)

2. Change in income stream/growth:

\[
\frac{\partial (\partial m / \partial k)}{\partial T} < 0 \quad \text{and} \quad \frac{\partial T}{\partial (y_1 - y_0)} > 0. \quad \frac{\partial (\partial m / \partial k)}{\partial (y_1 - y_0)} < 0.
\]

This means that as income growth increases, indifference curve becomes less steep. As no change in price curve, the optimal \( k \) increases meaning the borrower prefers an ARM loan. When the difference between future income and current income increases rapidly, the optimal cap increases to push the borrower to choose an ARM loan. Intuitively, at a certain-priced house, the borrower with rising income has more ability to tolerate interest-rate risk in the future. As a result, the borrower favors an ARM loan. Figure 2.2 portrays the impact of increase in income growth on mortgage choice.
3. Change in current income \((y_0)\) and cost of house \((v)\):

Current income has negative direct impact on \(\Gamma\) or \(\frac{\partial \Gamma}{\partial y_0} < 0\). When \(v\) becomes a choice variable, as current income increases, the borrower prefers to have larger cost of house or \(\frac{\partial v}{\partial y_0} > 0\). On the other hand, \(\frac{\partial \Gamma}{\partial v} < 0\), therefore indirectly \(y_0\) has also negative impact on \(\Gamma\). As \(\frac{\partial (\partial m / \partial k)}{\partial \Gamma} < 0\) and \(\frac{\partial \Gamma}{\partial y_0} < 0\), \(\frac{\partial (\partial m / \partial k)}{\partial y_0} > 0\). This means that as current income increases, indifference curve becomes steeper. As no change in price curve, the optimal \(k\) decreases meaning the borrower prefers an FRM loan. When current income increases and \(v\) becomes a choice variable, the borrower selects a larger house value. The effect of higher income and larger house price increases the slope of the indifference curve.

Figure 2.2: The Impact of Increase in Income Growth on Mortgage Choice
curve, in which case the optimal cap decreases, urging the borrower to select an FRM loan. Intuitively, as the borrower’s income increases along with the consequent cost of house, the borrower who makes a large investment in housing prefers a mortgage with a low interest risk. Therefore, borrower with a higher income prefers an FRM loan. Figure 2.1 can also represent the impact of increase in current income and cost of house.

4. Change in level of risk aversion:

As \( \frac{\partial \Gamma}{\partial \sigma} \) is ambiguous, change in level of risk aversion (\( \sigma \)) has ambiguous impact on the slope of indifference curve. The results of Brueckner’s research show that a more risk-averse borrower prefers an FRM loan, only if income grows slowly; on the other hand, if income grows rapidly, the borrower with higher risk aversion prefers an ARM loan. Consequently, the impact of risk aversion on mortgage choice is ambiguous.

5. Change in down-payment ratio:

When positive \( \beta \) is introduced into the problem, the expression \( \Gamma \) becomes:

\[
\Gamma = \phi^{-1} e^{-\sigma \left( y_2 - x - k + x(1-\beta)w_2 \right)} + \int_0^{-k} e^{-\sigma \left( f_k - x - k - x(1-\beta)w \right)} f dY_{i} + \int_{-k}^{0} f dY_{i} \tag{2.1.22}
\]

Then, as \( \frac{\partial \Gamma}{\partial \beta} > 0 \) and \( \frac{\partial (\partial m / \partial k)}{\partial \Gamma} < 0 \), \( \frac{\partial (\partial m / \partial k)}{\partial \beta} < 0 \). This means that as down payment ratio increases, indifference curve becomes less steep. As no change in price curve, the optimal \( k \) increases meaning the borrower prefers an ARM loan. The higher down-payment ratio lowers current disposable income and raises future disposable income; therefore borrower feels more tolerance to the interest-rate risk in the future. Moreover, with higher down payment ratio reduces housing interest costs; consequently borrower
has more ability to tolerate change in interest-rate in the future. Thus, increase in down-payment ratio leads the borrower to select an ARM loan unambiguously. Figure 2.2 can also portray the impact of increase in down payment ratio.

6. Change in interest rate expectation:

   a. Borrower anticipates interest rate increase in the future and lender anticipates no change:

   Brueckner introduced shift parameter $\tau$, which represents a shift in the distribution of period 1 interest rates, into $f$ in equation (2.1.19), where $\frac{\partial (\partial m / \partial k)}{\partial \tau} > 0$. This means that if future interest rate increases, indifference curve becomes steeper. As no change in price curve, the optimal $k$ decreases meaning the borrower prefers an FRM loan. Intuitively, as expected future interest rate increases, borrower looks at higher margin loan, which is an FRM, to protect him from higher interest rate. Figure 2.1 can also depict the impact of higher borrower’s interest rate expectation.

   b. Both borrower and lender expect higher interest rate in the future:

   Brueckner introduced shift parameter $\tau$ into $f$ in equation (2.1.19), where $\frac{\partial (\partial m / \partial k)}{\partial \tau} > 0$. On the other hand, Brueckner also introduced same shift parameter $\tau$ into $f$ in price curve equation (2.1.8) and slope of price curve equation (2.1.9). The first derivative of price curve and slope of price curve with respect to $\tau$ are positive or $\frac{\partial m}{\partial \tau} > 0$ and $\frac{\partial (\partial m / \partial k)}{\partial \tau} > 0$. Therefore, when borrower and lender have higher expectation of interest rates, the indifference curve is steeper and price curve shifts up and later becomes steeper. At first, when indifference curve
becomes steeper and price curve shifts up. optimal \( k \) decreases meaning the borrower prefers an FRM loan. Then, as price curve becomes steeper and its steepness rises faster with \( t \) than the steepness of the indifference curve, the optimal \( k \) increases meaning the borrower chooses an ARM loan. Intuitively, as borrower expects higher future interest rates, borrower chooses an FRM loan to protect him from higher interest rates. On the other hand, lender reacts to the higher expected future interest rates by adjusting combination of \( m \) and \( k \) to protect lender from decreasing return, then lender offers more attractive ARM loan so that this loan overwhelm the borrower’s willingness-to-pay higher margin loan. Consequently, the borrower prefers an ARM loan to an FRM loan. Figure 2.3 portrays the impact of increase in interest rate expectation by borrower and lender on mortgage choice.

Brueckner concluded that the borrower who considers a high value on future consumption favors a small interest-rate cap, and hence prefers an FRM to an ARM loan. However, the borrower prefers some type of ARM when they have rapidly rising income streams and can pay large down payments. Brueckner also showed that if lender and borrower have the same higher expectation of future interest rates, the borrower chooses an ARM loan, but the borrower prefers an FRM loan if only the borrower expects higher future interest rates in the future. While under the assumption that house price is a choice variable. Brueckner concluded that higher income raises house consumption and a wealthy borrower prefers an FRM loan to finance their large housing expenditures.
From these theoretical studies, all studies showed that a high fixed-adjustable interest rate spread leads borrowers to select ARMs. Brueckner implicitly showed that spread influence mortgage choice as he described that high margin and low cap indicates the borrower prefers an FRM loan and low margin and high cap implies the borrower chooses an ARM loan. While, high (low) margin and low (high) cap can be represented by small (large) spread. Moreover, of the four theoretical models, only Brueckner considered expectations of interest rate. Based on his prediction, if only borrowers consider high expectations of interest rate, the borrower may choose FRMs. In contrast, if both borrowers and lenders consider high expectations of interest rates, the borrower may
select ARMs. His prediction may indicate that if a study considers only the borrower or demand side, increased expectations of interest rates may lead the borrower to select FRMs. However, if a study also considers both the demand and supply sides, increases in expected interest rates may drive the borrower to choose ARMs.

Based on four theoretical studies, it can be hypothesized that the borrower prefers ARMs to FRMs if the rate of FRMs and the fixed-adjustable interest rate spread are high. The borrower would also prefer ARMs if any of the following increase the down payment ratio, housing prices, return on risky asset, income and inflation. On the other hand, based on borrower characteristics, borrowers are more likely to choose FRMs if they have high current income and initial wealth, and consider higher discount rate. Rates of risk aversion have been shown to have an ambiguous impact on the mortgage decision, as risk adverse borrowers choose FRMs if income grows slowly and choose ARMs if income grows quickly. Furthermore, an increase in growth rate of income leads borrowers to choose FRMs according to Alm & Follain, however this study agrees with Brueckner's theoretical prediction that income growth drives borrowers to choose ARMs as rising income makes borrowers more tolerant of interest-rate risk.

2.2. Cross Section Studies

Parker, Phillips and Sharma (1996) used a logit model to examine the impact of both borrower and price characteristics on mortgage choice and applied revealed preference theory to the mortgage choice problem. Sa-Aadu and Sirmans (1995) estimated a multinomial logit (MNL) model to investigate whether price and borrower characteristics influenced borrower choice of a mortgage loan, however their study does
not build on a specific theoretical model. Kwack (1993) applied Alm & Follain's theoretical model and used a nested logit model (NLM) and conditional logit model (CLM) to examine the effect of both price and borrower characteristics on mortgage choice. Phillips and Vanderhoff (1992) expanded Brueckner & Follain's empirical model to examine whether price, borrower and market characteristics influenced mortgage choice and housing demand. Brueckner and Follain (1989) used a two-stage procedure to estimate a probit model of mortgage choice and housing demand, examining whether all three characteristics impacted the choice of mortgage loans and housing demand. Based on Brueckner and Alm & Follain's theoretical model, Brueckner and Follain (1988) estimated an empirical model based on probit analysis to investigate the impact of price and borrower characteristics on mortgage choice. Using probit analysis, Dhillon, Shilling and Sirmans (1987) estimated the impact of mortgage pricing and borrower characteristics on choice between FRMs and ARMs.

Parker et al. applied revealed preference theory to the mortgage choice problem. They stated that "Revealed Preference Theory refers to the approximation of an individual’s utility function by the consumer revealing which bundle of equally attainable services is preferred" (p. 221). They also cited Nicholson’s argument that the consumer chooses one bundle over another, revealing which bundles he or she prefers. In their study, the consumer chooses bundles of fixed-against adjustable-rate mortgages that are merely a bundle of financial services.

Parker et al. tested several variables, such as region of the country, income level, age, lender type, mortgage size, amount of down payment, points, and the initial mortgage interest rate. They used the logit model and a sample of 818 cases from the
Consumer Housing Survey conducted in 1987. Their findings showed that only the type of lender had an impact on the choice of mortgage loans. Compared to the "average" person, who tries to get an ARM loan, a borrower who seeks a loan from a commercial bank would have a 15% greater chance of getting the ARM loan. Moreover, a borrower who seeks a loan from a savings and loan institution would have a 14.96% greater chance of getting the ARM loan. This finding seems to indicate that both lending institutions influenced borrowers to choose the ARM loan and that both lending institutions tended to prefer issuing ARMs. In contrast, they found that other variables had no impact on mortgage choice. Therefore, Parker et al. concluded that the results of this study did not really support several prior studies in the mortgage choice.

Sa-Aadu and Sirmans (1995) MNL model of mortgage choice as they assumed that mortgages are differentiated products. They argued that borrowers selected specific contracts from a list differentiated by the interest-rate adjustment period and their selection indicated their preferred level of interest-rate exposure. Their model showed that estimated MNL coefficients indicate the impacts of prices, borrower characteristics, and market expectations on the probability of choosing the ARM loan relative to the FRM loan. The researchers used a pool of 345 mortgage loans from a large Midwestern federally chartered savings and loan association in the period of 1979 to 1984.

Sa-Aadu and Sirmans' findings suggested that ARMs are not generic contracts as the effect of mortgage price on choice differs across alternative mortgages. They reported that contract rates and points negatively affect the probability of choosing the ARM loan. They also found that the magnitude of the contract rate coefficients was larger for contracts with a shorter adjustment period; in other words, an increase in contract rate
had a greater impact on ARMs with a shorter adjustment period, than on ARMs with a longer adjustment period.

In addition, they also reported that borrower characteristics were important factors in the mortgage decision. Sa-Aadu and Sirmans found that more mobile and younger borrowers preferred a shorter adjustment period contract. At the same time, they found that income level had very little effect on mortgage choice, however income growth positively influences choice of ARMs. Moreover, based on the interest rate expectations represented by the spread between thirty-year and six-month constant treasury yields, their study showed that as interest rates were expected to rise, borrowers would be less likely to choose ARMs. Finally, using the same model and data, Sa-Aadu and Megbolugbe (1995) added the fixed-adjustable interest-rate spread variable to the model and found that the spread positively influenced the choice of ARM loans.

Kwack (1993) used the primary data from NAR Home Financing Transactions in the period of 1985 to 1991 to examine the factors influencing the mortgage choice of homebuyers. In addition, he used data from the Security Price Index Record, Current Business Statistics, CPI Detailed Report, and the Federal Housing Finance Board News. He used 3,911 observations, after excluding some missing values from 10,546 original observations, constructing two sub-samples of ARMs: the COFI (Cost of Fund Index) ARM and TEA (U.S. Treasury Security-Based Index) ARM.

Kwack applied two logit models the CLM and NLM to examine the way that borrowers make their choice of a mortgage loan. He applied the CLM model to investigate the simultaneity of borrowers’ decision in choosing FRM, COFI ARM, and TEA ARM. NLM was applied if borrowers based their decision on a sequential process,
which means that the borrowers would first choose either FRM or ARM, and then decide whether to choose COFI ARM or TEA ARM. Furthermore, Kwack's study investigated whether both borrower and market characteristics affect the borrower's choice of a mortgage loan.

Based on Hausman and McFadden's test, Kwack showed that CLM is more relevant than NLM, which means that when borrowers chose a mortgage loan, they considered all of FRM, COFI ARM, and TEA ARM, simultaneously. Kwack also found that both the market and borrower characteristics influenced mortgage choice. He found that the fixed-adjustable interest-rate spread was the most important factor among the market characteristics. As the interest-rate spread increased, borrowers were more likely to choose both ARM loans (COFI and TEA ARM). Moreover, as the variance of the ARM interest rate and the covariance between the mortgage interest rate and expectation of income growth increased, borrowers were more likely to choose an FRM loan. However, borrowers were more likely to choose both ARM loans, if the covariance between the mortgage interest rate and the expected appreciation of housing prices increased.

Kwack also reported that as the covariance between the mortgage interest rate and the inflation rate increased, borrowers were more likely to choose COFI ARM compared to FRM. In contrast, borrowers were more likely to choose a FRM loan if they had to choose between FRM and TEA ARM. Furthermore, they were more likely to choose an FRM loan as some borrower characteristics such as age and the difference between long-term and short-term yield increased. Nevertheless, borrowers were more likely to choose an ARM loan with increasing loan size. Finally, Kwack observed that the higher the
income and the larger the family-size, the more likely were borrowers to choose FRM compared to COFI ARM. At the same time, these two variables did not have any impact when borrowers had to choose between TEA ARM and FRM.

As in the Brueckner and Follain's empirical model, Phillips and Vanderhoff (1992) applied a two-stage procedure. First, they used the probit analysis to estimate the mortgage choice model. Second, they used the probability of choosing an ARM loan from the probit analysis to estimate the housing demand equation. In the first stage, they used data from FHLBB surveys in relevant regions. Next, they used data from the NAR panel surveys on housing and housing finance transactions in the period of 1986 to 1988. The sample size from the NAR home financing panel was more than 1,800 observations; however, they used only 818 observations—the same number of observations available from FHLBB survey.

Based on the probit analysis, the researchers reported that price variables such as the initial discount rate, relative points, and the difference between ten-year and one-year treasury yields, and market characteristics represented by median house prices significantly influenced the borrower's choice. The larger the ratio of the initial contract ARM rate to the current fully adjusted ARM rate, the less likely were borrowers to choose an ARM loan. In contrast, the larger the difference between ten-year and one-year U.S. treasury yields, the larger the ratio of points on FRM loans to points on ARM loans, and the higher the median housing price, the more likely were borrowers to choose an ARM loan. At the same time, if buyers were new to the Standard Metropolitan Statistical Area (SMSA), they were more likely to choose an ARM loan, whereas other variables from borrower characteristics were not significant.
From the housing demand equation, Phillips and Vanderhoff showed that all variables (estimated property tax, initial discount rate, change in fully adjusted ARM rate, and change in points) had a negative impact on housing demand. In contrast, change in income, median housing price and estimated change in per capita personal income positively influenced housing demand. They also reported that demand for housing increased by approximately 13 percent as lenders offered ARM loans. They argued that as ARM loan provides a low initial discount rate, with expectations of total payments of a mortgage loan being lower than total payments with an FRM loan. As a result, the low initial discount rate of an ARM loan had strong impact on housing demand.

Brueckner and Follain (1989) used data from the Residential Mortgage Finance Panel Survey conducted by the National Association Realtors (NAR) in the period of 1984 to 1987 to estimate housing demand. They also estimated housing demand, conditional on mortgage choice. Therefore, they employed a two-stage procedure. First, they used the probit analysis to examine factors that influence a borrower's choice of mortgage. Second, they used predicted choice probabilities from the probit analysis with other variables such as housing price index, income and family size to estimate housing demand.

From the probit analysis, Brueckner and Follain found that borrowers were more likely to choose ARM loans as the fixed-adjustable interest-rate spread increased. Based on the FRM rate and the quadratic FRM rate, they reported that the choice of mortgage is sensitive to changes in the interest rates when the rates were high; otherwise, the FRM rate had no effect on mortgage choice. Based on market characteristics represented by housing price index, this study reported that as borrowers facing high housing
prices, they were more likely to choose ARMs. Judging borrower characteristics, younger and more mobile borrowers seemed to be more likely to choose an ARM loan. Other borrower characteristics such as income, families size, and repeated buyer had no impact on borrower’s choice of mortgage. Borrowers were less likely to choose an ARM loan if they lived in the northeast.

Furthermore, based on housing demand, Brueckner and Follain found that ARM borrowers did not only consider the initial ARM rate but also other factors to derive their housing demand. ARM borrowers reduced their housing demand in the period of high FRM rates, because it indicated higher future ARM rates. Compared to the ARM-borrower housing demand, the FRM-borrower housing demand was more sensitive to the changes in the initial interest rates, given the fixed-adjustable interest-rate spread, because the FRM rate is permanent, while the initial ARM rate is temporary. Finally, ARM borrowers demanded more housing if they were protected from extreme rate increases.

Brueckner and Follain (1988) used a large national database (Residential Mortgage Finance Database) collected by the National Association of Realtors to estimate an empirical model of mortgage choice. The database was based on over 1,000 residential real estate transactions in late 1984 and 1985. However, some transactions were excluded because of a variety of different criteria. As a result, they had a working sample of 475 observations, which consisted of 316 FRMs and 159 ARMs.

Brueckner and Follain used probit analysis to investigate a borrower’s choice between ARM and FRM loans. The independent variables contain borrower characteristics such as income, age, family size, intermetropolitan mobility, repeated
buyer and region, and price characteristics such as the FRM rate, and the fixed-adjustable interest-rate spread. They found that the fixed-adjustable interest rate and the FRM rate influenced the choice of mortgage. Borrowers were more likely to choose an ARM loan as the fixed-adjustable interest-rate spread and the FRM rate increased. Furthermore, not all borrower characteristics influenced a borrower's choice: only income and intermetropolitan mobility impacted the choice between ARM and FRM. The higher the income and the more mobile the borrowers, the more likely were borrowers to choose ARM loans. Finally, western borrowers preferred ARM loans to FRM loans.

Dhillon et al. used data collected from the Baton Rouge, Louisiana office of a national mortgage banker on loans closed from January 1983 to February 1984 to examine the choice of mortgage contracts. Of 78 observations, 46 were FRMs, and 32, uncapped ARMs. The researchers applied the probit analysis to explore the impact of mortgage pricing and borrower characteristics on the choice between fixed and adjustable rate loans.

Dhillon et al. showed that the price variables, such as fixed interest rate, margin, the difference between long-term and short-term yield of securities, and points had significant impact on borrower's choice. The borrower was more likely to choose an ARM loan if fixed interest rates increased, and if the margin, yield difference, and points decreased. Individual borrower characteristics such as households with co-borrowers, married couples, and short expected housing tenures or mobility had weak impact on choice of mortgage. Other borrower characteristics, such as age, education, first-time home buying and self-employment did not have any influence on a borrower's decision. Dhillon et al. also found that payments to income ratio and networth did not have any
impact on borrower's decision. In short, only price variables influenced borrower's choice of mortgage, not borrower's characteristics.

From six of cross-sectional studies reviewed, only Parker et al., Kwack, and Brueckner and Follain (1988) studies are based on a theoretical model of mortgage choice. However, Parker et al. did not explain clearly how revealed preference theory applied in the model. The other studies focus on the impact of the fixed-adjustable interest rate spread. All of these studies, except Phillips and Vanderhoff, found that the increase in fixed-adjustable interest rate spread leads borrowers to choose ARMs. Sa-Aadu and Sirmans, Kwack, and Dhillon et al. examined the impact of interest rate expectations represented by the slope of yield curve and reported that if interest rates are expected to fall, borrowers prefer ARMs to FRMs. In contrast, Phillips and Vanderhoff found that borrowers were more likely to select ARMs when interest rates are expected to rise. Only Phillips and Vanderhoff, and Brueckner and Follain (1989) examined the impact of housing prices, showing that ARMs were picked more often when prices are expected to rise. Furthermore, Sa-Aadu and Sirmans, Phillips and Vanderhoff, Brueckner and Follain (1988 and 1989) and Dhillon et al., showed that more mobile borrowers choose ARMs. According to Parker et al., Brueckner and Follain (1988) and Dhillon et al., the borrower age does not have any impact on borrower choice of mortgage loan. In contrast, Sa-Aadu and Sirmans, and Brueckner and Follain (1989) observed that younger borrowers prefer ARMs to FRMs. Finally, all these studies except Brueckner and Follain (1988) and Kwack found that income does not have any impact on mortgage choice.
2.3. Time Series Studies

Using time series data, Jones, Miller and Riddiough (1995) estimated a simultaneous equation model to examine factors affecting mortgage choice. Unlike most previous studies, which ignored the supply side and focused only on the demand side, Jones et al. investigated the impact of price, borrower and market characteristics on mortgage choice. Devaney (1994) used time series data to examine price characteristics, specifically the impact of the fixed-adjustable interest rate spread on mortgage choice. Like most previous studies using time series data, Nothaft and Wang (1992) focused on the demand side to investigate the effect of borrower and price characteristics on mortgage choice.

Jones et al. used aggregate data from the Federal Housing Finance Board’s weekly survey in a simultaneous equation model to examine factors affecting mortgage choice. Based on the supply equation, they reported that the ARM share, the difference between long-term and short-term bond yields, and the percentage of securitized ARM originations positively influenced the level of the fixed-adjustable interest rate spread. However, only ARM shares and yield premium on long-term Treasury bonds over short-term bonds showed high significant level. This indicated that as these two factors changed, the lenders made spread adjustments to influence borrower choice of mortgage loans. They also showed that there were no differences in the supply function from 1986 to 1989 and from 1989 to 1992, indicating no structural changes in the supply function.

Based on the demand equation, the researchers found that the fixed-adjustable interest rate spread and the interest rate of FRM positively influenced the ARM share, while housing price negatively influenced the ARM share. Furthermore, the demand
function was not stable, as borrowers were more sensitive to changes in the interest rate of FRM and housing prices from 1989 to 1992 and were sensitive to changes in interest-rate spread from 1986 to 1989, but not from 1989 to 1992. Therefore, it was concluded that the price characteristics (interest-rate spread and interest rate of FRM) and market characteristics (housing prices) were not appropriate variables for predicting the choice of mortgage loans over the late 1980s to early 1990s.

Devaney (1994) used the difference between the rate on 30-year FRM and the rate on 1-year ARM and monthly proportion of ARM loans to examine mortgage choice. Devaney pointed out that lenders might possess some level of influence over borrowers in determining their mortgage choice. He used monthly data from July 1983 to May 1989 that were taken from the Mortgage Interest Rate Survey. His argument was based on results of a Granger Causality test. This test showed the percentage of ARMs for all new and existing homes or ARM share (AS) to be causing changes in the fixed-adjustable interest rate spread (S) rather than S causing AS as one would expect in a choice model.

If this is the case, then Devaney's findings confirm the mortgage term structure research, which focuses on the supply side of the mortgage market as the major determinant of choice. Based on his findings, rather than the expectations of the borrower he suggested that the expectations of the investor or lender had stronger influence on mortgage choice. Implicitly, he believes that the expectations theory of term structure may prevail to influence mortgage choice. Devaney's finding is unlike other studies of mortgage choice, which specified models where fixed-adjustable interest rate spread caused changes in the ARM share or ARM choice. However, Devaney found that the long-run relationship between S and AS was weak, as the co-integration test was
significant at only the 10% level. Therefore, it is not strong enough to state that ARM share Granger causes fixed-adjustable interest rate spread; rather, the AS only precedes the S. In conclusion, Devaney’s study does not have strong evidence that the lenders adjust the fixed-adjustable interest-rate spread to influence borrower choice.

Nothaft and Wang (1992) also drew monthly data from the Mortgage Interest Rate Survey (MIRS) and used a series ranging from January 1982 to December 1987. Unlike previous studies that already accepted fixed-adjustable interest-rate spread as independent variable on the ARM share equation, they first tested whether the data shows that the fixed-adjustable interest-rate spread can be an independent variable on the ARM share equation. Consequently, they treated the impact of interest-rate spread on the ARM share as a testable hypothesis and applied reasonable coefficient restrictions to verify whether the interest rate is an appropriate regressor. Their study found that the data support applying the fixed-adjustable interest-rate spread as an independent variable on the ARM share and their estimation model:

\[ AS_t = \beta_0 + \beta_1(ARM_t - FRM_t) + \sum \beta_j X_{it} + \gamma AS_{t-1} + \epsilon_t \]

can work for the national as well as the four regions such as Northeast, Midwest, South, and West. Where \( AS_t \) is the ARM share, \( \beta_0 \) is a constant, \( (ARM_t - FRM_t) \) is the spread, \( X_{it} \) is other variables affecting mortgage choice, such as the housing affordability index and the interest-rate expectation, and \( AS_{t-1} \) is the lag of ARM share.

Furthermore, Nothaft and Wang reported that autocorrelation was found in the static model; therefore, they used a dynamic model by inserting the lag values of independent variables. Their estimated model found that the fixed-adjustable interest-rate spread, interest-rate expectations represented by slope of the Treasury yield
curve, and the housing affordability index were statistically significant, affecting the level of the ARM share. The researchers found that 1) a 30-basis-point decrease in the fixed-adjustable interest-rate spread, 2) a 30-basis-point increase in the difference between 10-year and 1-year Treasury yields, and a 3) 10-unit increase in the housing affordability index would decrease the national ARM share by 10%, 2%, and 14%, respectively. In addition, they reported that the availability of convertible ARM would increase the ARM share by 20%, nationally. Nevertheless, the increases of ARM share were significant in the Midwest and South, but there was only little change in the Northeast and West.

These time series studies do not use a specific theoretical model of mortgage choice. However, Jones et al. and Devaney implicitly used an expectation theory of term structure to support their argument that lenders adjust fixed-adjustable interest rate spreads to influence borrower's choice of mortgage loans. Nothaft and Wang reported that a decrease in fixed-adjustable interest rate spread, and an increase in expectations of interest rates and an affordability index would decrease ARM share, which means that borrowers prefer FRMs to ARMs. On the other hand, Jones et al. showed that an increase in the fixed-adjustable interest rate spread and FRM rates, and decreases in housing price would increase ARM share. The impact of fixed-adjustable interest rate spread in their study is the same as in Nothaft and Wang's study. Moreover, Devaney reported that lenders might indirectly influence the borrower's decision as ARM shares Granger caused fixed-adjustable interest rate spread. However, he found only a weak long-run relationship between the fixed-adjustable interest rate spread and ARM share, therefore his argument that the mortgage decision tends to focus on the expectation of the lender is not wholly supported by the empirical results. Using similar data, Jones et al.
observed that increased ARM share, interest rate expectations and percentage of
securitized ARM originations would increase the fixed-adjustable interest rate spread.
The results of their study may indicate that the expectation theory of term structure may
prevail and it may support what Devaney's study implied. Therefore, based on these three
studies, the fixed-adjustable interest rate spread and the ARM share may simultaneously
influence each other. In other words, a study of mortgage choice cannot only focus on
the demand side, but also should consider the supply side, paying special attention to the
possibility that lenders may affect borrower's choice of mortgage loans.

2.4. Survey Studies

Lino (1992) used survey data and logit analysis to examine whether eligibility
requirements, financial cost of mortgages, financial planning of mortgage choice and risk
of mortgages influenced borrower's choice of mortgage loans. He developed a conceptual
model based on an economic environment in which he considered lender constraints,
consisting of availability of mortgage types and the eligibility requirements, and borrower
considerations, including financial cost of mortgage, how a mortgage fits in a financial
plan and the risk of a mortgage. Khazeh, Decker and Winder (1990) used survey data to
determine which differential rate between FRM and ARM that lead borrowers to choose
ARMs. Colton, Lessard and Solomon (1979) used survey data and a trichotomous logit to
examine the probability of choosing Graduated Payment Mortgages (GPM) and Variable
Rate Mortgages (VRM), which is now known as an ARM, over standard mortgages or
FRMs. Basically, they applied a life cycle model to explore how borrowers manage their
income flow to fulfill expected mortgage payments. Albaum and Kaufman (1977) used
survey data to determine which borrower characteristics influence mortgage choice.

Lino conducted a survey by sending 352 questionnaires to 180 households with FRMs and 172 households with ARMs, who made mortgage payments between January and November 1986 in Tompkins County, New York. He hypothesized that eligibility requirements, the financial cost of various types of mortgages, financial planning aspects of mortgage choice, and the risk of each mortgage type were the key factors that influenced borrowers' choice. He distinguished the financial planning aspects from the financial cost aspects of mortgage choice. He argued that the first aspect includes adjusting expected future mortgage payments, income, and other non-housing expenses to avoid financial difficulties in mortgage payments. The later aspect contains evaluating overall costs that will be paid with the FRM or ARM loan.

Lino used the logit analysis and found that only the financial planning aspect of mortgage choice and the risk related to a mortgage loan type significantly impacted mortgage choice. He showed that if borrowers believed the FRM best fit with their expected future income and expenses, they were more likely to choose an FRM. In contrast, if they believed an ARM best fit with their expected income and expenses, they were less likely to choose an FRM loan. Then if borrowers thought ARMs were more risky, they were more likely to choose an FRM. The eligibility requirements and the financial cost aspect did not appear to influence mortgage choice. The choice to take maximum loan amount was not related to the borrowers' choice of an FRM loan, because only borrowers who were eligible were included in the sample. They also showed that borrowers' choices were not influenced by their belief that either FRMs or ARMs had higher expected costs. Finally, the implication of the study was that consumer
education programs were needed to help borrowers make mortgage decisions, as they should make adjustments on expected future expenses, income, and mortgage payments.

Khazeh et al. performed a mail survey based on real estate records in Wicomico County, Maryland during 1986 through 1988. They mailed the questionnaires to 773 households, but only 150 responses could be used for the study. The main factor that drew homebuyers toward FRMs seemed to be the certainty of the interest rate of an FRM. The homebuyers preferred fixed to adjustable rates due to general aversion to risk on some homebuyers. However, if the initial interest rate were at least 1.5% to 2% lower than the interest rate of FRMs, they found that homebuyers would choose the ARM. Moreover, their study showed that the homebuyer choices were not affected by the disclosure of past trends in interest rates on adjustable rate mortgages. This fact indicated that homebuyers did not consider the interest-rate trends in choosing mortgage loans. The results of the above research indicate that lenders and legislators should reconsider the usefulness of recent disclosure legislation.

Khazeh et al. also found that some homebuyers (26%) who chose their mortgage company based on the real estate agent's recommendation were less satisfied with the company's professional competence and concern for customers, compared to other homebuyers. Homebuyers (33%) who picked their own mortgage company were more satisfied than others, because they understood the reputation of the company.

Colton et al. conducted a national telephone survey of 2,348 households selected through a random, clustered probability sample. After screening interviews and selecting households that were considering a home purchase or that had been in the housing market, they performed full interviews on 1,047 households. Mail surveys followed to
learn more about attitudes and tradeoffs regarding particular mortgage features. From 1,047 households that agreed to complete the questionnaire, only 611 returned the questionnaire. Half of the mail survey focused on GPM, which has monthly payments starting out at a low level and gradually rising above monthly payments of conventional mortgage, and the other half stressed on ARM. Colton et al. also conducted panel group discussions in some areas to gain a better understanding of consumer attitudes with regards to housing finance and alternative mortgage instruments.

Colton et al. used a trichotomous logit regression to analyze the probability of choosing GPM over a FRM loan. They showed that owner households with higher wealth were more likely to choose the GPM loan, while other factors (payment to income ratio, uncertainty of real income and race) did not have any impact on the choice of mortgage. When the researchers put the owner and renter households together in one group, they found that the higher expectation of real income resulted in higher probability of choosing GPM over a standard mortgage. The age of households had a negative impact on the probability to choose a GPM. Renter households, they were also more likely to choose a GPM loan. Other factors such as income, payment to income ratio, wealth, uncertainty of real income, and race did not have any impact on renters' choice of mortgage.

Using the same trichotomous logit regression to analyze the probability of choosing ARM over standard mortgage, Colton et al. found that payment to income ratio, wealth, expectations of real income, uncertainty of real income, race and expectations of housing prices did not have any impact on the households' mortgage decision. As a group, both the ages of owner and renter households did not have any impact on which mortgage
loan they chose. However, the income of renter households influenced the choice of the mortgage. The higher the income of renter households, the more likely they were to choose an ARM loan. Other factors such as tenure, payment to income ratio, wealth, expectations of real income, uncertainty of real income, race and expectations of housing prices did not have any impact on renter households' choice.

From Colton, Lessard and Solomon's study, we can infer that wealth, expectations of real income, age, and tenure status of households influenced households' decision to choose GPM over standard mortgage. Income was the only factor that had an impact on a household's decision to choose ARMs over FRMs. Another important result of this study is that households faced a trade-off between the possible lower cost of the ARM and a household's aversion to uncertainty about future payment. Therefore, households might choose an ARM loan only if they planned to stay in the house for a relatively short time, because they were less interested in the long-term uncertainty of ARM. They also found that only a few of the households preferred ARMs to FRMs, if this mortgage did not have features such as greater flexibility in refinancing, no prepayment penalties, open lines of credit, portability, and assumability. Finally, they concluded that although households asked the lenders to offer not only FRMs but also alternative mortgage instrument, the households still needed borrower protection and education in dealing with an alternative mortgage instrument.

Albaum and Kaufman (1977) conducted a survey to analyze consumer attitudes toward variable rate mortgages. Their study surveyed actual and potential borrowers in California in 1976. They collected the data by sending 2,534 questionnaires, of which 1,255 responses were used for the study. From demographic characteristics, they
found that mortgage borrowers with variable-interest-rate (VIR), which is now identical to ARM, had lower average incomes and lower housing and financial assets than FRM borrowers. Another characteristic that was different between ARM and FRM borrowers was their expectations regarding future interest rates. Most borrowers who expected interest rates to increase in the future selected an FRM loan. In the ethnic background, education and expectations of the future values of the houses, neither group had any differences.

From features of mortgage plans, Albaum and Kaufman found that ARM borrowers placed more importance on guaranteed transferability of the mortgage, while FRM borrowers considered the stability of monthly payments to be more important. Both groups believed some features (monthly payment size, closing costs, prepayment, maturity, open credit line and expected length of ownership) have approximately equal importance. Furthermore, Albaum and Kaufman found that ARM borrowers had more knowledge about the provision of ARM plans than FRM borrowers. According to borrowers' perception, ARM borrowers considered this mortgage loan to be more favorable than the FRM loan. However, based on satisfaction, ARM borrowers had lower satisfaction with their mortgage, compared to FRM borrowers. As a result, ARM borrowers were more likely to avoid this type of loan in the future.

From four studies reviewed in this section, only Lino, and Colton et al. build on a theoretical model of choice. Lino showed that the financial planning and risk aspects of mortgages are the most important factors that influence borrower's choice. Colton et al. and Khazeh et al. reported the same findings—that ARM borrowers prefer to stay in the house for a relatively short time. According to Albaum and Kaufman, ARM
borrowers tend to have lower income. In contrast, Colton et al. reported that ARM borrowers have higher income. Finally, from all four-survey studies, only Khazeh et al. observed that fixed-adjustable interest rate spread influenced mortgage choice.

2.5. Other Studies

Two studies that examined the consequences of choosing ARMs, rather than the factors that influence mortgage choice, are reviewed below. Sprecher and Willman (1993) used a Monte Carlo simulation to examine whether ARM borrowers should stay for a short or long period in the house. Sa-Aadu (1987) used present value and consumer surplus concepts to examine the windfall gain available to borrowers choosing ARMs.

Sprecher and Willman used data from the NAR’s Home Financing Transaction 1987 database to determine whether the ARM borrowers may have lower interest costs compared to the FRM rates. They selected 210 observations of ARM borrowers; however, they only used 158 observations, as they excluded 52 observations with incomplete and erroneous information, a five-year and less than six-month adjustment period and large loan size. They used two approaches in comparing ARM and FRM interest rates.

First, they compared the geometric mean of the ARM rate between the third quarter of 1987 and the second quarter of 1991, with the FRM rate at the time the ARM loan was chosen. Based on the 1987 ARM rate, they calculated ARM rates by adding the margin to the beginning rate at the adjustment period and compared this resulting rate with the current ARM rate plus the adjustment period cap. They then chose the lower rate as the ARM rate, reporting that the geometric mean of the ARM rate was 1.48% below the
FRM rate and 88% of the sample had a lower interest cost during a 16-quarter holding period. Therefore, their results suggested that ARM borrowers had lower interest costs compared to FRM borrowers in the short term.

Second, Sprecher and Willman compared ARM rates with FRM rates at each adjustment period. They observed that the interest rate of an ARM was lower than the interest rate of an FRM at the beginning of observations. Then, they showed that it took about two years for the interest rate of ARM to be equal or exceed the interest rate of FRM. Therefore, according to the opportunity cost framework, ARM loans would be more costly in the long term, especially in a period of rising interest rates.

Sa-Aadu used two approaches in calculating the gain or loss induced by the fixed-adjustable interest-rate spread. His first approach defined the windfall gain or loss as the present value of the difference in mortgage payments (PVDP) between the ARM and the alternative FRM. In his second approach, he calculated the windfall gain or loss as the present value of compensating variation of consumers' surplus (PVCV). Using either approach, he found that although some individual borrowers had a windfall loss, on the average borrowers had the windfall gain when they chose an ARM loan. Moreover, Sa-Aadu’s research showed that the frequency of interest-rate adjustment had an impact on the size of windfall gain. The mean of windfall gain increased with the length of adjustment frequency in both approaches. Borrowers who had ARMs with a periodic interest-rate cap had higher windfall gains compared to borrowers who had ARMs without a periodic interest-rate cap. The slope of the yield curve correlated with the size of windfall gains. As the yield curve was upward sloping, the mean windfall was larger than windfall of the downward or flat slopes. However, he also found that
negative or positive windfall were sensitive to the length of stay. They reported that 16% and 36% of all the borrowers in the sample who stay until maturity had windfall loss calculated by PVDP and PVCV, respectively. Then, if borrowers stay for ten years, only 7% and 13% of borrowers calculated by PVDP and PVCV, respectively would have windfall loss.

Sprecher and Willman reported that ARMs are good for households planning a short length of stay, and it will be more costly for households if they stay more than two years, especially in the period of rising interest rates. According to Sa-Aadu, borrowers who choose an ARM loan would reap windfall gains, and increase the gains as interest rates rise, represented by upward sloping yield curve. Nevertheless, whether or not borrowers acquire a windfall loss or gain depended on the length of stay in the home. Finally, based on these two studies, the fixed-adjustable interest rate spread was considered the main factor that determined mortgage choice.

2.6. Summary

Overall, the previous studies of mortgage choice have shown that prices and household characteristics are the two key determinants of mortgage choice. While, the housing price showed inconclusive effect on mortgage choice as some researchers found that increasing housing price leads borrowers to choose ARM loans, on the contrary other researchers found that increasing housing price drives borrowers to select FRM loans. It seems that the housing affordability index is a better variable for estimating mortgage choice as this index captures not only housing price, but also median family income and interest rates. Increasing housing affordability index leads borrowers to select FRM loans.
The price of mortgages was most commonly measured by expectations of interest rates and fixed-adjustable interest rate spreads. As the spread between fixed and adjustable rates increased, borrowers preferred to choose adjustable rate mortgages. In contrast, borrowers tended to select fixed rate mortgages if interest rates are expected to rise in the future. This implies that the mortgage choice problem is approached from the borrowers' side as prices are the determinant factor in the demand for mortgages. However, if both borrowers and lenders have the same expectation of rising interest rates, borrowers might be "coerced" into adjustable rate mortgages, as lenders increase interest rate spreads. Moreover, ARM share could actually influence the interest rate spread, as lenders react to a change in ARM share. This implies that the lender adjusts interest rate spreads if the lender and borrower have same interest rate expectation and if the lender observes changes in ARM share. Therefore, the mortgage choice problem needs to be approached from both the borrowers' and the lenders' side.

Based on borrower characteristics, mobility, age, growth of income and wealth appear to be factors of influence on choice of mortgage loan. In general, high-income growth, young and mobile borrowers had a tendency to choose adjustable rate mortgages. On the other hand, high wealth borrowers preferred FRMs to ARMs because wealthy borrowers want to avoid uncertainty in ARM rates when they make large commitments to housing.

From the previous studies, it is clear that a study of mortgage choice should be approached from both the supply and demand sides. It is also clear that price characteristics are the main factors that influence mortgage choice, and time series studies have the advantage of working with data with price variability. On the other
hand, borrower and market characteristics also have influence on mortgage choice. Table 2.1 depicts a summary of previous studies.
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<td>43. Var[ARM]</td>
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<td>44. Cov[ARM; HP]</td>
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<td>45. Cov[ARM; RRA]</td>
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<td>46. Cov[ARM; IG]</td>
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<td>47. Cov[ARM; Inflation]</td>
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<td>48. Var[FRM]&gt;Var[ARM]</td>
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<td>49. Lender: CB &amp; S/L</td>
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<td>50. Belief: ARM fits with expected income and expenses</td>
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Notes: +: Borrower prefers an ARM loan  
-: Borrower prefers an FRM loan  
*: Initial ARM rate  
**: Cov[ARM; IG] < 0  
***: + for COFI ARM and - for TEA ARM  
****: Ratio of initial ARM to current fully adjusted ARM  
: Ratio of FRM point to ARM point  
A: ambiguous  
AA: If borrower lives in northeast.  
w: weak  
AAA: Western borrowers.  
AAAA: Direct and indirect effect of the spread.  
#: indirect effect of the spread.  
NE: Not effective  
(continued)
Table 2.1 (continued)

<table>
<thead>
<tr>
<th>Author</th>
<th>Study</th>
<th>Method/Framework</th>
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<tbody>
<tr>
<td>1 Yohanes (1991)</td>
<td>Theoretical</td>
<td>Present Value</td>
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<tr>
<td>2 Smith (1987)</td>
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<td>Single period</td>
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<td>3 Aim &amp; Follain(1987)</td>
<td>Theoretical</td>
<td>Two period uncertainty</td>
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<tr>
<td>4 Bruckner (1988)</td>
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<td>Two period uncertainty</td>
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<td>5 Parker et al(1996)</td>
<td>Cross Section</td>
<td>Logit</td>
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<td>6 Sa-Aadu/Sirmans(1995)</td>
<td>Cross Section</td>
<td>Multinomial Logit</td>
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<td>7 Kwack (1993)</td>
<td>Cross Section</td>
<td>Nested Logit Model and Conditional Logit Model</td>
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<td>8 Phillips/Vanderhoff(1992)</td>
<td>Cross Section</td>
<td>Probit</td>
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<td>9 Bruckner/Follain (1988)</td>
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<td>10 Bruckner/Follain (1988)</td>
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<tr>
<td>13 Devaney (1994)</td>
<td>Time Series</td>
<td>Unit root, cointegration and Granger causality tests</td>
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<td>15 Lino (1992)</td>
<td>Survey</td>
<td>Logit</td>
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<tr>
<td>17 Colton et al (1979)</td>
<td>Survey</td>
<td>Trichotomous Logit</td>
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<td>19 Sprecher/Willman (1993)</td>
<td>Other</td>
<td>Simulation</td>
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<tr>
<td>20 Sa-Aadu (1987)</td>
<td>Other</td>
<td>Present Value of the Difference in the Payment (PVDP) and Present Value of the Compensating Variation (PVCV)</td>
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CHAPTER 3

EMPIRICAL METHODS TO STUDY THE HISTORY OF MORTGAGE DECISIONS

This chapter follows Brueckner’s (1986) theoretical study to specify the empirical model. The first model developed implies that the spread alone influences mortgage choice. Fixed-adjustable interest rate spread is implicitly in the Brueckner’s model as he discusses the impact of margin and cap on mortgage choice. High margin and low cap indicate a low spread, which means that borrowers prefer an FRM loan. On the other hand, low margin and high cap indicate a high spread, which means that borrowers prefer an ARM loan. Therefore, this study examines any potential long-run and ‘causal’ relationship between fixed-adjustable interest rate spread (S) and mortgage choice represented by ARM share (AS).

According to Brueckner’s comparative static analysis described in chapter 2, discount rate, increase of housing demand as income increases, and income growth influence mortgage choice directly. Based on Brueckner’s theoretical model, the second model developed considers mortgage choice as influenced by fixed-adjustable interest rate spread and the consumer confidence index, housing affordability index and family income growth. Consumer confidence index (CCI) is used to represent the discount rate as this index provides information on consumer appraisals of the
present situation and expectations for the future. A higher discount rate and lower CCI have the same impact on mortgage choice. Housing affordability index (AI), which is a ratio between family income to qualifying income, is used to represent housing value demanded as income increases because this index covers the cost of a house, mortgage rates, monthly payment and family income. In short, higher AI indicates the case where FRM loans are more affordable; therefore, higher housing value demanded as income increases and higher AI have identical impact on mortgage choice. Finally, family income growth (IG) is used to examine the impact of borrower’s income on the mortgage decision as income growth has better prediction than income itself. Finally, we examine any long-run and ‘causal’ relationship between ARM share and spread together with other factors.

According to Brueckner’s theoretical model, interest rate expectation (IRE) is considered to indirectly affect mortgage choice. If the borrower and lender have the same expectations, the lender makes interest rate adjustments to influence borrower decision to meet lender’s expectation. Therefore, a third model is based on the interest rate expectation influencing spread adjustment. In this way, this study examines any potential long-run and ‘causal’ relationship between fixed-adjustable interest rate spread and interest rate expectations.

This study applies time series methods to analyze any potential long-run and ‘causal’ relationship that may exist in these three models. The economic series in these three models are the key variables in the mortgage choice model, some or all of which may not be stationary series. Therefore, each series is first tested for the presence of a unit root and appropriate procedures are used to account for the revealed time series
properties of the data, that is co-integration and Granger causality tests.

However, before unit root, co-integration and Granger causality tests are conducted, this study examines the stability of each of three models. It is important to know whether there are any structural changes in each of three models as Maddala (1992) argued that in estimating the co-integrating regression, parameter instability due to structural change should not be ignored. This study employs the switching regression technique of Goldfeld and Quandt (1973) to examine whether there are any regime shifts or partitions in each of three models. This method applied to find regime shifts by minimizing the sum of the squared errors (SSE) of the two periods in each of the three models. Moreover, following Jones et al. this study performs the calculation of SSE using an OLS estimation since each of the three models relies on the use of a single-regression model. After that, a Chow (1960) test is conducted to test for structural change between the first and second period. If the F statistics is more than the critical value from an F distribution, then there is evidence of a structural change. The results of the switching regression technique and Chow tests for each of three relationships are in Appendix A. Then, the data based on the regime partition are used for unit root, co-integration and Granger causality tests.

Finally, the hypotheses and procedures for tests of stationary series, long-run and causality relationships are described in section 3.1, 3.2, and 3.3 consecutively. Section 3.4 describes the data used in this study. Then, this section also shows the descriptive statistics.
3.1. Stationary Series

3.1.1. Hypothesis

Based on Figure 3.1 to 3.6, the historical data at level form have upward / downward linear trends. However, a single linear trend line in each series cannot represent the real trend of data because there is a possibility of a regime shift. For example, the AS series has one linear trend line for the period January 1984 to December 1986, another for January 1987 to December 1988, another for January 1989 to December 1993, and yet another for January 1994 to December 1996. This indicates that the trend line is shifting and this means that the trend in AS series is not a deterministic trend, instead the AS series displays a stochastic trend. On the other hand, the first differences of AS series display a flat linear trend. Moreover, it seems that all other series have also stochastic trends and have flat linear trends in their first differences. Therefore, all of these series are hypothesized as non-stationary series or they have a unit root. This means that the series are integrated of order 1, I (1). In addition, this study also hypothesizes that all the series in each partition are non-stationary series. This study applies unit root test to test all these hypotheses. The following sub-section describes the procedure of unit root testing.
Figure 3.1: Level Form & First Difference of Monthly ARM Share, 1984-1996

Figure 3.2: Level Form & First Difference of Monthly Fixed-Adjustable Interest Rate Spread, 1984-1996
Figure 3.3: Level Form & First Difference of Monthly Consumer Confidence Index, 1984-1996

Figure 3.4: Level Form & First Difference of Monthly Affordable Index, 1984-1996
3.1.2. Unit Root Tests

In general, "a stochastic process is said to be stationary if its mean and variance are constant over time and the value of covariance between two time periods depends only on the distance or lag between the two time periods and not on the actual time at which the
covariance is computed. If the series are not stationary, standard statistical techniques break down. For example, ordinary least squares regressions no longer produce useful $R^2$. Durbin Watson or t-statistics (Granger and Newbold, 1974). In fact, these traditional tests may show a significant relationship among variables, although this actually is not the case.

One way to test for stationarity is based on the autocorrelation function (ACF). The sample ACF, represented by $\hat{\rho}_k = \hat{\gamma}_k / \hat{\gamma}_0$ which is the ratio of the sample covariance to sample variance. Then, the plot of $\hat{\rho}_k$ against $k$ (number of lags) is known as the sample correlogram. If all the $\hat{\rho}_k$ coefficients are individually statistically significant different from zero and the autocorrelation coefficient decreases gradually as $k$ increases, it indicates that the time series is non-stationary. Testing the joint hypothesis that all sample autocorrelation coefficients are simultaneously equal to zero can test whether all autocorrelation coefficients are significantly different from zero. The test uses the statistics calculated by Ljung and Box (1978) or the LB statistic, which is a modification of a Q statistic, developed by Box and Pierce (1970). If the calculated LB exceeds the critical value from the chi-square table at certain significance levels, the null hypothesis that all $\rho_k$ are simultaneously equal to zero should be rejected, implying that the time series is not stationary.

---

According to Gujarati (1995), using the correlogram to test the stationarity of the series is an informal level of stationary test. The formal level to test the stationarity is by finding out whether the time series has a unit root. The Dickey-Fuller (DF) and augmented Dickey-Fuller (ADF) tests can be applied for this objective.

This study selects the formal level to indicate the stationarity of a time series by applying unit root tests. The ADF is most frequently used for the unit root test, as it may avoid the possibility of serial correlation within the test itself. The simple way of presenting this test is to consider the simple model of the series \( Y \) in equation (3.1.2.1):

\[
Y_t = Y_{t-1} + \varepsilon_t
\]  

(3.1.2.1)

where \( \varepsilon_t \) is the stochastic error term with mean zero, constant variance \( \sigma^2 \), and non-autocorrelated. The value of \( Y \) at time \( t \) is regressed on \( Y \) at time \((t-1)\). Basically, if the coefficient of \( Y_{t-1} \) is equal to 1, the \( Y \) time series contains a unit root, which means that the series is non-stationary. The estimated model of equation (3.1.2.1) can be rewritten as:

\[
Y_t = \rho Y_{t-1} + \varepsilon_t
\]  

(3.1.2.2)

In this equation, if \( \rho = 1 \), it means that the stochastic variable \( Y_t \) is a random walk time series. Moreover, subtracting \( Y_{t-1} \) from both sides of equation (3.1.2.2) leads to:

\[
\Delta Y_t = (\rho - 1)Y_{t-1} + \varepsilon_t
\]

\[
= \alpha_0 Y_{t-1} + \varepsilon_t
\]  

(3.1.2.3)

where \( \alpha_0 = (\rho - 1) \) and \( \Delta Y_t = Y_t - Y_{t-1} \) is the first difference of the series. In this estimated model, \( \alpha_0 = 0 \) is the same as saying that \( \rho = 1 \), which means that the stochastic variable \( Y_t \) in equation (3.1.2.2) has a unit root. Therefore, the null hypothesis in equation (3.1.2.3) now becomes \( \alpha_0 = 0 \) and it is the same as testing whether \( \rho = 1 \) in equation (3.1.2.2).
To examine whether a time series $Y_t$ is non-stationary or stationary, it is necessary to run the regression (3.1.2.2) and check whether $\hat{\rho}$ is significantly different from 1. It is similar to estimating (3.1.2.3) and finding out if $\hat{\alpha}_0$ is significantly different from 0. Based on the $r(tau)$ statistic developed by Fuller (1976), Dickey and Fuller (1979) and Dickey and Fuller (1981). In this test, the test statistics cannot be compared to the ordinary $t$ distribution, because if $\rho = 1$, the data generating process of $Y_t$ changes over time. This means that $Y_{t-1}$ does not satisfy the standard assumptions required for asymptotic analysis and ordinary $t$-tests are not suitable to test the null hypothesis of a unit root. Therefore, instead of using the $t$ statistic, the unit root test uses the $r$ statistic, whose critical values have been recorded by Dickey and Fuller, based on Monte Carlo simulations. This test has become well known as the Dickey-Fuller (DF) test, as they calculated these critical values, which were extended later by MacKinnon (1991). As this study uses various numbers of observations based on the number of observations between regime shift, this study calculates the DF critical values based on MacKinnon’s means of surface regressions. The calculated DF critical values for any finite sample size or number of observations are in Appendix B.

If the calculated absolute value of the $r$ statistic is more than the absolute DF critical values, then the null hypothesis that $\rho = 1$ should be rejected. This means that the time series data are stationary. In contrast, if the calculated value is less than the absolute DF critical value, the null hypothesis of non-stationarity is not rejected. The DF critical values can be used in the estimated model of equation (3.1.2.3) and also in the following estimated models:
\( \Delta Y_t = C + \alpha_0 Y_{t-1} - \varepsilon_t \) \hspace{1cm} (3.1.2.4)

\( \Delta Y_t = C + \alpha_0 Y_{t-1} - \alpha_1 T + \varepsilon_t \) \hspace{1cm} (3.1.2.5)

where \( C \) is the constant term and \( T \) is the time or trend variable. Moreover, to avoid the possibility that the error term \( \varepsilon_t \) is autocorrelated, inserting the lags of \( \Delta Y_t \) modifies equation (3.1.2.3), (3.1.2.4) and (3.1.2.5) in the following forms:

\[ \Delta Y_t = \alpha_0 Y_{t-1} + \sum_{j=1}^{p} \gamma_j \Delta Y_{t-j} + \varepsilon_t \] \hspace{1cm} (3.1.2.6)

\[ \Delta Y_t = C + \alpha_0 Y_{t-1} + \sum_{j=1}^{p} \gamma_j \Delta Y_{t-j} + \varepsilon_t \] \hspace{1cm} (3.1.2.7)

\[ \Delta Y_t = C + \alpha_0 Y_{t-1} + \alpha_1 T + \sum_{j=1}^{p} \gamma_j \Delta Y_{t-j} + \varepsilon_t \] \hspace{1cm} (3.1.2.8)

The test using these last three forms is known as the augmented Dickey-Fuller (ADF) test, where its test statistic has the same asymptotic distribution as the DF statistic; therefore, the same critical values are used in these forms. If the \( \tau \) calculated is greater than \( \tau \) critical value at a certain significant level, the hypothesis \( \alpha_0 = 0 \) should be rejected, implying that the time series is stationary and standard econometric techniques remain valid. This study uses ADF tests; however, if the lagged difference terms (\( \Delta Y_t \)) are jointly insignificant, this study uses DF tests as they are more powerful tests than ADF tests (Engle and Granger, 1987).

There are several immediate implications of finding a series to be non-stationary. Firstly, a shock has permanent impact on the series. As series \( Y \) has a unit root, equation (3.1.2.1) can be recalled. Then, by assuming that \( Y_0=0 \) and \( \varepsilon_t \) is a white noise
error term with constant mean \( \mu \) and variance \( \sigma^2 \), \( Y_1 = \varepsilon_1 \), \( Y_2 = \varepsilon_1 + \varepsilon_2 \) and by successive substitution \( Y_t \) can be written as:

\[
Y_t = \sum_{i=1}^{t} \varepsilon_i
\]

Supposed a shock \( S \) occurs at \( t=1 \), \( Y_t = \varepsilon_1 + S \) or \( Y_t = \sum_{i=1}^{t} \varepsilon_i + S \). It is clear that this shock will have permanent impact on the series. Then, if a policy recommendation will be made impacting or based on this series, "the repercussions of the policy change will remain in the system, at the strength of the initial impact, forever" (Fox, 1995). Therefore, the permanent changes in the underlying process that analysts are trying to describe may cause further complicated problems for consumer policy analysts. Consequently, analysts have to find out whether the variable of interest is a stationary or a non-stationary series before making any policy recommendations. Secondly, there are implications to be drawn from the fact that the variance of a non-stationary series varies over time. As \( Y_t = \sum_{i=1}^{t} \varepsilon_i \), \( \text{Var} [Y_t] = \sum_{i=1}^{t} \text{Var} [\varepsilon_i] = t \sigma^2 \). It is clear that the variance is growing over time. On the other hand, statistical inference depends on a constant variance; therefore, once the variance is known to be growing over time, or the variance is a function of time, unreliable statistical inference will be the result. Finally, if a non-stationary series is regressed on another non-stationary series, standard t and F testing procedures are not valid and the regression is spurious.

### 3.2. Long-run Relationships

#### 3.2.1. Hypothesis

Based on Brueckner's theoretical model, there are three hypothesized long-run relationships to be tested. The first hypothesis is that ARM share and fixed-
adjustable interest rate spread have a long-run relationship or they are co-integrated. Moreover, this study predicts that the parameter of spread will be positive in this co-integration regression. The second hypothesis is that ARM share and fixed-adjustable interest rate spread, consumer confidence index, affordability index, and family income growth have a long-run relationship. In addition, based on its co-integration regression, this study predicts that spread, consumer confidence index, and family income growth positively affect choice of adjustable rate mortgage loan and affordability index negatively influences choice of adjustable rate mortgage loan. Finally, it was hypothesized that interest rate expectation and fixed-adjustable interest rate spread have a long-run relationship. Moreover, this study predicts that the parameter of IRE will be positive in this co-integration regression. The co-integration tests are applied by using monthly data from January 1984 to December 1996. In addition the co-integration tests are also conducted on each various partitions of the series. This study uses co-integration tests to test all these hypotheses. The following sub-section describes the procedure of co-integration testing.

3.2.2. Co-integration Tests

The implication for modeling are significant if a series is determined to be non-stationary. According to Dickey and Fuller (1987) and Philips (1987), the standard t and F statistics are not valid in the basic regression model if non-stationary series are used. In fact, the regression could easily yield a spurious relationship which makes the relationship looks good, but actually there is no true relationship between the series. It may happen because the time series of dependent and independent variables are under strong influence of trends and regression results may falsely exhibit a high degree of
fit or $R^2$. Therefore, a regression with a high $R^2$ may not represent a true relationship between the dependent and independent variables. Granger and Newbold (1974) suggested that regression results with high $R^2$ and low value for the Durbin-Watson statistic are likely to be spurious. Tests for co-integration, in a real sense, are tests for long-run relationships which circumvent this spurious regression problem.

One way to test whether the regression represents a true long-run relationship is the Co-integrating Regression Durbin-Watson (CRDW) test, whose critical values were first calculated by Shargan and Bhargava (1983). If the calculated DW is greater than critical values at a certain significance level, the null hypothesis of the DW being equal zero ($d = 0$) can be rejected. This means that the dependent variable and independent variable are co-integrated. In other words, the dependent and independent variables have a long-run relationship.

Furthermore, Engle-Granger (EG) and augmented Engle-Granger (AEG) tests can be used to test long-run relationships between variables. The regressions between dependent and independent variables known as the co-integration regression can be written in the following forms:

$$Y_{tl} = C - \sum_{j=2}^{M} \beta_j Y_q + u_t$$  \hspace{1cm} (3.2.2.1)

$$Y_{tl} = C - \beta_1 T + \sum_{j=2}^{M} \beta_j Y_q + u_t.$$  \hspace{1cm} (3.2.2.2)

From these equations, the estimation results such as standard $t$ and $F$ testing procedures are not valid if both $Y_{tl}$ and $Y_q$s series are not stationary. However, their linear combination in the form of residual values from equation (3.2.2.1) and (3.2.2.2) might be stationary. The linear combination of these variables can be written in the following...
forms:

\[ u_t = Y_t - C - \sum_{j=2}^{M} \beta_j Y_{q} \]  

(3.2.2.3)

\[ u_t = Y_t - C - \beta_1 T - \sum_{j=2}^{M} \beta_j Y_{q} \]  

(3.2.2.4)

In short, the EG test is actually a test of stationarity of the residual value \( u_t \), therefore: the DF test can be applied to test the stationarity of \( u_t \). However, since the estimated \( u \) is based on the estimated co-integrating parameter \( \beta_j \), the DF and ADF critical values are not appropriate. Engle and Granger (1987) calculated these critical values known as EG critical values. The EG critical values can be used in the estimated model of equation (3.2.2.5) as follows:

\[ \Delta \hat{u}_t = \gamma \hat{u}_{t-1} + v_t \]  

(3.2.2.5)

where \( v_t \) is the error term with mean zero and constant variance \( \sigma^2 \).

In addition, to avoid the possibility that the error term \( v_t \) is autocorrelated: inserting the lags of \( \Delta \hat{u}_t \) modifies equation (3.2.2.5) in the AEG equation in the following form:

\[ \Delta \hat{u}_t = \gamma \hat{u}_{t-1} + \sum_{j=1}^{P} \phi_j \Delta \hat{u}_{t-j} + v_t \]  

(3.2.2.6)

The test using this form is known as the augmented Engle-Granger (AEG) test, where its test statistic has the same asymptotic distribution as the EG statistic; therefore, the same critical values are used in these forms. This study uses the EG critical values that were based on MacKinnon’s means of surface regressions (1991). The calculated EG critical values for any finite sample size or number of observations are in Appendix B. If the
\( r \) calculated from equation (3.2.2.5) and (3.2.2.6) is greater than \( r \) critical value at a certain significance level, the hypothesis \( \gamma = 0 \) should be rejected. This means that the time series of residual value is stationary. Therefore, the dependent and independent variables are co-integrated or they have a long-run relationship. Moreover, this study uses AEG tests; however, if the lagged difference terms (\( \Delta u_i \)) are jointly insignificant, this study uses EG tests as EG tests are more powerful than AEG tests. The reason is the same as Engle and Granger’s argument in using DF tests when the lagged difference terms in the actual series (\( \Delta Y_t \)) are jointly insignificant in unit root tests. Finally, in this study, the co-integration test will be conducted on the relationship between ARM share and fixed-adjustable interest rate spread, the relationship between ARM share and fixed-adjustable interest rate spread and other factors, and the relationship between fixed-adjustable interest rate spread and interest rate expectation.

3.3. Causality Relationship

3.3.1. Hypothesis

Following the theoretical model proposed by Brueckner, this section presents three hypotheses. First, this study hypothesizes that fixed-adjustable interest rate spread Granger-causes or predicts mortgage choice represented by ARM share. Moreover, this study hypothesizes that fixed-adjustable interest rate spread, consumer confidence index, affordability index and family income growth Granger-cause mortgage choice. Finally, this study hypothesizes that interest rate expectation Granger-causes fixed-adjustable interest rate spread. These hypotheses are tested by using Granger causality tests; however, this test is only conducted on dependent and independent variables that have a
long-run relationship. The following sub-section describes the procedure of testing for Granger causality.

3.3.2. Granger Causality Tests

This study will use vector autoregressive (VAR) models in the testing for causality. The process of the VAR model is to list all of the variables and to consider them as potentially endogenous. Then, each variable in the model is regressed on lagged values of the variable and the lagged values of other variables. In the case with a system of two variables, both variables are regarded as endogenous variables and the lagged values of the endogenous variables are considered as regressors on the right-hand side of the equation. This system of two variables is actually known as the bivariate vector autoregressive (BVAR) model.

In the case of the VAR model with \( p \) lags, the dynamic linear vector autoregression is as follows:

\[
\begin{align*}
y_{1t} &= k_1 + \sum_{i=1}^{p} c_{11,i} y_{1t-i} + \sum_{i=1}^{p} c_{12,i} y_{2t-i} + \ldots + \sum_{i=1}^{p} c_{1m,i} y_{mt-i} + \varepsilon_{1t} \\
y_{2t} &= k_2 + \sum_{i=1}^{p} c_{21,i} y_{1t-i} + \sum_{i=1}^{p} c_{22,i} y_{2t-i} + \ldots + \sum_{i=1}^{p} c_{2m,i} y_{mt-i} + \varepsilon_{2t} \\
y_{mt} &= k_m + \sum_{i=1}^{p} c_{m1,i} y_{1t-i} + \sum_{i=1}^{p} c_{m2,i} y_{2t-i} + \ldots + \sum_{i=1}^{p} c_{mm,i} y_{mt-i} + \varepsilon_{mt}
\end{align*}
\]

These \( m \) equations can be expressed in matrix notation as:

\[
Y_t = K - C_1 Y_{t-1} + C_2 Y_{t-2} + \ldots + C_p Y_{t-p} + E_t
\]

then it can be simplified as:
\[ Y_t = C + \sum_{i=1}^{P} C_i Y_{t-i} + E_t \]  

(3.3.2.5)

where \( Y_t = \begin{bmatrix} y_t \\ y_{-1} \end{bmatrix} \); \( K = \begin{bmatrix} k_1 \\ k_{-1} \end{bmatrix} \); \( C_i = \begin{bmatrix} c_{i1} & c_{i2} & \cdots & c_{i, k_{-1}} \end{bmatrix} \) and \( E_t = \begin{bmatrix} e_t \\ e_{-1} \end{bmatrix} \).

In this system, the right-hand side variables are the lagged values of the variable and lagged values of other variables, where they are the same in each equation. Therefore, they can be estimated separately by OLS without any loss of estimation efficiency (Zúñiga-Fallas, 1993).

The number of the lags, or the specification order of the VAR model should be specified before this model is estimated. The reason is that the higher the order, the larger the possibility to capture the dynamics of the system being modeled; however, the more parameters that must be estimated, the fewer the degrees of freedom. The selection of the appropriate number of order for the VAR model is very important, because an arbitrary lag length may cause under-parameterization, which will bias the results or over-parameterization, which will reduce the power of the tests as the efficiency of the model decreases. Therefore, this study will use statistical tools such as the Akaike information criterion (AIC) to determine the appropriate order. The lag length is chosen when the AIC is minimized. Just as in the univariate models, as the time series model has been estimated, the adequacy of this model should be checked. The error terms should not show any forecastable pattern. In other words, they should be white noise. Therefore, the Ljung-Box (LB) statistic will be used to check this problem.

The VAR and BVAR model can be used not only for forecasting but also for the
recently popular statistical examination of the ‘causal’ relationship between variables.
The important point to consider in using Granger causality tests to realize the premise used by Granger, explained as:

“The future cannot cause the present or the past. If event A occurs after event B, we know that A cannot cause B. At the same time, if A occur before B, it does not necessarily imply that A causes B. ... In practice, we observe A and B as time series and we would like to know whether A precedes B, or B precedes A, or they are contemporaneous.”

Based on this premise, it is clear that Granger causality does not mean exactly causality, instead it means that one variable precedes another variable. If the variables have a long-run relationship as shown by a co-integration test, the result of Granger causality tests may show that one variable is qualified to forecast another variable (Granger, 1969) or it is more popular among econometricians to say one variable Granger-causes another variable. In other words, the result of the test shows necessary information for a ‘causal’ relationship. However, Granger causality does not mean X always causes Y, in this context ‘causality’ has to be defined in econometric term, which has a meaning more on the lines of ‘to predict’ rather than to ‘produce’.

---

In the BVAR or two variables context, Granger causality can be achieved if lagged values of $y_{1t}$ and independent variable $y_{2t}$ in equation (3.3.2.1) provide a better estimation of $y_{1t}$ than the estimation performed by inserting only lagged values of $y_{1t}$. This means that the information in the past and present of $y_{2t}$ refines the estimation of the $y_{1t}$ variable, because the variance of the estimated error of $y_{1t}$ based on lagged values of $y_{1t}$ and $y_{2t}$ is smaller than the variance of the estimated error of $y_{1t}$ based on only lagged values of $y_{1t}$. As a result, a variable $y_{2t}$ is said to Granger-cause a variable $y_{1t}$.

This study will examine whether the fixed-adjustable interest rate spread Granger-causes mortgage choice represented by ARM share. This examination means verifying the long-run relationship between the spread and ARM share and examining their 'causal' relationship. If based on the co-integration test they have a long-run relationship, then by using the Granger causality test, this study will examine the 'causal' relationship between the fixed-adjustable interest rate spread and ARM share. Furthermore, this study will also examine whether fixed-adjustable interest rate spread and other factors Granger-cause mortgage choice. In addition, this study will also investigate the long-run and 'causal' relationship between the interest rate expectation and spread adjustment represented by the fixed-adjustable interest rate spread. Finally, if two variables are co-integrated, implying that one variable Granger-causes another variable. Therefore, co-integration tests become a prerequisite of the Granger causality tests.

3.5. Data

The long-run relationship between ARM share and interest rate spread was tested using time series monthly data from the Federal Housing Finance Board. The long-run relationship between interest rate expectation, which was approximated by
the difference between yield on the 30-year Treasury securities and the yield on 1-year Treasury securities, and interest rate spread was also tested using time series monthly data. The yield difference or yield premium was calculated using data from Federal Reserve Bank of New York. Moreover, the data for other factors was obtained from several institutions. The consumer confidence index was obtained from the Conference Board’s Consumer Research Center. The affordability index and family income growth were obtained from National Association of Realtors.

The length of the data was 156 monthly periods and it stretched from January 1984 to December 1996. As the availability of the ARM data from Federal Housing Finance Board was only from January 1984, this study used that month as the beginning point. This study used the Shazam 7.0 statistical package to apply the unit root tests. The same statistical package was used to apply co-integration and Granger causality tests; however, the first difference data were used in the Granger causality tests. The descriptive statistics of data can be seen in Table 3.1.

The summary statistics detailed in Table 3.1 indicate that interest rates of FRMs were higher than interest rates of ARMs and the fixed-adjustable interest rate spread was lower than interest rate expectations. Based on maximum and minimum values, the S, AS and IRE series are more volatile compared to FRM and ARM series. The correlation matrix shows that FRM and ARM have high positive correlation indicating that changes in one of these series will be positively followed by changes in the other series. The positive correlation between S and IRE is quite high and it is higher than the positive correlation between S and AS. These correlation coefficients may indicate that changes in S will be positively followed by a change in AS and changes in IRE will be
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<th>St. Dev</th>
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<th>Min</th>
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<td>15.77</td>
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<tr>
<td>IG</td>
<td>0.35</td>
<td>0.22</td>
<td>2.16</td>
<td>-0.50</td>
</tr>
</tbody>
</table>

**Table 3.1: Descriptive Statistics of Data, 1984-1996**
positively followed by a change in spread. Moreover, the absolute value of the correlation coefficients between S and CCI, AI, and IG are less than 0.30. While, the absolute value of correlation coefficients between CCI and AI and IG are greater than 0.40, but they are still below 0.50. The absolute value of the correlation coefficient between AI and IG is 0.42. Therefore, the presence of multicollinearity in the AS and S. CCI, AI and IG relationships may be less likely as the correlation coefficients are all less than 0.50.
CHAPTER 4

EMPIRICAL RESULTS

This chapter applies unit root, co-integration, and Granger causality tests to each of three models developed in chapters 2 and 3. Before the unit root, co-integration, and Granger causality tests are conducted, this study examines the stability of each of three models. Figure A.1 shows that the regime shift on the first model happened in July 1989. However, Figure 1.5 displays the relationship between AS and S, which appears to consist of four different periods of relationship. The first period between January 1984 and early 1985 shows that the relationship between AS and S was weak. In the second period from early 1985 to the late 1980s or early 1990s, the relationship became stronger. However, since the beginning of the 1990s to mid-1994, the relationship became weak again. Then, the relationship became strong again from mid-1994 to the end of 1996. Therefore, the stability of this model is tested again in the current research. The first test is in the period of January 1984 to July 1989, and the second test is from August 1989 to December 1996.

Figure A.2 shows that the regime shift from the first test happened in January 1985, while Figure A.3 displays the regime shift from the second test occurred in May 1994. Therefore, the unit root and co-integration tests for the relationship between AS
and S are conducted in five different periods. The first period spans the whole period from January 1984 to December 1996; the second period runs from January 1984 to January 1985; the third from February 1985 to July 1989; the fourth from August 1989 to May 1994; and finally the fifth, from June 1994 to December 1996.

In addition, Figure A.4 shows that the regime shifts on the second model happened in December 1989. Therefore, the unit root and co-integration tests for the relationship between AS and S together with CCI, AI and IG were conducted in three different periods. The first period spans the whole period from January 1984 to December 1996; the second, from January 1984 to December 1989; and the third, from January 1990 to December 1996.

Figure A.5 shows that the regime shift on the third model happened in May 1995. However, Figure 1.6 displays the relationship between S and IRE that consists of five different periods. The first period between January 1984 and early 1987 shows the relationship between AS and S was strong. In the second period from early 1987 to the end of the 1980s, their relationship became weak. However, since the end of the 1980s to the beginning of the 1990s, the relationship became strong again. Then, the relationship became weak again from the early 1990s to early 1995 and finally strong again from early 1995 to December 1996.

Therefore, the stability of this model is tested again for the period of January 1984 to May 1995 in the current research. The results of this test are shown in Figures A.6, A.7, and A.8, which show that the other regime shifts on the third model occurred in May 1987, May 1989, and February 1992, respectively. Therefore, the tests for the relation-
ship between S and IRE are conducted in six different periods. The first period covers the whole period from January 1984 to December 1996; the second period runs from January 1984 to May 1987; the third period from June 1987 to May 1989; the fourth from June 1989 to February 1992; the fifth from March 1992 to May 1995; and the sixth, from June 1995 to December 1996.

In this chapter, the unit root and co-integration tests for each model are conducted on each related partition. Then, the Granger causality test follows the co-integration test, if the test shows that the dependent and independent variables have a long-run relationship. Section 4.1 displays the graphical analysis of mortgage choice. Section 4.2 shows the empirical results of these three tests on the first model that is spread, influencing the mortgage choice. Section 4.3 exhibits the empirical results of these three tests on the second model that is spread and other factors influencing mortgage choice. Finally, section 4.4 shows the empirical results of these three tests on the third model that is interest-rate expectation influencing the spread-adjustment.

4.1. Graphical Analysis of Mortgage Choice

As described in chapter 3, graphically all the series have stochastic trends. These stochastic trends in each series should be examined to discover whether the series are stationary or non-stationary. Therefore, unit root tests are conducted in the next three sections to determine the stationarity of the series. It is important to know the stationarity of the series in order to avoid drawing inference from a regression that might be spurious.

Based on the theoretical model, certain variables may influence mortgage choice. However, what is interesting about the time series analysis is that the related variables
that are used to describe borrower's mortgage choice may coincide with specific events that are related to mortgage history. Consequently, the related variables may not have any impact on mortgage choice in a certain period.

Based on the Brueckner theoretical model, this study believes that the interest rate spread influences the borrower's decision in choosing the type of mortgage loan. But it seems that spread did not have a strong impact on mortgage choice in the period from January 1984 to January 1985, as can be seen in Figure 1.5. This might happen because the interest rate, including interest-rate expectation, decreased as the Federal Reserve started loosening money policy as the inflation rate began to decline in 1983. Decreasing interest rates increased demand for mortgage loans, and since the borrower had the ARM loan as an alternative choice, the borrower preferred the ARM loan to the FRM loan. This means that the borrower had the tendency to consider ARM rates rather than spread in choosing a mortgage loan (especially given the ARM loan was a relatively new choice at the time). Later, as the borrower had more knowledge about the ARM loan, the fixed-adjustable interest rate spread may have become a more important factor for borrowers to consider in the period from February 1985 to July 1989.

In the period from August 1989 to May 1994, it seems that the spread did not influence borrowers in choosing a mortgage loan. This might have happened because in the early 1990s, the United States entered the recession era, which resulted in low consumer confidence about the economy, as can be seen in Figure 4.1. Although the spread increased during this period, ARM share did not increase, perhaps because low consumer confidence index brought down the ARM share. In addition, Figure 4.2
displays lower family income growth in the recession era. Lower income growth also
brought down the ARM share. On the other hand, although the U.S. economy was in
recession in the early 1990s, the housing affordability index increased. This might have
happened because households postponed purchasing a house; or a decrease in demand for
housing may have resulted in lower housing prices. The increasing affordability index
has a negative impact on the choice of an ARM loan because as housing is more
affordable, households prefer the FRM loan to the ARM loan. Consequently, this factor
also contributed to bringing down the ARM share, as can be seen in Figure 4.3.

Figure 4.1: Monthly Consumer Confidence Index & ARM Share, 1984-1996
Figure 4.2: Monthly Income Growth & ARM Share. 1984-1996
Moreover, in the period from June 1994 to December 1996, the borrower appears to be coming back to considering the spread in choosing a mortgage loan as the economy started to recover. It appears that the other three factors did not have any impact on mortgage choice in this period. Therefore, in the next two sections, this study examines not only the impact of spread on mortgage choice, but also the impact of spread and other factors on mortgage choice.

On the other side of the mortgage market, theoretically interest rate expectation influences the lender’s decision in adjusting a fixed-adjustable interest-rate spread. But it
seems that interest-rate expectation did not have a strong impact on spread adjustment in the period from June 1987 to May 1989 and in the period from March 1992 to May 1995, as can be seen in Figure 1.6. This might have happened because in the period from June 1987 to May 1989 the lender may have had a different interest-rate expectation than the borrower, as the Federal Reserve had the tendency to increase the Federal Funds rate from 6.58% in July 1987 to 9.85% in March 1989, in order to combat rising inflation since early 1987. Therefore, the lender might expect increasing interest rate; consequently, instead of adjusting the spread down, the lender might adjust the spread up. This means that the lender thought the ARM loan was more profitable in this period as the lender tried to channel borrowers toward ARM loans as much as possible.

In the period from March 1992 to May 1995, it seems that lenders did not follow the movement of decreasing interest rate expectation either, especially since early 1994 to May 1995. This might have happened because the inflation rate started increasing again in 1994 and the Federal Reserve started to raise the Federal Funds rate; therefore, the lender might expect increasing the interest rates rather than decreasing. Therefore, section 4.3 formally examines the impact of interest-rate expectation on spread adjustment in six different periods.

4.2. Spread Influencing Mortgage Choice

Table 4.1 shows the unit root tests in AS and S on the five periods for levels and first differences. The unit root tests for levels were insignificant in all five periods in three different ADF forms except for the S series with the third ADF form in the period between August 1989 and May 1994. However, since results were only significant at the
10% level, and all unit root tests performed on the level forms were insignificant at the 5% level, these results indicate that these two series, in all five periods, were not stationary. Moreover, the unit root tests for the first differences were significant at least at the 5% level, except for the AS series with the second ADF form in the period between January 1984 and January 1985. However, the third ADF form, which includes constant and trend variables, is a more complete form than the first and second ADF form. Therefore, since all unit root tests for the first difference of the AS series with the third ADF form in this period were significant at the 5% level, the unit root test of all first differences of these two series were significant at least at the 5% level. Clearly, the results suggest that the AS and S series on five periods were integrated of order 1, I(1). In addition, the DW statistics for the first difference with the third ADF forms indicates that autocorrelation in the residuals of the third ADF form was not a problem. As both series were integrated of order 1, the co-integration test between AS and S series followed the unit root test.

Table 4.2 reports co-integration tests between AS and S on five different periods. The long-run relationship between current AS and current S and 1-, 2- and 3-month lags in S was examined. The reason to use the lag in S is that the borrower commits to closing the contract about two or three months before the contract is actually signed, so that it is often necessary for the borrower to make a decision based on the level of spread three months prior (Devaney, 1994). The co-integration test using the first form of co-integration regression in the period from February 1985 to July 1989 with 1-and 2-month lags in S shows that AEG statistics were significant at the 5% level. Moreover, the co-
integration test using the second form of co-integration regression in the period from June 1994 to December 1996 with a 1-month lag in S shows that AEG statistics were significant at the 5% level. The results suggest that the AS and S series had a long-run relationship in the period from February 1985 to July 1989 and also in the period from June 1994 to December 1996, while co-integration tests in other periods did not show any long-run relationship.

As AS and S series are co-integrated, the related co-integration regression may not be spurious. Based on two related co-integration regressions, a 1- and 2-month lag in S has a positive influence on AS. These results are consistent with the hypothesis in section 3.2. Therefore, it appears that these results support the graphical analysis in section 4.1. In addition, as both series have long-run relationships in the period between February 1985 and July 1989 and in the period between June 1994 and December 1996, the Granger-causality test follows the co-integration test.

Table 4.3 reports Granger causality tests between AS and S in the period from February 1985 to July 1987 and in the period from June 1994 to December 1996. In the period from February 1985 to July 1989, this test started from a seven-month lag on each variable and tested down to reach the minimum AIC in order to find the best vector autoregressive model. As minimum AIC is reached at lag 2, the vector autoregressive model of order 2 was selected. When ΔAS is treated as a dependent variable, the F-score on lagged values of ΔAS was insignificant, while the F-score on lagged values of ΔS was significant at the 1% level. The R-square of this equation is 0.55 and the Q-statistics indicate that there is no autocorrelation problem in the residual. On the other hand, when
ΔS is treated as a dependent variable, the F-score on lagged values of ΔAS and ΔS were insignificant. The R-square of this equation is only 0.09, although the Q-statistics indicate that there is no autocorrelation problem in the residual. The result of this test suggests that there is uni-directional Granger causality from S to AS. In other words, S Granger-caused or preceded AS in the period from February 1985 to July 1989.

Furthermore, in the period from June 1994 to December 1996, this test started from a five-month lag on each variable and tested down to reach the minimum AIC in order to find the best vector autoregressive model. As minimum AIC is reached at lag 1, a vector autoregressive model of order 1 was selected. When ΔAS is treated as a dependent variable, the F-score on lagged values of ΔAS was insignificant, while the F-score on lagged values of ΔS was significant at the 10% level. The R-square of this equation is 0.12 and the Q-statistics indicate that there is no autocorrelation problem in the residual. On the other hand, when ΔS is treated as a dependent variable, the F-score on lagged values of ΔAS was insignificant, while the F-score on lagged values of ΔS was significant at the 10% level. The R-square of this equation is 0.11 and the Q-statistics indicate that there is no autocorrelation problem in the residual. The result of this test shows that there is uni-directional Granger causality from S to AS at the 10% significance level. Therefore, S weakly Granger-caused or preceded AS in the period from June 1994 to December 1996.
| Series: | 01/84 - 12/06: | 
|---------|----------------| | 01/84 - 01/85: | 
|         | ADF1 DW | ADF2 DW | ADF3 DW | ADF1 DW | ADF2 DW | ADF3 DW | ADF1 DW | ADF2 DW | ADF3 DW | ADF1 DW | ADF2 DW | ADF3 DW |
| S       | -0.81   | 1.9859  | -2.33   | 1.9295  | -2.28   | 1.9381  | -12.42***| 1.9957  | -12.38***| 1.9959  | -12.39***| 1.9949  |
| AS      | -0.65   | 1.6691  | -0.57   | 1.5090  | -0.85   | 1.9334  | -2.73** | 1.7198  | -2.60   | 1.7024  | -4.22** | 2.0522  |
| S       | -0.23   | 2.4335  | -1.61   | 2.0164  | -2.25   | 2.3016  | -4.20** | 1.9573  | -4.00** | 1.9620  | -4.05** | 2.0090  |
| AS      | -1.02   | 1.9199  | -1.77   | 1.9691  | -1.62   | 1.9684  | -3.75***| 1.8878  | -3.72***| 1.9008  | -3.70** | 1.9172  |
| S       | -0.61   | 1.3716  | -1.22   | 1.3162  | -0.77   | 1.3625  | -5.46***| 2.0029  | -5.44***| 2.0103  | -5.43***| 2.0003  |
| AS      | -0.11   | 1.7515  | -2.12   | 1.5548  | -1.86   | 1.5651  | -6.51***| 1.9110  | -6.47***| 1.9138  | -6.53***| 1.9299  |
| S       | -0.60   | 2.1813  | -1.74   | 2.1038  | -3.17*  | 1.9191  | -8.08***| 1.9250  | -8.22***| 1.9465  | -8.15***| 1.9455  |
| AS      | -0.96   | 1.7854  | -1.11   | 1.7285  | -1.35   | 1.6878  | -4.72***| 2.0278  | -4.68***| 2.0252  | -4.59***| 2.0245  |
| S       | -1.68   | 2.5176  | -1.37   | 2.4624  | -1.54   | 2.2907  | -6.50***| 1.9225  | -6.76***| 1.9348  | -6.80***| 1.9442  |

Notes:
The Dickey-Fuller statistics were computed from regressions of the following forms:

\[
\Delta Y_t = \alpha_0 Y_{t-1} + \sum_{j=1}^{p} \gamma_j \Delta Y_{t-j} + e_t \text{ for ADF1; } \Delta Y_t = \alpha_0 Y_{t-1} + \sum_{j=1}^{p} \gamma_j \Delta Y_{t-j} + \epsilon_t \text{ for ADF2; } \Delta Y_t = \alpha_0 Y_{t-1} + \alpha_1 t + \sum_{j=1}^{p} \gamma_j \Delta Y_{t-j} + e_t \text{ for ADF3.}
\]

Asymptotic Dickey-Fuller Critical Values are shown in Table B.1.

*** Significant at 1% level; ** Significant at 5% level; * Significant at 10% level

Table 4.1: Tests for Unit Roots in ARM Share (AS) & Fixed-Adjustable Interest Rate Spread (S)
Table 4.2: Tests for Co-integration between ARM Share (AS) & Fixed-Adjustable Interest Rate Spread (S)
Table 4.2 (continued)

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<td>-2.46</td>
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Notes:
The Engel-Granger statistics were computed from co-integration regressions of the following forms:

1: \( Y_t = C + \sum_{j=1}^{H} \beta_j Y_{t-j} + u_t \)

2: \( Y_t = C + \beta T + \sum_{j=1}^{H} \beta_j Y_{t-j} + u_t \)

and a residual regression of the following form:

\[ \Delta \hat{u}_t = \alpha \Delta \hat{u}_{t-1} + \sum_{j=1}^{r} \phi_j \Delta \hat{u}_{t-j} + \nu_t \]

Asymptotic Engel-Granger Critical Values are shown in Table B.2.

*** Significant at 1% level; ** Significant at 5% level; * Significant at 10% level
<table>
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<tr>
<th>Dependent Variable</th>
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<th>Coefficients</th>
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<th>R-Square</th>
<th>Q</th>
<th>Joint significance of</th>
<th>F-score</th>
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<td></td>
<td>∆S1</td>
<td>19.79</td>
<td>6.10***</td>
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<td>∆AS1</td>
<td>0.01</td>
<td>1.07</td>
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<tr>
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<td>-1.43</td>
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</tr>
</tbody>
</table>

Notes:
1) Vector Autoregressive of order 2 is selected as minimum AIC is reached at lag 2
2) Vector Autoregressive of order 1 is selected as minimum AIC is reached at lag 1
*** Significant at 1% level; ** Significant at 5% level; * Significant at 10% level

Table 4.3: Granger Causality Tests (based on first differences) between ARM Share (AS) & Fixed-Adjustable Interest Rate Spread
4.3. Spread and Other Factors Influencing Mortgage Choice

Table 4.4 shows the unit root tests in AS, S, CCI, IG and AI on the three periods for levels and first differences. The unit root tests for levels were insignificant in all three periods in three different ADF forms except for the IG series with the second ADF form in the period of January 1984 to December 1996. In addition, unit root tests for the IG series with the second and third ADF forms in the period of January 1990 to December 1996 were also significant. However, since these results were only significant at the 10% level, and all unit root tests performed on the level forms were insignificant at the 5% level, these results indicate that these five series in the three periods were not stationary. Moreover, the unit root tests for the first differences were significant at least at the 5% level, except for the AI series with the second and third ADF forms in the period from January 1984 to December 1996. Since the third ADF form includes constant and trend variables, this form is a more complete than the first and second ADF form. Therefore, it is believed that the unit root tests for the first difference of the AI series was not stationary in this period. This means that the AI series in the whole period was not integrated of order 1 and might be integrated of some higher order.

Therefore, following the rules concerning linear combinations of integrated series.\textsuperscript{15} the co-integration test in this period cannot be conducted, as one of the independent variables in the co-integration regression is not integrated of order 1. Clearly, the results suggest that the AS, S, CCI, IG and AI series on two periods other than the whole sample period were integrated of order 1, I (1). As all series were integrated of order 1, the co-

integration test between the AS and S, CCI, IG and AI series followed the unit root test in
the period of January 1984 to December 1989 and in the period of January 1990 to
December 1996.

Table 4.5 reports co-integration tests between AS and S and other factors on two
different periods. Similar to section 4.2, the long-run relationship between the current AS
and current S and other factors and 1-, 2- and 3-month lags in S and in other factors was
examined. The co-integration tests using the first and second form of the co-integration
regression in the period of January 1984 to December 1989 with 1 and 2 lags in S and in
other factors show that AEG statistics were significant at the 5% level. On the other hand,
the co-integration tests in the period of January 1990 to December 1996 shows that all
AEG statistics were insignificant. The results suggest that AS and S and other factor
series had a long-run relationship in the period from January 1984 to December 1989,
while the co-integration tests in the other period did not show any long-run relationship.

As AS and S and other factor series are co-integrated, the related co-integration
regression may not be spurious. Based on four related co-integration regressions, the
impact of a 1- and 2-month lag in S, CCI, AI and IG on AS is consistent with the
hypothesis in section 3.2. The only unexpected result is the impact of a 2-month lag in AI
in the second co-integration form, which is not significant and does not exhibit the
expected sign. In addition, as AS and S and other factors have a long-run relationship in
the period from January 1984 to December 1989, the Granger-causality test follows the
cointegration test.

Table 4.6 reports Granger causality tests between AS and S and other factors in the
period between January 1984 and December 1989. In this period, this test started from a nine-month lag on each variable and tested down to reach the minimum AIC in order to find the best vector autoregressive model. As minimum AIC is reached at lag 1, vector autoregressive of order 1 was selected. When ΔAS is as a dependent variable, the lagged values of ΔS, ΔCCI, ΔAI and ΔIG was jointly significant at the 1% level. In addition, the F-score on lagged values of ΔAS, ΔS, and ΔCCI was significant at the 5%, 1% and, 5% levels, respectively. On the other hand, the F-scores on the lagged values of ΔAI and ΔIG were insignificant. The R-square of this equation is 0.50 and the Q-statistics indicate that there is no autocorrelation problem in the residual. On the other hand, when other factors besides ΔAS become a dependent variable, there is no F-score that was significant at the 5% level, except the F-score on lagged values of the dependent variable itself. The result of this test suggests that there is uni-directional Granger causality from S and other factors to AS. In other words, S and other factors Granger-caused or preceded S in the period from January 1984 to December 1989.
<table>
<thead>
<tr>
<th>Series:</th>
<th>Level Form</th>
<th>First Difference</th>
</tr>
</thead>
<tbody>
<tr>
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<td>ADF1</td>
<td>DW</td>
</tr>
<tr>
<td>01/84 - 12/96:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>-0.81</td>
<td>1.9959</td>
</tr>
<tr>
<td>CCI</td>
<td>-0.20</td>
<td>2.0519</td>
</tr>
<tr>
<td>AI</td>
<td>0.95</td>
<td>2.0841</td>
</tr>
<tr>
<td>IG</td>
<td>-1.25</td>
<td>2.0233</td>
</tr>
<tr>
<td>01/84 - 12/89:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AS</td>
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</tr>
<tr>
<td>S</td>
<td>-0.80</td>
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</tr>
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<td>CCI</td>
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<td>2.0627</td>
</tr>
<tr>
<td>AI</td>
<td>1.20</td>
<td>1.9935</td>
</tr>
<tr>
<td>IG</td>
<td>-1.52</td>
<td>2.1353</td>
</tr>
<tr>
<td>01/90 - 12/96:</td>
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<td></td>
</tr>
<tr>
<td>AS</td>
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</tr>
<tr>
<td>S</td>
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</tr>
<tr>
<td>CCI</td>
<td>-0.18</td>
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</tr>
<tr>
<td>AI</td>
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<td>2.0056</td>
</tr>
<tr>
<td>IG</td>
<td>-1.35</td>
<td>2.1390</td>
</tr>
</tbody>
</table>

Notes:
The Dickey-Fuller statistics were computed from regressions of the following forms:

\[
\Delta Y_t = \alpha_0 Y_{t-1} + \sum_{j=1}^{n} \gamma_j \Delta Y_{t-j} + \epsilon_t \text{ for } ADF1; \Delta Y_t = \gamma + \alpha_0 Y_{t-1} + \sum_{j=1}^{n} \gamma_j \Delta Y_{t-j} + \epsilon_t \text{ for } ADF2; \Delta Y_t = \gamma + \alpha_0 T + \alpha_1 T + \sum_{j=1}^{n} \gamma_j \Delta Y_{t-j} + \epsilon_t \text{ for } ADF3.
\]

Asymptotic Dickey-Fuller Critical Values are shown in Table B.1.
*** Significant at 1% level; ** Significant at 5% level; * Significant at 10% level

Table 4.4: Tests for Unit Roots in ARM Share (AS) & Fixed-Adjustable Interest Rate Spread (S), Consumer Confidence Index (CCI), Affordability Index (AI) and Income Growth (IG)
<table>
<thead>
<tr>
<th>Co-integration</th>
<th>01/04 - 12/88</th>
<th>01/04 - 12/89</th>
<th>01/00 - 12/96</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current S, CCI, AI &amp; IG:</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>18.89 (11.61)</td>
<td>33.00 (14.55)</td>
<td>12.91 (7.16)</td>
</tr>
<tr>
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<td>18.75 (10.47)</td>
<td>32.03 (10.04)</td>
<td>15.08 (8.53)</td>
</tr>
<tr>
<td>CCI</td>
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<td>0.61 (6.04)</td>
<td>0.39 (7.78)</td>
</tr>
<tr>
<td></td>
<td>0.43 (9.84)</td>
<td>0.65 (4.35)</td>
<td>0.24 (3.73)</td>
</tr>
<tr>
<td>AI</td>
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<td>-0.61 (-5.40)</td>
<td>-0.11 (-1.39)</td>
</tr>
<tr>
<td></td>
<td>-0.47 (-3.59)</td>
<td>-0.54 (-2.78)</td>
<td>-0.61 (-3.99)</td>
</tr>
<tr>
<td>IG</td>
<td>3.04 (0.80)</td>
<td>72.84 (0.77)</td>
<td>-1.79 (0.72)</td>
</tr>
<tr>
<td></td>
<td>68.05 (5.64)</td>
<td>(4.09)</td>
<td>(0.72)</td>
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<tr>
<td>T</td>
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<td>0.25 (3.74)</td>
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<td>- (0.00)</td>
<td>- (0.00)</td>
<td>-0.08 (0.08)</td>
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<tr>
<td>C</td>
<td>24.97 (2.92)</td>
<td>23.00 (1.76)</td>
<td>-8.99 (2.69)</td>
</tr>
<tr>
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<td>29.65 (-1.42)</td>
<td>36.52 (-1.39)</td>
<td>50.56 (2.69)</td>
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<td>36.52 (-1.39)</td>
<td>-36.52 (-1.39)</td>
<td>50.56 (2.69)</td>
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<td>1-month lag in S, CCI, AI &amp; IG:</td>
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<tr>
<td>S1</td>
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<td>36.74 (19.99)</td>
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<td>20.32 (11.83)</td>
<td>35.29 (14.02)</td>
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<td>0.39 (8.14)</td>
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<td>0.41 (8.83)</td>
<td>0.61 (5.14)</td>
<td>0.24 (4.09)</td>
</tr>
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<td>-0.41 (-3.29)</td>
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Table 4.5: Tests for Co-integration between ARM Share (AS) & Fixed-Adjustable Interest Rate Spread (S), Consumer Confidence Index (CCI), Affordability Index (AI) and Income Growth (IG)
Table 4.5 (continued)

<table>
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<th>01/84 - 12/89</th>
<th>01/90 - 12/96</th>
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</tr>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>1</td>
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<td>19.29</td>
<td>14.91</td>
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<td>(1.19)</td>
<td>(-2.46)</td>
</tr>
<tr>
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<td>-4.21</td>
<td>-5.18**</td>
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<td>(15.50)</td>
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<tr>
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<td>(9.18)</td>
<td>(5.89)</td>
</tr>
<tr>
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<td>-0.22</td>
<td>-0.40</td>
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<tr>
<td></td>
<td>(-7.41)</td>
<td>(-1.72)</td>
<td>(-3.64)</td>
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<td>(2.31)</td>
<td>(7.27)</td>
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<td>(1.75)</td>
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<td>(-3.01)</td>
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<td>-4.39</td>
<td>-4.83**</td>
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<tr>
<td>S3</td>
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<td>(9.93)</td>
<td>(8.29)</td>
<td>(9.91)</td>
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(continued)
### Table 4.5 (continued)

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<td>1</td>
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<td>CCI3</td>
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<td>(7.67)</td>
<td>(8.14)</td>
<td>(4.07)</td>
</tr>
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<td>AI3</td>
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<td>-0.04</td>
<td>-0.29</td>
</tr>
<tr>
<td></td>
<td>(-6.05)</td>
<td>(-0.30)</td>
<td>(-1.93)</td>
</tr>
<tr>
<td>IG3</td>
<td>9.73</td>
<td>8.52</td>
<td>91.25</td>
</tr>
<tr>
<td></td>
<td>(2.28)</td>
<td>(2.00)</td>
<td>(5.27)</td>
</tr>
<tr>
<td>T</td>
<td>-</td>
<td>-0.11</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>(-2.65)</td>
<td>(-5.08)</td>
<td>(-5.08)</td>
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<tr>
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<tr>
<td></td>
<td>(1.53)</td>
<td>(-0.920)</td>
<td>(-2.38)</td>
</tr>
<tr>
<td>AEG</td>
<td>-4.41*</td>
<td>-4.24</td>
<td>-3.49</td>
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</table>

**Notes:**

The Engel-Granger statistics are computed from co-integration regressions of the following forms:

1. \( Y_{it} = C + \sum_{j=1}^{k} \beta_j Y_{ij} + \eta_i \)
2. \( Y_{it} = C + \beta T + \sum_{j=1}^{K} \beta_j Y_{ij} + \eta_i \)

and a residual regression of the following form:

\( \Delta \hat{\eta}_i = \alpha \hat{\eta}_{i-1} + \sum_{j=1}^{L} \varphi_j \Delta \hat{\eta}_{i-j} + \nu_i \)

Asymptotic Engel-Granger Critical Values are shown in Table B.2.

*** Significant at 1% level; ** Significant at 5% level; * Significant at 10% level
<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Independent Variables</th>
<th>Coefficients</th>
<th>T-Ratio</th>
<th>R-Square</th>
<th>Q</th>
<th>Jointly significant of</th>
<th>F-score</th>
</tr>
</thead>
<tbody>
<tr>
<td>ΔAS</td>
<td>ΔAS1</td>
<td>0.21</td>
<td>2.23**</td>
<td>0.50</td>
<td>10.43</td>
<td>ΔAS</td>
<td>4.99**</td>
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<td></td>
<td>ΔS1</td>
<td>17.29</td>
<td>6.07***</td>
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<td>ΔS</td>
<td>36.83***</td>
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<tr>
<td></td>
<td>ΔCCI1</td>
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<td>-2.08**</td>
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<td></td>
<td>ΔCCI</td>
<td>4.33**</td>
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<td>ΔS ΔCCI ΔAI ΔIG</td>
<td>11.35***</td>
</tr>
<tr>
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<td>ΔAS1</td>
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<td>ΔAS</td>
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<td></td>
<td>ΔS1</td>
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<td>1.44</td>
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<td></td>
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<td></td>
<td>ΔCCI1</td>
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<tr>
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<td></td>
<td>ΔS</td>
<td>0.38</td>
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<tr>
<td></td>
<td>ΔCCI1</td>
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<td>-3.51***</td>
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<td>ΔCCI</td>
<td>12.35***</td>
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<td>ΔIG1</td>
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<td>ΔIG</td>
<td>1.73</td>
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<tr>
<td>Constant</td>
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<td>0.32</td>
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<td>ΔS ΔS ΔAI ΔIG</td>
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</tr>
</tbody>
</table>

Table 4.6: Granger Causality Tests (based on first differences) between ARM Share (AS) & Fixed-Adjustable Interest Rate Spread (S), Consumer Confidence Index (CCI), Affordability Index (AI) and Income Growth (IG)

(continued)
Table 4.6 (continued)

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Independent Variables</th>
<th>Coefficients</th>
<th>T-Ratio</th>
<th>R-Square</th>
<th>Q</th>
<th>Jointly significance of</th>
<th>F-score</th>
</tr>
</thead>
<tbody>
<tr>
<td>ΔAl</td>
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<td>-1.20</td>
<td>0.15</td>
<td>9.87</td>
<td>ΔAS</td>
<td>1.44</td>
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<td></td>
<td>ΔS1</td>
<td>3.39</td>
<td>1.79*</td>
<td></td>
<td></td>
<td>ΔS</td>
<td>3.21*</td>
</tr>
<tr>
<td></td>
<td>ΔCCL1</td>
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<td>-0.83</td>
<td></td>
<td></td>
<td>ΔCCL</td>
<td>0.69</td>
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<td></td>
<td>ΔAl1</td>
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<td>-2.34**</td>
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<td></td>
<td>ΔAl</td>
<td>5.47**</td>
</tr>
<tr>
<td></td>
<td>ΔIG1</td>
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<td>ΔIG</td>
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<td>Constant</td>
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<td>1.20</td>
<td></td>
<td></td>
<td>ΔAS ΔS ΔCCL ΔIG</td>
<td>1.38</td>
</tr>
<tr>
<td>ΔIG</td>
<td>ΔAS1</td>
<td>0.001</td>
<td>0.64</td>
<td>0.03</td>
<td>17.85</td>
<td>ΔAS</td>
<td>0.41</td>
</tr>
<tr>
<td></td>
<td>ΔS1</td>
<td>0.01</td>
<td>0.38</td>
<td></td>
<td></td>
<td>ΔS</td>
<td>0.15</td>
</tr>
<tr>
<td></td>
<td>ΔCCL1</td>
<td>0.001</td>
<td>0.84</td>
<td></td>
<td></td>
<td>ΔCCL</td>
<td>0.70</td>
</tr>
<tr>
<td></td>
<td>ΔAl1</td>
<td>-0.001</td>
<td>-0.48</td>
<td></td>
<td></td>
<td>ΔAl</td>
<td>0.23</td>
</tr>
<tr>
<td></td>
<td>ΔIG1</td>
<td>-0.04</td>
<td>-0.29</td>
<td></td>
<td></td>
<td>ΔIG</td>
<td>0.09</td>
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<tr>
<td>Constant</td>
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<td>-1.01</td>
<td></td>
<td></td>
<td>ΔAS ΔS ΔCCL ΔAl</td>
<td>0.43</td>
</tr>
</tbody>
</table>

Notes:
1) Vector Autoregressive of order 1 is selected as minimum AIC is reached at lag 1
*** Significant at 1% level; ** Significant at 5% level; * Significant at 10% level
4.4. Interest Rate Expectation Influencing Spread Adjustment

Table 4.7 shows the unit root tests in S and IRE on the six periods for levels and first differences. The unit root tests for levels were insignificant in the six periods in three different ADF forms except for the IRE series with the second ADF form in the period of January 1984 to May 1987, for the IRE series with the third ADF form in the period of March 1992 to May 1995, and for the S series with the second ADF form in the period of June 1995 to December 1996. Since all unit root tests for the level form of IRE and S series with the third ADF form in all periods were insignificant at the 5% level, these two series in all periods were determined to be non-stationary. Moreover, the unit root tests for the first difference were significant at least at the 5% level except for the IRE series with all ADF forms in the period of June 1987 to May 1989 and for the IRE series with the third ADF form in the period of June 1995 to December 1996.

Based on the third ADF form, it is believed that the unit root tests for the first difference of the IRE series were not stationary in the period of June 1987 to May 1989 and in the period of June 1995 to December 1996. This means that the IRE series in these two periods are not integrated of order 1 or this series may be integrated of order two. Therefore, following the rules concerning linear combinations of integrated series, the co-integration test in these two periods cannot be conducted on levels, as the independent variable in the co-integration regression was not integrated of order 1. Therefore, co-integration tests between S and IRE series would be conducted for the four other periods, as S and IRE series in these periods were integrated of order 1, I(1).

Table 4.8 reports co-integration tests between S and IRE on four different periods.
The long-run relationship between the current S and current IRE and 1-, 2- and 3-month lags in IRE was examined. The reason to use the lag in IRE is that the lender may consider the level of IRE in the previous three months. The co-integration tests using the first and second form of co-integration regression in all four periods with 1, 2 and 3 lags in IRE shows that AEG statistics were not significant at the 5% level. The results suggest that the S and IRE series did not have any long-run relationship in all four periods. These results are not consistent with the hypothesis in section 3.2. Therefore, it appears that these results do not support the graphical analysis in section 4.1. In addition, as the series do not appear to have long-run relationship in all four periods, the Granger-causality test was not conducted.
### Table 4.7: Tests for Unit Roots in Fixed-Adjustable Interest Rate Spread & Interest Rate Expectation (IRE)

<table>
<thead>
<tr>
<th>Series:</th>
<th>Level Form</th>
<th>First Difference</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>ADF1</td>
<td>DW</td>
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<tr>
<td>01/84 - 12/96:</td>
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<tr>
<td>S</td>
<td>-0.81</td>
<td>1.9959</td>
</tr>
<tr>
<td>IRE</td>
<td>-1.14</td>
<td>1.9705</td>
</tr>
<tr>
<td>01/84 - 05/97:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>-0.30</td>
<td>1.6246</td>
</tr>
<tr>
<td>IRE</td>
<td>-0.88</td>
<td>1.6865</td>
</tr>
<tr>
<td>06/87 - 05/89:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>-0.42</td>
<td>2.0146</td>
</tr>
<tr>
<td>IRE</td>
<td>-1.64</td>
<td>2.0504</td>
</tr>
<tr>
<td>06/89 - 02/92:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>0.18</td>
<td>1.9065</td>
</tr>
<tr>
<td>IRE</td>
<td>3.51</td>
<td>1.772</td>
</tr>
<tr>
<td>03/92 - 05/95:</td>
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<td></td>
</tr>
<tr>
<td>S</td>
<td>-0.96</td>
<td>2.1228</td>
</tr>
<tr>
<td>IRE</td>
<td>-1.57</td>
<td>1.5522</td>
</tr>
<tr>
<td>09/95 - 12/96:</td>
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</tr>
<tr>
<td>S</td>
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</tr>
<tr>
<td>IRE</td>
<td>-0.01</td>
<td>1.5996</td>
</tr>
</tbody>
</table>

**Notes:**
The Dickey-Fuller statistics were computed from regressions of the following forms:

\[
\Delta Y_t = \alpha_0 Y_{t-1} + \sum_{j=1}^{k} \gamma_j \Delta Y_{t-j} + \epsilon_t \text{ for } ADF1;
\Delta Y_t = C + \alpha_0 Y_{t-1} + \sum_{j=1}^{k} \gamma_j \Delta Y_{t-j} + \epsilon_t \text{ for } ADF2;
\Delta Y_t = C + \alpha_0 Y_{t-1} + \alpha_1 T + \sum_{j=1}^{k} \gamma_j \Delta Y_{t-j} + \epsilon_t \text{ for } ADF3.
\]

Asymptotic Dickey-Fuller Critical Values are shown in Table B.1.

*** Significant at 1% level; ** Significant at 5% level; * Significant at 10% level
Table 4.8: Tests for Co-integration between Fixed-Adjustable Interest Rate Spread (S) & Interest Rate Expectation (IRE)
Table 4.8 (continued)

<table>
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<tr>
<th>Co-integration regressions with:</th>
<th>01/84 - 12/96</th>
<th>01/84 - 05/87</th>
<th>06/89 - 02/92</th>
<th>03/92 - 05/95</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
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<tr>
<td>3-month lag in IRE:</td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>IRE3</td>
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<td>0.27</td>
<td>0.34</td>
<td>0.33</td>
</tr>
<tr>
<td></td>
<td>(10.10)</td>
<td>(10.12)</td>
<td>(5.84)</td>
<td>(5.48)</td>
</tr>
<tr>
<td>T</td>
<td>-</td>
<td>-0.005</td>
<td>-</td>
<td>-0.005</td>
</tr>
<tr>
<td></td>
<td>(-0.85)</td>
<td>(-1.71)</td>
<td>(1.66)</td>
<td>(1.79)</td>
</tr>
<tr>
<td>C</td>
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<td>0.94</td>
<td>0.57</td>
<td>0.70</td>
</tr>
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<td></td>
<td>(16.89)</td>
<td>(13.62)</td>
<td>(5.21)</td>
<td>(5.38)</td>
</tr>
<tr>
<td>AEG</td>
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<td>-2.99</td>
<td>-3.03</td>
<td>-2.50</td>
</tr>
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</table>

Notes:
The Engel-Granger statistics are computed from co-integration regressions of the following forms:

1: \( y_i = c + \sum_{j=1}^{n} \beta_j y_{j,t} + u_t \)

2: \( y_{1t} = c + \beta T + \sum_{j=1}^{n} \beta_j y_{j,t} + u_t \)

and a residual regression of the following form:

\( \Delta \hat{u}_t = \sigma \hat{u}_{t-1} + \sum_{j=1}^{m} \phi_j \Delta \hat{u}_{t-j} + v_t \)

Asymptotic Engel-Granger Critical Values are shown in Table B.2.

*** Significant at 1% level; ** Significant at 5% level; * Significant at 10% level
CHAPTER 5

SUMMARY, IMPLICATIONS, AND CONCLUSIONS

As the main goal of this study was to have a better understanding of the factors that have had consistent influence on borrower's choice of mortgage loans, this study incorporated history, theory, and methods in the time series analysis of mortgage choice. This study shows that certain historical events affect theoretical predictions. Moreover, the present study explicitly tests for long-run relationships and uni-directional Granger causality over various distinct periods in the mortgage market. Furthermore, this study used newer econometric techniques to avoid basing conclusions on relationships that may be spurious.

In this chapter, the implications of this research are discussed through a summary of the importance, main focus, and methods of this study. The hypothesis is also revisited to highlight important findings.

5.1. Summary

Since 1981, ARM loans have been becoming an alternative way for households to finance their homeownership. Households' decisions to choose between ARM and FRM loans is important on their overall allocation of expenditures for housing and other consumption. The decision to choose between ARM and FRM loans may
influence the financial health of households. At the market level, the history of housing finance in the United States shows that the existence of ARM loans has provided lenders with another option to avoid interest-rate risk. Moreover, the ARM loan option in a mortgage loan plays a substantial role in maintaining smoother production levels in the housing industry. To policymakers, this loan option has been important part of homeownership programs. Therefore, the study of mortgage choice is meaningful not only for households and lenders, but also for all other groups interested in homeownership.

In this study, the choice of mortgage loans has been investigated from both the borrower and lender’s point of view. Using the spread influencing mortgage-choice model, this study examined the impact of the spread on mortgage choice represented by the ARM share. It also examined the impact of other factors such as consumer confidence index, affordability index, and family income growth together with the spread on mortgage choice. From the lender’s perspective, interest rate expectation’s influence on spread was modeled.

Since historical events may influenced the stability of the models, this study employed the switching-regression technique of Goldfeld and Quandt (1973) to examine whether there were any regime shifts or partitions in each of the three models. Then, unit-root tests were conducted on the series in each partition of a certain model. If the series were integrated of order one, co-integration tests were conducted. These tests examined whether the series had long-run relationships or not in each partition of the model. Finally, if the series in each partition exhibited a long-run relationship, the Granger causality tests were conducted.
In the spread influencing mortgage-choice model, stability test results show that this model was not stable; thus, the model was divided into four partitions. The unit-root test results in each partition were consistent with the hypothesis that all AS and S series were integrated of order 1. The instability of the model was in accordance with the co-integration test results. The results show that the AS and S series had a long-run relationship in the period from February 1985 to July 1989 and from June 1994 to December 1996. In contrast, over the period as a whole and in the periods from January 1984 to January 1985 and from August 1989 to May 1994, the AS and S series did not have any long-run relationship.

One possible explanation of the instability of the model is that borrowers may have the tendency to consider ARM rates and to ignore the spread in choosing a mortgage loan, as the ARM loan was relatively new in the period from January 1984 to January 1985. Then, as borrowers became more familiar with ARM loans, the spread between fixed and adjustable rates may have become a more important factor in choosing a mortgage loan in the period from February 1985 to July 1989. Another possible explanation is that the recession in the early 1990s brought down family income growth and consumer confidence, and caused the FRM loan to appear more affordable. Consequently, the borrower did not choose an ARM loan, although the spread was increasing in the period from August 1989 to May 1994. A final explanation for the instability of the model is that as the U.S. economy started to recover in the period from June 1994 to December 1996, borrowers started again to consider the spread in choosing a mortgage loan in this period.
Furthermore, the co-integration regression for the period from February 1985 to July 1989 with a 1- and 2-month lag in S and for the period from June 1994 to December 1996 with a 1-month lag in S show that the spread has a positive influence on the borrower's decision to choose an ARM loan. These results are consistent with the prediction that the parameter of S in the co-integration regression will be positive. Moreover, the Granger causality test results show that the spread significantly Granger-caused or predicted the ARM share in the period from February 1985 to July 1989, and the spread weakly Granger-caused or predicted the ARM share in the period from June 1994 to December 1996. These results are consistent with the hypothesis that the spread may predict the ARM loan choice and may indicate that the borrower considers the spread in choosing the ARM loan in those periods. This means that the consumer is responding to changes in the fixed-adjustable interest-rate spread, and not the opposite. This opposite case is where lenders adjust rates to mortgage demand.

In the spread and other factors influencing mortgage-choice model, stability test results show that this model was not stable, hence the model was divided into two stable partitions. The unit root test results were consistent with the hypothesis that all AS and S series in each partition were integrated of order 1, except for the AI series in the whole period. Therefore, a co-integration test in the period from January 1984 to December 1996 was not conducted. The instability of the model is confirmed by the co-integration test results, which show AS and S together with the CCI, AI, and IG series had a long-run relationship only in the period from January 1984 to December 1989. In contrast, in the period from January 1990 to December 1996, AS and S together with the CCI, AI,
and IG series did not have any long-run relationship.

A possible explanation of the instability of the AS, S, CCI, AI and IG model is that in the period from January 1990 to December 1996 the U.S. economy was in recession most of the time; consequently, other factors had more impact than S on AS. Implying that other factors may have dominated S in their influence on the borrower’s mortgage decision. As CCI and IG had the tendency to have a lower rate and AI had the tendency to have a higher rate in this period, the borrower tended to avoid the ARM loan. Then, S and other factors as a whole had no impact on the choice of an ARM loan in this period. Thus, it seems that the borrower disregards all four factors when the U.S. economy is in recession. Thus may be why statistically, S and other factors did not have any long-run relationship with AS in the period from January 1990 to December 1996. This result is evidence that certain events as described in section 4.1 may affect the long-run relationship between AS and S together with other factors. Thus, the structures of the mortgage-choice decision model, which changed from no recession era in the period from January 1984 to December 1989 into mostly recession era in the period from January 1990 to December 1996 influence the long-run relationships between AS and S, together with other factors.

In addition, the co-integration regression for the period from January 1984 to December 1989 with a 1- and 2-month lag in S, CCI, IG, and AI show that spread, consumer confidence, and family income growth have a positive influence on the borrower’s decision to choose an ARM loan. In contrast, AI has a negative influence on the choice of an ARM loan. These results are consistent with the prediction that the parameter of S, CCI, and IG in the co-integration regression will be positive. and
the parameter of AI will be negative. The only unexpected result is the impact of a 2-month lag in AI in the second co-integration form that is not significant and does not exhibit an expected sign.

Moreover, the Granger causality test results show that spread, consumer confidence, housing affordability, and family income growth significantly Granger-caused or predicted the ARM share in the period from January 1984 to December 1989. This result is consistent with the hypothesis that those four factors may predict the ARM loan choice. This indicates that borrower choice is influenced by the spread, consumer confidence, housing affordability, and family income growth from January 1984 to December 1989. This means that the consumer is responding to a change in the fixed-adjustable interest-rate spread and other factors, rather than the lender responding to consumer choice. Consequently, the results from this model confirm that of the first model, and again lenders did not appear to be adjusting the spread to meet mortgage demand.

The supply side of the market was more directly studied in the interest-rate expectation influencing the spread adjustment model. The unit root test results on four different periods were consistent with the hypothesis that the S and IRE series were integrated of order 1. On the other hand, stability test results show that this model was not stable. These results are contrary to the co-integration test results, which show that the S and IRE series do not have any long-run relationship in the period from January 1984 to December 1996. Neither do they have any long-run relationship in the other three partition periods, which were in the period from January 1984 to May 1987, June 1989 to February 1992 and March 1992 to May 1995.
In contrast, the co-integration test in the period from June 1987 to May 1989 and in the period from June 1995 to December 1996 are not conducted as the IRE series is not integrated of order one in these two periods. These results are contrary to the hypothesis that S and IRE have a long-run relationship and they are also contrary to the graphical analysis in section 4.1. which describes that certain events may affect the long-run relationship. The results show that S and IRE did not have any long-run relationship under any circumstances. This may indicate that the lender does not make any spread adjustment as interest-rate expectations change, which means that the lender is not responding to changes in interest-rate expectations. In other words, the results in this model are in accordance with the results from the two other models confirming that the supply of the mortgage market, as measured by spread and interest rate expectations, is not as responsive as the consumer side of the market.

5.2. Implications and Limitations

As described in the previous section, the study of mortgage choice is meaningful for borrowers, lenders, the housing industry, and policymakers. Hence, this study may have implications for each of these groups. However, this study also has certain limitations. Before discussing the implications of this study, this section describes the limitations of the study and recommendations for further research.

Using nationwide aggregate data, this study has taken a step in the direction of investigating the long-run and ‘causal’ relationships between consumer confidence, housing affordability, family income growth, interest rate spreads and mortgage choice.
and also between spread and interest-rate expectation. It is possible of course that a certain region with more specific characteristics may produce different results. In addition, it is important to emphasize that methodological limitations in the model design limit this study’s interpretations. The approach outlined in this study should be replicated in many regions of the country in order to capture certain characteristics of the region. In brief, for further research this study recommends to use regional data in investigating mortgage-choice problems.

From the borrowers’ point of view, borrowers should consider the fixed-adjustable interest-rate spread when choosing their mortgage loan. However, the consumer confidence index, the affordability index, and family income growth also appear important in the mortgage decision. In order to avoid financial problems in allocating expenditures for housing and other consumption in the future consumers appear to be reacting to changes in expectations, housing affordability and income. These three factors are very important in making a mortgage loan decision, especially under certain economic conditions like a recession. If borrowers only consider the spread in choosing a mortgage loan, especially during the recession, they may face financial problems because without considering the other three factors, they may make the wrong decision.

History shows that lenders ‘borrow short to lend long’ to finance housing loans, and before 1980 sources of funding were mainly from savings deposits, with lenders bearing all of the interest-rate risk. Therefore, lenders embraced the introduction of the ARM loan to avoid interest-rate risk. Channeling the ARM loan to borrowers could transfer the risk to these borrowers. In the period from January 1984 to December 1996, the empirical results show that lenders seemed not to be as concerned about interest-rate risk, as
they did not make spread adjustments to influence borrower's decisions. This may also reflect the grading number of sources of funding to finance a housing loan now available to lenders.

The secondary mortgage market has been increasing since the 1970s, and these secondary providers have been dominating the market as the source of funds since the end of the 1980s. Nowadays, lenders can 'borrow long to lend long' or 'borrow short to lend short.' Therefore, as long as they stick to basic asset and liability management in financing a housing loan, lenders may choose either to channel ARM or FRM loans. In short, lenders do not need to be worried about channeling FRM loans even if the expected interest rate is rising, as long as the source of funding to finance FRM loans comes from liabilities with similar terms.

The empirical results of this study imply that borrowers are not under the lender's influence in choosing their mortgage loan. This finding is contrary to the argument that lenders may adjust the spread to influence borrowers' decision to meet lenders' expectations (Brueckner, 1986; Devaney, 1994; and Jones et al., 1995). Thus, this finding shows the presence of consumer sovereignty in the mortgage market and it is in accordance with much of the mortgage literature, which only focuses on the borrower's side. In addition, as lenders do not make spread adjustments, this may indicate that the lender views ARM and FRM loan markets as not being intertwined. This means that the lender may have a specialty in channeling a mortgage loan. The lenders' focus on a certain mortgage loan depends on their loan portfolio strategy. For example, certain lenders may focus on channeling ARM loans as they borrow short, while other lenders prefer to channel FRM loans as they borrow long. It seems that from the
lender’s viewpoint, each of these two markets is efficient. Therefore, it is important for further research to examine whether a market-efficient hypothesis prevails in the mortgage market.

History shows that the availability of funding to finance a housing loan may influence the housing industry. In the past, the housing industry has been hurt because of a lack of funds. At the present time, the housing industry does not need to worry about a lack of funds, because lenders have a lot of sources of funding to finance housing loans and consumers have sovereignty to choose a mortgage loan that fits their financial condition. However, housing industry analysts have realized the impact of a downturn of real demand for housing, as first-time homebuyers have been decreasing since the 1980s as household formations have decreased. Based on demographic trends, it seems that this decreasing demand for housing will continue into the next century. Therefore, the housing industry has to anticipate this continuously decreasing demand.

In an era of decreasing demands for housing, the presence of consumer sovereignty in choosing a mortgage loan and lots of sources of funding, policymakers may wish to re-evaluate policies on federal insurance on deposits. As described earlier, lenders may channel a certain type of mortgage loan that fits their loan portfolio strategy. As long as they stick to sound asset and liability management, they can support the government in promotion of homeownership. However, policy enforcing federal insurance on deposits may force lenders to violate basic portfolio management rules. Based on this policy, the federal government insures deposits in financial institutions to encourage depositors to provide funds for housing finance. Mortgage history in the U.S. shows that these guaranteed deposits were used to finance housing loans in order to promote
homeownership.

In the present day, these guaranteed deposits should not be used to finance a housing loan, especially an FRM loan. As deposit funds are fungible, lenders may allocate these guaranteed short-term funds to finance FRM loans. If this happens, many lenders will face a funding mismatch again, as they had experienced in the period from mid 1960s to 1980s. Then, the government will have to bailout financial institutions again and the social cost for this may be higher than the social gain to promote homeownership. Therefore, policymakers should restrict lenders in using these guaranteed short-term funds to finance a housing loan, especially an FRM loan.

5.3. Conclusions

Finally, based on the information given above, this study draws conclusions:

1. The spread between the fixed and adjustable rate positively influences the borrower in choosing an ARM loan. This result is consistent with the theoretical prediction. However, the borrower does not always consider the spread in choosing an ARM loan, because certain historical events may lead the consumer to ignore the spread. During the period from January 1984 to January 1985, when the ARM was relatively new, the borrower appeared to only consider the ARM rate when deciding mortgage loan. In addition, if the U.S. economy is in recession, as in the early 1990s, the spread does not have any impact on the borrower's choice of a mortgage loan.

2. Besides the spread, the borrower also considers consumer confidence index, affordability index, and family income growth in making a mortgage loan decision. The empirical results show that CCI and IG positively influence the borrower in choosing the ARM loan, while AI has a negative impact on the choice of the ARM loan.
loan. These results are in accordance with theoretical predictions. However, those three factors, together with the spread, seem not to play a role in the choice of an ARM loan when the U.S. economy is in recession.

3. Based on the results from the interest-rate expectation influencing the spread-adjustment model, the spread and interest-rate expectations do not have any long-run relationship. This means that the lender does not make any spread adjustments when interest-rate expectations change. This result is contrary to the theoretical prediction. In addition, based on the Granger causality test from the first and second models, the lender does not make any spread adjustments when he or she observes changes in consumer choice.

4. Based on the 3 conclusions above, the demand side appears to dominate the supply side of the mortgage market, as the borrower is responding to changes in spread and other factors, and the lender is not responding to changes in consumer choice and interest-rate expectations.
APPENDIX A

PARTITION MONTHS & SIGNIFICANCE OF REGIME SHIFTS
Figure A.1: Total SSE to Locate Partition Month of AS & S Relationship and F-value to Verify Significance of Regime Shift in January 1984 – December 1996
Figure A.2: Total SSE to Locate Partition Month of AS & S Relationship and F-value to Verify Significance of Regime Shift in January 1984 – July 1989
Figure A.3: Total SSE to Locate Partition Month of AS & S Relationship and F-value to Verify Significance of Regime Shift in August 1989 – December 1996
Number of Month in First Period
(N1)

F-value = 19.42 (P-value = 0.00) at
N1 = 72 or in December 1989 (end of
period one)

Minimum Total SSE = 6592.70 at
N1 = 72 or in December 1989 (end of
period one)

Figure A.4: Total SSE to Locate Partition Month of AS & S, CCI, AI and IG Relationship and F-value to Verify Significance of
Figure A.5: Total SSE to Locate Partition Month of S & IRE Relationship and F-value to Verify Significance of Regime Shift in January 1984 – December 1996
Figure A.6: Total SSE to Locate Partition Month of S & IRE Relationship and F-value to Verify Significance of Regime Shift in January 1984 – May 1995
Figure A.7: Total SSE to Locate Partition Month of S & IRE Relationship and F-value to Verify Significance of Regime Shift in June 1987 - May 1995
Figure A.8: Total SSE to Locate Partition Month of S & IRE Relationship and F-value to Verify Significance of Regime Shift in June 1989 – May 1995
APPENDIX B

CRITICAL VALUES
<table>
<thead>
<tr>
<th>Observations</th>
<th>( \tau ) for first ADF**</th>
<th>( \tau ) for second ADF***</th>
<th>( \tau ) for third ADF ****</th>
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<tbody>
<tr>
<td>(T)</td>
<td>1%</td>
<td>5%</td>
<td>10%</td>
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</table>

Notes:

\[
** \Delta y_t = \alpha \Delta y_{t-1} + \sum_{j=1}^{\delta} \Delta y_{t-j} + \epsilon_t
\]

*** \Delta y_t = \gamma_t \Delta y_{t-1} + \sum_{j=1}^{\delta} \Delta y_{t-j} + \epsilon_t

**** \Delta y_t = \gamma_t \Delta y_{t-1} + \sum_{j=1}^{\delta} \Delta y_{t-j} + \epsilon_t

Table B.1: Dickey-Fuller Critical Values for Unit Root Tests *
<table>
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<th>( \tau ) for second co-integration form***</th>
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<td></td>
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<td>5%</td>
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<td>-5.1022</td>
<td>-4.5068</td>
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</tbody>
</table>

Notes:

** \( y_t = c + \sum_{j=2}^{M} \beta_j y_{t-j} + u_t \)

*** \( y_t = c + \beta t + \sum_{j=2}^{M} \beta_j y_{t-j} + u_t \)

Table B.2: Engle-Granger Critical Values for Co-integration Tests *
LIST OF REFERENCES


158


