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論文題目 DETERMINANTS OF INTEREST RATES
IN HIGHLY DOLLARIZED CAMBODIA

地主 敏樹研究室

学籍番号 1062280e

氏名 TANN HOKLOING

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INTRODUCTION

Determination of interest rates has been one of the most interesting themes that many economists and policymakers have been investigating both theoretically and empirically. The studies have been strikingly conducted, particularly after a well-known economist Irving Fisher hypothesized the so-called Fisher effect in his 1930's *The Theory of Interest*. Fisher posits that expected inflation is the main factor determining nominal interest rate. Fisher equation, the relation that nominal interest is equal to real interest rate plus expected inflation, suggests that when the inflation is expected to increase by one percent, the nominal interest rate will increase by one percent, leaving the real interest rate independent of the expected inflation. The one-for-one relationship between the nominal interest rate and the expected inflation is called the Fisher hypothesis or the Fisher effect. Thus far, the Fisher effect has been extensively examined in various periods in many economies, specifically in developed countries and emerging economies. However, there have been relatively few researches on the Fisher effect in developing countries and least developed countries (LDCs). Cambodia, in particular, is a least developed country in which the Fisher effect and/or the determination of the interest rates have not been studied and published so far. For this reason, this paper seeks to shed some light on the determinants of the (nominal) interest rates in Cambodia, incorporating other tentative determinants into the conventional Fisher equation.

The Fisher equation well explains the situation of the United States during the last 50 years. Nonetheless, it does not work well for the period of late 19th and early 20th centuries. Recent research suggests that this happens because the Fisher effect relates the nominal interest rate to expected inflation, and the inflation during the early period was quite unexpected (Mankiw, 2010, pp.94-97). Every economic agent cares about real return on assets they are holding. However, since actual inflation is unknown when the nominal interest rate is set at a given time, the real return is also unknown. Therefore, the economic agent has to assess the *ex ante* real interest rate by forming expectation of the inflation. If the inflation expectation is uncertain, the real interest rate will also

become unpredictable. This uncertainty of the inflation can be interpreted as the risk the economic agent takes into account when making a portfolio decision. A risk-averse investor prefers a higher return for a given level of risk, or a lower risk for a given level of return. Therefore, it is reasonable to say that the higher uncertainty of the inflation should be associated with the higher return (equivalently, the higher nominal interest rate). See, for example, Berument and Malatyli (2001). In this regard, the uncertainty of the inflation—inflation risk—feasibly becomes another determinant of the nominal interest rate.

When contemplating Cambodia's economy, particularly banking and financial sector, dollarization is an inevitable phenomenon to be taken into account as Cambodia has been one of the most highly dollarized countries in the world ¹. The causes of the dollarization in the country are as follows. The National Bank of Cambodia (NBC), the central bank of the country, was established in 1954 after the country gained the independence from France in 1953. The riel, the national currency, was the legal tender until 1975. Unfortunately, under the radical *Khmer Rouge* regime from 1975 to 1979, the central bank was closed, the whole banking system was completely destroyed, and the riel banknotes were no longer used (NBC's website). After the so-called Khmer Rouge regime collapsed in 1979, the riel was reintroduced in 1980, and Cambodia became a centrally planned economy. Thanks to Paris Peace Agreements in 1991, unsettled political conflicts ended, and the country shifted from the centrally planned economy to a market-oriented one. During 1988-1991, NBC printed a massive amount of money to finance the recurrent budget deficits, resulting in high inflation in the range of 90-177 percent a year, and in an erosion of public confidence in the riel (Zamaróczy and Sa, 2002). The exchange rates also jumped from around 700 riels per dollar in 1991 to around 2,700 riels per dollar in 1992 (Samreth, 2010). From 1991 to 1993, United Nations Transitional Authority in Cambodia (UNTAC) took over the country's administration in the purpose of peacekeeping, and then organized the first general elections in 1993. The cost of this two-year operation was estimated to be close to US\$2 billion, almost 75% of Cambodia's GDP in 1993 (Zamaróczy and Sa, 2002). Since then, foreign currency deposits have increased, and the dollarization has gradually risen. The

dollarization, measured as the ratio of foreign currency deposits to broad money, has risen from about 60% in late 1990s to about 80% in 2010 (Duma, 2011). This increasing dollarization is happening simultaneously with impressive macroeconomic and political achievements; Menon (2008) calls this simultaneous phenomenon a paradox. It is worth noting that during 2000s, economic growth has averaged over 9%, income per capita has doubled, and annual inflation has also been maintained low at a single digit during this period, except in 2008.

Given the fact that Cambodia is a highly dollarized economy, the U.S. Federal Reserve's monetary policy is highly likely to substantially affect Cambodia's economy, particularly financial sector. It is exceedingly convincing that the U.S. (nominal) interest rate influences the (nominal) interest rates in Cambodia ². The U.S. interest rate, therefore, is also included in the estimation of the determinants of the interest rates in Cambodia.

As mentioned earlier, the main objective of this paper is to investigate the determinants of the interest rates in Cambodia. In the investigation, four questions are of interest. Firstly, does the Fisher hypothesis, suggesting that there is a positive relationship between the expected inflation and the interest rates, hold in Cambodia? And if the hypothesis is rejected, what factors could lead to the rejection? Secondly, does the inflation risk (i.e., the inflation uncertainty) affect the interest rates? Thirdly, is the interest rate in the U.S. positively correlated with the interest rates in Cambodia? If the relationships exist, does the interest rate in the U.S. Granger-cause the interest rates in Cambodia? Additionally, does Friedman-Ball hypothesis, which states that a higher level of inflation leads to a higher inflation uncertainty, hold in Cambodia? The final question is seemingly irrelevant to the determination of the interest rates, but it could be easily addressed since the inflation uncertainty will have been already calculated.

This thesis is structured as follows. Chapter one reviews existing literature on interest rate determination. Chapter two introduces research methodology including econometric models such as ARMA, GARCH, and Granger causality test. Data description and unit root tests are explained in chapter three. In chapter four, all of the empirical results are reported and discussed. Finally, the last part is conclusion.

ENDNOTES:

1. Thus far, there have been several studies on the dollarization in Cambodia. They include Viseth (2001), (Zamaróczy and Sa, 2002), Kang (2005), Menon (2008), Samreth (2010), and Duma (2011).
2. In this thesis, when “interest rate” is used, it is simply referred to “nominal interest rate” unless otherwise specified.

CHAPTER 1: LITERATURE REVIEW

The literature on determination of interest rates is predominantly centered on the Fisher hypothesis. Cooray (2003) provides a very great review on the previous empirical studies on the Fisher effect, and describes the methodologies employed in those studies. Most of the researches done so far have focused on developed countries, of which the United States is one of the most observed economies. By contrast, the studies on the developing countries have been sparse.

In his pioneering work, Fisher (1930) used annual data during 1890-1927 for the United States and during 1820-1924 for the United Kingdom to investigate the relationship between the nominal interest rate and the price changes. He found that there were no apparent short-run relationships between the nominal interest rates and price changes in the two countries. However, when many lagged price changes were included, the correlation he obtained was 0.86 for the U.S. and 0.98 for the U.K. He therefore concluded as on page 451 that: “We have found evidence general and specific, from correlating P’ with both bond yields and short term interest rates, that price changes do, generally and perceptibly affect the interest rate in the direction indicated by *a priori* theory. But since forethought is imperfect, the effects are smaller than the theory requires and lag behind price movements, in some periods, very greatly. When the effects of price changes upon interest rates are distributed over several years, we have found remarkably high coefficients of correlation, thus indicating that interest rates follow price changes closely in degree, though rather distantly in time”.

Fama (1975) examines the market for one- to six-month U.S. Treasury bills to explore whether the market is efficient. An efficient market, according to him, accurately uses all relevant information in setting prices. He concludes that, during 1953-1971, there exist relationships between nominal interest rates and subsequent inflation rates and that “the bill market seems to be efficient in the sense that nominal interest rates summarize all the information about future inflation rates that is in time-series of past inflation rates.” Also, he finds some evidence to support the hypothesis that real returns on the treasury bills are constant during the period studied ¹.

Recognizing that in the United States the strong Fisher effect exists during certain periods but not for others ², Mishkin (1992) attempts to explain why this is the case. Utilizing monthly data between January 1953 and December 1990, he finds no evidence for a short-run Fisher effect in which changes in expected inflation and in interest rates are correlated, but support for a long-run Fisher effect in which both inflation and interest rates trend together. He interestingly argues that the Fisher effect will exist only during samples in which both expected inflation and interest rates exhibit stochastic trends. The reason is that if these two series have trends, their trends will be the same. Fahmy and Kandil (2003), by using the U.S. monthly data in 1980s and early 1990s, provide additional support to Mishkin (1992), finding that the short-run Fisher effect is insignificant, while long-run Fisher effect exists since the cointegration relationship between nominal interest rates and inflation cannot be rejected.

In the case of Australia, Mishkin and Simon (1995) find that there is a long-run Fisher effect, but no short-run Fisher effect. They suggest that short-run changes in interest rates reflect changes in monetary policy, while longer-term levels are primarily driven by inflation expectations.

Following Mishkin's (1992) work, Crowder (1997) finds that nominal interest rate and inflation together contain unit roots over the period from the first quarter of 1960 to the fourth quarter of 1991, and there is cointegration between the two series and thus long-run Fisher effect in Canada. However, the relationship (between the interest rate and the inflation) for the last three decades is not so stable due to two structural breaks—one in 1971, and the other in 1982.

Kousta and Serletis (1999), by using post-war quarterly data and employing nonstructural bivariate autoregressive methodology, reject the strong Fisher effect, but provide little support to the weak Fisher effect in eleven advanced economies—Belgium, Canada, Denmark, France, Germany, Greece, Ireland, Japan, the Netherlands, the United Kingdom and the United States. In their conclusion on page 124, they write: “Our results are consistent with most of the existing literature on the Fisher effect, which mostly shows (by tests other than the one that we have conducted) that fully anticipated inflation has less than a unit effect on nominal interest rates, and thus reduces real

interest rates even in the longest of runs.” Applying the concept of fractional cointegration to monthly series of the three-month interest rates and the inflation rates in G7 countries over the period between January 1970 to March 2001, Lardic and Mignon (2003) find that, except for the case of Germany, there is a fractional cointegration relationship between the interest rate and the inflation rate, and thus a Fisher effect. Berument *et al.* (2007), using data in G7 countries and 45 developing countries to find whether the Fisher effect is universal, provide additional evidence that in all the G7 countries the traditional Fisher effect holds in the weak form (in which the coefficient of expected inflation is positive and less than one) and the augmented Fisher effect (by which they refer to the new estimation of the Fisher effect, incorporating inflation uncertainty into the conventional Fisher equation) also exists.

Overall, various studies on the Fisher effect in developed countries do not produce unanimous results. However, most of them give some evidences to support the weak form of the Fisher effect; that is, the less-than-unity Fisher effect. Empirical researches on the Fisher effect in developing countries are presented below.

Payne and Ewing (1997) employ the Johansen-Juselius cointegration approach to evaluate the Fisher effect in nine lesser-developed countries, namely, Argentina, Fiji, India, Malaysia, Niger, Pakistan, Singapore, Sri Lanka, and Thailand. The cointegration method suggests that there is a long-run relationship between nominal interest rates and inflation in four countries—Malaysia, Pakistan, Singapore, and Sri Lanka. Additional investigation indicates that among these four countries, the full Fisher effect (the one-for-one relationship between nominal interest rates and inflation) is present in three countries (i.e., Malaysia, Pakistan, and Sri Lanka). Considering various nominal interest rates, Ahmad (2010) utilizes relatively new approach, that is, autoregressive distributed lag (ARDL)-bond testing, to examine the validity of the Fisher effect in India, Bangladesh, Pakistan, Sri Lanka, Kuwait, and Saudi Arabia. From the empirical evidence, he concludes there is a weak form, rather than strong form of the Fisher effect in India, Pakistan, Kuwait, and Saudi Arabia. Nonetheless, he cannot find enough evidence to support the Fisher effect in Bangladesh, and find no clear-cut results in the case of Sri Lanka.

Almost all the studies in the literature, in the exception of Berument and Malatyali (2001), Berument *et al.* (2007), and Lorde *et al.* (2008), focus only on the Fisher effect. In other words, they aim at examining whether or not inflation (or expected inflation) affects interest rates.

Berument and Malatyali (2001) incorporate inflation risk (i.e., conditional standard deviation of inflation, deriving from GARCH specification) and maturity into the traditional Fisher equation to explore the determinants of nominal interest rates in Turkey. Their empirical results show that both the expected inflation and the inflation risk have positive effects on the nominal interest rates. Surprisingly, the maturity factor, by contrast, is negatively correlated with the interest rates. As a recommendation for policymaker, the authors suggest that the government uses both auction interest rates and maturity as an instrument for lowering the debt burden because the creditors in the country tend to desire shorter maturity while requiring high risk premiums.

Augmenting the conventional Fisher effect by including inflation uncertainty into the equation, Berument *et al.* (2007) find that, in contrast to the G7 countries in which both the inflation and the inflation uncertainty have positive correlation with the interest rates, among the 45 developing countries under consideration the positive relationship between the inflation and the interest rates exists in only 23 countries and the relationship between the inflation uncertainty and the interest rates is positive in 18 countries and negative in the other 7 countries.

In an attempt to find out the determination of nominal interest rates in five small developing Caribbean countries—the Bahamas, Barbados, Guyana, Jamaica, and Trinidad and Tobago, Lorde *et al.* (2008) also employ an augmented Fisher equation. Unlike the works of Berument and Malatyali (2001) and Berument *et al.* (2007) in which the traditional Fisher equation is augmented with the inflation risk, Lorde *et al.* (2008) augment the Fisher equation with the US nominal interest rate since those economies greatly depend on the U.S. economy, particularly imports. Their results of the cointegration examination suggest the existence of a long-run relationship for The Bahamas, Jamaica (when the country adopts flexible exchange rate), and Trinidad and Tobago. The Fisherian link between the nominal interest rate and expected inflation is

not present in Barbados and Guyana, while the link is negative for Trinidad and Tobago. The nominal interest rate in The Bahamas moves one-for-one with the US interest rate, whereas the movement is more than one-for-one in the other countries.

ENDNOTES:

1. However, the work of Fama (1975) has been challenged by some researchers such as Carlson (1977) and Nelson and Schwert (1977).
2. Mishkin (1992, p.196) documents: “Although the Fisher effect is widely accepted for the period after the Fed-Treasury Accord in 1951 until October 1979 in the United States, this relationship between the level of short-term interest rates and future inflation is not at all robust. The level of short-term interest rates has no ability to predict future inflation in the United States prior to World War II or after October 1979.”

CHAPTER 2: RESEARCH METHODOLOGY AND MODELS

In this chapter, research methodology and models are presented. The previous chapter reviews the literature on determination of nominal interest rates. As discussed in literature review, most of the studies center on the validity of the Fisher hypothesis in which expected inflation is the main determinant of nominal interest rates. Among those studies, only Berument and Malatyali (2001), Berument *et al.* (2007), and Lorde *et al.* (2008) extend the Fisher equation, incorporating more factors to detect what determine the nominal interest rates in the countries under their consideration. In the augmentation of the Fisher equation, Berument and Malatyali (2001) add inflation risk, whereas Lorde *et al.* (2008) include nominal interest rate of the United States. Unlike these studies, my thesis incorporates both inflation risk and the U.S. nominal interest rate in addition to the expected inflation in order to explore how nominal interest rates in Cambodia reflect to these factors.

Section 2.1 provides a description of how the expected inflation and the inflation risk are assessed. Next, estimation models in which the expected inflation, the inflation risk, and the U.S. nominal interest rate are incorporated are the tasks of section 2.2. Finally, section 2.3 introduces Granger causality test approach.

2.1- Method for Assessing Expected Inflation and Inflation Risk

Before introducing how to assess the inflation risk, it is necessary to discuss the method from which the expected inflation is formed. In this thesis, the inflation π_t is assumed to follow an autoregressive moving-average (ARMA) process with the order of (p, q) . Formally, π_t follows ARMA(p, q).¹

$$\pi_t = \alpha_0 + \alpha_1\pi_{t-1} + \dots + \alpha_p\pi_{t-p} + \varepsilon_t + \beta_1\varepsilon_{t-1} + \dots + \beta_q\varepsilon_{t-q} \quad (1)$$

Here α_p and β_q are the coefficient of the p^{th} lag of the inflation and the coefficient of the q^{th} lag of the residual ε_t . The assumption for the residual is $\varepsilon_t | I_{t-1} \sim N(0, h_t^2)$, where I_{t-1} denotes information set at time $t - 1$ and h_t^2 is

conditional variance of the inflation. From equation (1), the conditional expected value of the inflation at time t with the given information set available at time $t - 1$ is as follows:

$$E_t(\pi_t|I_{t-1}) = \alpha_0 + \alpha_1\pi_{t-1} + \dots + \alpha_p\pi_{t-p} + \beta_1\varepsilon_{t-1} + \dots + \beta_q\varepsilon_{t-q} \quad (2)$$

The inflation risk is the uncertainty or the volatility of the inflation. When the inflation is volatile and uncertain, an economic agent will face uncertainty of their future real return. The uncertainty of inflation affects the agent's welfare and his portfolio decision. In this sense, inflation uncertainty or volatility is called inflation risk. Conditional variance and its square root; that is, conditional standard deviation of the inflation are commonly used as inflation uncertainty or inflation risk. The conditional variance of the inflation can be assessed using autoregressive conditional heteroskedasticity (ARCH) estimation. The ARCH approach was developed by Engle (1982). In his groundbreaking work, Engle (1982) uses the ARCH models in estimating the variance of the United Kingdom inflation. The ARCH models assume that conditional variance of the inflation model can be explained by the lagged values of the model's squared residuals. With m lagged values of the squared residuals, the conditional variance is defined as follows:

$$h_t^2 = \gamma_0 + \sum_{i=1}^m \gamma_i \varepsilon_{t-i}^2 \quad (3)$$

Where, ε_{t-i}^2 are the squared residuals and γ_i are the ARCH parameters. When $m = 0$, there is no ARCH effect and the residual ε_t simply becomes white noise.

To generalize the ARCH model, Bollerslev (1986) includes lagged values of the conditional variance into (3). It is therefore called generalized autoregressive conditional heteroskedasticity (GARCH) model ². With k lagged values of the conditional variance, the GARCH(m, k) can be written as follows:

$$h_t^2 = \gamma_0 + \sum_{i=1}^m \gamma_i \varepsilon_{t-i}^2 + \sum_{i=1}^k \delta_i h_{t-i}^2 \quad (4)$$

Where, γ_i are the ARCH parameters and δ_i are the GARCH parameters. If $k = 0$, the GARCH(m, k) model becomes ARCH(m), and if $k = m = 0$, then ε_t simply is white noise. The conditions for the conditional variance to be non-negative and non-explosive are: all the estimated coefficients in (4) must be positive; and the sum of all γ_i and δ_i must be less than unity.

2.2- Estimation of Nominal Interest Rates

Fisher (1930) posits that expected inflation is the main factor that determines nominal interest rate. Therefore, the estimation of the Fisher equation is written as:

$$i_t = c_0 + c_\pi \pi_t^e + u_t \quad (5)$$

Where, i_t and π_t^e respectively denote the nominal interest rate and the expected inflation at time t . Next, c_π is the coefficient of the expected inflation and c_0 is constant term, reflecting real interest rate. Finally, u_t is the error term.

As explained in the introduction part, investors are concerned about real return rather than nominal return. However, when the nominal interest rate is set at a given time t , the inflation is not yet known at that time. Hence, the investors have to form expectation of the inflation to assess the real interest rate. Since the expected inflation and the realized inflation are not always the same due to some uncertainty of the inflation, the investors face some risk that the realized real return might deviate from their expected real return. To compensate for this, the inflation risk, measured as the conditional standard deviation of the inflation, must be reflected in the nominal interest rate. In other words, the inflation risk influences the interest rate:

$$i_t = c_0 + c_\pi \pi_t^e + c_h h_t + u_t \quad (6)$$

Where, h_t is the conditional standard deviation of the inflation at time t and c_h is its coefficient. The others are the same as mentioned above (see their descriptions below the equation (5)).

Given the fact that Cambodia's economy is highly dollarized, it is plausible that the economy is influenced by the U.S. monetary policy. Thus, the interest rate in Cambodia is highly likely to be influenced by the interest rate in the United States. Incorporating the U.S. interest rate, the model of the interest rate in Cambodia becomes:

$$i_t = c_0 + c_\pi \pi_t^e + c_h h_t + c_{us} i_t^{us} + u_t \quad (7)$$

Where, i_t^{us} denotes the U.S. interest rate at time t and its coefficient is c_{us} . The other variables are the same as mentioned previously. OLS regression is used to estimate the models of interest rate. It should be noted that the error term u_t is assumed to have zero mean and constant variance. Recent statistical software advance allows the expected inflation π_t^e and the conditional variance h_t^2 (and thus the conditional standard deviation h_t) to be calculated easily by fitting ARMA-GARCH models.

2.3- Granger Causality

Granger (1969) invents a marvelous method for testing causality between two variables. One variable (x_2) is said to Granger-cause another variable (x_1) if, given the past values of x_1 , the past values of x_2 help in predicting x_1 . Granger causality test is usually performed with a vector autoregressive (VAR) model. Consider a VAR(s) model of two stationary series below.

$$\begin{aligned} x_{1,t} &= \varphi_{10} + \sum_{j=1}^s \varphi_{11}(j)x_{1,t-j} + \sum_{j=1}^s \varphi_{12}(j)x_{2,t-j} + u_{1,t} \\ x_{2,t} &= \varphi_{20} + \sum_{j=1}^s \varphi_{21}(j)x_{1,t-j} + \sum_{j=1}^s \varphi_{22}(j)x_{2,t-j} + u_{2,t} \end{aligned} \quad (8)$$

To find whether x_2 Granger-causes x_1 , the null and alternative hypotheses are produced as follows:

$$H_0 : \varphi_{12}(1) = \varphi_{12}(2) = \dots = \varphi_{12}(s) = 0$$

$$H_A : \varphi_{12}(1) \neq 0 \text{ or } \varphi_{12}(2) \neq 0 \text{ or } \dots \text{ or } \varphi_{12}(s) \neq 0$$

If the null hypothesis H_0 is rejected, it implies that x_2 Granger-causes x_1 .

ENDNOTES:

1. For more explanation on the ARMA models, see, for example, Enders (1995, pp.63-128), Enders (2010, pp.49-118), Lütkepohl and Krätzig (2004, pp.8-85).
2. See, for instance, Enders (1995, pp.135-206), Enders (2010, pp.121-176), Lütkepohl and Krätzig (2004, pp.197-220) for detailed explanation on ARCH and GARCH models.

CHAPTER 3: DATA AND UNIT ROOT TEST

3.1- Data

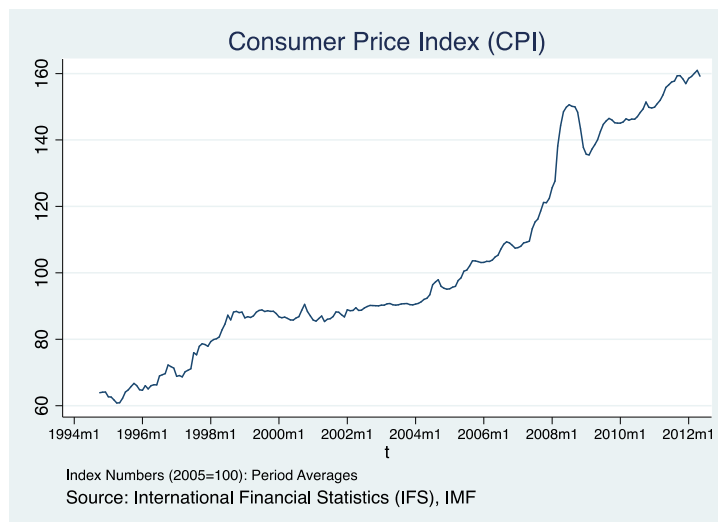
Monthly data series are used in this research. All the available data are used as the sample period—from October 1994 to May 2012. Hereafter, the letter “m” denotes month. In particular, it will be appearing along the x-axis, representing time—month, in almost all of the graphs. For example, 1994m10 and 2012m5 are referred to October 1994 and May 2012, respectively.

Usually, inflation can be calculated from many price indices such as consumer price index (CPI), wholesale price index (WPI), and GDP deflator. However, in Cambodia only consumer price index is available for monthly data. Monthly and quarterly GDP deflators do not exist due to the lack of monthly and quarterly GDP data. This thesis uses monthly consumer price index (CPI) series data from the International Financial Statistics (IFS) CD-ROM, produced and published by the International Monetary Fund (IMF). From the CPI data, inflation (π_t) is calculated as follows ¹:

$$\pi_t = 100 \times (\ln CPI_t - \ln CPI_{t-1}) \quad (9)$$

Here we multiply the difference of $\ln CPI$ by 100 in order to make the unit of the inflation to be in percent. Figure 3.1 shows the graph of the monthly CPI.

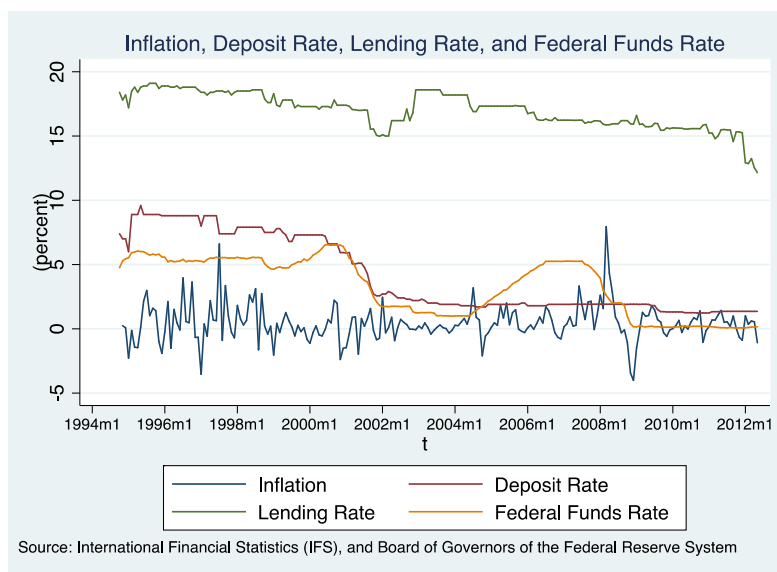
Figure 3.1: Monthly Consumer Price Index



Data on interest rates in Cambodia are so limited. The National Bank of Cambodia (NBC), the central bank of the country, has published statistics of interest rates on deposits and loans denominated in Khmer riel, and deposits and loans denominated in the U.S. dollar on their homepage only from 2010. I have inquired the bank of how to get those interest rates series data, but there has been no any response from the bank. Therefore, deposit rate and lending rate series data from the IFS are utilized. It is worth noting that, according to the definitions by the IFS, the deposit rate is the simple average of rates on *domestic-currency* savings deposit reported by 10 banks with largest deposits holding, and the lending rate is the simple average of rates on *foreign-currency* loans to private enterprises by 10 banks with largest deposits holding. The IMF's IFS reports only these two interest rates for the case of Cambodia. In most studies existing in the literature, authors have used interest rates on treasury bills or bonds, for instance, 3-month T-bill. Unfortunately, in Cambodia thus far there have been no these types of interest rates due to the absence of treasury bills and government-backed bonds. Accordingly, there are no alternative but to use both the deposit rate and the lending rate produced by the IMF's IFS. Some researchers, such as Berument and Jelassi (2002), Berument *et al.* (2007), Ahmad (2010), also use deposit rate and/or lending rate in their analyses.

The federal funds rate series data from Board of Governors of the Federal Reserve System is used as the interest rate of the U.S. Like the call rate in Japan, the federal funds rate is the interest rate at which depository institutions lend balances at the Federal Reserve to other depository institutions overnight. The reason to choose the federal funds rate here is that it is the shortest-term rate, thus the most influential interest rate, affecting the level of all other interest rates in the U.S. economy. According to the website of the Board of Governors of the Federal Reserve System, it documents in Federal Open Market Committee (FOMC) section that “Changes in the federal funds rate trigger a chain of events that affect other short-term interest rates, foreign exchange rates, long-term interest rates, the amount of money and credit, and, ultimately, a range of economic variables, including employment, output, and prices of goods and services.”

Figure 3.2: Deposit Rate, Lending Rate, Federal Funds Rate, and Inflation



From Figure 3.2, several remarkable inferences can be drawn. Firstly, the inflation from the beginning of the sample period until the end of 1998 is more volatile than that after 1998. This happened because the political stability had been unfavorable until the end of 1998. The high level of inflation in 1997m7 was the result of the political conflict in July 1997 (see IMF, 1998)². Thanks to elections in 1998 resulting in a coalition government, and the surrendering of the last *Khmer Rouges*, the political situation became stable at the end of 1998 (see Zamaróczy and Sa, 2002). Secondly, the inflation in early 2008 was very high, stemming from the global financial crisis and the hikes in global food and oil prices preceding the global financial crisis (see Sochet, 2013 and Sovuthea, 2013). Thirdly, the deposit rate movement has been almost in parallel with the U.S. federal funds rate for the full sample period, except for mid-2000s. Fourthly, the movement of the lending rate from the beginning of the sample period until the end of 2001 had been in parallel with the federal funds rate, while the movement after 2001 has not been responding to the federal funds rate movement. Particularly, there is a substantial rise in lending rate soon after the end of 2001. Finally, the interest rate spread—lending rate minus deposit rate—is very large. Furthermore, the spread between the lending rate and the federal funds rate is also great. These wide spreads reflect the high country risk, the insufficient financial intermediation, and the

high costs of banking such as legal uncertainty, litigation costs, and default rates, due to few secure lending opportunities (Zamaróczy and Sa, 2002, p.25). For summary of the descriptive statistics of the series, see Table 3.1.

Table 3.1: Descriptive Statistics for Main Variables

Variable	Mean	Maximum	Minimum	S.D	Observations
DER	4.0958	9.6000	1.2300	2.9436	212
LER	17.0029	19.1000	12.1600	1.3692	212
FFR	3.2880	6.5400	0.0700	2.2448	212
π	0.4326	7.9500	-4.0066	1.4094	211

Notes:

1. DER, LER, FFR, and π denote Deposit Rate, Lending Rate, Federal Funds Rate, and Inflation, respectively.
2. S.D denotes Standard Deviation.

3.2- Unit Root Tests

In order to avoid a spurious regression, unit root tests for all variables of interest have to be conducted. As pointed out by Granger and Newbold (1974), a spurious regression arises when time series appear related when they are actually not. They appear to be related because the regression results come out with high degree of fit, measured by R^2 or \bar{R}^2 , and high t-values. However, the Durbin-Watson statistic is extremely low. Given the concern on such a spurious specification, time series analysts have been testing for unit root to find out whether or not the considered series are stationary, before running regressions. In this regard, this thesis employs two unit root tests— Augmented Dickey–Fuller (ADF) test developed by Dickey and Fuller (1979), and Phillips–Perron (PP) test developed by Phillips and Perron (1988).

Table 3.2 reports the results of the ADF unit root test for the four series—the deposit rate, the lending rate, the federal funds rate, and the inflation—with both their levels and first differences. The results indicate that the inflation is stationary in its level since the null hypothesis that the inflation has a unit root is rejected at 1% significance

level. Thus, additional test for unit root in its first difference is not done. Interestingly, for all of the interest rates (i.e., the deposit rate, the lending rate, and the federal funds rate), the null hypotheses that the variables contain unit root are accepted, meaning that these interest rates are non-stationary in their levels. However, they become stationary after they are first differenced, because the null hypotheses are rejected at 1% significance level.

Table 3.2: Augmented Dickey–Fuller (ADF) Unit Root Test

Variable	Level		First Difference	
	Intercept	Intercept & trend	Intercept	Intercept & trend
DER	−0.867(0)	−1.541(0)	−6.390(5)***	−6.486(5)***
LER	−0.504(0)	−2.501(0)	−16.629(0)***	−16.737(0)***
FFR	−1.463(2)	−2.245(2)	−7.135(0)***	−7.100(0)***
π	−7.104(1)***	−7.085(1)***	N/A	N/A

Notes:

1. DER, LER, FFR, and π denote Deposit Rate, Lending Rate, Federal Funds Rate, and Inflation, respectively.
2. ADF statistic is obtained by $\Delta y_t = \mu + \beta y_{t-1} + \sum_{i=0}^p \gamma_i \Delta y_{t-i} + u_t$ (in case of intercept), and by $\Delta y_t = \mu + \delta t + \beta y_{t-1} + \sum_{i=0}^p \gamma_i \Delta y_{t-i} + u_t$ (in case of intercept and trend), for $p = 0, 1, 2, \dots$ ($\gamma_0 = 0$), where Δ is the difference operator, μ, δ, β , and γ_i are the coefficients to be estimated, y is the variable whose time series properties are examined, and u is the white-noise error term.
3. The numbers in the parentheses indicate the optimal lag lengths selected by BIC by setting maximum lag length to 12.
4. The null hypothesis is $H_0: \beta = 0$ (the series has a unit root or is non-stationary), while the alternative hypothesis is $H_A: \beta < 0$ (the series has no unit root or is stationary).
5. *** denotes the rejection of the null hypothesis at 1% significance level.
6. N/A means that the unit root test for the first difference of inflation π is not conducted since its level variable is already stationary.

The results of the Phillips–Perron unit root test for the same variables are reported in Table 3.3. It is apparent that the Phillips–Perron test produces the same results as the ADF test does. The results show that the inflation is stationary in its level, while the deposit rate, the lending rate, the federal funds rate are non-stationary in their levels, but they become stationary after being first differenced. The level of significance of the Phillips–Perron test statistics is 1%, like that of the ADF test statistics.

Based on the results in Table 3.2 and Table 3.3, it can be concluded that only the inflation is stationary while all the interest rates are non-stationary, but their first differences are stationary. In other words, the inflation is $I(0)$ while the deposit rate, the lending rate, and the federal funds rate are $I(1)$.

Table 3.3: Phillips–Perron (PP) Unit Root Test

Variable	Level		First Difference	
	Intercept	Intercept & trend	Intercept	Intercept & trend
DER	−1.047	−4.349	−241.120***	−241.079***
LER	−0.523	−16.459	−237.527***	−235.980***
FFR	−1.739	−6.156	−79.229***	−79.289***
π	−158.401***	−158.541***	N/A	N/A

Notes:

1. DER, LER, FFR, and π denote Deposit Rate, Lending Rate, Federal Funds Rate, and Inflation, respectively.
2. PP test suggests a non-parametric method of controlling for higher order autocorrelation in a series and is based on the AR(1) process: $\Delta y_t = \mu + \beta y_{t-1} + u_t$, where Δ is the difference operator, μ and β are the coefficients, y_{t-1} is the first lag of the y_t , and u_t is white noise.
3. The lag truncation is set at five. The results of PP test are not sensitive to the choice of the lag truncation.
4. The null and the alternative hypotheses are the same as those of the ADF test.
5. *** denotes the rejection of the null hypothesis at 1% significance level.
6. N/A means that the unit root test for the first difference of inflation π is not conducted since its level variable is already stationary.

ENDNOTES:

1. Actually, $\ln CPI_t - \ln CPI_{t-1}$ is approximately equal to $\frac{\Delta CPI_t}{CPI_{t-1}}$ ($= \frac{CPI_t - CPI_{t-1}}{CPI_{t-1}}$)

when ΔCPI_t is small. This means that the change of the logarithm of the CPI is approximately equal to the proportional change of the CPI when the difference of the CPI is small. Thus, $100 \times (\ln CPI_t - \ln CPI_{t-1})$ is the percentage change in the CPI; that is, inflation. See Stock and Watson (2011, pp.520-521) for more explanation related to this.

2. The July-1997 political crisis substantially affected Cambodia's economy. IMF (1998) documents that "During the first months of 1997, the macroeconomic performance was broadly in line with the second-year ESAF (Enhanced Structural Adjustment Facility) program, but the situation deteriorated markedly in the aftermath of Second Prime Minister Hun Sen's seizure of power in July and the regional financial crisis. The effects of the political crisis seem to have been much stronger than those of the regional financial crisis as they undermined growth and investors' confidence." The output growth in 1997 was estimated at 2%, down from 6.5% in 1996. In that troubled year, the instruction activities declined by 1% while service sector growth accounting for about 36% of the GDP slowed to around 1%. Moreover, the monthly tourist arrivals in July plunged to around 6,000 from over 29,000 in March. In addition, Pum and Vanak (2010) mention that the domestic political instability in 1997 led to postponement of aid activities by the international assistance institutions, a halt in production by foreign firms, and a dramatic fall in FDI.

CHAPTER 4: EMPIRICAL RESULTS

In this chapter, all of the empirical results are presented. The chapter proceeds as follows. Firstly, in section 4.1 the inflation estimation with ARMA model is discussed. Section 4.2 explains the estimation of the inflation and inflation variance with ARMA-GARCH(1,1) regression model. The validity of the Friedman-Ball hypothesis is examined in section 4.3. Afterwards, the Fisher effect, and determinants of interest rates in Cambodia are discussed in section 4.4, and section 4.5, respectively.

4.1- Estimation of Inflation with ARMA Model

As mentioned previously, the inflation is assumed to follow an autoregressive moving-average (ARMA) model (see equation (1)).

Before fitting time-series models, a necessary condition is that the series in consideration must be stationary. Since the stationarity of the inflation is confirmed by the ADF unit root test and the Phillips–Perron unit root test presented in chapter 3, it is possible to fit the inflation with ARMA models. The Box–Jenkins approach is utilized in this section because it is a very vital method regarding ARMA modeling of time series (Becketti, 2013, pp.226-227; Enders, 2010, pp.78-81). The Box–Jenkins method consists of three stages—identification stage, estimation stage, and diagnostic checking stage. The main task in the identification stage is to visually examine the time plot of the series, the autocorrelation function (ACF), and the partial autocorrelation function (PACF). From the visual ACF and PACF, an analyst may have some ideas on several plausible models. In the second stage—estimation stage, the analyst fits all the tentative models chosen in the first stage, considers the coefficients estimated, and then chooses a model that has a good fit. When comparing the goodness of fit in ARMA models, it is believed that using Akaike Information Criterion (AIC) and/or Bayesian Information Criterion (BIC) is more appropriate than other measures of goodness of fit such as R^2 , or the average of the residual sum of squares. In the final stage, diagnostic checking must be conducted to ensure that there is no autocorrelation in the residuals of the model selected. A common way to do this is to use Ljung–Box test.

After considering the ACF and the PACF of the inflation, the tentative ARMA models are likely to be $(p = 1, 2, q = 0)$, $(p = 1, 2, 12, q = 0)$, $(p = 1, q = 2)$, and $(p = 1, 2, q = 12)$. The 12th lag is also considered here because there is a spike at lag 12 and lag 24 in the ACF, and at lag 12 in the PACF. This implies that there is significant seasonality in the inflation series since the monthly inflation data is seasonally unadjusted. Therefore, including lag 12 in the model seems to be plausible and it also helps control for the seasonality effect.

Table 4.1 presents the results of all the four tentative models. In model 1, all the coefficients are statistically significant. Unfortunately, based on the Ljung–Box Q-statistics for all cases of 12 lags, 24 lags, 36 lags, 48 lags, and 52 lags, the null hypotheses that $Q = 0$ are rejected at 1% significance level, meaning that the lagged residuals of this model have very high serial autocorrelation. Therefore, model 1 is apparently inadequate. Since the Ljung–Box test indicates no significant serial autocorrelations in the lagged residuals, model 2 in which the 12th lag of the inflation is added performs very much better, although the constant term α_0 has a bit low t-value (=1.62) and is significant at 10.5% level. In the same fashion as model 1, model 3 has acceptable coefficients, but the lagged residuals of the model exhibit high serial autocorrelations. Hence, model 3 should be also eliminated from consideration. For the final model—model 4, each coefficient is statistically significant. From the Ljung–Box Q-statistic for 24 lags of the residuals, however, it is apparent that the null hypothesis that $Q = 0$ is rejected at about 6% level, indicating considerable serial autocorrelation. Furthermore, the AIC and BIC of model 4 are greater than those of model 2. Based on these comparisons, model 2 has the best fit among the four tentative models considered. The following is model 2 estimation of the inflation, with t-values in the parentheses.

$$\pi_t = 0.412 + 0.217\pi_{t-1} + 0.172\pi_{t-2} + 0.256\pi_{t-12} + \varepsilon_t$$

(1.62) (4.26) (2.55) (4.31) (10)

Overall, model 2 is finally selected to be fitted with GARCH model, and their estimation is presented in the next section.

Table 4.1: Estimates of Inflation with ARMA Models

	(Model 1) p=1,2 q=0	(Model 2) p=1,2,12 q=0	(Model 3) p=1 q=2	(Model 4) p=1,2 q=12
α_0	0.427** (2.50)	0.412 (1.62)	0.429*** (2.71)	0.421** (2.07)
α_1	0.245*** (4.51)	0.217*** (4.26)	0.238*** (4.44)	0.250*** (4.45)
α_2	0.174** (2.46)	0.172** (2.55)		0.179** (2.49)
α_{12}		0.256*** (4.31)		
β_2			0.235*** (3.56)	
β_{12}				0.224*** (3.58)
AIC	724.65	710.90	722.52	712.56
BIC	738.06	727.66	735.93	729.32
Q(12)	36.21 [0.0003]	9.60 [0.6514]	30.89 [0.0021]	11.30 [0.5037]
Q(24)	66.07 [0.0000]	28.98 [0.2209]	56.49 [0.0002]	35.42 [0.0625]
Q(36)	82.91 [0.0000]	37.97 [0.3795]	71.25 [0.0004]	45.72 [0.1286]
Q(48)	97.22 [0.0000]	46.71 [0.5259]	83.28 [0.0012]	56.70 [0.1822]
Q(52)	101.35 [0.0001]	50.46 [0.5348]	87.68 [0.0014]	60.38 [0.1987]

Notes:

1. All the coefficients α and β are reported with t-values in the parentheses ().
2. ** and *** denote 5% and 1% significance levels, respectively.
3. Q(n) reports the Ljung–Box Q-statistic for the autocorrelations of the n residuals of the estimated model. Significance levels are in the square brackets []. According to Enders (2010, pp.69-70), the maximum number of sample autocorrelations to use is typically set equal to T/4. Here, with 211 observations, T/4 is approximately equal to 52.

4.2- Estimation of Inflation and Inflation Risk with ARMA-GARCH (1, 1)

So far, we have discussed the ARMA models, and after considering various models, we have selected model 2 with $(p = 1, 2, 12, q = 0)$. This simply means the $ARMA(p, q)$ becomes $AR(p)$ because $q = 0$. In the model selected, Ljung–Box test suggests that there is no significant residual autocorrelation. However, let us continue to check whether the residuals are homoskedastic or heteroskedastic ¹. Homoskedastic is used to describe when a stochastic variable has a constant variance while heteroskedastic is used when the variance changes, depending on time. To see if the residuals are conditionally heteroskedastic, the Engle’s ARCH-LM test can be utilized.

Table 4.2: ARCH-LM Test for ARCH Effects

Lags	LM	Lags	LM
1	1.71 (0.1909)	18	22.56 (0.2079)
3	2.38 (0.4148)	24	24.44 (0.4366)
6	6.37 (0.3831)	30	24.89 (0.7302)
9	19.57 (0.0208)**	36	20.32 (0.9836)
12	19.88 (0.0694)*	48	28.48 (0.9888)
15	22.37 (0.0985)*	52	31.55 (0.9888)

Notes:

1. The null hypothesis is that there are no ARCH effects in residuals as opposed to the alternative hypothesis.
2. LM represents the test statistic, following chi-squared distribution.
3. * and ** denote the rejection of the null hypothesis at 10% and 5% significance levels, respectively.

Table 4.2 reports the results of the ARCH-LM tests for presence of ARCH effects. The null hypotheses that there are no ARCH effects are rejected at 5% significance level for 9 lags, and at 10% significance level for 12 lags, and 15 lags. This implies that there exist ARCH effects in residuals for 9, 12, and 15 lags. Enders (2010, p.135) posits “as is typical of ARCH errors, the ACF and PACF of the squared residuals

(i.e., ε_t^2) show significant correlation.” Following this, the Ljung–Box tests for autocorrelation of the squared residuals are carried out, showing that for the lags of 9 to 18 the autocorrelations are statistically significant at conventional levels.

It is believed that GARCH model performs better than ARCH model, especially when the ARCH effects exist at long lags since estimating a totally free lag distribution often leads to violation of the non-negativity constraints of the conditional variance (Bollerslev, 1986). One of the superior characteristics of the GARCH specification is that it can be modeled with much shorter lag lengths. Moreover, empirically, a large number of time series with a conditionally heteroskedastic residual have been adequately modeled with a GARCH(1, 1) specification (STATA, 2013, p.25). In this regard, we model the ARMA($p = 1,2,12, q = 0$), which we have chosen in the last section, with GARCH(1,1). The specification results with t-values in the parentheses are as follows:

$$\begin{aligned} \pi_t &= 0.224 + 0.220\pi_{t-1} + 0.140\pi_{t-2} + 0.205\pi_{t-12} + \varepsilon_t \\ &\quad (1.25) \quad (2.60) \quad (1.52) \quad (3.16) \\ h_t^2 &= 0.0857 + 0.2500\varepsilon_{t-1}^2 + 0.7456h_{t-1}^2 \\ &\quad (3.93) \quad (3.81) \quad (15.96) \end{aligned} \tag{11}$$

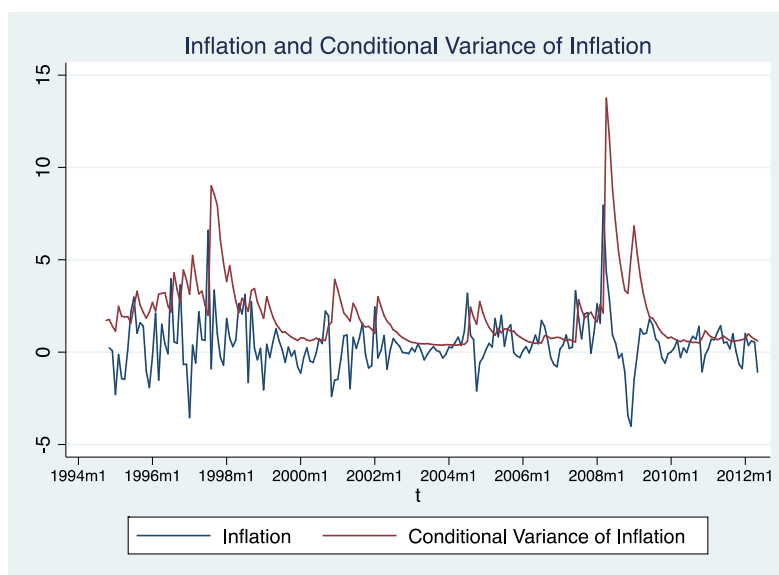
Here, π_t and h_t^2 are the inflation and its conditional variance, respectively. Apparently, the inflation estimation with ARMA-GARCH(1, 1) produces very similar results as the inflation estimation with ARMA($p = 1,2,12, q = 0$). All coefficients are significant at conventional levels, except the coefficients of the constant term and the second lag in the inflation equation. For the two coefficients of the constant term and the second lagged inflation, their t-values are a bit low (1.25 and 1.52), implying that they are statistically significant at 21% and 12.9% levels. Although they are insignificant at the conventional levels, they are collectively significant with the other coefficients in the equation ². Moreover, we cannot remove the second lag from the estimation as its removal leads to autocorrelation problem ³. In the conditional variance equation, every coefficient is significant at 1% level. Furthermore, all the coefficients

are positive, following the non-negativity condition of the variance. In addition, the coefficients of the ARCH term (i.e., ε_{t-1}^2) and the GARCH term (i.e., h_{t-1}^2) are 0.2500 and 0.7456 respectively, and the sum of the two is less than unity. This means that the variance is stationary and it does not violate the non-explosive condition. We have checked with other GARCH models, but the results tell that they are not superior to the GARCH(1, 1). Hence, we conclude that the ARMA-GARCH(1, 1) is appropriate.

4.3- Examination on Friedman-Ball Hypothesis Validity

As mentioned previously, the Friedman-Ball hypothesis suggests that there is a positive correlation between inflation and inflation uncertainty, and the causality runs from the inflation to its uncertainty⁴. However, Cukierman and Meltzer (1986) argue that increased inflation uncertainty leads to higher average inflation, meaning that the causality runs from the inflation uncertainty to the inflation. This section attempts to examine whether there is a positive relationship between the inflation and the inflation uncertainty in Cambodia, and if the relationship exists, whether it supports the Friedman-Ball hypothesis or Cukierman and Meltzer (1986). In order to address the questions, the Granger causality test is performed. Following the prevailing researches, the conditional variance of the inflation obtained in the last section is used as the inflation uncertainty⁵.

Figure 4.1: Inflation and Its Conditional Variance



From the visual graphs in Figure 4.1, it is obvious that there is a positive relationship between the inflation and its uncertainty (i.e., conditional variance). The periods with high inflation experience relatively high conditional variances, particularly in mid 1997 and in early 2008. To understand the direction of the causality, the Granger causality test is carried out, and the test results are reported in Table 4.3.

Table 4.3: Granger Causality Test for Inflation and Inflation Uncertainty

H_0 : Inflation does not Granger-cause inflation uncertainty	H_0 : Inflation uncertainty does not Granger-cause inflation
39.117*** (+) (0.000)	0.594 (0.441)

Notes:

1. *** indicates the rejection of the null hypothesis at 1% conventional level.
2. The numbers in the parentheses below the test statistics are p-values.
3. The lag length selection is determined by AIC, BIC, and HQIC. Here, the three information criteria unanimously choose the lag length of 1. Other lag lengths are also tested, showing that the results remain the same.
4. (+) indicates that the coefficient is positive and significant.

In the results of the Granger causality test reported in Table 4.3, the null hypothesis that the inflation does not Granger-cause the inflation uncertainty is rejected at 1% significance level, indicating that the inflation Granger-causes the inflation uncertainty. By contrast, the null hypothesis that the inflation uncertainty does not Granger-cause the inflation is accepted. These results evince that there is a positive relationship between the inflation and the inflation uncertainty, with the causality running from the inflation to the inflation uncertainty⁶. This suggests that in Cambodia the Friedman-Ball hypothesis holds, while the argument of Cukierman and Meltzer (1986) is rejected by the test.

4.4- Examination on Fisher Effect

In this section, we examine whether the Fisher effect exists in Cambodia. In other words, we attempt to investigate whether there is a positive relationship between the deposit rate and the expected inflation, and between the lending rate and the expected inflation. The ordinary least squares (OLS) method is employed to test for the relationship between the expected inflation and the interest rates. Because both the deposit rate and lending rate, as seen in the unit root tests section, are non-stationary, their first differences whose stationarity was confirmed are used instead. Both ADF and PP unit root tests suggest that the expected inflation derived from the ARMA-GARCH(1, 1) model discussed above is stationary. Here, the results of the unit root tests for the expected inflation are not reported since they are not the main part of this section. Because all the series to be regressed are stationary, the regressions are admissible.

By regressing the first difference of the deposit rate on the expected inflation, and the first difference of the lending rate on the expected inflation, the estimation results are as follows.

$$\begin{aligned}\Delta DER_t &= 0.002 - 0.089\pi_t^e \\ &\quad (0.08) \quad (-2.30) \\ \Delta LER_t &= -0.032 + 0.006\pi_t^e \\ &\quad (-1.03) \quad (0.12)\end{aligned}\tag{12}$$

Here, ΔDER_t , ΔLER_t , and π_t^e are the first difference of the deposit rate, the first difference of the lending rate, and the expected inflation, respectively. The numbers in the parentheses below each coefficient are the t-values of those coefficients.

For the case of the deposit rate, the coefficient of the expected inflation is negative and statistically significant at 5% level, with the t-value equal to -2.30 . This implies that when the monthly inflation is expected to increase by 1 percent, the first difference of the deposit rate will decrease by 0.089 percent. Therefore, it is against the Fisher hypothesis. The constant term is not significantly different from zero since it has

an extremely low t-value of 0.08.

For the case of the lending rate, the coefficient of the expected inflation is 0.006 with a positive sign, seemingly supporting the weak form of the Fisher effect, but its t-value of 0.12 suggests that it is not significantly different from zero. Also, the constant term is not significant at conventional levels.

These estimation results demonstrate that the Fisher effect does not hold for the case of Cambodia during the full sample period (i.e., October 1994 to May 2012). Actually, Cambodia is not the only country that the Fisher effect is absent. Some studies also find no Fisher effect in many countries, particularly in developing economies. For instance, using GARCH approach to estimate the expected inflation, Berument *et al.* (2007) find that the Fisher hypothesis holds in all the G7 countries, but among 45 developing economies under their consideration, the relationship between interest rate and expected inflation is positive and significant in only 23 economies. For the other 22 developing countries, the Fisher effect is not supported. Among these 22 countries, Egypt is the only country that the estimated coefficient of the expected inflation is negative and statistically significant. The developing countries where the estimated coefficient of the expected inflation is statistically insignificant include Armenia, Albania, Bahrain, Bulgaria, Dominica, Ghana, Grenada, Kuwait, Lao People, Lithuania, Malawi, Namibia, Nepal, Sierra Leone, Solomon Islands, Sri Lanka, St Lucia, Swaziland, Uganda, Zambia and Zimbabwe. The authors argue that there might be some reasons behind the absence of the Fisher effect in these economies. Firstly, the Fisher hypothesis contains an implicit assumption that nominal interest rates can freely adjust to changes in actual or expected inflation; so if interest rates are suppressed, the hypothesis may not hold. Secondly, interest rates may not or may only partially respond to the changes in inflation in those economies where the money markets are not sufficiently sophisticated. Thirdly, in some countries interest rate adjustment may be difficult since it is believed to be a 'sin' for cultural reasons.

Lorde *et al.* (2008) employ cointegration method to investigate the long run relationship between interest rate and expected inflation in five small developing Caribbean countries—the Bahamas, Barbados, Guyana, Jamaica, and Trinidad and

Tobago. Their finding is that the relationship holds in 3 countries (the Bahamas, Jamaica, and Trinidad and Tobago), and the relationship is negative for Trinidad and Tobago. For the other two countries, there is no long run relationship between the two variables. The authors' explanation on the reason why the nominal interest rate is inversely related to expected inflation in Trinidad and Tobago is as follows: "It is possible that some unknown influence may be driving the nominal interest rate and inflation rate in opposite directions, a phenomenon that probably warrants further research to identify other possible determinants of the nominal interest rate in Trinidad and Tobago."

Given the findings in the existing studies, the nonexistence of the Fisher effect in Cambodia is neither unique nor bizarre. Most of the explanations on why the Fisher effect does not hold in some countries by Berument *et al.* (2007) and Lorde *et al.* (2008) are likely to be applicable as well for the case of Cambodia. The first and the second reasons mentioned by Berument *et al.* (2007) seem to be true in Cambodia; their third reason, however, is not convincing. As seen from Box 4.1 (General Functions and Duties of National Bank of Cambodia), the National Bank of Cambodia (NBC), the central bank of the country, has a duty to set interest rates (i.e., the 12th duty in Box 4.1). Although by law the NBC has a duty to set interest rates, some economists argue that this function is not operated effectively due to some monetary constraints such as high dollarization; and practically, each commercial bank can set interest rates on deposits and loans by themselves based on market competition (see Pum and Vanak, 2010, p.69). However, NBC might, to some extent, be able to affect the interest rates by both direct regulations and indirect ways; e.g., through raising or lowering the reserve requirement ratio (RRR) and the minimum capital requirement (MCR) ⁷. Secondly, the interest rates in Cambodia might not respond to the inflation because the money and capital markets in the country are underdeveloped and undiversified. Up to the present, there have been no bill and bond markets, and interbank markets. Cambodia just opened its stock exchange on July 11, 2011, becoming the last country in the Association of Southeast Asian Nations (ASEAN) to introduce the securities market. Thus far, there has been only one listed company, Phnom Penh Water Supply Authority (PPWSA), whose initial public offering (IPO) ushered on April 18, 2012.

Box 4.1: General Functions and Duties of National Bank of Cambodia

The National Bank of Cambodia shall have the following functions and duties:

1. To determine monetary policy objectives, in consultation with the Royal Government and consideration of the framework of the economic and financial policy of the Kingdom;
2. To formulate, implement and monitor monetary and exchange policies aimed at the determined objectives;
3. To conduct regular economic and monetary analysis, make public the results, and submit proposals and measures to the Royal Government;
4. To license, delicense, regulate and supervise banks and financial institutions and other relevant establishments such as auditors and liquidators;
5. To oversee payments systems in the Kingdom, and to enhance interbank payments;
6. To act as the sole issuer of national currency of the Kingdom;
7. To undertake and perform, in the name of the Kingdom, transactions resulting from the participation of the Kingdom in public international institutions in the banking, credit, and monetary spheres;
8. To establish the balance of payments;
9. To participate in the management of external debt and claims;
10. To participate in the formation and supervision of the money and financial markets;
11. To license, delicense, regulate and supervise all those operating in the securities and foreign exchange markets, the market for precious stones and precious metals;
12. To set interest rates.

Source: National Bank of Cambodia (NBC)

Finally, considering the reason explained by Lorde *et al.* (2008), there might be other factors leading the deposit rate and the expected inflation to move in opposite directions. Further study on these factors should be conducted by later researchers. Here,

one tentative factor; that is, money supply is considered. This might be able to be explained by the liquidity preference theory⁸. The liquidity preference theory asserts that the nominal interest rate is determined by the supply and demand for money, where the supply curve is vertical since the money supply is controlled by the central bank and it does not depend on the interest rate, while the demand curve is downward sloping since the quantity of money demanded decreases when the interest rate rises, implying a higher cost of holding money. When the central bank increases the money supply, the supply curve shifts to the right, and the interest rate becomes lower. At the same time, an increase in the money supply implies a rise in the price level because of the lower purchasing power resulting from the more money injected in the economy. If this is true, it means that the money supply drives the interest rate and the expected inflation to move inversely. This might be true for the case of the deposit rate. But why it cannot explain for the case of the lending rate? To answer this, two facts are noteworthy. First, as explained in the data section in chapter 3, the deposit rate used in this research is the simple average of the rates on savings deposits denominated in the national currency, the riel, whereas the lending rate is the simple average of the rates on loans denominated in the U.S. dollar. Secondly, the central bank of Cambodia cannot manipulate the supply of the U.S. dollar; the dollar is freely and widely used in all forms of the three functions of money (i.e., medium of exchange, unit of account, and store of value) throughout the country. That is why money supply (riels) might influence the deposit rate (on deposits denominated in riel), but it might not affect the lending rate (on loans denominated in the U.S. dollar).

4.5- Determinants of Interest Rates in Cambodia

In the last section, the validity of the Fisher effect in Cambodia is discussed. The estimation results suggest that the Fisher effect in Cambodia, like some other developing countries, does not hold. In this section, the inflation risk and the interest rate in the U.S. are incorporated in the estimation in order to see how these factors might affect the interest rates in Cambodia. Following Berument and Malatyali (2001), the conditional standard deviation of the inflation (i.e., h_t) is used as the inflation risk⁹.

As mentioned previously, the U.S. federal funds rate is used as the nominal interest rate in the U.S. The estimation results are as follows ¹⁰:

$$\begin{aligned}
 \Delta DER_t &= -0.102 - 0.113\pi_t^e + 0.094h_t + 0.358\Delta FFR_t \\
 &\quad (-2.05) \quad (-2.85) \quad (2.46) \quad (3.29) \\
 \Delta LER_t &= -0.079 - 0.005\pi_t^e + 0.043h_t + 0.176\Delta FFR_t \quad (13) \\
 &\quad (-1.21) \quad (-0.09) \quad (0.86) \quad (1.25)
 \end{aligned}$$

Here, ΔDER_t , ΔLER_t , π_t^e , h_t , and ΔFFR_t are the first difference of the deposit rate, the first difference of the lending rate, the expected inflation, the conditional standard deviation of the inflation, and the first difference of the U.S. federal funds rate, respectively. The numbers in the parentheses below each coefficient are the t-values of those coefficients.

From the estimation results, all the coefficients in the first difference of the deposit rate are statistically significant at conventional levels. Based on the t-values, the coefficient of the expected inflation and the coefficient of the first difference of the federal funds rate are significant at 1% level, while the coefficient of the inflation risk and the constant term are significant at 5% level. The coefficient of the expected inflation is equal to -0.113 , meaning that when the expected inflation increases by 1%, the first difference of the deposit rate will decrease by 0.113%. The coefficient of the inflation risk is 0.094, implying that when the inflation risk measured by the conditional standard deviation of the inflation increases by 1%, the change in the deposit rate will increase by 0.094%. Finally, the coefficient of the first difference of the federal funds rate of 0.358 suggests that when the change in the federal funds rate rises by 1%, the change in the deposit rate will rise by 0.358%. Overall, the expected inflation has a negative effect, while the inflation risk and the federal funds rate have positive effects on the deposit rate in Cambodia.

The coefficients in the equation of the first difference of the lending rate for the full sample period, on the contrary, are statistically not different from zero at all conventional significance levels. To reveal why the lending rate specification is not

statically significant, it is worth going back to examine the lending rate movements. As shown in Figure 3.2, there are some jumps in the lending rate after the end of 2001. What happened then? Was there a structural change in late 2001?

Actually, there was a striking change in late 2001; that is, the introduction of some new regulations on banking and financial institutions in the country. The late-2001 implementation of the minimum capital requirement (MCR) and the reserve requirement ratio (RRR) is the most influential factor driving the lending rate to jump soon after the end of 2001. According to Pum and Vanak (2010, p.67), article 1 of the *Prakas*¹¹ on banks' minimum capital states that to "obtain a license, banks locally incorporated as companies, must have a paid-up minimum capital equal to at least 50,000,000,000 riels." Furthermore, another *prakas* on bank's capital guarantee dated October 15, 2001 stipulates that each bank has to deposit 10% of its minimum capital requirement as capital guarantee at the National Bank of Cambodia (NBC, 2004). In addition to the MCR, the reserve requirement ratio was then set for its first time at 8%. This means that every bank (commercial bank) has to keep at least 8% of its total deposits with NBC. That is why the lending rate graph exhibits some jumps soon after the end of 2001¹². Since then, many more regulations on banking and financial institutions have been legislated.

Given such a dramatic change at the end of 2001, estimation of the lending rate with a restriction of time $t \leq 2001m12$ is conducted. The following is the estimation result.

$$\Delta LER_t = -0.079 - 0.029\pi_t^e + 0.040h_t + 0.389\Delta FFR_t$$

$$(-0.64) \quad (-0.44) \quad (0.50) \quad (2.17) \quad (14)$$

The result of this estimation is better than that of the estimation without restriction. The coefficient of the first difference of the federal funds rate increases to 0.389 and is now statistically significant at 5% level (with t-value equal to 2.17). This implies that until the end of 2001, when the change in the U.S. federal funds rate increases by 1%, the change in the lending rate in Cambodia will increase by 0.389%. The other coefficients, however, are almost still the same as those of the estimation

without restriction; they are not statistically different from zero at all conventional significance levels. This suggests that before 2002, the expected inflation and the inflation risk do not have significant influence on the lending rate (on dollar-denominated loans).

The same approach is applied to the estimation of the lending rate after the end of 2001, but it does not produce any significant results. The main reason behind this might be because the lending rate has been substantially suppressed by the regulations enforced more and more by NBC since after official launch of the Law on Banking and Financial Institutions in 2000 and the implementation of the RRR and MCR in late 2001.

From the estimation results discussed above, it appears that the relations between the federal funds rate and the deposit rate and between the federal funds rate and the lending rate before 2001m12 are quite strong. As a robustness test for the direction of the causal relations between the U.S. federal funds rate and the interest rates in Cambodia, the Granger causality test is performed.

Table 4.4: Granger Causality Tests for Federal Funds Rate and Deposit Rate

H_0 : Change in the federal funds rate does not Granger-cause change in the deposit rate	H_0 : Change in the deposit rate does not Granger-cause change in the federal funds rate
9.789* (+) (0.081)	8.703 (0.121)

Notes:

1. * indicates the rejection of the null hypothesis at 10% significance level.
2. The numbers in the parentheses below the test statistics are p-values.
3. The lag length selection is determined by AIC, BIC, and HQIC. Here, it is equal to 5.
4. (+) indicates that the sum of the coefficients is positive and significant.

Table 4.5: Granger Causality Tests for Federal Funds Rate and Lending Rate*(t ≤ 2001m12)*

<i>H</i> ₀ : Change in federal funds rate does not Granger-cause change in lending rate	<i>H</i> ₀ : Change in lending rate does not Granger-cause change in federal funds rate
23.234*** (+) (0.000)	2.157 (0.707)

Notes:

1. *** indicates the rejection of the null hypothesis at 1% significance level.
2. The numbers in the parentheses below the test statistics are p-values.
3. The lag length selection is determined by AIC, BIC, and HQIC. Here, it is equal to 4.
4. (+) indicates that the sum of the coefficients is positive and significant.

Table 4.4 and Table 4.5 report the results of the Granger tests for the causality between the federal funds rate and the deposit rate and between the federal funds rate and the lending rate before 2001m12, respectively. As evident from the results in Table 4.4, the change in the federal funds rate Granger-causes the change in the deposit rate, whereas the change in the deposit rate does not Granger-cause the change in the federal funds rate. Similarly, Table 4.5 indicates that the change in the federal funds rate Granger-causes the change in the lending rate, while the change in the lending rate does not Granger-cause the change in the federal funds rate before 2001m12. These results confirm that the interest rates in Cambodia are influenced by the interest rate in the United States, but they cannot influence the interest rate in the United States.

The estimation results in this section can be concluded as follows. The expected inflation has negative effect on the deposit rate, indicating the nonexistence of the Fisher effect in Cambodia. There might be some other factors driving the expected inflation and the deposit rate to move in opposite directions. One tentative factor is money supply manipulated by NBC, the central bank of Cambodia. It can happen through the effect as explained by the liquidity preference theory. Nonetheless, the

inflation risk measured by the conditional standard deviation of the inflation has positive influence on the deposit rate. Besides, the deposit rate in Cambodia is directed by the U.S. federal funds rate; an increase in the federal funds rate leads to a rise in the deposit rate. The lending rate, on the other hand, is not significantly influenced by the expected inflation, the inflation risk, and the federal funds rate when the estimation is performed, using the whole sample period. However, it is significantly affected by the federal funds rate after the estimation is restricted with $t \leq 2001m12$. It is restricted so because of the fact that there was a substantial structural change in late 2001. Since then, the lending rate has been highly likely to be partially affected by various regulations imposed by the central bank. As robustness tests, the Granger causality tests suggest that the federal funds rate in the U.S. does Granger-cause the deposit rate and the lending rate in Cambodia, while the deposit rate and the lending rate do not Granger-cause the federal funds rate.

ENDNOTES:

1. Some researchers have used “homoscedastic” and “heteroscedastic” instead of “homoskedastic” and “heteroskedastic”, respectively. For instance, Engle (1982) uses the former in his pioneering research.
2. A test to see whether the coefficients of the first lag, the second lag, and the twelfth lag of the inflation are collectively significant and different from zero is conducted. The test statistic, which follows the chi-squared distribution with degree of freedom of 3, is 27.13, indicating that null hypothesis is rejected at 0% significance level. Based on the test result, the coefficients are significant collectively.
3. The Ljung–Box Q-statistics of the residuals of the ARMA($p = 1,2,12, q = 0$), the model from which the second lagged inflation is omitted, indicate that the autocorrelations are significant at the conventional levels for almost all of the lags, especially for the lags of 2, 8, and 18. The autocorrelations for the lags of 2, 8, and 12 are $\rho_2 = 0.178$, $\rho_8 = -0.174$, and $\rho_{18} = -0.161$, respectively.

4. In his Nobel lecture, Friedman (1977) points out the potential of increased inflation to create nominal uncertainty. He documents on page 465 that “the most fundamental departure is that a high inflation rate is not likely to be steady during the transition decades. Rather, the higher the rate, the more variable it is likely to be.” Ball (1992) uses game theory to justify Friedman’s argument. In Ball’s theoretical analysis, there are two kinds of monetary policymakers—one is conservative, and the other is tough. When the inflation is low, both types of the policymakers will choose to keep it low; thus the public feels certain that future inflation will be still low. But when the inflation rises, there is a fear of recession if they choose disinflation. Then, only the tough policymaker will decide to disinflate. However, the public does not know which type of the future policymaker will be, and whether or not the disinflation will happen.
5. See, for example, Grier and Perry (1998) and Berument and Dincer (2005).
6. The results are consistent when we use conditional standard deviation h_t as the inflation uncertainty instead of the conditional variance h_t^2 .
7. Reserve requirement ratio (RRR) is the minimum reserve-deposit ratio that the central bank imposes on banks. Here, reserve-deposit ratio is the fraction of deposits that banks keep in reserve. The higher RRR, the fewer loans banks can make, and the less money banks create from every dollar of reserve. Therefore, an increase in the RRR lowers the money multiplier and the money supply, thus raises interest rates. Minimum capital requirements (MCR) are the central bank’s regulations that require banks to keep sufficient capital so that the banks can pay off their depositors. Like RRR, higher MCR leads to higher interest rates. See Mankiw (2010, pp.550-556) for more explanation.
8. For detailed discussion on the liquidity preference theory, see Ball (2009, pp.97-102) and Mankiw (2010, pp.301-304).
9. ADF and PP unit root tests indicate that the conditional standard deviation of the inflation is stationary.
10. Like the earlier section, since the deposit rate and the lending rate have unit root, their first differences, whose stationarity is confirmed, are used instead. Similarly,

the first difference of the federal funds rate is used instead of its level because the level series is non-stationary and the first difference is stationary.

11. *Prakas* is a kind of official announcement made by a ministry or equivalent institution to the public for use in a new law or regulation.
12. As also explained above in endnote number 7, higher RRR and/or MCR mean less loans a bank can make, thus raise the lending rate. The graph of lending rate in Figure 3.2 exhibits jumps soon after the end of 2001 because the RRR and MCR were put into effect then.

CONCLUSION

This final part concludes the thesis, points out policy implication, raises some cautions in interpreting the empirical results, and finally suggests the subject of further research.

In examination of determination of interest rates, most studies have been extensively conducted by testing validity of the so-called Fisher hypothesis and most of them have focused on developed economies, leaving the researches on developing economies, particularly least developed countries, relatively sparse. Thus far, there has been no research regarding determination of interest rates, or even on the Fisher effect, in Cambodia. Given this fact, this thesis seeks to throw some light on the determinants of nominal interest rates in Cambodia, by incorporating inflation risk (i.e., conditional standard deviation of inflation) and the U.S. interest rate into the conventional Fisher equation. Data used in this thesis are monthly series with the sample period from October 1994 to May 2012. Consumer price index (CPI), deposit rate, and lending rate in Cambodia are taken from the IMF's International Financial Statistics CD-ROM, whereas the U.S. federal funds rate is from Board of Governors of the Federal Reserve System. The main findings are as follows. Firstly, Augmented Dickey–Fuller (ADF) unit root test and Phillips–Perron (PP) unit root test suggest that only the inflation is stationary while all the interest rates—deposit rate, lending rate, and federal funds rate—are non-stationary at their levels but their first differences are stationary. In other words, the inflation is $I(0)$ while the deposit rate, the lending rate, and the federal funds rate are $I(1)$. Secondly, after considering various ARMA models of the inflation following the Box–Jenkins approach, it is concluded that $ARMA(p = 1, 2, 12, q = 0)$ is the best model. This implies that monthly inflation in Cambodia can be explained by its past values at lag 1, 2, and 12. Thirdly, given the result that ARCH-LM test indicates the presence of ARCH effects, we fit the ARMA model obtained above together with GARCH models and results suggest that $ARMA-GARCH(1, 1)$ is adequate. Therefore, the expected inflation and the inflation risk can be computed by fitting this $ARMA-GARCH(1, 1)$. Fourthly, the validity of the Friedman–Ball hypothesis, which

postulates that inflation and inflation risk (inflation uncertainty) are positively correlated and the causality runs from inflation to inflation risk, for the case of Cambodia is investigated by employing the Granger causality test. The Granger causality test results suggest that the inflation Granger-causes the inflation risk, but the inflation risk does not Granger-cause the inflation. These results support the Friedman–Ball hypothesis and reject what proposed by Cukierman and Meltzer (1986) that argue that the causality runs from the inflation risk to the inflation. Fifthly, empirical evidence indicates that the Fisher hypothesis does not hold in Cambodia. The expected inflation has no significant effect on the lending rate, while it surprisingly has a significantly negative effect on the deposit rate. Cambodia is not the only country where the Fisher effect is absent; 22 countries among 45 developing countries under study by Berument *et al.* (2007) and 3 countries among 5 developing Caribbean countries under study by Lorde *et al.* (2008) as well as some more countries examined by other researchers also experience the nonexistence of the Fisher effect. Also, for Egypt in Berument *et al.* (2007) and Trinidad and Tobago in Lorde *et al.* (2008), the relationship between expected inflation and interest rate is negative. Exploring the reasons behind the absence of the Fisher effect in Cambodia might be the subject of further study. A few tentative explanations are as follows. First, the interest rates, especially the lending rate, are likely to be affected by regulations of the National Bank of Cambodia (NBC), at least to some extent. Second, the interest rates in Cambodia might not respond to the inflation because the money and capital markets in the country are underdeveloped and undiversified. Finally, there might be unknown factors driving the deposit rate and the expected inflation to move in opposite directions. One factor might be money supply. It can be explained by the liquidity preference theory, which states that nominal interest rate is determined by the supply and demand for money. When NBC injects more riels (national currency) into the market given the other factors unchanged, the vertical supply curve shifts to the right leaving the downward-sloping demand curve unchanged. This shift results in a fall in interest rate for riels. At the same time, an increase in money supply implies an increase in price level, and thus a rise in expected inflation.

When the nominal interest rate is set at a given time, the inflation for that period is unknown. Since investors are interested in real return when making a portfolio decision, they therefore assess the *ex ante* real interest rate by forming expectation of the inflation. In this regard, the inflation uncertainty is a risk to be taken into account and it is reflected in the nominal interest rate. Empirical results show that the inflation risk has positive influence on the interest rates in Cambodia, particularly the deposit rate. However, this influence is seemingly insignificant for the lending rate. Given the results that indicate a positive relationship between interest rate and inflation risk, this suggests that the government should adopt any policies that fight against the volatility of the inflation if it wants to keep interest rate low so that the economy is boosted by investment activities.

Additionally, the interest rate in the United States (i.e., the federal funds rate) substantially directs the interest rates in Cambodia. The estimation results suggest that when a change in the federal funds rate increases by 1%, a change in the deposit rate in Cambodia will increase by 0.358%. The results also indicate that from October 1994 to December 2001, when a change in the federal funds rate increases by 1%, a change in the lending rate in Cambodia will increase by 0.389%. The relationship between the federal funds rate and the lending rate seems to be insignificant after the end of 2001. This is the case since there was a striking change in the banking and financial sector in Cambodia since around the end of 2001. In late 2001, NBC introduced many new laws among which the implementation of RRR (reserve requirement ratio) and MCR (minimum capital requirement) remarkably affected the lending rate, and since then many supplementary regulations have been enforced. Finally, as robustness tests, the Granger causality tests are carried out in order to confirm the causal relationships between the U.S. federal funds rate and the interest rates in Cambodia. The results of the Granger causality tests confirm that the federal funds rate Granger-causes the interest rates in Cambodia, but the interest rates in Cambodia do not Granger-cause the federal funds rate. The empirical evidences presented above support our hypothesis proposed at the beginning that the U.S. monetary policy influences Cambodia's economy, specifically through interest rate channels. Given this, it is recommended that the

government and especially NBC should take into account the U.S. monetary policy when considering any economic and monetary policies to be adopted and put into effect in the country.

When interpreting the empirical results obtained in this thesis, it is important to bear in mind that the interest rates—deposit rate and lending rate—used in this thesis are subject to their definitions given by the IMF's IFS, and thus do not reflect all of the types of interest rates in Cambodia. According to IFS, the deposit rate is the simple average of rates on domestic-currency savings deposit reported by 10 banks with largest deposits holding, and the lending rate is the simple average of rates on foreign-currency loans to private enterprises by 10 banks with largest deposits holding. Using other interest rates provided by other institutions, if available, might produce different results. It would be better or even best if various data on deposits and loans denominated in riel and on those denominated in the U.S dollar were provided by Cambodian authorities, particularly NBC. This thesis suffers from the unavailability of those useful data.

This thesis utilizes the approach of ARMA-GARCH process from which the expected inflation and the inflation risk are assessed, and then uses OLS method to estimate the interest rates. The analysis of the Fisher effect with these techniques, therefore, can be viewed as a test for the short-run Fisher effect. Despite it is suggested in this thesis that there exists no short-run Fisher effect in Cambodia, alternative approaches such as cointegration relationship examination might give support to a long-run Fisher effect. This is another subject of further research.

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