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Essays on Vietnam's Financial Reforms: Foreign Exchange Statistics and Evidence of Long-Run Equilibrium

Vuong Quan Hoang

In this paper, we examine exchange rates in Vietnam's transitional economy. Evidence of long-run equilibrium are established in most cases through a single co-integrating vector among endogenous variables that determine the real exchange rates. This supports relative PPP in which ECT of the system can be combined linearly into a stationary process, reducing deviation from PPP in the long run. Restricted coefficient vectors $\beta' = (1, 1, -1)$ for real exchange rates of currencies in question are not rejected. This empirics of relative PPP adds to found evidences by many researchers, including Flre *et al.* (1999), Lee (1999), Johnson (1990), Culver and Papell (1999), Cuddington and Liang (2001). Instead of testing for different time series on a common base currency, we use different base currencies (USD, GBP, JPY and EUR). By doing so we want to know the whether theory may posit significant differences against one currency? We have found consensus, given inevitable technical differences, even with smaller data sample for EUR. Speeds of convergence to PPP and adjustment are faster compared to results from other researches for developed economies, using both observed and bootstrapped HL measures. Perhaps, a better explanation is the adjustment from hyperinflation period, after which the theory indicates that adjusting process actually accelerates. We observe that deviation appears to have been large in early stages of the reform, mostly overvaluation. Over time, its correction took place leading significant deviations to gradually disappear.

JEL Classifications: C12; C22; C53

Keywords: Exchange rates equilibrium; Co-integration; Purchasing power parity; Vietnam.

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Université Libre de Bruxelles – Solvay Business School – Centre Emile Bernheim
ULB CP 145/01 50, avenue F.D. Roosevelt 1050 Brussels – BELGIUM
e-mail: ceb@admin.ulb.ac.be Tel. : +32 (0)2/650.48.64 Fax : +32 (0)2/650.41.88

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SOLVAY BUSINESS SCHOOL
Ecole Doctorale de Gestion

Vuong Quan Hoang
Hanoi - Bruxelles September 2003
E-mail: hoangvq@empirics.net

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13th September 2003

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Abstract: In this paper, we examine exchange rates in Vietnam's transitional economy. Evidence of long-run equilibrium are established in most cases through a single co-integrating vector among endogenous variables that determine the real exchange rates. This supports relative PPP in which ECT of the system can be combined linearly into a stationary process, reducing deviation from PPP in the long run. Restricted coefficient vectors $\beta' = (1, 1, -1)$ for real exchange rates of currencies in question are not rejected. This empirics of relative PPP adds to found evidences by many researchers, including Flre *et al.* (1999), Lee (1999), Johnson (1990), Culver and Papell (1999), Cuddington and Liang (2001). Instead of testing for different time series on a common base currency, we use different base currencies (USD, GBP, JPY and EUR). By doing so we want to know the whether theory may posit significant differences against one currency? We have found consensus, given inevitable technical differences, even with smaller data sample for EUR. Speeds of convergence to PPP and adjustment are faster compared to results from other researches for developed economies, using both observed and bootstrapped HL measures. Perhaps, a better explanation is the adjustment from hyperinflation period, after which the theory indicates that adjusting process actually accelerates. We observe that deviation appears to have been large in early stages of the reform, mostly overvaluation. Over time, its correction took place leading significant deviations to gradually disappear.

J.E.L. Code: C12; C22; C53

Keywords: Exchange rates equilibrium; Co-integration; Purchasing power parity; Vietnam.

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1 Introduction

"To be a good doctor, practice in war.
To be a good economist, practice in Vietnam."
— Unknown.

This study has its root in the seminar paper, presented at SBS/CEB research seminar in May 2003. Its previous name was "Exchange Rate Dynamics of the Reforming Vietnam: An Evidence of Long-Run Equilibrium". In this seminar, I received many useful and specific comments from professors, colleagues and doctorants. In particular, I am most grateful for comments from Professors André Farber and Ariane Szafarz (*Ecole de commerce Solvay*), and Marius Stefan (Department of Mathematics, U.L.B.; the main discussant of this paper). Fruitful discussion and idea exchanges with other doctorants also help shape this final form of the study, for which I am pleased to thank them here, Kim Oosterlinck, Marie-Paule Laurent, to name a few.

1.1 A brief overview

Vietnam is clearly a fledgling market economy, with the market 'seeds' were only planted in late 1980s. Over the past 16 years, the national financial system is still developing in its infancy. Even today basic banking facilities are not familiar with the community. With the recent opening of Vietnam's first post-war stock exchange, named as Ho Chi Minh City Securities Trading Center, the population has new investment opportunities, and more importantly a renewed interest in financial markets. However, some 30 months after the first stock trade, many have realized that investing in a stock market is much of a challenge.

In general, the most common investing vehicles for the population have not been diverse. We will name a few major 'items' that Vietnamese people tend to in their common portfolios. The first option is keeping gold as stored value. This is understandable as many, especially aged people, underwent difficult periods of time in the past. An example should be the hyperinflation period of 1986-1989, through which they observed the value of gold had been kept, to a large extent, stable. The second is the US Dollar, an increasingly important item in households' savings portion, plus other hard currencies, if any (more recently the Euro of the EMS has been emerging as a major rival to the

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US Dollar). The third is land and housing ownership. In fact, private land ownership is not legalized by law, only land-use-right that does. However, land and related real estates are regarded as fairly safe investments and savings, and in reality they grant de facto individual ownership rights.

Unlike before 1990s, when people's income level and savings were generally very low, the economic reform has improved living standards and savings of the population significantly, in different ways. Businesses that deal with foreign currencies and problem of economic exposure caused by exchange rate ups and downs are also increasing, due to the lifting of international trade barriers to domestic trading firms. These all, plus the importance of hard currencies in households' savings proportion, have made the public more aware of exchange rate behaviors and interested of understanding what has happened and would likely happen with exchange rates of the currencies of interest.

The above is the root of this empirical study on exchange rates of major foreign currencies available for trading in Vietnam's foreign exchange markets. This study will also consider different aspects of gold price as one type of money, which is usually influenced by the movement of the world price like foreign currencies. As these two are critically important to the population, and archrivals to corporate equities as alternative investments, a good explanation of their empirical pattern and behavior over the past will facilitate our understanding and reasoning of inhabitants' investment preferences. Organization of this paper is as follows. The next section will provide for a thorough knowledge of Vietnam's financial economy reform, which has laid down early cornerstones for financial market in existing status. This section will touch on key factors that will serve as our research objects in analyses that follow, namely the local currency, domestic inflation, and gold as one main value store means. Section 2 serves as a detailed, and fairly lengthy, introductory discussion, due largely to little exposure of the outside world to Vietnam. By elaborating on this, we hope to familiarize readers to the economy in a changing course of reforms. Section 3 moves on to review relevant part of finance literature, which deals with close aspects and benefits our analysis. Also in the section, we present key hypotheses that will be studied as focal points of this paper, together with a subsection on data treatment and estimation methods, specific to this study. Section 4 supplies detailed empirics that enable us to understand better the research objects in compliance to our determined research questions. Key findings will be summarized towards necessary inferences towards questioned hypotheses. Drawn

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upon significant findings, a few remarks will be given in Section 5. Further research suggestion for Vietnam exchange rates will be proposed later.

1.2 More words on the Vietnamese financial reforms

Vietnam has gradually abandoned the previously opted old-style centrally planned economy since mid-1980s. The drop of this long-standing economic structure had its root in chaotic economic position of the nation early 1980s. Major problems were low productivity in agricultural production, declining living standards in both country and urban areas, and stagnation in industrial growth. During the 1980s, the fact that Vietnam, a nation of agriculture by definition, had to import foodstuff for population's basic needs was an apparent paradox, although it used to be an exporter of rice in the early twentieth century. The economic reform notoriously started with the issue of Vietnam's ever post-war foreign direct investment law, promulgated in 1986 after the Vietnam Communist Party Congress VI. The move was inspired by a new definition of an economy in reform, which officially recognized the existence and contribution of the non-state economic forces, including private households, privately run companies and foreign-invested economic agents.

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2 Vietnam's financial reforms: An emphasis on the re-emergence of financial markets

A broader recognition of the private economy has greatly helped stimulate investment, both from outside and within. This is regarded as the major growth engine for the country over the past 16 years of reform. Induced by the fast and ever-evolving change of economic structures, the financial system also re-emerged almost from scratch. Similar to other restructure in Vietnam, financial reform, too, was implemented from top down. The first observed restructure started with the spin-off of commercial lending functionality of the old-fashioned quasi central bank, National Bank of Vietnam (predecessor of today's State Bank of Vietnam), to commercial banks. The change helped form the two-tiered banking system, which enables the re-emergence of shareholding banks (about 48 now), which by nature have had much more diverse ownership than rigid state-run commercial banks (currently 5). Sequentially, non-bank finance companies of different forms came into place, such as leasing firms, non-deposit taking finance companies, investment funds. These changes were first happening during the fast-changing period of late 1980s and early 1990s.

Besides the existence and operation of formal economic units in the financial economy, private households operating financial services within the population, especially in urban areas, also mushroom. They are gold and foreign currency trading shops and counters. In private transactions, these units, too, function as commercial lenders to private households doing business without access to formal banking and financial resources. In brief, the reemergence of the financial economy, with participants being both state-run and non-state financiers; formal and informal ones, has contributed a great deal to the re-opening and operation of financial markets. Today's financial markets in Vietnam although still in its primitive forms already include crucial ones serving imperative needs of a modern market-oriented economy, comprising of interbank foreign exchange market, interbank wholesale lending market, commercial money and capital markets, and most recently, an equity market launched in July 2000. Several futures transaction floors were also introduced, including those specifically designed for trading of cashew nuts, cotton, rice, coffee, and aquatic-fishery products.

Given the revival of a crucial financial sector inside the economy of Vietnam, inhabitants also shifted their economic interests more towards investment problems and new

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value-creating financial assets, namely the domestic currency, gold, hard currencies (especially US Dollar), besides the realty assets. Naturally, these new assets are of our interests throughout this study, whose brief description of them follows. We will shortly observe the volatility and different price trends of them, which have in reality changed holding preferences of the population over a fairly short history of their existence.

2.1 Domestic currency and hard currencies

The legal domestic money of Vietnam is called Vietnamese Dong, abbreviated VND. The VND experienced different periods of changes, according to contemporary history of the country, which took on several painful wars in 58 years, marking 1945 as year of Declaration of Independence of Vietnam. There had been several large changes of money before the most recent change in 1986, from which the money remains almost the same until today.

1. In 1946, People's Democratic Republic of Vietnam, the predecessor of today's Socialist Republic of Vietnam, issued its war-resistance government's paper money.

2. In 1958, Vietnam changed its money the second time.

3. In 1978, the reunified Vietnam after a 20-year liberation war, changed money the third time, and both North and South now used the same currency. In this event, a new VND was worth old VND 500 and 350 Liberation Dong (local currency used in the Southern Vietnam before).

4. In 1985, Vietnam changed its money the fourth time, to reduce the denominator 10 times. Thus, one new VND was in exchange for 10 dongs printed in 1978. This was the latest substantial change, which required the replacement of all paper money in circulation then.

2.1.1 From a fixed to a more flexible exchange rate regime

During the closed-door time, Vietnam's foreign trade was modest. Most of the trade focused on old-time Socialist countries, namely the former Soviet Union, Eastern Europe countries (e.g., former East Germany, Czechoslovakia, Poland, Bulgaria), and China. The Soviet ruble therefore played a critical role, defined as the currency of computation and payment in trades. For almost the entire period, the country applied a fixed exchange rate regime, by which the currency rate was predetermined by a governmental

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administration agency, still existent today, the Government Pricing Committee. This was expected because under a strict centrally planned mechanism, almost all goods, including currencies, needed to be priced *fixedly*. The fixed regime never counted the actual output growth, the need of money and purchasing power, because there was then no notion of supplies and demands existent (which had been replaced by plans and distributions by the state totally). However, the regime was pushed to change when the country started trading with other countries than the socialist countries, especially when the Soviet Union and former socialist nations reformed own economies.

The economic shakeout took place in late 1980s and early 1990s, where economic aids to Vietnam dropped suddenly and many conventional Eastern Europe markets fell out of the reach of Vietnam's producers. The needs for goods and services from the world markets retained, and the country had to look up for new trading partners. The reforming of trading activities represented one of the most imperative needs of Vietnam in early days of reform. "Hard currencies" were then one of the most frequent words that one could read from newspapers. The US Dollar abruptly became a familiar notion of money, and quickly replaced the rubble. Clearly, the exchange rate regime had little choice but to have adopted necessary changes to really reflect a new economic structure and positions, be it trading, investment or financing settlements.

Issues in relation to exchange rate, especially USD against VND, have become increasingly prevalent within the business community, as well as the populace. For businesses, the problem is generally to find ways to hedge their economic exposures caused by currency risks. For normal population, whose savings needs are of primary concern, it is the puzzle of value preservation, value appreciation and/or interest revenues. The popular problem regarding holding foreign currencies, most critically with US Dollar, from 1995 to date, has been US Dollar-denominated deposits and under-pillow holding by both households and enterprises. During the frequent shortfalls of USD available for settling debt and trade payments, the government usually intervenes in the market in different ways, namely opening the hard currencies reserves to forcing enterprises with export earnings in foreign currencies to sell their hard currencies. In critical time, such as late 1998, exporters were requested to turn in up to 80their revenues in hard currencies. The exchange rates, because of practices and interventions, exhibit much of expectations from foreign exchange markets, government, and population.

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In another effort to revive the confidence of the people in the domestic financial sector after a number of crises, the government launched a total propaganda in mid-1990s towards *dedollarization* in the economy. But until now this effort has proven fruitless, as a large portion of population's portfolio has still been in US Dollar deposits at commercial banks. Also, within the banking sector, the practice of lending in USD in part helps maintain the habit of using this foreign currency in the economic cells, borrower enterprises. In summary, we realize that the foreign currencies, with the single most important being US Dollar, play a critical role in the economy. Much of national savings is in the form of deposits of this currency. Many enterprises hold foreign currencies for twofold objectives of (i) servicing international payment; and (ii) hedging against future changes, in most cases appreciation (we will have an opportunity to look at statistical properties of USD in detail to verify this point). The world and domestic economic signals that may impact the behavior of foreign currencies have now been objects for observation and studies, not only by researchers and professionals, but also individual investors and households.

2.2 National inflation situation

Inflation had not been a formal recognition of the Vietnamese government while in the command economy. This is similar to other socialist economies, where the major economic doctrine negates the existence of the inflation evil, same as unemployment. However, the computation of consumer price index remained in the past, although received very modest attention compared to things like plans, orders and accomplishment of orders. One of the major reasons for use of CPI in this study is data availability. This although can only be obtained after some painstaking effort is the only inflation data one can have in Vietnam.[1]

However, immediately when facing a more open world economy, the inflation notion became so real that everybody could feel it constantly. One of the notable periods is that of 1986-1992, when many striking changes were initially implemented. In this period, Vietnam dropped its long-standing Soviet-style distribution through food stamp and rice book. This represents a vibrant shift together with a large-scale layoffs of state budget salary earners. Inflation started rocketing in 1986 and this trend continued

[1] Data availability is a known issue and largest obstacle to any economic researchers who wish to study Vietnam's economy. Financial data is even a harder object, as agreed by all concerned economists.

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through end of 1992. The highest actual inflation, gauged by year-on-year CPI change, was recorded in late 1986, when inflation level increased nearly 8 times on an annual basis. We call this period the 1986-92 hyperinflation (figure (**??**) shows the situation.)

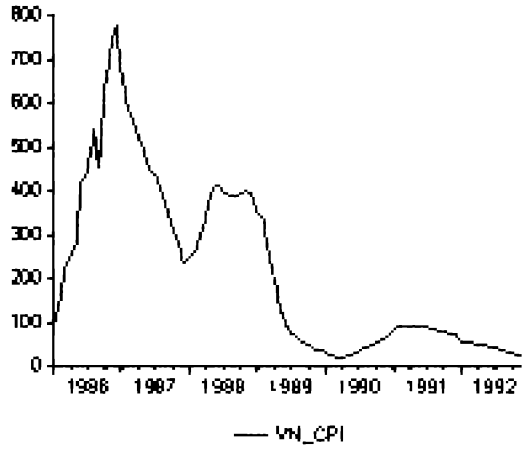

Figure 1: Vietnam CPI growth rate

Some statistics of the high inflation period (1986-1992) unveil a difficult period for an average Vietnamese, whose living standards dropped quickly as purchasing power of the their income diminished. The highest annualized inflation is 774.7% in December 1986, and the lowest 17.43% in April 1990. Mean level of annualized consumer price is 215.73% for the total period, and the median 91.56% per annum. We also note that this period sustained for about 60 months, nearly one third of the total length of time since the beginning of Vietnam's reform.

Inflation stabilizing period: The high inflation trend was only stopped when new growth engines, i.e. private and foreign-invested sectors, came into efficient production. FDI inflows initialized manufacturing, agricultural production and services industries efficiently in the first half of 1990s. FDI level itself picked up fast, with record registered FDI capital in 1996, standing at annual USD 8.6 billion. In economic sense, capital investment and cash inflows (from both FDI and domestic entrepreneurs) helped alleviate financial distress and improve inhabitants' income. GDP growth rate picked up, too, representing better production output and purchasing power. Positive economic trends and settings contributed to have stabilized the consumer prices. The figure below indi-

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cated that level of deviation from 'tractable' level of key economies' inflation has gone down dramatically and constantly in the following period of 1993-2002 to acceptable levels.

Inflation levels of selected countries: 1993:01-2002:12 are shown in figure (2.2) below.[2].

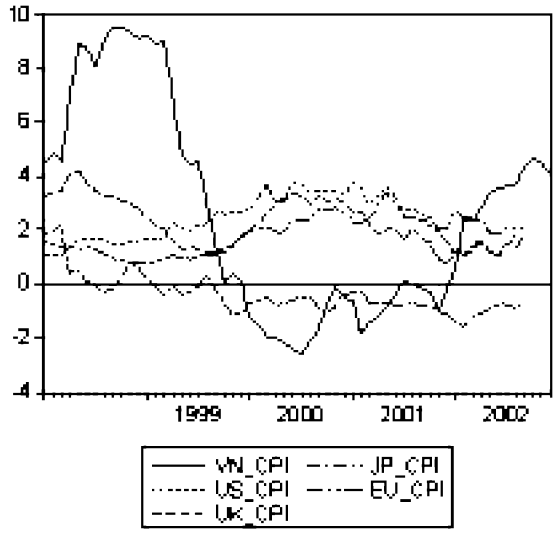

Figure 2: Comparative national CPI levels

Nonetheless, as generally agreed among economists, despite the danger of hyperinflation, a '*reasonable*' positive inflation level should by no means be denounced. We now understand that an affordable inflation has several, but important, positive impacts on Vietnam's economic growth. First off, some inflationary gap is desirable for achieving GDP growth. Second, to this agriculture-based economy, inflation would likely push price levels of agro-products up, generating more income and purchasing power for a majority of the domestic population. When this understanding gets clearer to economic agents, economists and businesspeople realized a worrisome deflationary trend happening, at some time lags (about 12 months), after the well-known 1997-98 Asian financial

[2]N.B.:The most varying CPI line is Vietnam's; Comparative CPI levels are of the USA, UK, Japan, and the European Union (shorter line). CPI data have been monthly price levels, annualized to possess integrity; stated in percent p.a. Data for developed economies come from IMF international macroeconomic statistics; data for Vietnam from national sources: General Statistical Office, VN Economic Times, and the author's databases.

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crisis. One can get a sense of deflation in Vietnam's economy by observing the national CPI level in the aforesaid chart, in which first time since its reform in 1986, the country was facing downward general price trend, causing new headache of economic downturn and stagnation.

Not unexpectedly, in this period, FDI level in Vietnam dropped drastically to around USD 1 billion per annum, compared to the peak of nearly USD 9 billion in 1996. Literally in figures, for the 24-month period (2000-2001), the Vietnamese economy experienced 23 months in deflation, with the most serious drop in price is -2.60% (YOY) in July 2000, and the only improvement seen a year later, in July 2001, +0.09%. Average CPI level is -1.114%, with median almost identical -1.104%. Given an estimated growth rate of GDP at about 7% during 2002, inflation also picked up positively, standing at +4.06% (YOY) at 2002-end.

2.3 Few words on the gold prices

Now we look at another indicator of public confidence in terms of economic stability: the price of gold. Gold is doubtless a precious metal that carries labor value and scarcity. Beyond the divine belief in value of gold, constant interest and easiness in getting information from prevailing gold shops around Vietnam have also made it a favorable object for valuable savings. Economic textbooks and examples frequently invoked gold as a good example of value. Traditionally, people still use gold as intermediate measure for computing and payment in most real estate transactions, which account for a large portion of Vietnamese assets.

In the above graph (2.3), the daily gold price data were obtained from market sources, reflecting a consensus of major gold trading households in Hanoi and Ho Chi Minh City. The database has been uniquely organized and updated by Mezfin Co.'s research team. The graph represents an average daily price, between buying and selling for cash transaction (different from another notion of 'transfer payment', which solely refers to bank account settlements for generally case of larger amount exchange). Unit price is VND 1,000 per 1/10 of a Chinese tael of gold (1 tael=31.1 grams).

We now mention a rule of thumb in observing the gold price in Vietnam. Vietnamese believe in value of gold, especially in periods of uncertainty (and this is perhaps true

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to many other countries, as well). However, people understand that keeping will not get them more money. In contrary, holding interest-bearing deposits or dividend-paying stocks does pay off, more often than not. Therefore, they would only tend to revert to gold during higher uncertainty period, because gold is always liquid domestically compared to many other real property and financial assets. Also, its price almost certainly appreciates when values of VND and USD depreciate (although the reverse may not be true). Having grasped the point, we now return to the price of gold in Vietnam over the past five years with an understanding that gold price had been quite stable until early 2002. In 2002 alone, gold price has gone up by +25.34%. The upward trend does not reflect the genuine domestic demand, but mirroring world gold price, amid the concern of gloomy world economy, especially the USA slow and fragile recovery, as well as a threat of US-led war against Iraq in the turn of 2002.

Statistics on daily return from gold price changes during 2002 (through 236 obs., see figure(2.3)) shows that the mean return is 0.099%, max gain 2.1414% and the worst loss -2.2202%. Standard deviation is 0.568%, skewness -11.613 and kurtosis 6.4895. This shows a clear leptokurtic distribution, with substantial mass centering on in between of mean and median return values. A look at the above frequency distribution of daily return facilitates this knowledge. The distribution as unveiled by out statistics is nothing like Gaussian, with a few noticeable outliers.

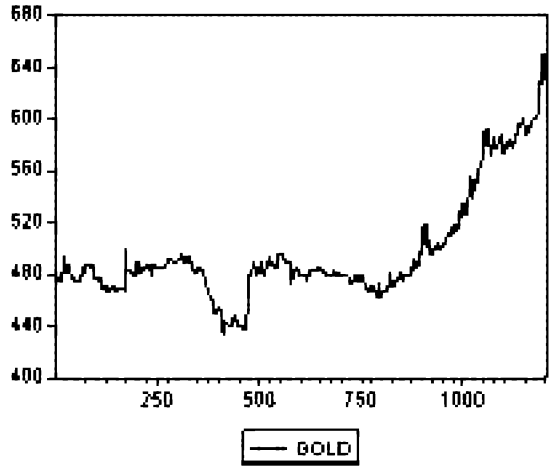

Figure 3: Daily gold price evolution: 1998:01-2003:01

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We have just walked along issues of substantive factors in Vietnam's financial system. The financial markets in Vietnam and their prices were rarely studied in a detailed scientific framework; therefore the section is believed to deserve the above length of discussion, before moving on more technical aspects of our current paper. Having emphasized the importance of these factors in the contemporaneous economy, as well the future, it is quite natural to state about the necessity of this research, i.e. the why's. The natural importance of the trio money-inflation-gold and growing concerns from the investing public, who have an increasing need of diverse and well-informed investment decisions require research efforts to grasp a thorough understanding of behaving patterns, for many reasons, from risk management to asset allocation. The point is while the finance literature regarding similar issues in the developed world is very large; one could hardly locate an earnest and scientific one about Vietnam (currently most papers are primitive and avoid the hard part of the issue, the empirics.) Thus, we have been inspired by both the need of a better understanding of Vietnam's financial factors themselves and of a useful application of the world's rich empirical literature into a specific emerging market; vastly unknown to a majority of world economic researchers. We do hope the rationale is both justifiable and self-explaining.

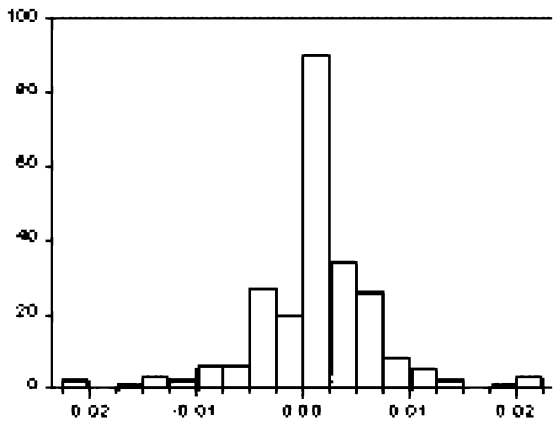

Figure 4: Frequency of gold daily return in 2002

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3 Literature Review and Motivation of the Research

This section continues with a review on relevant literature, which enlightens our direction for the study, as well as the chief research interest in the particular situation of Vietnam's foreign exchange market. As to the literature review part, we briefly summarize important international empirics that have dealt with the related research issues for long, through a voluminous reference for existing literature worldwide. Some reference to Vietnam's existing studies on related issues is provided next, although the empirical study field in the nation has been underdeveloped so far. This also adds to our motivation for researching long-standing issues that have been left unanswered, despite the growing concern inside the economy.

3.1 Related literature

3.1.1 World literature

As mentioned earlier, the literature regarding empirical properties of asset prices, returns, such as foreign currencies, gold, and its relation to endogenous economic variable, e.g. inflation, has been quite rich. For this applied study, identifying relevant frameworks stands right in the way to an efficient solution. The job is neither obvious nor straightforward. We now survey related literature that can walk us to an applied (perhaps to-be-modified) consideration. This should not go freely due to the bound of economic theories underscoring our empirical hypotheses and methods. Also, data is always an issue whenever a study of young emerging market takes place, no matter how thoughtful and well prepared the undertaker is. We will make effort to address these issues in this section.

There exists a vast literature on issues relating to exchange rates. Many of the researches focus on the verification of a Ricardo proposition of purchasing power parity (PPP) in early 19th century. On the one hand, scientists pay large attention to the theoretical foundations of the exchange rate dynamics under economic settings. On the other, many explore statistical properties and empirical evidence of exchange rates over different regimes, historical. Results are quite mixed. Some key definitions, such of the long versus short run, are still arguable among researchers. For empirical study, many researchers explore large samples of long period of time, while others attempt to model some long-run equilibrium relationship of endogenous variables given short-run data.

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One of earlier theoretical works by Fama and Farber (1979) explores the modeling of the possible interrelationships that underscore economic interaction between monies, bonds and international asset portfolios and exchange rate movement. It places an emphasis on the role of money as durable productive asset and nominal bonds in transforming the money into portfolio asset. Beyond critical linkages of nominal spot exchange rates and equilibrium condition to forward exchange rates, they also postulate neglect of 'inadequate appreciation' by scholars towards underlying economic implications of PPP:

> "Purchasing power parity (PPP) is primarily a condition on equilibrium in open markets for commodity [...] With PPP, however, the changes in exchange rates are precisely those needed to offset differential rates of change in purchasing powers of different monies. [...] The implications of the presence or the absence of PPP for the presence or the absence of exchange risks from international investment are straightforward, but they are not well appreciated in the literature."
> — (Cf. Fama and Farber: 1979[7], p.646).

Clearly, the above postulation is one of the major reasons that necessitate our study. However, it will be overwhelmingly difficult to use many of the above theoretical models to enlighten the situation of Vietnam's exchange rates, due largely to unavailability of required macroeconomic data; as well as specific properties of a newborn financial economy. Thus, the major focus of this study is about the capturing of important empirical properties of exchange rates focusing on univariate time series. For this reason, our empirics will center on a verification of several important models, which mainly involve data series available for research; namely testing validity of PPP theorem versus random walks, and a modeling of real exchange rates behavior. In compliance with this approach, the following summarizes key literature that can help formulate our own problems in detail as well as set up a relevant framework for the empirics.

Frenkel (1981:[9]) contributes to empirical knowledge about the exchange rates and prices during 1970s, when several critical changes took place. In this work, the author considers both efficiency of foreign exchange market and exchange rate movement. Frenkel's main conclusions support the efficiency of foreign exchange markets during 1970s, despite turbulences. Exchange rates during this period of study exhibit high volatility, reflecting the macroeconomic setting changes, and news is one of the major

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factors that influences exchange rate primarily. From a rather innovative view, Adler and Lehmann (1983:[1]) concentrate on the gap between PPP belief and their observed martingale behavior under both fixed and flexible change rate regimes for numerous currencies, on a long-run sample from 1964 to 1981. By focusing on the RER innovation behavior, their work in effect finds little empirical relevance for long run PPP. In this work, Adler and Lehmann also suggest some model changes, to correct Frenkel (Cf.[9])'s likely spurious regression, due largely to now agreed-on nonstationarity of both nominal exchange rate and CPI variables in level. This work, in fact, focuses on univariate analysis of the RER, paving a way for subsequent works on RER variable, which presents a number of different ways for adjustment (while CPI is only one of the foremost factors), and its changes.

In light of the enormous interests in discovering data-dependent empirical results on PPP versus the overwhelming difficulty to reject random walk in real exchange rate variable, Rogoff (1996:[12]) offers a concise, yet comprehensive survey on the purchasing power parity doctrine. In his conclusion, the question of full reconciliation of high short-run RER volatility and the speed of mean reversion, 15% p.a. (with which the PPP deviations die out) still lingers. This leads him to suggest a number of qualitative explanations, which opened up further research interests in econometric works, such as multivariate VAR. But Rogoff, too, does not feel 'comfortable' with own reasoning of the puzzle (Cf.[12], p.665). Choi (1999:[2]) works with real exchange rates to find evidence of serial correlation in the log-differenced real exchange rates. This work deals with monthly forex sample from 1960 to 1993. It considers USD real exchange rates versus CAD, DEM, JPY and SFR. The null hypothesis of random walks in log-differenced real exchange rates seems to be confirmed with most currencies for post-Bretton Wood period. However, in the longer run, the author synthesized the statistics as a verification of PPP for 3/4 currencies in the considered sample. Mixed results have led to continuous debate about supporting evidence for or against the long-standing PPP theorem.

In an earnest effort to improve empirical findings, alleviating mixed (and somewhat not unambiguous) results on the PPP debate, Flôres, Jorion, Preumont and Szafarz (1999:[8]) proposes a multivariate framework to have been a weight over univariate test frameworks, suggesting strong evidence in favor of long-run PPP, allowing for different speeds of mean reversion in real exchange rates across countries 10 countries under the test; especially US Dollar against major European currencies. We have mentioned

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several quintessential research papers in the field that will benefit this study, on both theoretical modeling and empirics. The richness of literature that go on for testing Cassel's PPP doctrine reflects an interest of understanding why the random walk has been so difficult to be beaten, especially with works designed for univariate time series tests while several other empirical paradigms have supported the PPP for the long run, usually more or less a century of monthly (or quarterly) data. The mixed research results trigger a large research community to further calibrate testing methodologies, with new estimators, aiming at acquiring better explaining and persuasive outcome for a long-standing debate between the unit-rooters and those supportive of PPP.

3.1.2 Related literature in Vietnam

The exchange rate problem has emerged in Vietnam since the start of the economic reform. In the regional setting, the recent 1997-99 Asian financial crisis already sparks the concern about future stability of regional currencies. One of the first and foremost factors is, clearly, the foreign exchange rates. Issues in relation to foreign exchange rates, and considerations of consumer prices are considered solely operational, and occasionally briefed on professional reports. However, general and qualitative reports as such could rarely address specific issues. Nor can they provide for any rigorous analysis framework, as well as firm understanding, leaving the land for exchange rates research unchartered.

There does not exist a genuine line of research on exchange rates in Vietnam's economic literature. However, several independent studies from time to times stress the issue, focusing on the foreign exchange market in Vietnam in the reform time. In a recent study focusing particularly on Vietnam's USD exchange rates (Vuong et al. (2001):[19]) go on to analyze the statistical properties of the exchange rate of the US Dollar, with an emphasis on short-run forecasts, using the low-order ARIMA models. In a more recent work, Vuong and Ngo (2002:[18]) discuss the existence of the parrallel exchange rate system in the nation as a possible cushion, reducing the hard blow of the regional financial crisis on the national financial system. In fact, the study promotes the development of free-market exchange rates systems.

In a more closely related study, Vuong (2003:[16, 17]) focuses solely on the the different long-run and short-run dynamics of price-based exchange rate considerations. This

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particular study is the predecessor of this study, following many useful contributions and constructive comments of Solvay seminar's participants in May-2003. However, the whole research line is empty, and has only recently be filled in by several separate issues of interest to authors. The fact that no systematic literature has been in place, thus far, appears to have given rise to the need of research.

3.2 Motivation for the study

The overall theme of this dissertation is about the evolution and changes of Vietnam's financial markets in the reforming time. Associated properties of variables in those re-emerging markets are the essential part of the knowledge, besides general observation of the market operations. Specifically, we are studying a newborn market economy of Vietnam, a nation that has been out of centrally planned (command) economy not long. This context gives rise to our research, of course, because it provides us with several concrete motivations as follows:

1. It has been said that the market-economy seeds have been planted in the Vietnamese economy since the start of the reform in 1986. Deep down, one has to make this statement more rigorous by considering testing different aspects of it. We have a good motivation to look at the foregin exchange market, one of the first markets existing in Vietnam, and operating actively due to international trade liberalization.

2. The knowledge about exchange rates and associated issues has practical implications on the growing business community. A lack of systematic and quantitative line of research on the issue has thus far impeded the development of the market, transaction, and financial intruments that could have otherwise functioned appropriately. An example of that is the delay in the introducing of currency options, which enterprises have for long been in a bad need of.

3. The economy of Vietnam used to undergo a vibrant and painful hyperinflation chapter. The nation was praised for its effort to curb inflation problems in mid-1990s. To a large extent, the inflation problem is closely related to exchange rate issues. Behaviors of both are of our concern. If we are to posit any true relation between the two, this empirical work become necessary.

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4. What we embark on this piece of work also relates to the long-run equilibrium, one way or the other reflecting the classic PPP postulation. This has a critical implication. If we cannot find evidence that establishes that the PPP holds, we will have in effect rejected the policy implications through which central bank and relevant authorities may have wished to stabilize this important market, because evaluations on the situation (under- versus overvaluation of currency) become overwhelming, if not impossible.

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4 Econometric methods and datasets

This section is to stress the importance of methodoly and data in this type of applied econometrics, by providing necessary materials for building the work.

4.1 Econometric methods

Specifically in this work, we intend to implement a multivariate paradigm of Johansen, the VAR co-integration test in conjunction with Engle-Granger framework; and a number of auxiliary empirical considerations. This is to help verify the situation of Vietnam exchange rates, as a chief concern of the domestic economists, who are right now still puzzled with pieces of information that have never been gathered together. Naturally, such works will likely lead to a comment on over- versus under-valuation of the Vietnamese Dong (VND), the one that has recently been thought of as overvalued against world hard currencies. One should note that such thinking without solid statistical verification may easily lead to unjustifiable adjustments and changes in policies, doing more harm to the overall economy. This will be a pure regret if occurring at all. The section that follows further discusses technical details of possibly relevant economic hypotheses and econometric paradigms for our study.

4.1.1 The econometric hypothesis

We have experienced the richness of finance literature in relation to examining the long-run relationship between different endogenous and exogenous variables and the nominal exchange rates of a domestic currency. A long-run equilibrium relationship confirmation plays a critical role in policy-making process due mainly to its impact on the view of policy makers. We hereunder establish relevant paradigm(s) for hypothesis tests that come in the next section.

The PPP doctrine and unrestricted VAR representation

The long-standing establishment of PPP doctrine of exchange rate equilibrium relationship can be postulated by the simple equation:

$$P = KSP^{\star} \tag{1}$$

where, $P, P^{\star}$ are are domestic and foreign currencies, respectively; S denotes the ex-

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change rate, stated as the domestic currency price of a unit of the considered foreign currency (e.g. in Vietnam's case VND 15,500 per USD 1.0); and K a constant that helps define the PPP relationship in the theoretic system.

By definition, we superimpose that the relationship $P = KSP^{\star}$ holds in the long run, and this implies that K is established as the constant. Conventionally, in the logarithmic form, eq.(1) is usually re-defined as:

$$p_t = \kappa_0 + s_t + p_t^{\star} \tag{2}$$

where small letters denote natural logarithms of previous variables. We also have a re-arrangement of the above equality to have another meaningful relationship for the PPP equilibrium when exchange rates are allowed to move by economic variables:

$$s_t = \kappa + p_t - p_t^{\star} \tag{3}$$

where, κ represents some constant that establishes the equilibrium.

Johansen procedure (1991:[10]), for analyzing the long-run relationship between stationary (or non-stationary) variables is represented by the following unrestricted vector autoregression (VAR) system:

$$X_t = \mu + \sum_{i=1}^{k} \Phi_i X_{t-i} + \delta t + \epsilon_t \tag{4}$$

where X_t is an $(p \times 1)$ vector of stochastic variables, integrated of order one or less[3]; Φ are coefficient matrices; $\epsilon_t \sim N.I.D\,(0, \Sigma_\epsilon)$, that is a white-noise process vector with non-diagonal covariance matrix; and μ a deterministic term, represented by a $(p \times 1)$ vector; δ is a $(p \times 1)$ coefficient vector on linear trend terms.

The VAR system can be transformed into a vector error-correction model (VECM) generally represented by equation ([?])

$$\Delta X_t = \Gamma_1 \Delta X_{t-1} + \Gamma_2 \Delta X_{t-2} + \cdots + \Gamma_{k-1} \Delta X_{t-k+1} + \Pi X_{t-k} + \mu + \delta t + \epsilon_t \tag{5}$$

[3]Naturally, $I\,(2)$ and higher-order are excluded.

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Paying attention to the long-run relationship between stochastic variables in the system, the $(p \times p)$ coefficient matrix Π can be decomposed into α and β, both being $(\pi \times r)$ matrices. The relation is formulated in the equation (6):

$$\Phi(1) - I = \Pi = \alpha\beta' \tag{6}$$

Here, we note that the $(p \times r)$ matrix α is the E-C coefficients matrix, which gauges the rates at which variables of the system adjust to indicate the behavioral long-run equilibrium. In addition, our $(p \times r)$ matrix β indicates co-integrating vectors, i.e. the long-run equilibria, of the system, if convergent at all. Our rule of thumb here for the modeling work is when series are difference stationary and some co-integration relationship is confirmed, a representation in VECM can be worthwhile.

Two major approaches in treating VAR systems are initiated in pioneering theories of Engle-Granger (1987:[6]) and Johansen (1988). In Johansen (1988, 1991), the approach recommends a foremost focus on short-run dynamics of exchange rates by regressing ΔX_t and X_{t-1} on $\Delta X_{t-1}, \Delta X_{t-2}, \Delta X_{t-k+1}, 1$ and t. Given residual series of R_{0t} and R_{1t}, product moment matrices (S_{ij}) and $(p \times 1)$ vector of eigenvalues $(\hat{\lambda_i^p})$ can be obtained in the following eq.(7):

$$\begin{aligned} S_{ij} &= T^{-1} \sum_{t=1}^{T} R_{it} R'_{jt} \\ \mid \lambda S_{11} - S_{10} S_{00}^{-1} S_{01} \mid &= 0 \end{aligned} \tag{7}$$

<u>Co-integrating equations and long-run system equilibrium:</u>

As the nominal exchange rates and individual prices in level of both domestic and foreign countries are well known for their nonstationarity, searching for possible co-integration of first order is quite plausible. Co-integrating vectors in exchange dynamics (through interaction of RER components) are welcomed as explanation of long-run equilibrium and finite duration of convergence to expected RER.

The re-parameterized eq.(5) represents a vector error correction model (VECM), with the presence of cointegration is indicated by the rank of Π. Clearly, if Π is either full or zero rank, no co-integrating equation exists in the long-run relationship, so the reversion

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to some future equilibria is highly unlikely. When the system shows that $p < r + 1$, the system's Π can be decomposed into a $(p \times r)$ matrix β, whose columns are linearly independent co-integrating vectors; while the $(p \times r)$ matrix α is interpreted as the adjustment matrix. α shows the speed at which the system adjusts the last period shocks to reduce deviations from the co-integrating relationships.

It is well known that a co-integration test represents a test for weaker version of PPP because the supporting argument for PPP only requires the following stochastic variable z_t defined by eq.(8):

$$z_t = s_t - \delta_1 p_t - \delta_2 p_t^\star \tag{8}$$

be stationary for some δ_1, δ_2. An informative test for co-integration in this type involves simply feasible examination given limited availability of data in Vietnam. The two well-known tests that are proposed in this study follow Engle-Granger (EG) and Johansen paradigms. As to Johansen paradigm, the examination comes up with a test statistic for likelihood ratio rank test of Π given in eq.(9):

$$-T \sum_{i=r+1}^{p} ln\left(1 - \hat{\lambda}_i\right) \tag{9}$$

as suggested by Johansen (1988, 1991). Finally, the trace statistic for the hypothesis if all the series in the VAR system are stationary (i.e. $r = p$), is as follows:

$$-Tln\left(1 - \hat{\lambda}_p\right) \tag{10}$$

The trace test statistic in eq.(10) applies to examine the null hypothesis that at least r co-integrating relationships in X_t system exist against an alternative of $(r + 1)$ co-integrating equations.

In establishing the form of desired VECM for PPP tests for different exchange rates, we rewrite the following dynamics:

$$\begin{aligned} \Delta p_t \quad = \quad & \textstyle\sum_{i=1}^{k-1}\left(\Gamma_{ip}\Delta p_{t-i} + \Gamma_{is}\Delta s_{t-i} + \Gamma_{ip\star}\Delta p_{t-i}^\star\right) \\ & +\alpha_1\left(p_{t-1} - \beta_2 s_{t-1} - \beta_3 p_{t-1}^\star - \beta_0\right) + \epsilon_{1t} \end{aligned} \tag{11}$$

The other ECM equations are also in the similar form. Thus, our vector of stochas-

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tic variables is:$X_t = (p_t\ s_t\ p_t^\star)'$. While in conducting these test conducts, we use the informational criteria AIC/SC, for which smaller values are preferred:

$$\begin{aligned} AIC &= -2l/T + 2n/T \\ SC &= -2l/T + nlog\,(T)\,/T \end{aligned}$$

where, $l = -\frac{T}{2}\left[k\,(1 + log2\pi) + log \mid \hat{\Omega} \mid\right]$, and $\mid \hat{\Omega} \mid = det\left(\frac{1}{T-p}\sum_t \hat{\epsilon}_t\hat{\epsilon}_t{}'\right)$.

We also note that the non-standard critical values are taken from Osterwald- Lenum (1992). These differ slightly from those reported in Johansen and Juselius (1990). Alternatively, we can also work with Engle-Granger (Cf.[6]) framework, whose route for testing co-integrating relationship between non-stationary stochastic variables is via examining EC terms of the spurious regression on non-stationary variables. The test can be implemented using either ADF or PP paradigm. For a typical dynamics of a two-variable system, we can consider the following:

$$\begin{aligned} y_t &\sim I\,(1) \\ x_t &\sim I\,(1) \\ z_t &= y_t - \gamma \cdot x_t \sim I\,(0) \end{aligned}$$

Our ECM can simply be the following dynamical system:

$$\begin{aligned} \Delta y_t &= \alpha_{11}y_t + \alpha_{12}\Delta y_{t-1} + \theta_{11}x_t + \theta_{12}\Delta x_{t-1} + \varsigma_1 z_{t-1} + u_{1t} \\ \Delta x_t &= \alpha_{21}y_t + \alpha_{22}\Delta y_{t-1} + \theta_{21}x_t + \theta_{22}\Delta x_{t-1} + \varsigma_2 z_{t-1} + u_{2t} \end{aligned}$$

The system unveils the following impositions. If y_t and x_t are co-integrated, standard VAR in difference selection is misspecified. Thus, using this approach, after verifying the $I\,(1)$ specification for variables of the model, we simply regress one variable against the others (in our PPP test, including $p_t, p_t^\star$) to examine the stationarity of residual series. Residuals stationarity can be tested using either ADF or PP regressions, referring to modified critical values provided in Phillips and Ouliaris (1988:[4]).

Unit root tests and long-run equilibrium relationship:

Critics of financial time series analysis well appreciate the impact of a unit root existence. In this study, several key considerations will involve examining existence of

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unit roots for a twofold reason. On the one hand, econometric method concerning regressing variables in a system cannot be useful when spurious analysis is achieved with non-stationary variable, however fit LS test statistics might be. On the other hand, acceptance or rejection of a unit root in our exchange rate (levels or changes) will help explain the nature of time series itself. In many circumstances, the conclusion can lead to explaining the equilibrium of the variables in question, such as between nominal ER, RER, and CPI.

Below we look at the ADF analysis from another view, in which the modified ADF paradigm proves useful to our consideration of the exchange rate long-run equilibrium conditions, too.

A long-run equilibrium condition of RER can be tested in two forms. First, real exchange rate, having accounted for difference of relative prices (local and foreign), exhibits relative (weaker-form) PPP, should the ADF regression support alternative of stationarity as in a normal ADF regression, for instance, the eq.(**??**). Now, consider the regression (**??**):

$$\Delta RER_t = \alpha + \delta t + \gamma RER_{t-1} + \sum_k \gamma_i \Delta RER_{t-i} + u_t \tag{12}$$

When this ADF consideration fails to reject H_0, we will need to revert to structural regression, in the form of either vector autoregression (VAR) or co-integrating vector models, for examining long-run equilibrium possibility. The analysis of ADF regression can lead to more informative results, such as half-lives of RER and speed of convergence to long-run equilibrium mean RER (see Culver and Papell (1999:[5]); Salehizadeh and Taylor (1999:[13]); Christev and Noorbakhsh (2000:[3]); Sarno (2000;[14]); Sarno and Taylor (1998:[15]); Lothian and Taylor (1996:[11]) for the richness of technical applications). We also note that for a typical verification of PPP theorem, time trend component is mostly eliminated to maintain economic meaning consistency. Thus, in most cases, our model mining will contain only a constant for both technical and economic reasons, and lagged dependent variables plus lag-differenced series.

4.2 On the dataset and economic variables

In this study, we will be using foreign exchange rates, stated in unit of Vietnamese Dong (VND). Thus, it is a bit different from normal approach where researchers consider many

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smaller values currencies to one larger-value USD or EUR. Our data sets are obtained from different sources, partially from IMF macroeconomic statistics. National sources include General Statistical Office publications over time, economic-business newspapers.

With regard to the organizing of the databases, besides the initial design, the job requires frequent updates. The author has maintained for years databases in relation to the foreign exchange and gold markets, from which this particular study and the next will be using time series of USD:VND, GPB:VND, EUR:VND, JPY:VND, Gold price, and CPI (index and periodic growth) for different data frequencies. The data frequency we use in this study is monthly, or 12 observations per month for exchange rate series, and CPIs. For this low-frequency analysis, we will be using longer sample period of 17 years.

However, the high-frequency modeling that is considered in the upcoming study uses daily observations, and the author maintains a database of 5 years and a half, containing over one thousand data points for the same variables in question, except CPIs[4].

4.2.1 Relative price ratio

Below are the graphs (4.2.1) of different price ratios, computed as differences in logs of exchange rates, stated per VND. Relative price ratios (levels) are for the entire period of 1986:01-2002:12.

The price ratio is defined simply as the log-difference between the two nations' CPI levels indicated by the index (not the percentage periodic growth rates, as usually published on official media.): $RP_{VND:USD} = p_{VND} - p_{USD}$, where: $p_i = ln\,(P_i)$, and P_i is the index of consumer price (weighted basket) for the nation i. The above graph supplies monthly CPI data.

4.2.2 Consumer price index - CPI

CPI is reconstructed for easier readings (without affecting the statistic computations) as in the figure below. By reconstructing, we have starting value of CPI is 100(%) in

[4]CPI data are given at the highest frequency as monthly. Such data even did not exist in Vietnam before the 1990s. They are usually published fairly late compared to other data, and statistics, such as foreign exchange rates, which we can observe through market transactions.

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1986:01. Naturally, after high-inflation period, the growth of Vietnam CPI is quite fast, while those of developed countries are reasonably low. What should be noteworthy in the comparative graph is the different graph scales shown in the vertical axes of the two. While spanning over about 17 years, the CPI levels of the 3 developed economies (whereby we choose their currencies as bases for this analysis), have grown, but at a fairly slow pace. Among these 3, Japan shows a slower growth in CPI, and the UK the highest. However, what we can see is that even in the UK, the price index cannot reach twice the initial index (100) after 17 years. The difference for Vietnam's CPI is enormous. The scale is huge compared to that of the other three. Index line shows a steep curve, indicating a rocketing inflation level in early days of the reform. The stabilized CPI could only be reached in late 1990s, when the most East and Southeast Asian nations faced the serious consequences of the regional (spread) financial crisis (which led many countries to devalue their currencies, and economies plunged into a recession and deflation stage).

Comparative consumer prices period 1986:01-2002:12

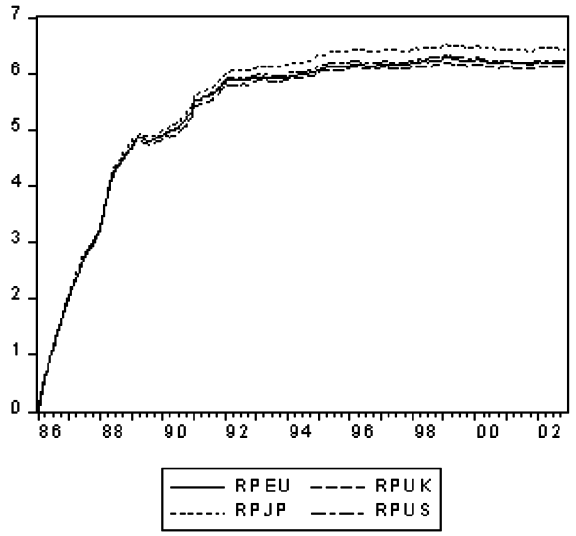

Figure 5: Comparative price ratio levels

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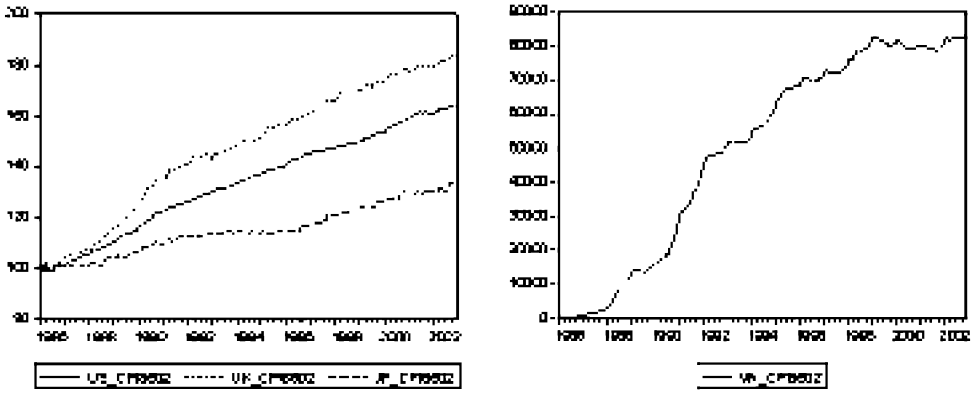

Note: Consumer prices are stated in index value; with 100 being in the first observation (1986:01). Note the large difference in magnitudes (relative index levels) between the US, UK and Japan and Vietnam's consumer prices.

Hyperinflation did not solely happen in Vietnam. Several other Eastern European nations also experienced the situation, moving out of the centrally planned economy model. The hyperinflation has even been regarded as an overall toppling of the old-fashioned price-planning mechanism in the former command economies. Rocketing inflation within the early reforming days shows actual reaction to economic uncertainty, and demand-supply adjustments for the economies where demands had exceeded supplies (from an unmotivated supplying source) for so long without actual remedies for returning to a balance. (On the surface, the State plan superceded any other market tools, and in reality never solved the supply shortage in the economy.)

In the economic theory, the behavior of CPI will highly likely impact behavior of the foreign exchange rates, once the nation like Vietnam opens up the door for the outside economic interactions. Later, we will have an opportunity to examine the role of the hyperinflation to re-stabilizing the PPP relationship in the long run, with respect to the case of Vietnam, through found empirical evidences.

4.2.3 Real exchange rates - RER

Real effective exchange rates, computed as the number of Vietnamese Dong (VND) units per a unit of corresponding foreign currency. In this study, we focus on time series of key hard currencies that have been traded most actively in Vietnam's interbank and free market, namely USD, GBP, JPY and recently emerging EUR. Our data treating approach appears to be a bit different from many other studies of exchange rates as we use different bases for exchange rate time series, while others tend to a common base, be it USD, EUR or GBP. We have own reasoning for this fact. VND is a small value

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currency, fractional to other hard currencies, even JPY. Also, the empirics we look for tend to study of different exchange rates in the view of hard currencies in relation to Vietnamese Dong. Thus, opting for this way can assure the relevance of data in question.

The graphs presented in figure (Appendix) unveil patterns of real exchange rate behavior in relation to bilateral relative prices (CPI-based) and CPI series. They exhibit similar trends between different exchange rate series of foreign currencies indicated in VND values. The major differences are caused by the differences of price (measured in natural logarithm of national index), which render the distance from the RER and the foreign price (log) series different among the foreign currencies in question. In general, however, they tend to behave in some consensus.

The bilateral relations between Vietnam's and other countries' inflation should stress on the adjustment of the real exchange rates. From a different view, we show in the scatter plots below data locations on the plane, representing the clusters of pairwise coordinates in CPI that govern the RER time series for our analysis.

Scatter plots (pairwise) consumer prices 1986:01-2002:12

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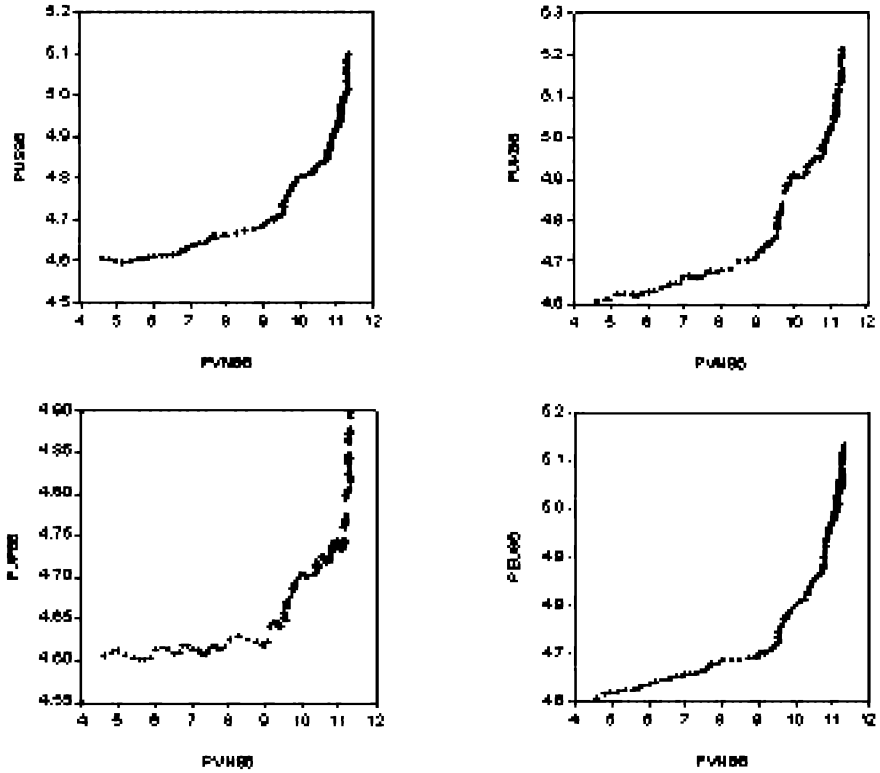

Note: Consumer prices (CPI) computed as natural logarithms of index with 1986 base (100). Data sample period: 1986:01-2002:12. Charts unveil overall picture of CPI movements of Vietnam in comparison with concerned countries.

The shape of the above scatter plots above looks quite different from US-UK consumer prices movements, where data points almost form a straight line that equalizes the plane quarter. Naturally, such a large difference will lead to the significance of influence of inflation on the bilateral exchange rate movements in our subsequent empirics. We refer to the example bilateral pairwise US-UK CPI scatter diagram for recognizing the difference.

Scatter plots (pairwise) consumer prices 1986:01-2002:12

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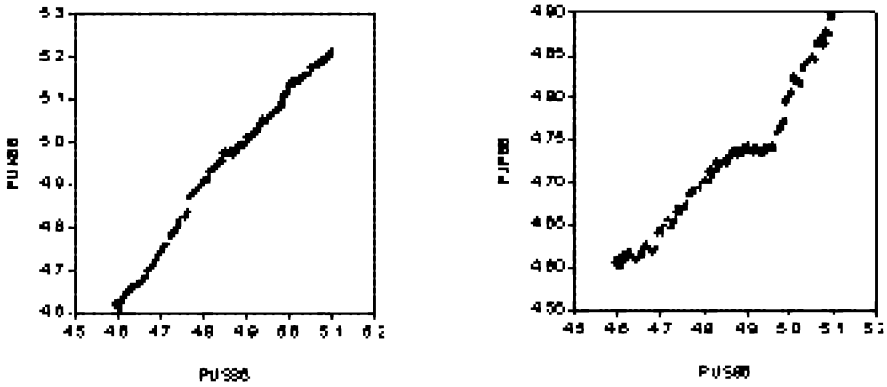

Note: Consumer prices (CPI) computed as natural logarithms of index with 1986 base (100). Data sample period: 1986:01-2002:12. Charts unveil overall picture of CPI movements of the USA in comparison with concerned countries.

We have discussed about the data used in this study. After relevant transformation, they are ready for being tested under our empirical frameworks.

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5 Empirical Results

5.1 An analysis of variables and the relevance of data used in the cointegration analysis

5.1.1 The nonstationary character of the variables

Univariate time series in financial markets are in many cases exhibiting non-stationary characters. In numerous papers, researchers have found evidence of non-stationarity for exchange rates (log) in levels, as well as consumer prices measured as index. Table (1) below presents results of our unit roots tests on univariate time series, in levels and first differences, before moving on to work with the models in focus. The series that are put to test span over the sample of 1986:01 to 2002:12; that is the entire reform period of Vietnam.

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Table 1: Nonstationarity versus stationarity of variables in use

RER	ADF	PP	RER	ADF		PP	
US	-2.2816	-2.1866	US	-8.5050	*	-11.0562	*
UK	-2.2391	-2.1447	UK	-8.6904	*	-10.8892	*
JP	-2.3640	-2.2074	JP	-8.6311	*	-10.9456	*
EU	-2.1077	-2.0921	EU	-7.3286	*	-10.0481	*
Nominal ER	ADF	PP	Nominal ER	ADF		PP	
US	-2.1137	-1.7839	US	-7.1192	*	-11.3809	*
UK	-2.2186	-1.8929	UK	-7.0403	*	-11.1623	*
JP	-2.2367	-1.9031	JP	-7.1568	*	-11.2472	*
EU	-2.6249	-2.3017	EU	-5.9040	*	-10.2491	*
CPI	ADF	PP	CPI	ADF		PP	
US	-0.6600	-0.0315	US	-9.0819	*	-10.2305	*
UK	-1.0769	-0.7547	UK	-4.3288	*	-11.8684	*
JP	-1.6302	-2.1626	JP	-10.8639	*	-12.5711	*
EU	-0.0072	-0.3001	EU	-9.6293	*	-13.5356	*
VN	0.8854	1.7307	VN	-2.8335	*	-3.5757	*

, $\star$ indicates the null hypothesis of unit root rejected at 1(5)% level. ADF regression specification is based on minimizing AIC/SC. Rates for RER, nominal ER and CP index are provided in natural logarithms. RER: ADF critical values for US, UK, JP at 1(5)% level: -4.0070 (-3.4333); for EU: -4.0179 (-3.4385); PP critical values for US, UK, JP at 1(5)% level: -4.0061 (-3.4329); for EU: -4.0158 (-3.4376). Nominal ER: ADF critical values for US, UK, JP at 1(5)% level: -4.0070 (-3.4333); for EU: -3.4727 (2.8798); PP critical values for US, UK, JP at 1(5)% level: -4.0061 (-3.4329); for EU: -3.4708 (-2.8789). CPI: ADF critical values for US, UK, JP, EU at 1(5)% level: -4.0070 (-3.4333); PP critical values for US, UK, JP at 1(5)% level: -4.0061 (-3.4329); for EU: -4.0061 (-3.4329).

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These tables indicate that exchange rates (both real and nominal log) and consumer prices in levels are non-stationary, given the optimal lag truncation, according minimizing AIC and SC. Both ADF and PP test statistics cannot reject the null of unit root existence in univariate series in levels.

We will be taking on a later starting date for our time series of RER for the reason that Vietnam officially recognized other hard currencies than the old Soviet rubble since June-1989. For this, trade and commerce in new hard currencies become more active, and the exchange rates reflect better commercial nature of the exchange rates dynamics. It is also important that during this recent period of the financial market evolution, the difference between 'black market' and official market exchange rates is quite negligible so that our data of official market is relevant to reflect the exchange rates in Vietnam's general economic settings. The figure [8] below shows the changes of RER of four key currencies of our study over the period 1989:06 to 2002:12. One could hardly imagine stationarity in RER variables.

RER time series for USD, JPY, GBP, and EUR 1989:01-2002:12

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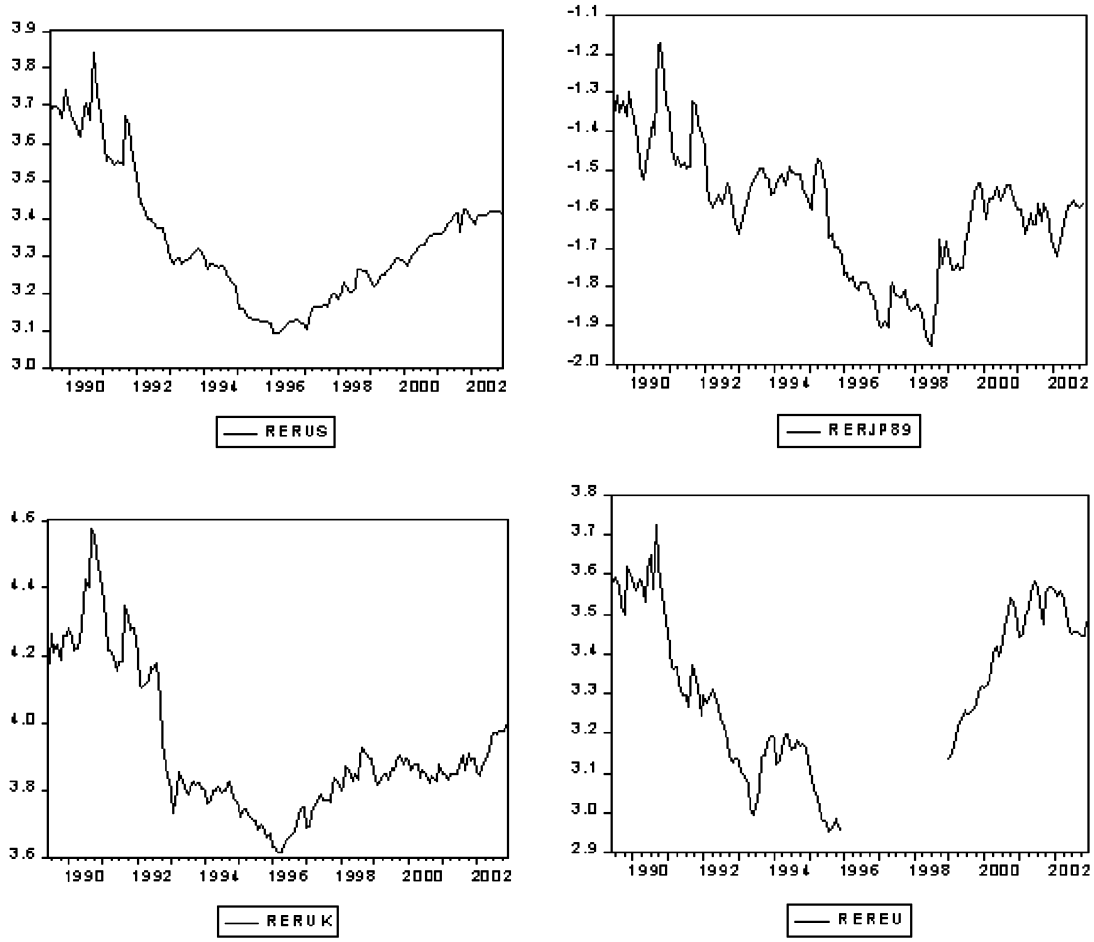

The RER series, although moving in different ways over the considered period, still indicate somewhat similar behavior, observing peaks and valleys. Netting effect of prices logarithms has partially wiped out divergent behaviors of nominal exchange rates of these currencies.

Again, this sub-sample unit root test cannot reject our null hypothesis of non-stationarity in all exchange rates series in levels, even at 10%. It is because all ADF and PP test statistic values fall well onto the acceptance region of the empirical distribution. However, test statistics decisively reject unit root hypothesis in all time series of first-order differences, at 1% level. We can also observe the correlogram of RER and CPI in level, say, for US, below, which also exhibit quintessential pattern of non-stationarity, where ACF does not die out after quite a number of lags. For instance, at lag 24, the autocorrelation coefficient is still significant, with rather large (positive) magnitude, as shown

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in the figure (5.1.1).

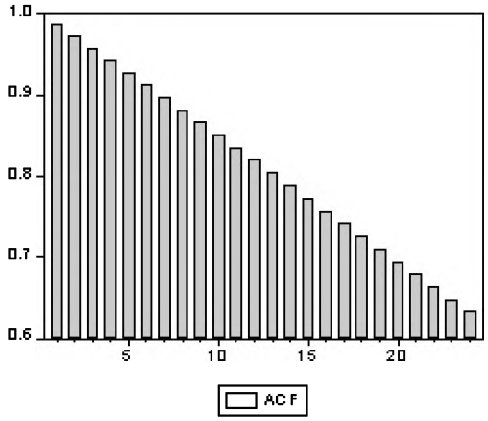

Figure 6: ACF for USD RER: not to die out quick enough

In brief, we recognize that all series appear to have followed a first-order integrated, i.e. $I(1)$. At this point, we are ready for further examination of cointegration and other relationship in equilibrium.

RER	k	ADF	AIC(SC)	PP	RER	k	ADF	AIC(SC)	PP
US	3	-1.96419	-4.2784	-2.5078	ΔUS	2	-10.909*	-4.2665	-13.1370*
			(-4.1835)					(-4.1906)	
UK	5	-1.5626	-3.6146	-1.9221	ΔUK	7	-6.4224*	-3.6076	-11.2432*
			(-3.4817)					(-3.4368)	
JP	5	-2.0335	-3.4123	-2.5368	ΔJP	4	-8.1425*	-3.3984	-11.2815*
			(-3.2794)					(-3.2845)	
EU	1	-1.0516	-3.5418	-1.1022	ΔEU	1	-9.3634*	-3.5445	-10.9964*
			(-3.4740)					(-3.4763)	

Note: *,**: Null hypothesis of unit root rejected at 1(5)% level. ADF regression specification is based on lag truncation (k) that minimizes AIC/SC. Rates for RER in natural logarithms. RER levels: ADF critical values for US, UK, JP at 1(5)% level: -3.4715(-2.8792); for EU: -3.4835(-2.8845); PP critical values for US, UK, JP at 1(5)% level: -3.4715(-2.8792); for EU: -3.4831(-2.8844); RER first-order difference: ADF critical values for US, UK, JP at 1(5)% level: -3.4715(-2.8792); for EU: -3.4839(-2.8847); PP critical values for US, UK, JP at 1(5)% level: -3.4715(-2.8792); for EU: -3.4835(-2.8845).

Table 2: ADF and PP tests on RERs

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5.2 Evidence of the cointegration and PPP

5.2.1 Co-integrated relations among s_t, p_t, and $p_t^\star$

This part of our test in effect examines weaker condition for PPP theorem to hold. The Engle-Granger (1987) work indicates that although non-stationary, these types of economic variable can be constructed into a linearly combined system that is stationary. Depending upon the specific test outcome, such a stationary linear combination can verify the extent to which long-run equilibrium will be reaching, given short-run data set. Outcomes derived from both Engle-Granger and Johansen's co-integration tests follow.

Co-integration under Engle-Granger two-stage analysis:

Engle-Granger (1987) method proposes a framework for bivariate relationship that presents a long-run equilibrium, in which case our consideration of exchange rates can be implemented. The trivariate system among s_t, p_t, and $p_t^\star$ will be grouped into the following eq.(13):

$$\begin{aligned} s_t &= \alpha_1 + \alpha_2 \left(p_t - p_t^\star\right) + u_t \\ s_t &= \alpha_1 + \alpha_2 d_{pp^\star} + u_t \end{aligned} \tag{13}$$

The last equation indicates that nominal exchange rates are not fixed (for instance in government's price peg policy); that is, allowed to fluctuate. A visual check for possibly interrelated s_t and $d_{pp^\star}$ is provided in figure [13] of the appendix. This situation is true for VND during the sub-sample period 1989:06-2002:12. Results of regression based on the last equation are summarized in the table (3) as follows.

We note that the test statistic for error-correction term $\hat{u_{i,t}}$ does not follow standard distribution as in usual ADF and PP test. Thus, our statistical inference has to revert to Phillips-Ouliaris (1988) critical values for m variables (Appendix-Table [13]; in our bivariate model, $m = 2$).

We have obtained empirical results from implementing the E-G framework that indicate co-integration between relative price difference and spot exchange rates for all data series in question. Statistics are summarized in table (4). Next, estimations of trivariate systems is provided in the table (5).

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N.E.R.			Estimation		
s_{USD}	s_t	=	+1.2892	$+1.3310 d_{pp^\star}$	$+ECT_{USD}$
			(0.13059)	(0.02516)	
			[9.23558]	[52.8952]	
s_{GBP}	s_t	=	1.7377	$+1.3594 d_{pp^\star}$	$+ECT_{GBP}$
			(0.1445)	(0.0265)	
			[12.0229]	[51.2570]	
s_{JPY}	s_t	=	−3.7692	$+1.3411 d_{pp^\star}$	$+ECT_{JPY}$
			(0.1330)	(0.0233)	
			[−28.3424]	[57.4928]	
s_{EUR}	s_t	=	1.3754	$+1.3137 d_{pp^\star}$	$+ECT_{EUR}$
			(0.1590)	(0.0296)	
			[8.6494]	[44.3272]	

Note: Standard error (s.e.) is reported in parentheses; t-Stat. in square brackets.

Table 3: E-G first-stage bivariate OLS regression

(ADF test statistic comparable to Phillips-Ouliaris simulated critical values)							
N.E.R.			Equation		ADF-Stat.	k	AIC(SC)
ECT_{USD}	$\Delta\hat{u}_t =$	−0.00574	$-0.1096\hat{u}_{t-1}$	$+0.3006\Delta\hat{u}_{t-1}$	$-4.3461^\star$	1	-0.5598
		(0.0127)	(0.0252)	(0.0653)			(−0.5106)
		[−0.4490]	[−4.3461]	[4.6049]			
ECT_{GBP}	$\Delta\hat{u}_t =$	−0.00532	$-0.1064\hat{u}_{t-1}$	$+0.3164\Delta\hat{u}_{t-1}$	$-4.2759^\star$	1	-0.5181
		(0.0131)	(0.0249)	(0.0653)			(−0.4689)
		[−0.4079]	[−4.2760]	[4.8462]			
ECT_{JPY}	$\Delta\hat{u}_t =$	−0.00556	$-0.1192\hat{u}_{t-1}$	$+0.3165\Delta\hat{u}_{t-1}$	$-4.5312^\star$	1	-0.5403
		(0.0129)	(0.0263)	(0.0652)			(−0.4912)
		[−4.4309]	[−4.5312]	[4.8502]			
ECT_{EUR}	$\Delta\hat{u}_t =$	−0.00830	$-0.1122\hat{u}_{t-1}$	$+0.2870\Delta\hat{u}_{t-1}$	$-4.0313^\star$	1	-0.3337
		(0.0159)	(0.0278)	(0.0722)			(−0.2770)
		[−0.5229]	[−4.0318]	[3.9758]			

Note: Standard error (s.e.) is reported in parentheses; t-Stat. in square brackets; * denotes the null hypothesis of nonstationarity rejected at 1% level, comparable to Phillips-Ouliaris c.v., for m=2. Tests are conducted for period 1986:01-2002:12. $\hat{u}_t$ denotes error-correction term from the first-stage E-G regression

Table 4: E-G second-stage bivariate regression using the ADF paradigm

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N.E.R.		Estimation			
s_{USD}	$s_t =$	$+2.2910$	$-1.5775p_{US}$	$+1.3508p_{VN}$	$+ECT_{USD}$
		(2.0619)	(0.5068)	(0.0478)	
		[1.1111]	[−3.1125]	[28.2835]	
s_{GBP}	$s_t =$	$+2.4144$	$-1.5309p_{UK}$	$+1.3767p_{VN}$	$+ECT_{GBP}$
		(1.9172)	(0.4850)	(0.0555)	
		[1.2593]	[−3.1564]	[24.8163]	
s_{JPY}	$s_t =$	-2.1498	$-1.7160p_{JP}$	$+1.3565p_{VN}$	$+ECT_{JPY}$
		(3.0939)	(0.7161)	(0.0377)	
		[−0.6948]	[−2.3964]	[35.9926]	
s_{EUR}	$s_t =$	-2.8477	$-0.2757p_{EU}$	$+1.2288p_{VN}$	$+ECT_{EUR}$
		(2.2347)	(0.5488)	(0.0537)	
		[−1.2743]	[−0.5024]	[22.8978]	

Note: Standard error (s.e.) is reported in parentheses; t-Stat. in square brackets.

Table 5: E-G first-stage trivariate OLS regression

The system separates domestic and foreign prices to reflect the relative PPP relation more clearly. (Standard errors in this situation are biased; reported for completeness.)

In the next tabulated summary (6), we provide test outcomes using the E-G second-stage trivariate regression based on the augmented Dickey-Fuller method.

For both original Engle-Granger bivariate and extended trivariate regressions, we mostly cannot accept the null hypothesis of non-stationarity nature of the error-correction terms derived from empirical data at 1conventional 5%. The optimal lag truncation in the two models for ADF tests on ECT is 1, minimizing both AIC/SC. Therefore, our empirics on the co-integration of the spot exchange rates and relative prices difference, and separate domestic-foreign prices, under E-G (1987), has verified the long-run equilibrium between the variables in the system. In reality, our short-run data although cannot confirm stationarity of RER levels, does unveil the behavior that endogenous variables of the system are interrelated and interact with one another in the long run to shape a stationarity over a long time span. This proves a relatively weak version of PPP theorem. It is also not uncommon that this two-stage co-integrating test may help alleviate the low power problem of ADF and PP unit root test frameworks.

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5.2.2 Error-correction mechanism in modified ADF regression:

The problem of low power in testing for non-stationarity is well known. We have in the previous conduct of Engle-Granger (1987) two-stage regression found an evidence that NER, prices and relative price ratio will tend to error-correct towards some future equilibrium. Now we implement a modified ADF test to indicate some empirical values of such tendency.

The major motivation for this modified paradigm is described in the following. In our original theory, strong-form PPP implies (3.1). An augmented Dickey-Fuller regression (for first-order autoregression) is:

$$\Delta RER_t = \alpha + \delta t + \gamma RER_{t-1} + \sum_{i}^{k} \gamma_i \Delta RER_{t-i} + u_t \tag{14}$$

In the testing framework, as well as shown by theory, δt should not be present in the

(ADF test statistic comparable to Phillips-Ouliaris simulated critical values)							
N.E.R.			Equation		ADF-Stat.	k	Min.AIC(SC)
ECT_{USD}	$\Delta\hat{u}_t =$	-0.005797	$-0.111129\hat{u}_{t-1}$	$+0.30270\Delta\hat{u}_{t-1}$	$-4.3988^\star$	1	-0.5597
		(0.0128)	(0.0253)	(0.0651)			(-0.5106)
		$[-0.4533]$	$[-4.3988]$	[4.6398]			
ECT_{GBP}	$\Delta\hat{u}_t =$	-0.005375	$-0.107583\hat{u}_{t-1}$	$+0.31789\Delta\hat{u}_{t-1}$	$-4.3158^\star$	1	-0.517462
		(0.0131)	(0.0249)	(0.0652)			(-0.4683)
		$[-0.4116]$	$[-4.3158]$	[4.8769]			
ECT_{JPY}	$\Delta\hat{u}_t =$	-0.005582	$-0.120845\hat{u}_{t-1}$	$+0.31842\Delta\hat{u}_{t-1}$	$-4.5856^\star$	1	-0.539348
		(0.0129)	(0.0264)	(0.0651)			(-0.4902)
		$[-0.4321]$	$[-4.5856]$	[4.8899]			
ECT_{EUR}	$\Delta\hat{u}_t =$	-0.007917	$-0.108769\hat{u}_{t-1}$	$+0.28182\Delta\hat{u}_{t-1}$	$-3.8887^\star$	1	-0.3364
		(0.0158)	(0.0280)	(0.0727)			(-0.2797)
		$[-0.4994]$	$[-3.8887]$	[3.8761]			

Note: Standard error (s.e.) is reported in parentheses; t-Stat. in square brackets; * denotes the null hypothesis of nonstationarity rejected at 1% level, comparable to Phillips-Ouliaris c.v., for m=3. Tests are conducted for period 1986:01-2002:12. $\hat{u}_t$ denotes error-correction term from the first-stage E-G regression

Table 6: E-G second-stage trivariate regression using the ADF paradigm

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estimation for the consistency of the PPP notion. Now we construct a slightly different analysis to better reflect the error-correction mechanism. Clearly, the new construction reads in the eq. (**??**) below:

$$\begin{aligned}\Delta s_t &= \alpha + \gamma RER_{t-1} + \phi \Delta dpp_t^{\star} \\ &+ \sum_{i=1}^{k}\left(\psi \Delta s_{t-i}\psi_{dpp^{\star}}\Delta dpp_{t-i}^{\star}\right) + \sum_{i=1}^{k}\delta_i \Delta dpp_{t+i}^{\star} + u_t\end{aligned} \tag{15}$$

where s_t is spot exchange rate (in logarithms); RER real exchange rate; and $dpp^{\star}$ relative price ratio. Lead term in relative price ratio has been added as well as its lagged values up to order k. Our empirical results are in the following table, examining the model for $i = 1$ in all lead and lag terms described in the eq.(**??**).

$\Delta s_t = \alpha + \gamma RER_{t-1} + \phi \Delta dpp_t^{\star} + \sum_{i=1}^{k}\left(\psi \Delta s_{t-i}\psi_{dpp^{\star}}\Delta dpp_{t-i}^{\star}\right) + \sum_{i=1}^{k}\delta_i \Delta dpp_{t+i}^{\star} + u_t$								
	α	γ	ϕ	ψ_{st}	$\psi_{dpp^{\star}}$	δ_1	Q_6	Q_{12}
USD	0.406902*	-0.117053*	-0.366671	0.214487*	0.061878	-0.503665	1.74	21.12
	(-5.1242)	(-4.9949)	(-0.4947)	(3.2832)	(-0.1011)	(-0.8327)	-0.94	-0.05
GBP	0.452088*	-0.111406*	-0.222998	0.234402*	-0.050719	-0.532069	3.12	21.96
	(-4.9967)	(-4.8762)	(-0.2978)	(3.582)	(-0.0826)	(-0.8791)	-0.79	-0.04
JPY	-0.184559*	-0.125864*	-0.302001	0.231126*	-0.305011	-0.297616	1.09	17.92
	(-4.5086)	(-5.2671)	(-0.4223)	(3.5562)	(-0.5122)	(-0.5109)	-0.98	-0.12
EUR	0.439262*	-0.126337*	-0.468250	0.185142*	0.079089	-0.573860	1.09	15.59
	(-4.8921)	(-4.7529)	(-0.5644)	(2.5538)	-0.1157	(-0.8530)	-0.98	-0.21

Note: (*) denotes significance at 1% level. t-Stat. in parentheses. Q_6, Q_{12} denote Ljung-Box statistic for serial correlation of up to 6 and 12 lags, respectively.

Table 7: A modified ADF analysis for the exchange rates

The results in table (7) unveil a pattern of the exchange rate dynamics that all γ_is are significant at 1% level and negative. The regression is satisfactory with residuals exhibit white-noise property; no serial correlation afterwards. In terms of absolute magnitude, they appear to have been close to one another. Absolute values of ϕ in all cases are well below the unity. ϕ and ψ_0 bear opposite signs, that is, negative in ϕ and positive with ψ_0 (correctly signed). For all tested currencies, their magnitudes, however, do not seem

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to equal, except the case of GBP.

The new dynamics for all exchange rates indicate that coefficient of first-order lagged RER in the regression is statistically significant and smaller than zero. The result is important in verifying the above E-G analysis because the negative coefficient in the long run becomes endogenous error-correction engine. Large deviation from PPP in the preceding term will contribute to reduce the divergence in the next term, a sufficient condition for the exchange rate to tend to some equilibrium in the future.

5.2.3 Co-integration test under Johansen's VAR paradigm:

We now report some empirical from max eigenvalue approach of VAR(2) analysis for searching for co-integrated equations amongst variables versus stationarity character of the data series used for the system. We repeat the previous note that the entire reform period of Vietnam can be seen as consisting of two major sub-periods, which are before 1989:06 and after. The main reasons of this is due to the liberalizing of the trade account since beginning of 1989, where international trading started becoming a more liberal field of activities and private forces could join the market efficiently. Therefore, we can test for PPP separately between the two sub-samples for a general understanding. This is equivalent to testing for a dummy of structural break.

The test outcome analyzed in table (8) supports the hypothesis that trivariate systems are co-integrated with reduced rank. In 3 out of 4 exchange rates in the test, at 5% level, we accept the hypothesis that there exist a single co-integrating relations among the three variables. In the case of EUR, the co-integration equation is one (at both 5 and 1% level). Normalized co-integrating vector and adjustment coefficient matrix are also provided in the table (8).

The co-integration equations reveal that these considered variables tend to combine well with leads in value to become a stationary linear combination, therefore supporting the mean-reverting nature of real exchange rates. In addition our obtained impulse response of the spot exchange rates (in level) to one standard deviation shock, given a future period of 20 months (using Monte Carlo simulation in EViews with 10,000 replications) shows that given other shocks held constant, effects of the spot exchange rates innovation alone on the future real exchange rates reduce over time, and fairly quickly. Similar

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	Estimation results for the sample period 1989:06-2002:12					
	Null	λ_{TR}	95% C.V.	C.E.s	Max.Eig.Val.	95% C.V.
USD	$r \leq 2$	1.97	3.76	1 (5%)	1.97	3.76
lag=1	$r \leq 1$	10.93	15.41		8.96	14.07
	$r = 0$	35.63**	29.86		24.69**	20.97
	Co-integrating coefficient			Adjustment coefficient		
	USD	PUS	PVN	ΔUSD	-0.003367	(0.00932)
	1.0	-1.077136	-0.863266	ΔPUS	0.001276	(0.00067)
		(1.04826)	(0.21486)	ΔPVN	0.018291	(0.00407)
GBP	$r \leq 2$	2.04	3.76	2 (1%)	2.04	3.76
lag=3	$r \leq 1$	17.32*	15.41		15.28*	14.07
	$r = 0$	61.19**	29.68		43.87**	20.97
	Co-integrating coefficient			Adjustment coefficient		
	GBP	PUK	PVN	ΔGBP	-0.009024	(0.00547)
	1.0	-4.215964	1.768729	ΔPUK	-0.002894	(0.00054)
		(1.97552)	(0.47104)	ΔPVN	-0.006823	(0.00165)
JPY	$r \leq 2$	2.98	9.24	1 (5%)	2.98	9.24
lag=2	$r \leq 1$	16.37	19.96	1 (1%)	13.39	15.67
	$r = 0$	48.74**	34.91		32.37**	22.00
	Co-integrating coefficient			Adjustment coefficient		
C	JPY	PJP	PVN	ΔJPY	-0.007480	(0.00470)
1.753425	1.0	-2.969302	0.642422	ΔPJP	-0.001861	(0.00049)
(13.0519)		(3.41700)	(0.44268)	ΔPVN	-0.005198	(0.00130)
EUR	$r \leq 2$	5.00	9.24	1 (5%)	5.00	9.24
lag=1	$r \leq 1$	11.46	19.96	1 (1%)	6.45	15.67
	$r = 0$	57.18**	34.91		45.72**	22.00
	Co-integrating coefficient			Adjustment coefficient		
	EUR	PEU	PVN	ΔEUR	-0.001832	(0.00483)
24.20761	1.0	-5.936672	-0.268316	ΔPEU	0.002438	(0.00038)
(7.69265)		(2.59973)	(0.55615)	ΔPVN	0.005575	(0.00165)

Note: *(**) denotes null hypothesis rejected at 1(5)% level. Co-integrating coefficient (beta) and adjustment coefficient (alpha) vectors are presented for one co-integration equation. Standard errors reported in parentheses. $\Delta(\cdot)$ denotes first-order difference of data in logarithms. VAR models selected for lag length of 10, although information criteria (LR, AIC and SC) indicate different lag choices. Johansen cointegration test is done with constant, but no trend in C.E.

Table 8: Results from Johansen test for co-integrating equations

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observation can be seen with individual shocks of domestic and foreign inflation levels.

5.2.4 VECM representation:

Co-integrating between endogenous variables of RER implies VECM, as vector autoregressive multiple equations can be presented in VEC specifications; or a system of autoregressive distributed lags, with first difference of lagged variables introduced into the model. Below are representations of vector error correction regression; using Johansen's multivariate analysis. For brevity, we show only the first estimation, applicable in the case of flexible (movable) exchange rates, in which changes in spot exchange rates on the LHS, while ECT followed by lagged changes in values of endogenous variables. The lag structure is identified based on AIC-minimizing information, and in our situation, 3 for all data series.

Each equation of VECM dynamical system is an ECM, and as shown in the theory contains the restrictions imposed by the decomposed α and β (although not unique) that forms the mentioned equation: $\Pi = \alpha\beta'$, where α represents a $(r \times 1)$ vector of adjustment coefficients, and β $(r \times 1)$ vector of coefficient building the long-run equilibrium between the endogenous variables of the sytem.

The making of the ECM for our first equation in the VECM will be interpreted as follows. Each ECM for the first equation of the VECM for one currency-based exchange rate will contain an ECT component, a short-hand name for error-correction term. We will explore the sign of the coefficient in front of the corresponding ECT. When it is negative, the ECM is said to provide for an error-correction mechanism whereby, a past shock to the system will be reduced over time, gradually reverting the series to the mean value. This is a necessary condition for the long-run equilibrium condition of real exchange rates that we are considering in the current study.

The actual empirics indicate the following ECM for the first equation in the VECM for each exchange rate:
<u>US Dollar:</u>

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$$\begin{aligned}\Delta s_{USD} &= -0.0016 - 0.0034\,(ECT_{USD,t-1}) \\ &\quad -0.0592\Delta s_{t-1} + 1.4280\Delta p_{US,t-1} + 0.4407\Delta p_{VN,t-1} + \epsilon_{USD,t}\end{aligned} \tag{16}$$

where, $ECT_{USD,t-1} = (s_{t-1} + 1.0771 p_{US,t-1} + 0.8633 p_{VN,t-1} - 5.4324)$.

<u>British Pound:</u>

$$\begin{aligned}\Delta s_{GBP} &= -0.001438 - 0.003367\,(ECT_{GBP,t-1}) + \\ &\quad +0.0416\Delta s_{t-1} + 0.0474\Delta s_{t-2} - 0.1108\Delta s_{t-3} \\ &\quad +1.2977\Delta p_{UK,t-1} + 0.0108\Delta p_{UK,t-2} + 1.8247\Delta p_{UK,t-3} \\ &\quad +0.2259\Delta p_{VN,t-1} + 0.0716\Delta p_{VN,t-2} - 0.2699\Delta p_{VN,t-3} + \epsilon_{GBP,t}\end{aligned} \tag{17}$$

where, $ECT_{GBP,t-1} = (s_{t-1} + 7.6300 p_{UK,t-1} - 3.2010 p_{VN,t-1} + 7.8023)$.

<u>Japanese Yen:</u>

$$\begin{aligned}\Delta s_{GBP} &= -0.00748\,(ECT_{JPY,t-1}) + \\ &\quad +0.1192\Delta s_{t-1} - 0.0242\Delta s_{t-2} \\ &\quad +0.8817\Delta p_{JP,t-1} - 0.6116\Delta p_{JP,t-2} \\ &\quad +0.3517\Delta p_{VN,t-1} - 0.2183\Delta p_{VN,t-2} + \epsilon_{GBP,t}\end{aligned} \tag{18}$$

where, $ECT_{JPY,t-1} = (s_{t-1} + 2.9693 p_{JP,t-1} - 0.6424 p_{VN,t-1} - 1.7534)$.

<u>Euro:</u>

$$\begin{aligned}\Delta s_{EUR} &= -0.0018\,(ECT_{EUR,t-1}) \\ &\quad -0.0188\Delta s_{t-1} + 0.9252\Delta p_{EU,t-1} + 0.4042\Delta p_{VN,t-1} + \epsilon_{EUR,t}\end{aligned} \tag{19}$$

where, $ECT_{EUR,t-1} = (s_{t-1} + 5.9367 p_{EU,t-1} + 0.2683 p_{VN,t-1} - 24.2076)$.

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Total VECM representations based on the empirical results provide us with the specific dynamics of the PPP deviation and error-correction mechanism. While the adjustment coefficient is negative, we realize that there exists at least a first order autoregressive feedback reducing the past deviation from the PPP theory. Such an error-correction short-run dynamics explains the mean-reverting tendency of the long-run relationship towards future equilibrium. In the Appendix of the study, we also provide matrix equations describing the results from both VECM dynamics and the long-run relations for one cointegrating equation hypothesis (that has been confirmed in all cases at test).

5.2.5 Restricted coefficients long-run relations

We now report further statistics that impose standard restriction for ECT of the long-run relationship. It is known that the coefficient vector of ECT in the PPP theorem must satisfy:

$$\beta' y_{i,t} \equiv (s_t + p_t - p_t^{\star}) \sim I(0).$$

Therefore, the restriction for absolute PPP (strong-form) becomes: $\beta' = (1\ 1\ -1)$. Below is an outcome table (9) analyzing test statistics for these restricted coefficients under Johansen procedure.

What we find from the above table (9) results is quite motivating. Given the restriction of the cointegrating vector β, for all cases, we can still reject the null of no cointegration. In effect, we cannot reject the constraint of the cointegrating vector $\beta' = (1\ 1\ -1)$. This is equivalent to our support to the holding of strict PPP in the long run through the restricted cointegrating relation because the LR test statistics do not reject the binding restrictions at any conventional levels, assuming the number of cointegrating relation is one.

5.3 Half-lives and convergence to long-run equilibria

We have found evidence that the exchange rates will be convergent in the future to some equilibrium. This expected equilibrium value will possibly be reached when the error-correction component tends to reduce the preceding deviation from PPP to a negligible magnitude. More exactly, the real exchange rate will come to approximate equilibrium point after some time. Such a process of reverting to an unbiased mean

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value (mean-reversion property of PPP) should indicate the speed at which deviation will be adjusted by the endogenous error-correction process.

5.3.1 Computed HLs

In the table (10) below, we summarize some values of half-lives (HL) for different real exchange rates under a widely used DF regression. The DF framework does not suggest a time trend for the regression, however, due to a possible time trend control (Balassa-Samuelson effect), the inclusion of time is also conducted for comparison.

FX	Rank	Lag	Restricted $L(\theta)$	LR test stat. $\chi^2(2)$	p-Val.	d.f.
s_{USD}	1	1	1636	3.74	0.15	2
					adjustment coefs.	
					α_1	-0.002649
					α_2	-0.000664
					α_3	-0.006212
s_{GBP}	1	3	1493	2.64	0.27	2
					adjustment coefs.	
					α_1	-0.007750
					α_2	-0.003154
					α_3	-0.007186
s_{JPY}	1	2	1416	0.52	0.77	2
					adjustment coefs.	
					α_1	-0.004647
					α_2	-0.001229
					α_3	-0.003620
s_{EUR}	1	2	1138	2.50	0.29	2
					adjustment coefs.	
					α_1	-0.000329
					α_2	-0.001261
					α_3	-0.002859

Table 9: Restricted β' cointegrating relationships

	$\Delta s_t = \alpha + \delta t + \gamma_i s_{t-1} + u_t$			$\Delta s_t = \alpha + \gamma_i s_{t-1} + u_t$			$\Delta s_t = \alpha + \gamma_i s_{t-1} + \phi_i \Delta s_{t-1} + u_t$		
	γ_i	$1+\gamma_i$	HL	γ_i	$1+\gamma_i$	HL	γ_i	$1+\gamma_i$	HL
USD	-0.0496	0.9504	13.62	-0.0355	0.9646	19.2	-0.0450	0.9550	15.05
GBP	-0.0447	0.9553	15.15	-0.0339	0.9661	20.07	-0.0439	0.9561	15.45
JPY	-0.0478	0.9522	14.16	-0.0355	0.9645	19.18	-0.0456	0.9544	14.84
EUR	-0.0658	0.9343	10.18	-0.0392	0.9608	17.35	-0.0477	0.9523	14.18

Table 10: Half-lives under D-F regressions

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In our computation, half-life is defined as the necessary lag length for the current deviation from PPP to decay by 50% of its original magnitude. It is quite straightforward to prove that the value of HL depends on the point estimates of γ_i, in which the HL measure is defined in eq.(20) below:

$$HL = \frac{ln\left(\frac{1}{2}\right)}{ln\left(1+\gamma_i\right)} \tag{20}$$

whereby, shocks of the regression decay monotonically (as has been verified in previous examination of autocorrelation function).

The test results show that for all three cases summarized in the table, HL of exchange rates in consideration, range from 0.85 to 1.67 years. Specifically, the case of DF regression with no first-order difference, the shortest time is 1.45 years (EUR) and longest 1.67 years (GBP). This speed of mean reversion is quite fast compared to those obtained by previous studies, where HL is typically ranging from 3 to 5 years. Our estimated half-lives clearly indicate that their mean values are not only finite, but also fairly small in magnitude, compared to many previously reported results. For example, Murray and Papell (2002) reported H-L of exchange rates denominated in US Dollar in a range like 0.89 (FFR), to 11.2 years (JPY), after bootstrapping an annual data sample of period 1900-1996. Most of values vary around 2.0-4.0 years.

5.3.2 Bootstrapping HLs

Our analysis above is based on a sample period of 1986:01-2002:12. For many previous studies on long-run equilibrium of real exchange rates, data samples usually span over decades, or even centuries, in which researchers find evidence supporting PPP validity. In this study, the data sample is limited due largely to a short period of reform (since 1986). It will then be worthwhile that we conduct a replication of many more samples based on the actual one to observe any significant changes in our previous note of finite HL for different currency rates.

The replication is done with a bootstrapping algorithm executed on the Mathematica environment (V4.1)[5], where we construct populations from different replications, specif-

[5] Bootstrap in Mathematica: The work uses bootstrap algorithms that work on Mathematica symbolic package. The specific package is named: bootstrappackage.m, developed by Enis Siniksaran of Istanbul

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ically 750, 1500, 5000 and 15000. Because bootstrap replication does not require known distribution of the stochastic variable, different percentile values of simulated mean γ_i are also reported. Thus, such as discussed in Murray and Papell (cf. 2001); a bootstrap for bounds of point estimates of lagged variable coefficient can help obtain asymptotically valid result.

Table 11: Bootstrapped half-lives for 4 RER time series

		No. of replications				
		750	1500	5000	15000	Observed
JPY	γ_i	-0.03324	-0.03412	-0.0347	-0.03339	-0.0355
	0.50%	-0.1853	-0.22004	-0.2486	-0.36369	
	2.50%	-0.18279	-0.19043	-0.21885	-0.22544	
	5%	-0.15907	-0.17267	-0.18871	-0.18538	
	95%	0.031564	0.027538	0.027589	0.027792	
	H-L	20.5	19.96	19.63	20.41	19.18
USD	γ_i	-0.03415	-0.03296	-0.03432	-0.03353	-0.03545
	0.50%	-0.22161	-0.25353	-0.26032	-0.31165	
	2.50%	-0.17177	-0.22655	-0.23848	-0.22741	
	5%	-0.14211	-0.18231	-0.19493	-0.18639	
	95%	0.044041	0.02604	0.028626	0.029717	
	H-L	19.95	20.68	19.85	20.33	19.2
GBP	γ_i	-0.03513	-0.03315	-0.03285	-0.03284	-0.03394
	0.50%	-0.19401	-0.23393	-0.29049	-0.30287	
	2.50%	-0.19096	-0.20282	-0.21374	-0.21631	
	5%	-0.16045	-0.1834	-0.18257	-0.18047	
	95%	0.032028	0.027179	0.028575	0.028218	
	H-L	19.38	20.56	20.75	20.76	20.07
EUR	γ_i	-0.03503	-0.03551	-0.03731	-0.03732	-0.03916
	0.50%	-0.23778	-0.24154	-0.29556	-0.34096	
	2.50%	-0.23778	-0.23836	-0.24051	-0.22517	
	5%	-0.19897	-0.18988	-0.19127	-0.19214	
	95%	0.028119	0.028425	0.031119	0.030216	
	H-L	19.44	19.17	18.23	18.22	17.35

In the result table (11) above, we note that for most cases, bootstrapped mean of half-lives is dragged on. The exception is for GBP 750-replication sample where H-L is little smaller than the observed value in D-F regression. The change, although small, in computed HL is because absolute values of most autoregressive parameters get a bit smaller

University, 2001, running well on version 4.1. Data can be loaded directly from Mathematica front-end in the form of time series for regression. Bootstrapping can deal with both pair regression and residual series. For evaluation of different sets of data, users are recommended to quit current Mathematica kernel session after all runs on each set of data.

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than the originally observed. It appears that the finiteness of H-L have been confirmed while increase in H-L after the treatment does not change the picture substantially. Frequency distributions of the autoregressive parameters after being bootstrapped are provided in the Appendix, where we see clearly that γ_i are not normally distributed but skewed to the right, containing more mass. The speed of correction towards PPP is obviously quite slow, however, it could still show fast pace of adjustment if compared to other world results.

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6 Concluding Remarks

In this paper, we have gone through a number of critical aspects if one has to observe exchange rates. It has significant meaning for an economy in transition towards a market model economy like Vietnam. We found evidence of long-run equilibrium in most cases through a single co-integrating vector among endogenous variables that determine the real exchange rates. This reduced rank confirmation for the trivariate system supports relative PPP (weaker-form) that ECT of the system can be combined linearly into a stationary process, which helps reduce deviation from PPP in the long run. However, for a strict form of PPP, we cannot even reject the restricted coefficient vector $\beta' = (1\ 1\ -1)$ for all currencies. The work also considers speed of convergence to PPP, and finds a fairly fast adjustment compared to results from other researches. Given both observed and bootstrapped H-L, the time for deviation decays in most cases is only two thirds of results obtained by various researchers for developed countries. Probably, a better explanation is the adjustment from hyperinflation period, after which the theory indicates that adjusting process normally accelerates.

Additionally, it is shown in the computation that deviation of currencies appears to have been large in early period of the reform, and mostly overvaluation of VND against foreign currencies. This is not uncommon as although VND is allowed to move against currencies, the move has mostly been precautious and requires some length of time. Nonetheless, its correction over time did happen and became negligible deviations very recently. Beyond the empirical discussion we provide hereunder a few points as additional concluding remarks of this study.

6.1 On the long-run equilibrium relationship and Law of One Price (LOP)

6.1.1 The long-run equilibrium

The evidence we have found in the preceding section supports the reduced rank hypothesis. In a sensible way, let us consider the case of one cointegrating equation for all four dynamical systems that govern our exchange rate behaviors. These cointegrating equations represent long-run equilibrium relationships among the three variables entered into the systems. Their empirical descriptions follow:

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RER	Long-run equilibrium
USD	$s_t = -5.4324 + 1.0771p_{US,t} + 0.8633p_{VN,t} + \hat{u}_t$
GBP	$s_t = +7.8023 + 7.6300p_{UK,t} - 3.2010p_{VN,t} + \hat{u}_t$
JPY	$s_t = -1.7534 + 2.9693p_{JP,t} - 0.6424p_{VN,t} + \hat{u}_t$
EUR	$s_t = -24.2076 + 5.9367p_{EU,t} + 0.2683p_{VN,t} + \hat{u}_t$

In these long-run equilibrium relations, the dynamics assume that there exist error-correction models such that deviations from the PPP will be adjusted by the coefficients established in the (3×1) α matrix. We stress that the coefficients α_1 in all our empirics carry a negative sign, apparently showing a reduction of deviations over time. These reductions help stabilizing the systems in the long run, hence supporting the equilibrium relations.

6.1.2 On the Law of One Price

We should here note something on the postulated Law of One Price (LOP). Vietnamese economic reforms have gradually removed the former Soviet-styled centrally planned model where prices had only nominal values. As mentioned earlier, since the reform started, the economy faced issues that it had never ever been confronted before, such as hyperinflation, currency depreciation, and so on. Our success to establish the equilibrium above represents a fact that following open-door policies, international trades have entered the economy and entities' economic transactions naturally. This factor is so important and serves to have the starting point for subsequent quantum economic restructures. In our theoretical view, subtracting transportation costs, identical goods in different countries should have the same price, when expressed in common currency. The arbitrage that helps bridge the difference is usually done via international trades. Hence, we would state that the outcome of our establishment here would not be likely without substantial economic changes occuring within the Vietnam's economy over the recent reform period.

6.2 Policy concern: assessing recent exchange rate misalignments

In line with our analysis of the long-run equilibrium, where we establish that it is very likely that real exchange rate dynamics will bind stochastic variables to a stationary relationship with finite speed of convergence, it is possible to explore behavioral process of

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real exchange rates over the considered sample. It is critical for this exercise as through 17 years of the economy, several important events may represent shocks that could drive real exchange rates from deterministic theoretic equilibrium levels. Economists and policy makers should also be wary of significant departure (in magnitude) from considered equilibrium.

In this aspect, we briefly examine three widely used benchmarks for detecting a departure from hypothesized equilibrium real exchange rates (ERER). The first is to regress RER data against a constant (i.e., a fixed ERER), the second on a constant but allowing for a time trend component (a linear time trend ERER), and the third by Hodrik-Prescott filtered data (fluctuating ERER).

Our full empirical analysis of RER misalignment is provided in the Appendix, table (13) of the study, and below are several key observations. In fact, given the same original data of RER, the three fitting will provide for different understanding. It is not unexpected that while this shows an undervaluation of USD in parity with VND, the other version may unveil an overvaluation. We now detect the consensus in two ways. First, if any two of the three show an overvaluation, we take the point with some caution. If all three agree on over- versus undervaluation, we accept the conclusion. RER_{USD} shows that USD was undervalued against VND significantly in early years of reform. The average undervaluation of USD is about 60% in 1987; 20% 1988. However, in 1989, the situation changed and USD became more or less overvalued by 15%; over 20% in 1990; 15% 1991; ¡15% 1992; and less than 10% for the period 1993-95. Period 1996-2002 shows negligible disparity towards undervaluation of USD, with undervaluation is estimated below 5% (average level of the year). Visualized different types of misalignment concepts are illustrated in figure (6.2).

The average undervaluation of GBP is about 50% in 1987; 15-20% 1988. Similar to USD, in 1989, GBP became more or less overvalued by 10-15%; 20-30% in 1990; 15-20% 1991; above 15% 1992; and about 1-5% for the period 1993-99. Period 2000-01 shows small undervaluation of GBP, with undervaluation is estimated 1-5%. Behavior of EUR is also quite relevant to GBP, with significant undervaluation in 1987 (50-60%) and 1988 (30%). One difference is undervaluation of EUR in 1995, when USD and GBP were overvalued in our computation. However, the magnitude is quite small, less than 3%. In the year of new EUR launching, 1999, EUR again became undervalued by 3%,

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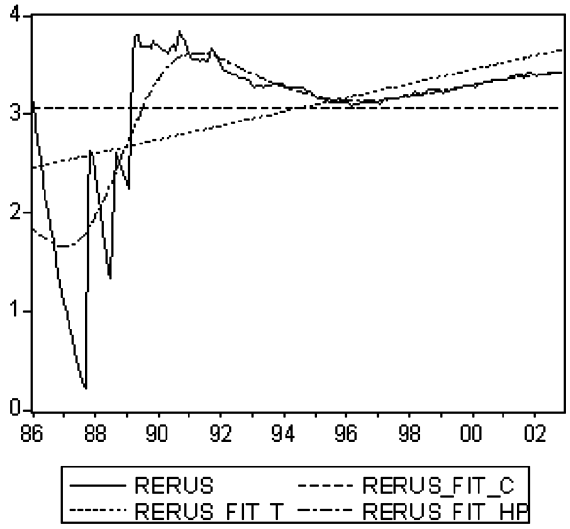

Figure 7: Assessing reform period exchange rate misalignments

and the situation reversed in 2000, where EUR gained over VND by about 5%. As the confidence and reputation of EUR got stronger, EUR was overvalued in 2001 by substantial percentage of over 10%. In 2002, however, the undervaluation returned by negligible 1-5%.

The Japanese yen behavior looked somewhat different from other strong currencies in this study. Period 1987-88 saw a strong yen, with magnitude of overvaluation in between of 40-60%. Yen in 1989-95 depreciated quickly and the parity undervaluation was in the range of 15-30%. It is noted that this period is considered a competitive-yen policy while VND reacts more to USD and EUR than JPY. In period 1996-98, yen regained the value, and became a bit overvalued by about 5-10% against VND, together with move of FDI and trade increase between the two nations. 1999-2000 saw the trend reversed where a negligible depreciation in RER of JPY. In 2001-02, JPY bounced back and the overvaluation was about less than 10%.

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7 Appendices

7.1 Appendix 1: VECM representations for empirical outcomes

VECM for the s_{USD}; one cointegrating equation

$$\begin{bmatrix} \Delta s_{USD,t} \\ \Delta p_{US,t} \\ \Delta p_{VN,t} \end{bmatrix} = \begin{bmatrix} -0.001578 \\ 0.001663 \\ 0.005952 \end{bmatrix} + \begin{bmatrix} -0.003367 \\ 0.001276 \\ 0.018291 \end{bmatrix} ECT_{t-1} + \tag{21}$$

$$\begin{bmatrix} -0.055924 & 1.427927 & 0.440665 \\ -0.002373 & 0.211413 & 0.012911 \\ 0.080565 & -0.896124 & 0.596273 \end{bmatrix} \begin{pmatrix} \Delta s_{t-1} \\ \Delta p_{US,t-1} \\ \Delta p_{VN,t-1} \end{pmatrix} + \begin{bmatrix} \epsilon_{1,t} \\ \epsilon_{2,t} \\ \epsilon_{3,t} \end{bmatrix}$$

where the ECT_{USD} is provided in eq.(16)

VECM for the s_{GBP}; one cointegrating equation

$$\begin{bmatrix} \Delta s_{GBP,t} \\ \Delta p_{UK,t} \\ \Delta p_{VN,t} \end{bmatrix} = \begin{bmatrix} -0.001438 \\ 0.003431 \\ 0.004889 \end{bmatrix} + \begin{bmatrix} -0.009024 \\ -0.002894 \\ -0.006823 \end{bmatrix} ECT_{t-1} + \tag{22}$$

$$\begin{bmatrix} 0.041636 & 1.297714 & 0.225891 \\ 0.001141 & 0.073908 & -0.096198 \\ 0.046874 & -0.875098 & 0.660372 \end{bmatrix} \begin{pmatrix} \Delta s_{t-1} \\ \Delta p_{UK,t-1} \\ \Delta p_{VN,t-1} \end{pmatrix} +$$

$$\begin{bmatrix} 0.047431 & 0.010827 & 0.071627 \\ 0.014777 & -0.129464 & 0.057701 \\ 0.039525 & 0.171701 & -0.200353 \end{bmatrix} \begin{pmatrix} \Delta s_{t-2} \\ \Delta p_{UK,t-2} \\ \Delta p_{VN,t-2} \end{pmatrix} +$$

$$\begin{bmatrix} -0.110821 & 1.824714 & -0.269940 \\ -0.007647 & -0.329294 & 0.062711 \\ -0.033720 & -0.054574 & 0.263962 \end{bmatrix} \begin{pmatrix} \Delta s_{t-3} \\ \Delta p_{UK,t-3} \\ \Delta p_{VN,t-3} \end{pmatrix} + \begin{bmatrix} \epsilon_{1,t} \\ \epsilon_{2,t} \\ \epsilon_{3,t} \end{bmatrix}$$

where the ECT_{GBP} is provided in eq.(17)

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VECM for the s_{JPY}; one cointegrating equation

$$\begin{bmatrix} \Delta s_{JPY,t} \\ \Delta p_{JP,t} \\ \Delta p_{VN,t} \end{bmatrix} = \begin{bmatrix} -0.007480 \\ -0.001861 \\ -0.005198 \end{bmatrix} ECT_{t-1} + \tag{23}$$

$$\begin{bmatrix} 0.119241 & 0.881655 & 0.351737 \\ 0.009621 & 0.092168 & 0.030251 \\ 0.026990 & -0.437225 & 0.694155 \end{bmatrix} \begin{pmatrix} \Delta s_{t-1} \\ \Delta p_{JP,t-1} \\ \Delta p_{VN,t-1} \end{pmatrix} +$$

$$\begin{bmatrix} -0.024181 & -0.611579 & -0.218275 \\ -0.005955 & -0.237641 & -0.043824 \\ 0.008772 & 0.165364 & -0.033316 \end{bmatrix} \begin{pmatrix} \Delta s_{t-2} \\ \Delta p_{JP,t-2} \\ \Delta p_{VN,t-2} \end{pmatrix} + \begin{bmatrix} \epsilon_{1,t} \\ \epsilon_{2,t} \\ \epsilon_{3,t} \end{bmatrix}$$

where the ECT_{JPY} is provided in eq.(18)

VECM for the s_{EUR}; one cointegrating equation

$$\begin{bmatrix} \Delta s_{EUR,t} \\ \Delta p_{EU,t} \\ \Delta p_{VN,t} \end{bmatrix} = \begin{bmatrix} -0.001832 \\ 0.002438 \\ 0.005575 \end{bmatrix} ECT_{t-1} + \tag{24}$$

$$\begin{bmatrix} -0.018820 & 0.925201 & 0.404187 \\ 0.005535 & 0.039021 & 0.003450 \\ 0.029184 & -0.563241 & 0.692148 \end{bmatrix} \begin{pmatrix} \Delta s_{t-1} \\ \Delta p_{EU,t-1} \\ \Delta p_{VN,t-1} \end{pmatrix} + \begin{bmatrix} \epsilon_{1,t} \\ \epsilon_{2,t} \\ \epsilon_{3,t} \end{bmatrix}$$

where the ECT_{EUR} is provided in eq.(19)

7.2 Appendix 2: Graphs and statistics

7.2.1 Combined graphs of differenced spot rates, domestic and foreign prices

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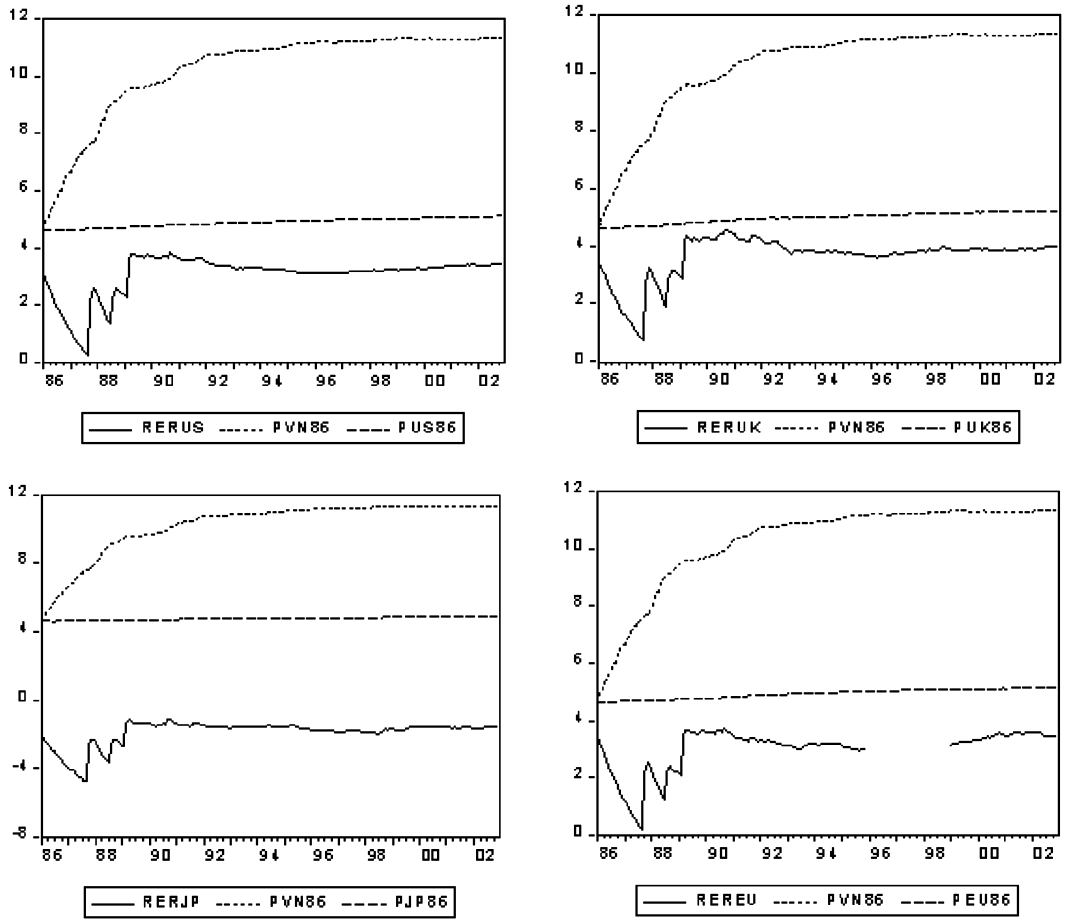

7.2.2 Asymptotic critical values for Engle-Granger (1987) two-stage co-integration examination

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Table 12: Phillips and Ouliaris (1988) asymptotic critical values

No. of vars.	Conventional significance level		
m	1%	5%	10%
Regression models contain a constant			
2	-3.96	-3.37	-3.07
3	-4.31	-3.77	-3.45
4	-4.73	-4.11	-3.83
5	-5.07	-4.45	-4.16
Regression models contain both constant and trend			
2	-4.36	-3.80	-3.52
3	-4.65	-4.16	-3.84
4	-5.04	-4.49	-4.20
5	-5.58	-5.03	-4.72

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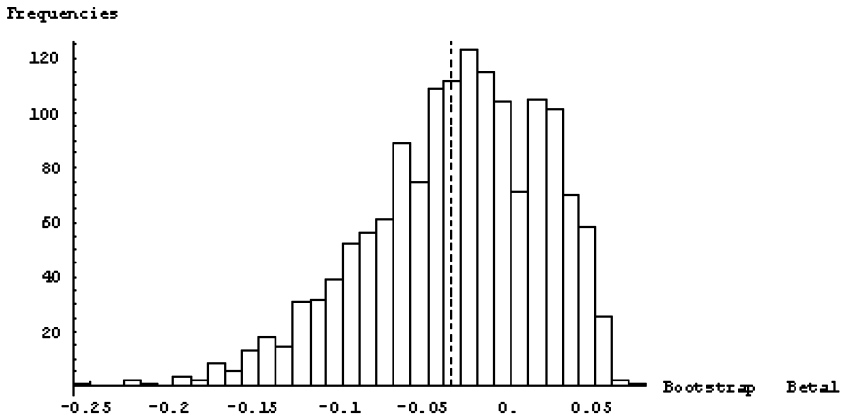
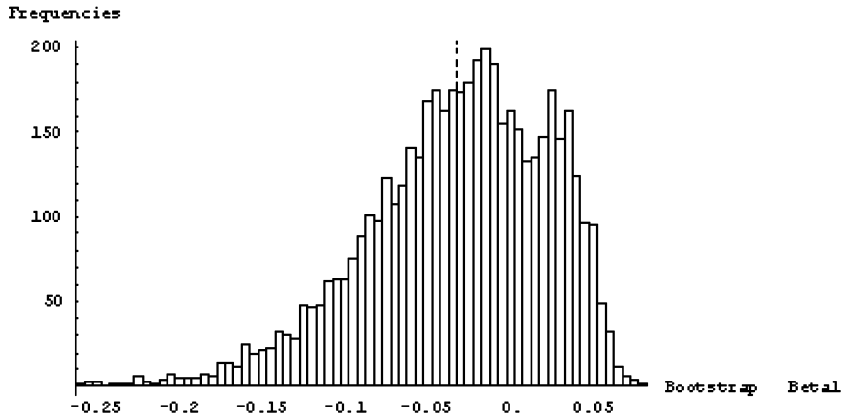
7.3 Appendix 3: Bootstrapped distributions

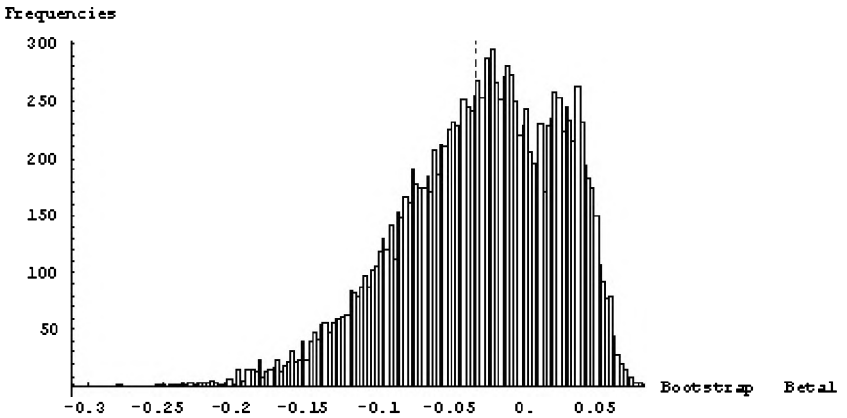
7.3.1 USD



1500 repl.



5000 repl.



15000 repl.

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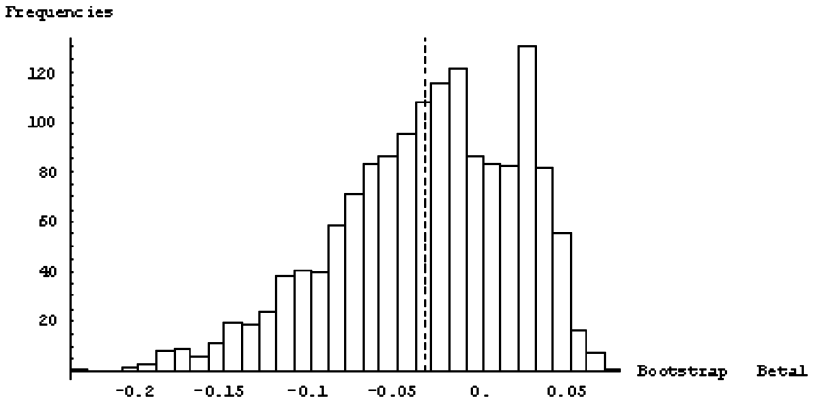
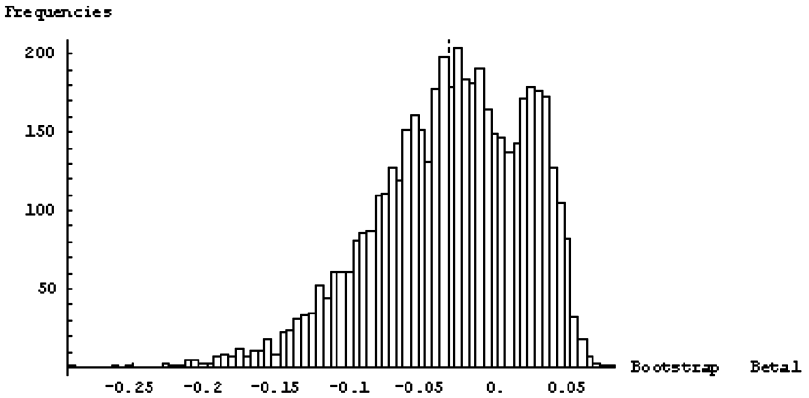
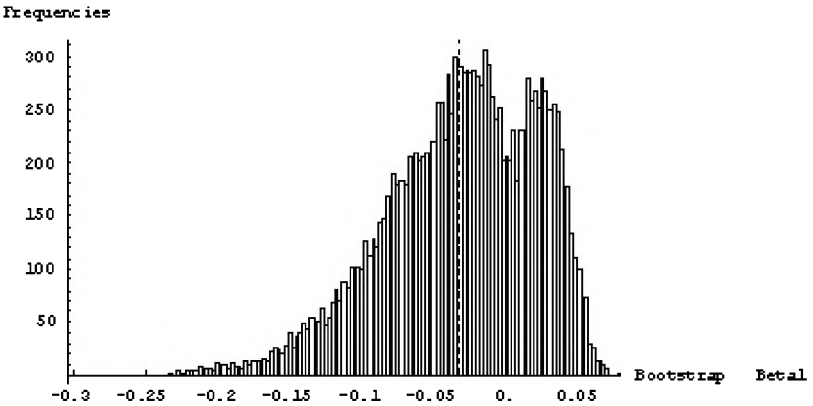
7.3.2 GBP



1500 repl.



5000 repl.



15000 repl.

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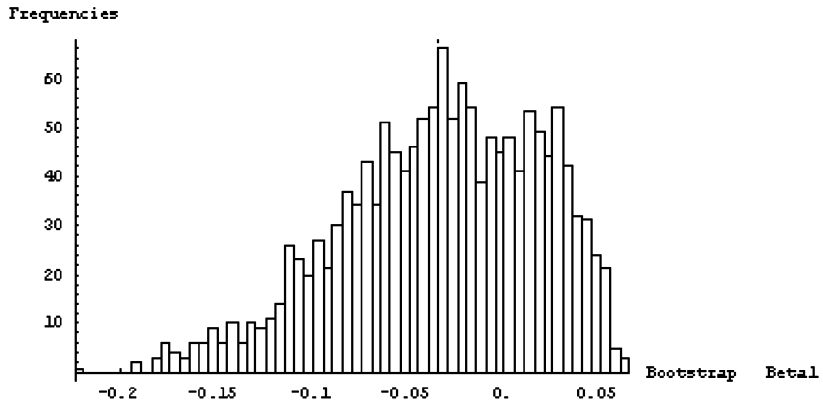
7.3.3 JPY



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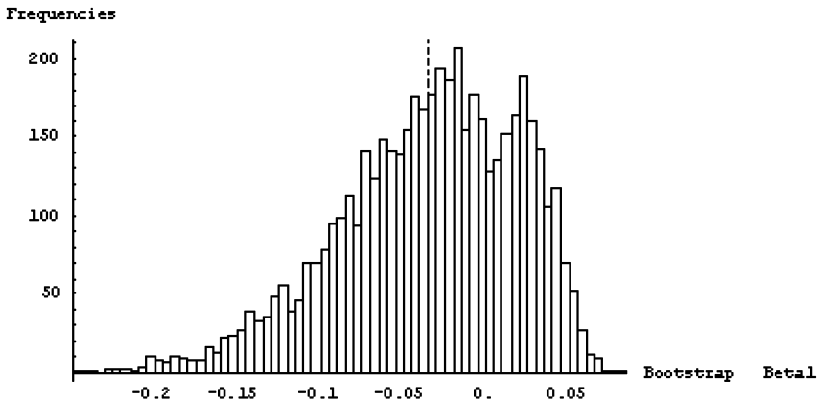
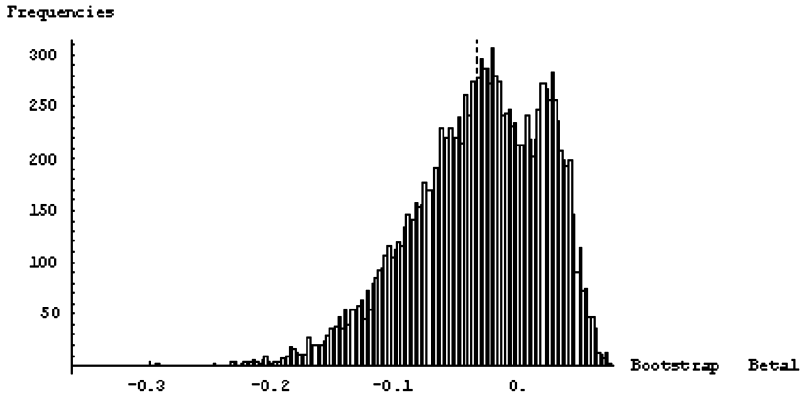


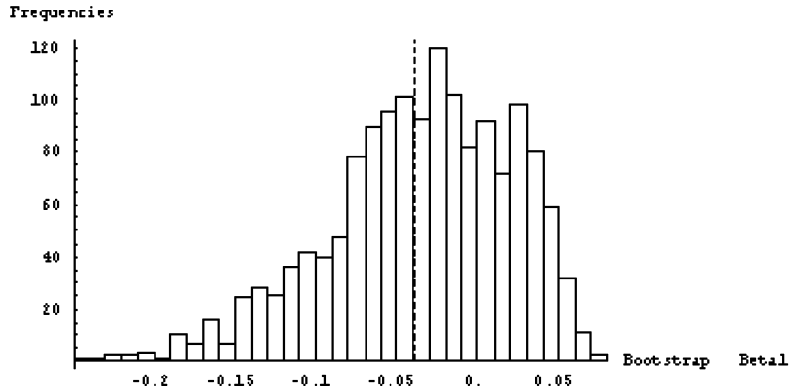
5000 repl.



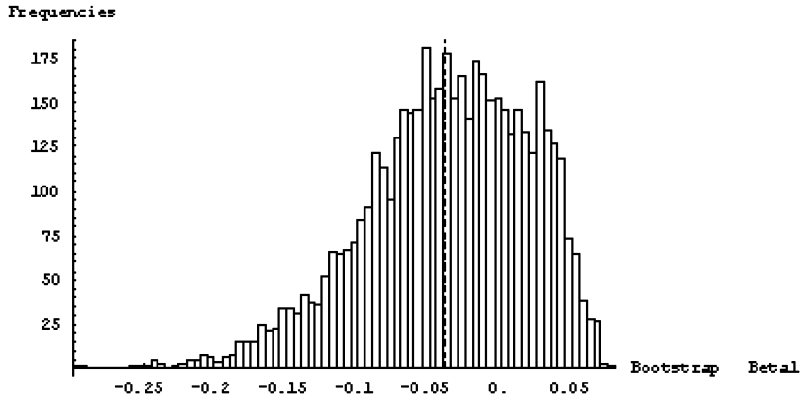
15000 repl.

Digitized by Google

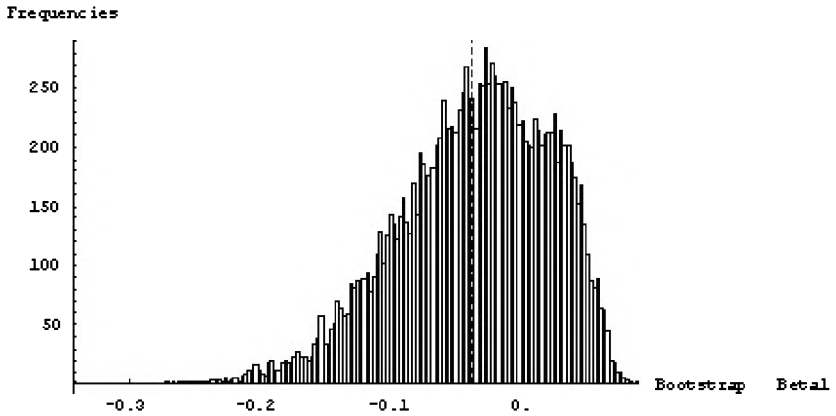
7.3.4 EUR



1500 repl.



5000 repl.



15000 repl.

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Table 13: Real exchange rate misalignment analysis

As of	USD			GBP			JPY			EUR		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
Jan-87	-56.8	-64.3	-34.3	-50.2	-57.5	-27.7	61.2	107.7	17.0	-52.0	-60.9	-33.9
Jul-87	-85.2	-87.6	-78.1	-72.4	-76.2	-61.5	94.4	146.7	43.6	-85.0	-87.6	-78.9
Jan-88	-7.7	-21.5	22.4	-5.7	-17.5	19.2	4.8	31	-17.5	-8.6	-23.1	20.3
Jul-88	-49.2	-56.2	-41.7	-40.7	-47.6	-33.8	54.9	90.6	35.5	-52.4	-59.3	-44.6
Jan-89	-12.7	-23.7	-13.4	-9.2	-18.8	-10.5	12.8	36.6	13.5	-17.9	-28.7	-16.7
Jul-89	36.5	20.9	20.5	30.1	17.6	15.8	-42.1	-31.0	-32.1	36.3	20.3	23.2
Jan-90	34.6	20.7	10.0	29.2	18.0	7.3	-38.7	-28.1	-17.7	34.1	20.1	12.3
Jul-90	33.3	21.1	4.8	32.2	22.0	5.7	-37.0	-27.4	-7.2	34.3	22.1	8.5
Jan-91	29.0	18.7	0.5	30.2	21.4	3.0	-37.0	-28.6	-3.6	25.2	15.6	0.7
Jul-91	24.4	15.9	-1.9	22.3	15.2	-2.2	-29.3	-21.2	7.7	17.7	10.3	-3.7
Jan-92	21.7	14.8	-1.4	21.7	15.9	-0.2	-30.7	-24.1	2.1	16.1	10.3	-2.2
Jul-92	16.0	10.7	-2.9	19.2	14.6	1.0	-22.1	-16.2	9.8	12.3	8.3	-2.0
Jan-93	11.3	7.6	-3.5	7.7	4.6	-5.3	-16.9	-12.2	12.2	7.1	4.7	-3.3
Jul-93	10.0	7.5	-1.5	6.4	4.4	-3.1	-22.8	-19.9	0.4	1.7	0.8	-5.3
Jan-94	8.9	7.7	0.5	5.6	4.7	-0.8	-19.3	-17.8	1.2	6.1	6.6	1.5
Jul-94	6.8	6.9	1.3	4.5	4.6	0.6	-20.6	-20.7	-4.2	3.8	5.7	1.9
Jan-95	2.8	4.1	0.0	2.4	3.5	0.7	-14.4	-16.2	-1.2	0.8	4.1	1.7
Jul-95	-0.1	2.3	-0.8	0.2	2.3	0.2	-14.5	-18	-6.3	-4.9	-0.5	-1.3
Jan-96	-1.6	1.9	-0.6	-2.8	0.1	-1.7	-0.8	-6.8	3.0	–	–	–
Jul-96	-2.7	1.9	-0.4	-2.9	1.0	-1.1	2.5	-5.6	1.3	–	–	–
Jan-97	-3.8	1.8	-0.7	-3.1	1.7	-1.1	11.1	0.2	5.4	–	–	–
Jul-97	-3.3	3.5	0.2	-1.9	3.9	0.2	8.9	-3.9	0.2	–	–	–
Jan-98	-3.8	4.1	0.1	-2.1	4.7	0.1	13.3	-2.2	2.2	–	–	–
Jul-98	-4.0	4.9	0.0	-2.0	5.7	0.3	22.2	3.1	9.4	–	–	–
Jan-99	-4.3	5.7	-0.1	-2.2	6.4	0.4	9.4	-9.8	-2.0	-8.1	4.9	-2.1
Jul-99	-4.6	6.5	-0.2	-3.0	6.5	0.2	11.0	-10.6	-0.2	-5.9	8.7	-0.7
Jan-00	-4.9	7.3	-0.4	-3.3	7.2	0.7	6.4	-16.4	-4.3	-5.0	11.0	-0.8
Jul-00	-4.5	8.8	0.1	-5.0	6.2	-0.4	8.6	-16.8	-3.0	-3.0	14.7	0.5
Jan-01	-4.7	9.7	0.2	-5.9	6.1	-0.6	13.2	-15.5	-0.5	-3.7	15.1	-0.5
Jul-01	-4.2	11.4	0.9	-6.2	6.7	-0.4	18.8	-13.6	2.0	-1.2	19.5	2.2
Jan-02	-5.4	11.1	0.0	-7.3	6.3	-1.2	26.2	-10.6	5.5	-2.6	19.1	1.2
Jul-02	-6.0	11.5	-0.2	-5.4	9.4	1.1	22.0	-16.0	-0.8	-6.6	15.5	-2.2
Jan-03	-6.8	11.4	-0.7	-5.4	10.2	1.3	24.2	-16.4	-1.2	-6.5	16.7	-1.4

N.B.: (1)-trend misalignment; (2)-constant misalignment; (3)-H-P misalignment

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7.4 Appendix 4: Misalignment evaluation

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