ABSTRACT

The Utility of the Passing Time
and Measurement of the Purchasing Power of Currencies
in the Flexible-Exchange-Rate System

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In economics, it is not the quantity that matters the most; it is the amount of utility. The purchasing power of a currency is not merely the volume of goods the money can obtain, but the amount of utility it can command. Primarily, money exchanges for some units of time spent laboring. As such, the ratio of the utility of time to the money wage should measure the purchasing power of the currency. This marginal utility of the time is the first derivative of the utility production function, derived from the compound interest equation, with respect to time. It follows that the purchasing power of the currency is dependent on both the rate of interest and the wage rate. This measure of purchasing power allows computation of a purchasing-power-parity exchange rate that truly reflects the fundamentals of the economy.

The Utility of the Passing Time
and Measurement of the Purchasing Power of Currencies
in The Flexible-Exchange-Rate System

by

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Approved by the Department of Economics

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ABBREVIATIONS

CAN$	*Canada dollar*
CPI	*Consumer price index*
EMS	*European Monetary System*
g-MP	*Good marginal product*
ICP	*International Comparison Program*
LOP	*Law of one price*
m-MP	*Money marginal product*
OECD	*Organization for Economic Co-operation and Development*
PPP	*Purchasing power parity*
PWT	*Penn World Table*
u-MP	*Utility marginal product*
US$	*United States dollar*

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<div align="right">Gilles-Eric Kotchi Seka</div>

To Ms. Yapi Florine Seka
And Mr. Pascal Kotchi Seka
My Mom and Dad

CHAPTER ONE

Introduction

By the end of the 1970s most economies had abandoned the gold standard and then the Bretton Woods system of fixed exchange rates, also known as the US dollar-standard exchange-rate system. A large majority adopted the floating rate regime commonly known as the flexible-exchange rate system. Contrary to the Bretton Woods system, where the relative values of currencies or their rates of exchange were fixed and determined by their respective pegs to the US dollar (whose own value was determined by its peg to the gold), currencies are believed to be unbacked in this new monetary order, with no intrinsic value. The rates of exchange between currencies are widely thought to be determined by the interplay of the laws of the demand and of the supply in foreign exchange markets.

In an increasingly global economy where diverse domestic economies are becoming more and more interdependent and integrated, large quantities of goods and services are easily moved from one border to another. But except for barter, before any goods or services are exchanged across borders, money must first be exchanged, converted from one denomination to another through the prevailing market rates of exchange. But market rates of exchange under the floating regime are often volatile and unpredictable. This volatility, exacerbated by currency speculation activities, has been blamed for frequent and recurrent world economic disturbances. It has also introduced economic agents to a new phenomenon known as foreign exchange risk exposure which, if not managed carefully or hedged against, could result in important losses. The ill

effects of this phenomenon have reinforced the status of foreign exchange rate as the most pivotal piece of information in international economics. Figuratively, a foreign exchange rate is to international economics what a domestic price is to a national economy, the established relation between two goods allowing them to be exchanged for one another. Accurate forecasting of foreign exchange rates has great importance in international economics because it will shield economic agents against foreign exchange risks that are growing larger and larger as economic activities increase.

The determination and forecasting of the exchange rate between currencies has always interested economists. Perhaps the first theory ever developed on the subject is known as the purchasing power parity theory, commonly abbreviated PPP. This relatively simple theory has dominated the science of international economics as the empirical model of reference in foreign exchange rate determination and forecasting since World War II. Its application was somewhat straightforward during the fixed rate regimes of the gold standard and of the Bretton Woods System. However, since the 1970s, economies with the floating rates have encountered large disparities between the exchange rates predicted by the PPP and the market exchange rates, leading to a radical reconsideration of how the determination of foreign exchange rates should be understood.

An exchange rate is nothing more than the price of one currency in terms of another, or their exchangeable value. Investigating the manner in which exchange rates should be understood is therefore investigating the manner in which the whole concept of value should be understood and determined. It is an investigation that ventures beyond the surface observable phenomena of production and distribution into the nature of the very thing that influences them.

This thesis is about foreign exchange rate determination and forecasting in the context of the floating rate regime. Since an exchange rate is the relative or exchangeable value of a currency, this thesis is consequently about value and its measurement. Here I am taking up this age-old and extensively discussed subject once more with the intent to positively and objectively contribute to our understanding of the phenomenon of value, of its measurement, precisely that of the currency, and of the determination of foreign exchange rates.

I am approaching the issue by asking a question that paraphrases that of Adolph Lowe:

> suppose that a universal amnesia were to wipe out the knowledge of all present prices, would there be a rule for reestablishing them? (Lowe 1981, 45)

In a similar sense this thesis starts by asking if there exists a rule for reestablishing all foreign exchange rates, should a universal amnesia wipe out all present knowledge of them. In other words, how can a foreign exchange rate be objectively established between the currencies of two countries that have never directly or indirectly traded before and for which no knowledge of past exchange rates exist?

The thesis is built around the following structure. In chapter two, a review of the literature presents in its first part the evolution of exchange rate determination theory from the PPP to contemporary models, and in its second part it addresses the dispute surrounding the measurement of utility because this concept is undoubtedly the source of all value. In chapter three, I present compelling reasons why price levels shouldn't be used as proxies for the purchasing power of currencies in the application of the PPP theory. I make a distinction between price and purchasing power. In chapter four, I argue that money is a good in the economy that is primarily exchanged for some units of

time. As such, there should be an equivalence between the utility of the unit of time and that of the money exchanging for it or its purchasing power. In chapter five, I show that the utility of the unit of time is in the aggregate equivalent to the utility of the entire labor force employed in the economy during this unit of time. And through a correspondence between labor and the principle of interest rate (time value) I derive a utility production function that allows measuring of the utility of the unit of time. In chapter six, based on the argument from the previous chapter, and with the tools of calculus and the theories of microeconomic analysis I derive a measure of the purchasing power of the currency and I propose an alternative method for the application of the theory of PPP that relies on the wage rate and the rate of interest. In chapter seven, the general conclusion provides reasons objective enough that seem to justify my approach in addressing the problem. And finally, in an appendix A, I use these results from chapter five to approximate the annual CAN$/US$ exchange rate from 1975 to 2005.

CHAPTER TWO

Review of Literature

Evolution of Exchange Rate Determination Theory

During the interwar period of the early twentieth century when the major industrial countries were looking for methods to reestablish the exchange rates between their respective currencies, restoring normal channels of trade disrupted by the conflict, they could have possibly asked themselves the same question this thesis is asking: is there any method for reestablishing the exchange rates between currencies?

During this same period, Gustav Cassel made the case for the century-old theory, giving to the PPP its authority and prestige in the field of international economics. In his argument, he wrote:

> Our willingness to pay a certain price for foreign money must ultimately and essentially be due to the fact that this money possesses a purchasing power as against commodities and services in that country. On the other hand, when we offer so and so much of our own money, we are actually offering a purchasing power as against commodities and services in our own country. Our valuation of a foreign currency in terms of our own, therefore, mainly depends on the relative purchasing power of the two currencies in their respective countries.(Cassel 1922, 138-139)

Ever since, the PPP became in the science of international economics the empirical model of reference in exchange rate approximation. The building block of the PPP has been and still is the law of one price (LOP) according to which, abstracting from transportation costs, insurance costs, taxes, tariffs, and other non-tariff barriers, the same goods should sell for the same price across countries once local currency denominated prices are converted into a common and single currency denomination. As such, the ratio of the

price levels as measured by the consumer price index (CPI) based on the household basket of goods and services should determine an approximation of the exchange rates between currencies.

Despite its simplicity, the PPP as the ratio of price levels was not without flaws. Already John Maynard Keynes highlighted issues with the PPP theory in the following terms:

> In practical applications of the doctrine there are, however, two further difficulties, which we have allowed so far to escape our attention,—both of them arising out of the words allowance being made for transport charges and imports and export taxes. The first difficulty is how to make allowance for such charges and taxes. The second difficulty is how to treat purchasing power of goods and service which do not enter into international trade at all….For, if we restrict ourselves to articles entering into international trade and make exact allowance for transport and tariff costs, we should find that the theory is always in accordance with the facts. (Keynes 1924, 89-92).

Large and persisting deviations of the PPP rate from the market rate have been observed. In an article published in 1996 Kenneth Rogoff provides an extensive account of the studies that have been undertaken on the PPP. The findings by various authors focusing on particular aspects of the issue are mentioned in this article. Concerning the law of one price, Rogoff pointed out that evidences were found that rejected the hypothesis of the law of one price. For instance analysis of disaggregated prices of tradable goods showed large and persisting deviations from the law of one price that reflected movements of nominal exchange rate. Furthermore, studies looking at export unit values from a single source found that the longer the distance form the exporting country the larger the volatility of price differential.

Concerning the divergence of the PPP support was found for the PPP on hyperinflation data but not on more stable monetary environments. In general these

studies arrived at a consensus that first, the PPP does not hold in the short run and that short run deviations from the market exchange rate are large and volatile; and second, that the PPP tends to hold and converge in the long run but that the speed of correction from short run deviation to long run convergence is actually very low. Furthermore, evidences for the long run convergence of the PPP remains however weak because the market exchange rate is believed to follow a random walk that this battery of tests has failed to disprove.

In his article Kenneth Rogoff also mentioned another group of economists that have demarked themselves by proposing modifications to the PPP. Balassa and Samuelson who distinguishing between tradable goods and non-tradable ones advanced the hypothesis according to which the persisting divergence of the PPP could systematically be the result of the difference in productivity between the tradable goods sector and the non-tradable goods sector. In their argument, price levels depend on the prices of both categories of goods; the prices of the tradable goods, being the same in both countries because of the law of one price and those of the non-tradable goods being different. They argue that high income countries have higher price levels than low income countries because they are relatively more productive in the tradable goods sector. They argued that in the case of the high income countries, the domestic prices of the tradable goods are tied down by the world prices as dictated by global competition. Therefore, as productivity increases in the tradable goods sector, wages in this sector are logically supposed to rise. However, because labor is mobile between sectors but not across borders, this increase of wages in the tradable goods sector has to be matched by an increase of wage in the non tradable goods sector in order for the producers in such

sector to retain their workers. This increase of wage across sectors will result in an increase in market prices and consequently in an increase in the overall price level in the high income countries.

However, the low income countries, with little increase of productivity in the tradable goods sector will have their overall price level low compared to those in their high income counterparts. As a result the PPP rate as the ratio of price level will overvalue the currencies of the low income countries relative to the currencies of the high income and vice versa.

Tests on the Balassa-Samuelsson model were also mentioned by Rogoff. Officer, one of the first to test the Balassa-Samuelson model found little support for it in data ranging from the 1950s to the 1970s. Engel decomposed variants of the real exchange rate into prices of tradable goods and prices of non-tradable goods. He has found that there is no convergence to the PPP even when one considers only tradable goods. A reason for this according to Obstfeld and Rogoff is that even tradable goods have large non-tradable components. And using data for the years 1979-1990 of the EMS countries, Froot and Rogoff found no significant effect for the difference in tradable goods sector growth differential across these countries. In general, studies find support for the Balassa-Samuelson model when comparing together only very poor countries or very rich ones (Rogoff 1996, 662).

Despite all the critics and all the evidences against it, the PPP has managed to survive and as for today is still of a great practical utility not only because of its important role in economic modeling but also because of its convenience in the international comparison of real income.

A more complex and more sophisticated method of price level measurement known as the International Comparison program (ICP) has been developed by the United Nations and has been used since the 1970s. The price level measurement uses the Penn World Table (PWT) data which presents price measures that are based on a common market basket of approximately 150 detailed categories of goods. Still, the ICP has limitations. Apart from the fact that it is very complex, data are gathered infrequently during benchmark surveys that are available only at five-year intervals starting from 1970. Also, not all countries are participating (160 countries in 2005), and for non-benchmark years and countries, data are filled in by extrapolation (Rogoff 1996, 651-52).

An important controversy surrounding the PPP is the use of the PPP exchange rate in the international comparison of real revenues of countries. The method has been criticized by the developing countries which argue that the PPP rate tends to overvalue their domestic currencies relative to the currencies of the rich countries and therefore to inflate their real income leading to a less accurate portrait of their economies (Gardner 1998, 30).

Eventually, alternative models of exchange rate determination were developed. While the PPP as a ratio of price levels focuses principally on the market of goods, the modern models emphasize the financial assets market. They are typically based on the assumption of perfect capital mobility between countries, providing for interest rate arbitrage through the covered interest rate parity principle. This covered interest rate parity basically relates the interest rate and the rate of exchange.

Among these modern models we distinguish the monetary approach and the portfolio-balance approach. The former assumes perfect substitutability of financial

assets internationally and the exchange rate between two currencies to be determined by the relative money supply and demand between the two countries; the latter on the other hand assumes imperfect substitutability between financial assets allowing the rate of exchange to be determined by both the relative bond supplies and demands and by relative money-market conditions.

Another important model in exchange rate economics is the Mundell-Fleming model, which in fact is an extension of the traditional IS-LM paradigm. The traditional IS-LM model by considering investment-saving equilibrium (IS) and the liquidity-preference-money-supply equilibrium (LM) was concerned only with an economy under autarky. To it, the Mundell-Fleming model adds the balance of payments (BP) condition under a small open economy. This model is more concerned with policy than determination of the rate of exchange.

Analysis of the rate of exchange remains by far the weakest link in microeconomics analysis. To date, alternatives to the PPP theory have fallen short in their predictions of the random walk of the market rate of exchange.

The PPP theory, which suggests that parity between the purchasing powers of currencies is the starting point for exchange rate determination, is logically coherent, so few have questioned its fundamental premise, despite all the compelling empirical evidence against it. Based on the law of one price, the PPP theory uses price levels as proxies for the utilities or the purchasing powers of currencies.

Value, it has been proven, comes from utility. It is logical then that the value of the currency comes from its utility or purchasing power. If the PPP exchange rate has a weak empirical foundation, we may conclude that price levels are not fit to serve as

proxies for the utilities of currencies. It all boils down to one issue: the best measurement of the purchasing power of the currency or that of its utility.

Utility Measurement

Since its introduction in economics, the measurement of utility has been puzzling economists, dividing them in two distinctive categories namely the proponents of the cardinal utility theory and those of the ordinal utility theory.

Proponents of the cardinal utility theory conceived utility as the satisfaction associated with the consumption of a good. This theory is based on the assumption that the consumer can provide an evaluation of the utility he will get in consuming any bundle of goods. The difficulty with such argument is that for a given product there will be as many measures of cardinal utility as there are humans, because there exists no standard of utility measurement.

Proponents of the ordinal utility opposed the idea of a cardinal utility. Instead, their theory suggests that the consumer can reasonably provide an order of his preference among goods based on the utility each can give him.

Another approach that demarks itself from the two previous ones is the expected utility theory proposed by economists such as Von Neumann and Oskar Morgenstern (1953, 15-31). This theory revived the idea of a cardinal utility in a sense that it also claims that utility can be absolutely measured. This theory however proposes a different approach. Its hypothesis is based on the assumption that individuals choose among alternatives that involve risk as if to maximize the expected utility. For each of these alternatives it is assigned a probability distribution.

The similarity shared by these theories of utility measurement is that they are all built around the individual who is supposed either to be able to evaluate the utility he receives in consuming a particular good or to be able to rank the goods to him available according to the utility each can provide. In their assumptions, the behavior of the individual is the main determinant of utility. Such argument seems to put aside the fact that the individual according to Jeremy Bentham (1948, 1) has been placed under the governance of two sovereign masters namely utility and disutility. Rather, it is these two sovereign masters that determine the behavior of the individual.

Bentham also mentioned that among dimensions to be considered when measuring utility or disutility are the duration and the intensity (Bentham 1948, 29). This argument was echoed by Jevons (1931, 49-51). But it is Walras who was the most insisting. He argued that utility is functionally related to time and because of such fact, time should figure explicitly in the problem, shifting the system from economic statics to economic dynamics (Walras 1954, 117).

CHAPTER THREE

PPP as the Ratio of Price Levels

Inconsistencies with Price Level as Proxy for the Purchasing Power

By calling for identical prices across borders for the same good once all domestic prices are converted into the same currency denomination, the law of one price has made the price levels the proxies for the purchasing power of the currencies in the practical application of the PPP theory. Mathematically, the law of one price is expressed as follows:

$$P = e.P^*$$ (3.1)

Where P and P^* are the price levels of the domestic and the foreign country respectively and e is supposedly the domestic to foreign currency exchange rate.

From the mathematical expression of the law of one price is derived the mathematical expression for the determination of the exchange rate:

$$e = \frac{P}{P^*}$$ (3.2)

The expression e becomes the factor that equalizes the two prices and is called the purchasing power parity rate or the PPP rate.

Figure3.1 displays the curves of the annual CAN$/US$ market exchange rate and the CAN$/US$ PPP rate using data spanning from 1975 to 2005. The data were collected from the World Development Indicator website provided by the World Bank. There is a great divergence between the PPP rate curve and that of the market exchange rate. The curve of the CAN$/US$ PPP rate cuts through the graph and does not follow the path of

the curve of the CAN\$/US\$ market exchange rate. This observation suggests little correlation between the PPP calculated as the ratio of price levels and the market exchange rate.
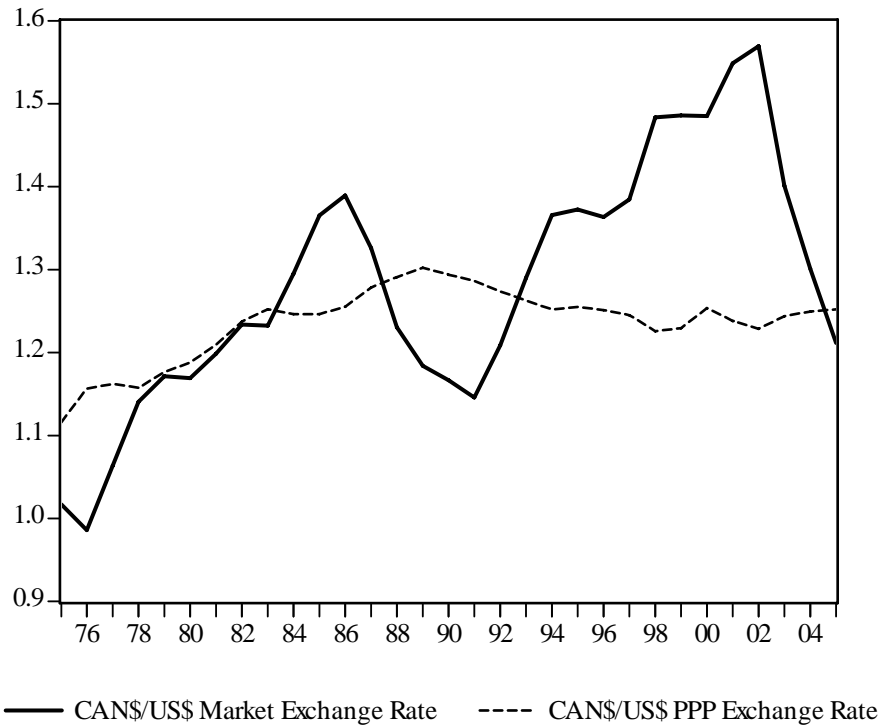
Figure 3.1. The CAN\$/US\$ Market Exchange Rate vs. the CAN\$/US\$ PPP Exchange Rate

There is a series of relationships to be considered in order to understand the logic behind the relationship between the exchange rate and the ratio of prices. Concerning the relationship between price and the purchasing power of the currency Irving Fisher writes:

> The purchasing power of money is indicated by the quantities of other goods which a given quantity of money will buy. The lower we find the price of goods, the larger the quantities that can be bought by the given amount of money, and therefore the higher the purchasing power of the money. The higher we find the price of goods, the smaller the quantities that can be bought by a given quantity of money, and therefore the lower the purchasing power of the money. In short, the purchasing power of money is the reciprocal of level of prices; so that the study of the purchasing power of money is identical with the study of the price level.(Fisher and Brown 1911, 13-14)

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The price level and the purchasing power of the currency are inversely correlated. Purchasing power of the currency and the rate of exchange are also inversely correlated. So logically, price and rate of exchange are positively correlated, this was to be expected because both are of the same nature; they are relative or exchangeable values whereas the purchasing power is a utility. Relative value and utility move in opposite directions. As the domestic price increases and the foreign price stays constant, the ratio of the domestic price to the foreign price increases, the domestic currency depreciates in value relative to the foreign currency; we can also say that the domestic currency becomes less useful than the foreign currency and the domestic-to-foreign currency exchange rate also increases. Because of these relations, the ratio of the domestic price to the foreign price meaning the PPP rate should increase or decrease with the market exchange rate. This relationship is not observed in the above graph between the curves of the CAN$/US$ market exchange rate and the CAN$/US$ PPP rate. The curve of the CAN$/US$ market exchange rate increases or decreases with the CAN$/US$ PPP rate. In the early 1975, the curve of the PPP rate increases while that of the market exchange rate decreases. In some periods of time common trends are observed, and in others opposite trends.

Many reasons have been proposed to explain the divergence between the market exchange rate and the PPP rate. The stickiness of prices is one of them. Indeed if prices are sticky, they do not react immediately to any loss of purchasing power by the currency. There will be a time delay between the moment when the currency loses some purchasing power and the moment when prices are adjusted to this loss. It is understandable that the domestic currency to the foreign currency exchange rate increases or decreases while the domestic price to foreign price ratio remains constant or decreases; what is probably a

matter of the sensitivity of the prices to the changes in the purchasing power of the currency.

The use of the price of tradable goods in computing the PPP rate does not solve the problem. The reason is simply that when a good is traded between the domestic and the foreign markets, its domestic currency denominated price has already been converted into a foreign currency denominated price using the prevailing foreign currency to domestic currency spot rate. It is therefore predictable in this situation that the domestic price to foreign price ratio yields a rate that is equal to the prevailing spot rate between these two currencies, providing all other related costs are ignored. But in this approach the market exchange rate is known in advance. It should be assumed from the very beginning that no prevailing exchange rate exists between the two currencies, meaning that the domestic and the foreign countries never had any exchange transaction before. Now that they are about to exchange goods with each other for the first time, how can an accurate exchange rate that truly reflects the fundamentals of their respective economies be determined?

A standardized basket of goods and services across countries might probably allow computing a ratio of prices that will converge with the market rate. Notwithstanding the impossibility of finding a truly representative basket of goods and services, there is another obstacle. The domestic currency denominated price of the domestically produced good reflects many external factors due to the interdependency of domestic economies.

The imported raw materials are paid domestic currency denominated prices that are foreign currency denominated prices converted using the domestic currency to

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foreign currency prevailing spot rates. These prices enter the costs of production and are part of the final domestic market price of this domestically produced good.

When entering the domestic market, the domestically produced good will face competition from imported competitors and substitutes. The domestic prices of these competitors and substitutes goods are their foreign currency denominated prices converted using the prevailing domestic to foreign currency spot rate. The final domestic market price of the domestically produced good will reflect these competitions because the domestic producer wants to remain price competitive in his home market.

The foreign currency denominated prices of the imported raw materials, those of the imported competitors and substitutes, each reflects the fundamentals of their respective economies of origin. Because these prices enter into the composition of the final domestic price of the domestically produced good, this price does not reflect only the fundamentals of the domestic economy, it also reflects fundamentals of all trading partner economies. The ratio of prices does not just reflect the fundamentals of the two economies considered, it also reflects fundamentals of all other economies that partner with them in trade.

Since the foreign currency denominated prices of the imported raw materials, and those of the imported competitors and substitutes are converted into domestic prices using the prevailing domestic to foreign currency spot rate, the domestic currency denominated price of the domestic good ends up being determined in part by the prevailing spot rate. We are left with the classical question of what in fact determines what; a problem of simultaneous causality that makes the price an unsuitable determining variable of currency exchange rate.

Distinction between Price and Purchasing Power

Should the ratio of price levels be called the purchasing power parity between two currencies? Answering this question requires that we use an appropriate example, namely the exchange rate itself.

The domestic to foreign exchange rate is expressed as the number of units of the domestic currency per unit of the foreign currency. From the point of view of the foreign economy, this is the expression of how many units of the domestic currency one unit of the foreign currency can buy; this is the purchasing power of the foreign currency in terms of the domestic currency. From the point of view of the domestic economy, this is the expression of how many units of the domestic currency are required to get one unit of the foreign currency; this is the price of the unit of the foreign currency in terms of the domestic currency. In the first case, we know the power of the unit of the foreign currency in purchasing some units of the domestic currency whereas in the second case we only know how many units of the domestic currency buy one unit of the foreign currency. Of course dividing the one unit of the foreign currency by the number of units of domestic currency required will give us the power of the unit of the domestic currency in buying the foreign currency, but this kind of operation is not possible in the goods market.

In the goods market, the price is the expression of how many units of the currency one unit of the good can generate. It can be thought of as the revenue power of the good. The purchased good cannot be fractionized per unit of currency; it is therefore impossible to find the purchasing power of the currency in terms of goods. Because the price is what allows the good to be purchased, the ratio of prices is more a purchasing price parity

rather than a purchasing power parity. When focusing on price, we focus on quantity, on

the number of units of money instead of the actual utility or the purchasing power of the

unit of money or in other words what actually the unit of money can accomplish.

CHAPTER FOUR

The Economy as a System of Voluntary Exchanges

The Human Experience and the Beginning of the Economy

As surprising as it might sound, by all accounts, humans originally were not made for labor for the satisfaction of their needs. Rather, they were made for a pleasurable life. In the Garden of Eden where they were originally placed, they could freely and continuously satisfy their needs with the abundance of natural resources that were produced in the Garden and this with absolutely no effort from their parts or in other words at no cost to them. Even though they were required to take care of the Garden, their survival or the satisfaction of their needs did not depend on that work.

An unfortunate turn of events forced humans out of the Garden of Eden into another land where the ground was cursed and natural resources were made scarce. The pain of humans was also multiplied and they were condemned to work all the days of their lives just to satisfy their needs; a life to which they were not accustomed.

Out of the Garden of Eden, the satisfaction of their needs was now to be done at the highest cost to humans; hence started the economy whose principal aim as in the words of Cournelle-Seneuil and Hearn, approvingly quoted by W.S. Jevons (1931, 41), "is to satisfy our wants with the least possible sum of labor." And the history of the development of human societies bears witness to this fact. All inventions, the industrial revolution, the technological and now the digital revolutions, all with no exception have the same and one objective: to make every day life easy for humans as they go about their various activities trying to satisfy their needs.

The dilemma in the system is that all humans are given roughly speaking the same needs to satisfy but, no human has absolute access to all the natural resources available. No human can successfully be self-sufficient and produce all goods he will ever desire for the satisfaction of his needs; hence the need for voluntary exchange which according to Adam Smith (1976) led to the division of labor. This voluntary exchange requires that each human at all times possesses something desired by others that can be used in the exchange. By nature, every human with no exception enters the system with a capital that is truly their own: his time. And it is time that is primarily used in the voluntary exchange.

The Essence of Voluntary Exchange

Voluntary exchange is the focus of human economic activity. The economy is a system or a network of countless voluntary exchanges in which the humans and their infinite number of needs, the commodities and the consumable goods are all active elements. The voluntary exchange is governed by a law requiring that each of the parties involved independently values what is being received more highly than he values what is being given away. But value as we have seen comes from the comparison of different utilities. So in this process of voluntary exchange, the parties are comparing the utility of the good they possess against the utility of the good possessed by the other party. For the exchange to be completed, each party must find better and stronger utility in the good of the opposing party than he finds in his own. Humans in this process exchange lower utility for higher ones. So in this economic system which is about exchange, humans are always in a quest for better and higher utility. It is therefore this quest that is the energy powering all exchange and consequently the economy. And it is safe to affirm that all

past and present progress and achievement ever made by humankind are due to this quest, and all future ones will also be due to this quest.

Money in the Economy

Money is often defined by the functions it plays in the economy: medium of exchange, store of value or even standard of account. Money in some cases is believed to state what exactly it is, "the legal tender for all debts, public and private;" but this in my opinion is simply its title, defining its authority. These diverse definitions of money consequently lead to some misunderstanding of what it is determines its value. Gary Shoup (1998, 18-19) argues that the value of money is "entirely determined by what the issuing governments say and do." But the government does not say how many goods and services the unit of money can by or how much debt private and public the unit of money can pay. Brown expressed the complexity of the issue concerning money as follows:

> We are accustomed to measuring the value of things in dollars. When asked the value of a dollar, we may need a moment's reflection to come up with several alternative commodities or with some representative packages. (Brown 1970, 175)

If we define the value or the purchasing power of the currency as the quantity of goods and service the money can buy, then there will be as many measures of the purchasing power of the same currency as there are goods and services exchangeable in the economy. Identifying the real nature of money, what the above definitions fail to do will give a starting point for how to measure its purchasing power.

Beyond all the possible definitions we can come up for it, money is simply a superior good that can be exchanged for all other goods in the economy. The price is a relation established between money and the produced goods. Should this relation be eliminated or nonexistent, no exchange will occur even with money remaining in the

system. The price is the means that allows money to play its role of medium of exchange, facilitating the exchange of goods and services. Likewise, the rate of exchange also a price is the mean that allows the money to play its role of medium of exchange that facilitates the exchange between currencies. But money even though a tangible good, enters the system in a very particular way.

Money as a Superior Good

In the system, money is a good that enjoys the status of medium of exchange because it has a relation established with all other produced goods and it can be exchanged for all of them. This is made possible because of the way money enters in the system.

When we pay for a particular good, the good itself does not receive the money; rather the economic agent, the laborer who produced the good does. The price, the relation between the good and the money is in fact a relation between the money and what the economic agent has given away when laboring. The activity of labor is also a voluntary exchange in which the economic agent gives away part of his primary wealth, his time in exchange for some units of money. When laboring the economic agent does not give away himself or his skills, rather he gives away part of his time and he receives some units of money. Money then enters in the system because it is primarily exchanged for the time of the economic agent. And money can be exchanged for all other goods in the system because by giving away his time, the economic agent produces these goods.

In all modern economies, money is paid according to some measures of time: per hour, per month and so forth. As the unit of time increases, the quantity of money paid out also increases. The total number of units of money then paid is a function of time and

of the number of laborers. The laborers produce some consumable goods and they are paid a real wage that is equivalent to their respective marginal physical products in terms of goods. Time on the other hand can be assumed to produce money and should be paid a marginal product in terms of money. But the activity of production of the laborer occurring within the limits of time, the marginal product of the laborer in terms of goods is equivalent to the marginal product of the unit of time in terms of money multiplied by the number of units of time spent laboring; this is the nominal wage of the laborer. This is where money as a tangible good gets its superiority among all other tangible goods. Primarily, time is paid the equivalence of its marginal product in terms of money. Money primarily then exchanges for or purchases some units of time; that's how it enters the system and determining the utility of time will allow measuring the utility or the purchasing power of the money.

CHAPTER FIVE

Aggregate Utility Production

Fundamental Value vs. Relative/Exchangeable Value

Even though value comes from utility, the process though which it is established will determine whether it is a fundamental value or a relative or exchangeable value also known as the price. On the subject of value, Knut Wicksell argued that:

> obviously, objects have value for us only in virtue of their utility, that is to say, because of the enjoyment and satisfaction which they give us, or , and this is fundamentally the same, because of the pain and discomfort from which they free us. (Wicksell 1954, 33)

Goods, money and labor included, do not have value; they only possess some utility. And this utility according to Wicksell is defined as the capability of the good to free humans from pain or discomfort; broadly speaking the utility of a particular item is what this particular item can accomplish or can contribute to the overall satisfaction of the human. It is this utility or the ability to satisfy human needs that confers to a particular good some value. A human need is disutility; it can also be thought of as expected utility or utility deficit. By nature, humans prefer or value utility more than disutility. So, a particular good will have some value only and only if for its utility there corresponds a particular human need or disutility. This is the fundamental value of the good that arises from the comparison of its utility to the disutility or the need felt by the human or in other words from the comparison of the utility of the good to the utility expected by the human. Fundamental value differs from relative value because the former does not permit voluntary exchange of goods whereas the latter does. In the context of voluntary

exchange where one good is exchanged for another one, the price of one good in terms of the other or their exchangeable or relative value arises when the utility of one is compared to that of the other. It follows from this argument that value is purely a relative concept. Any good has a fundamental value when its utility is measured against the need or the expected utility of the economic agent. And any two goods get their exchangeable value when their respective utilities are measured one against the other. Again, Knut Wicksell pointed out this fact when he wrote:

> everyday we compare different utilities with one another and weight their reciprocal magnitudes against each other. (Wicksell 1954, 45)

It is therefore this comparison of utilities that determines the relative value or price of one good in terms of another. The good with the greatest utility, the one that possesses the strongest capability to satisfy human needs will be valued more highly than the one with the lowest utility; and consequently the good with the greatest utility per unit will end up having a higher price per unit in terms of the one with the lowest utility, meaning that one unit of the former will exchange for more than one unit of the latter and vice versa.

Factors of Utility Production

Labor produces goods which have utility. It is therefore logical to suggest that labor is not a creator of objects merely, but of utility. Beyond the physical goods that are produced, we should see the utility they provide. Labor can then be seen as a factor of utility production. Once produced by the labor, the produced good becomes a working capital that possesses some utility of its own that is different from the utility of the labor that produced it in the first place. Every good, labor and money included create utility

and as such, they are factor of utility production. They are consequently paid their marginal product in terms of utility which is also their fundamental value. In conclusion, with regard to the fact that labor and all other goods possess some utility and are creators of more utility we can safely admit that utility creates more utility.

The Production of Additional Utility

Utility being defined as what an item can do, any item in the state of nature possesses some utility; any item in the state of nature can do something or can be used for something. Only items that possess some utility can produce additional utility, in other words, if an item does not possess some utility it cannot provide some. An item can provide or produce more utility only when it or to some extent its utility is consumed. When the economic agent is working, the utility of his labor is consumed by the employer and it is only then that he is producing additional utility. If the economic agent is not working, the utility of his labor is not consumed and he is not producing additional utility.

When a particular good is demanded or consumed, its utility has found a suitable match among the infinite number of human needs. This particular good ends up having some value to the human consumer. The need felt by the human can be thought of a utility deficit that the utility of the good replaces. But for the good to be able to satisfy the human need, it has to be working meaning that it has to do what it is it has been created for. It follows from this that the working economic agent and the working good are all in some way laborers, each working to do what it is they have been created for, providing some utility. The term labor here mentioned and all through the document does not refer just to human beings. Human beings are not the only one working in the

system and producing utility; non human beings or objects also in order to provide some utility and satisfy human needs have to function or to work. If the good that has been created does not work, it will not provide any utility. Because of this fact, labor is a broad term that includes both the labor of human being and that of non human beings. Because the economic agent and the good each possess some utility, it is the utility of their respective labor that produces additional utility. The system is designed in such a way that the utility of the human labor is the initial one.

If, then, we assume a total utility function that depends on a certain number of factors of production, the partial derivatives of this function with respect to each factor measure their respective marginal product in terms of utility, the thing that is actually produced. These partial derivatives are to some extent measures of the marginal utility of each factor and they determine the value attached to each of them. If then any existing thing possesses some utility and has to work or its utility has to be consumed in order for it to create additional utility, time being an existing thing, it possesses some utility and through its passing, its utility is consumed and in the process creates additional utility. Because the passing of time is continuous, its production of utility is also continuous. Because nothing or no human can stop its forward movement, the utility of time is always consumed whether the economic agent is working or not.

Within the unit of time, it is an entire labor force constituted of human laborers and goods that are working and creating additional utility. And within this unit of time each is paid his marginal product in terms of utility. It is the aggregate sum of all these marginal products in terms of utility that measures the utility of the unit of time within

which the labor is performed. Time therefore gets its own utility from the utility of the

entire labor force that performed within it.

Utility Production Derived from the Principle of Interest Rate

The main factor that is directly associated to the passing of time in economics is

the rate of interest. Its main application is to determine the future sum of money that has

been invested or put to work in the present. This relation is expressed as:

$$\text{Future Principal} = \text{Present principal} \cdot (1+i)^n \qquad (5.1)$$

with future and present principal being the future and the present sum of money, i the per

period rate of interest, n the number of compounding per period of investment time.

Equation 5.1 suggests that the sum of money that is not spent but rather put to

work during a given period of time is supposed to grow to a larger sum. But the rate of

interest should not be just applicable to money. On such subject, Irving Fisher has

argued that:

> the rate of interest is not a phenomenon restricted to money markets, but is
> omnipresent in economic relations. (Fisher 1907, vii)

The concept or principles of the rate of interest is applicable to everything. The term

principal can refer to anything that is put to work. Interest is in fact a natural

phenomenon. Suppose a farmer possesses only one corn seed that he sows into a fertile

soil instead of consuming it. Pretty soon, this corn seed will germinate to become a corn

plant. Over time this corn plant will bear corn ears with numerous of corn kernels. So

just one corn seed would have produced over time numerous corn kernels. Here, the

initial or present principal is the one corn seed that is put to work, sown into a fertile soil.

After a given period of time, this corn seed yields the future principal that is made of

numerous corn kernels. The rate of growth or of return can be found by dividing the numerous corn kernels by the one corn seed. If the produced corn kernels instead of being consumed are turned into corn seeds and in turn sown again into the fertile soil, over time they will produced even more corn kernels. And if the process is carried on further, from only one corn seed countless of corn kernels will be produced. The rate of interest is therefore a natural phenomenon that suggests that anything that is put to work over time should grow in the case of a positive rate of interest or should decay in the case of a negative one. Here we are more interested in the positive rate of interest.

Irving Fisher made another important argument:

When a man lends $100 this year in order to obtain $104 next year, he is really sacrificing not one hundred dollars in money, but one hundred dollars' worth of goods such as food, clothing, books, or pleasure trips, in order to obtain next year not one hundred and four dollars in money, but one hundred and four dollars' worth of other goods he desires. (Fisher 1907, 77)

So then when an individual is lending some money, he is forgoing the present utility he could get from the goods he could afford with this present sum of money for higher future utility he will be able to afford with the future sum of money. Beyond money, we should see the goods that can be afforded and beyond the goods we should see the utility they can provide. The term principal can therefore be substituted for by the term utility so that equation 5.1 becomes:

$$\text{Future Utility} = \text{Present Utility} \cdot (1+i)^n \qquad (5.2)$$

Utility Production Derived from the Concept of Labor

Time is the only item each economic agent possesses, a temporal capital that he can invest either in utility or in disutility. When time is invested in utility, the economic agent is consumer of utility. When time is invested in disutility, he is laborer, producer of

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utility. Only utility invested produces additional utility over time. A utility is invested when it is consumed. The greater the utility invested, the larger the additional utility created over time. The laborer is the starting point of utility creation; the utility of his labor is the initial investment which over time produces additional utilities. Adam Smith (1976, 48) referred to it as "the first price, the original purchase-money that was paid for all things."

Let us assume an empty system with a total utility amounting to zero. As soon as an economic agent is introduced into the system, the total amount of utility in the system increases to u_l the measure of the utility of his labor, because anything that exists possesses some utility and as a living being, the economic agent can contribute to the advancement or improvement of the system. When this economic agent engages himself in a particular labor, he invests the utility u_l of his labor that over time produces good that also possesses some utility u_g. But the utility u_l of the labor is not lost, it still exists because the economic agent is still living and can still work. So accounting for the total utility U_T in the system after one unit of time of labor, the total utility is the sum of the utility of the labor and the utility of the produced good expresses as follows:

$$U_T = u_l + u_g \tag{5.3}$$

When dividing the utility of the good by the utility of the labor:

$$\frac{u_g}{u_l} = \alpha \tag{5.4}$$

we get an hypothetical number α which measures the number of times the utility of the produced good is compared to the utility of the labor. Solving for the utility of the good we get:

$$u_g = \alpha \cdot u_l \tag{5.5}$$

Replacing the utility of the produced good in the total utility equation we get:

$$U_T = u_l + \alpha \cdot u_l$$

$$\tag{5.6}$$

$$U_T = u_l \cdot (1 + \alpha)$$

Once created into the system, the produced good can in turn provide some utility. It can do so only if it works, in other words only if it does what it is it has been created for. The produced good becomes also a factor of utility production causing the total amount of utility to be invested in future time to increase: to the initial utility of the labor is now added the utility of the produced good.

At t_0 when the economic agent is not working, the total utility U_T^0 in the system is equal to the utility of the labor of the economic agent so that:

$$U_T^0 = u_l \tag{5.7}$$

At t_1 when the economic agent has performed some labor and created a good, the total utility U_T^1 is the sum of these two utilities so that:

$$U_T^1 = u_l + u_g \tag{5.8}$$

we have seen that this can also be expressed as:

$$U_T^1 = u_l \cdot (1 + \alpha) \tag{5.9}$$

At t_2 as the process continues, the amount of utility invested in the system is U_T^1 which over time produces additional utilities u_g^2 so that the new total utility U_T^2 in the system becomes:

$$U_T^2 = U_T^1 + u_g^2 \tag{5.10}$$

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From the ratio $\dfrac{u_g^2}{U_T^1}$ we get a hypothetical number β so that $u_g^2 = \beta \cdot U_T^1$. The total utility

in t_2 becomes:

$$U_T^2 = U_T^1 + \beta \cdot U_T^1$$

$$U_T^2 = U_T^1 \cdot (1 + \beta)$$

(5.11)

Substituting U_T^1 by its value from t_1, the equation becomes:

$$U_T^2 = u_l \cdot (1 + \alpha) \cdot (1 + \beta) \tag{5.12}$$

Assuming $\alpha \approx \beta$ then the total utility at t_2 becomes:

$$U_T^2 = u_l \cdot (1 + \alpha) \cdot (1 + \alpha)$$

$$U_T^2 = u_l \cdot (1 + \alpha)^2$$

(5.13)

So at an indefinite number of time t, the total utility U_T in the system is:

$$U_T^t = u_l \cdot (1 + \alpha)^t \tag{5.14}$$

The Essence of Labor and Utility Production Function

The laborer and time cannot be dissociated from one another. Time without the laborer cannot produce any utility; likewise, the laborer without time cannot produce any utility. The same way we cannot disassociate time from the interest rate; interest rate without time and time without interest rate is not productive. This equivalence is suggestive of a relation between the labor and the rate of interest that I shall present in the following.

The basic principle of the concept of interest suggests that any economic agent who forgoes his utility for a specific period of time should be rewarded according to the

rate of interest. The economic system is consumer of utility and it rewards any utility to it provided. When a particular economic agent forgoes his utility, this utility is consumed by the rest of the system which rewards him by giving him back the same utility but in larger amount than that that was forgone earlier. But this utility forgone or invested by the economic agent cannot be rewarded or cannot have any value if for the rest of the system it does not work over the given period of time; in other words if this utility forgone does not satisfy any need. The present principal invested cannot increase to the future principal if this present principal is not working or in other words if the entire system does not see in it any value.

The economic agent when engaging himself in a particular labor, when spending his time working, he is according to Brown (1970, 178) giving up the activities he would have preferred to be engaging himself in for some activities he does not prefer. In other words he is choosing to invest his time in activities that he does not prefer rather than investing it in the ones he prefers. The activities the economic agent prefers provide him with some utility whereas the ones he does not prefer provide him with some disutility.

It follows from this that when laboring, the economic agent is forgoing some utility; but when forgoing some utility, the economic agent should be rewarded by the rest of the system according to the rate of interest. In laboring, the utility of the labor is the initial investment; in forgoing some utility over time, time is the factor that produces additional utility. Labor is therefore time in size. The function of the total utility in the economy is therefore expressed as:

$$U_T^t = u_l \cdot (1+\alpha)^t \qquad (5.15)$$

In every unit of time of labor, it is an entire labor force that is working; labor force that includes both humans and non humans. Every unit of time of labor produces some additional utility; this additional utility is the aggregate measure of the additional utility produced by all members of the labor force. Every unit of time of labor is also paid some units of money (to the entire labor force). This number of units of money paid for the unit of time of labor is therefore equivalent to the total amount of additional utility produced by the entire labor force during the same unit of time of labor. This equivalence will allow us to measure the purchasing power of currencies and consequently to estimate exchange rates through the application of the purchasing power theory. The issue now is how we go about measuring the utility of the unit of time of labor; it is an issue that is addressed in the next chapter.

CHAPTER SIX

Microeconomics Approach to Foreign Exchange Rate Estimation

The Natural Factor of Production

Every human and everything in the system is subjected to the passing of time.

Neither human nor anything has any control over the passing of time. In all observable

phenomena, time is the natural variable. In the particular case of the economy, time is

the ultimate natural and universal resource and the scarcest of all. How much is done

within the unit of time is what makes the difference between economic performances.

Time in the economy is also the natural factor of production. Even though the scarcest

natural resource of all, due to the fact that all humans are equally endowed with it

(twenty-four hours per day), time can be increased by increasing the number of humans.

Brown argues that:

> Even in the case of a man employing a hundred men in a factory, we can think of
> them, if not as literally multiplying the time at his disposal, at any rate as making
> his time the equivalent of 100 men's or him [the employer] the equivalent of 100
> men….Though he cannot get more time, in the time he has he can accomplish
> what he would otherwise take a 100 lives to do. (Brown 1970, 178-79)

Therefore in one hour if there are n laborers performing, it is actually n hours of labor and

each n-hour has to be compensated separately with the equivalent of its marginal product.

In our modern monetary system, when one hour of time is spent in labor,

simultaneously a good or service is produced, some units of money are paid out as a

wage but above all some additional utility is created. The time is a factor that is common

to the production of goods and services, the production of money, and the production of

utility. Because time is a variable common to the production function of goods and

service, to the production of money, and to the production of utility, we can establish some equivalence between its different marginal products derived from each production function.

The economy has a utility production function that is dependent on the number of laborers and the number of units of time and on the rate of interest. The derivative of the utility production function with respect to time will give the ratio of the change in total utility to the change in time which can also be interpreted as the contribution of the unit of time to the total utility produced, its marginal product in terms of utility or its fundamental value. This marginal product of the time expressed in terms of utility is equal to its marginal product in terms of physical consumable goods and to its marginal product in terms of money. The first equivalence measures the fundamental value of the produced good whereas the second measures that of the currency or its purchasing power. Bellow I consider the production of each of these elements separately.

The Production of Goods

The good-production function depends as explained above on the number of laborers performing and the number of units of time. This function can therefore be expressed as:

$$G = f(l;t) \tag{6.1}$$

With l and t being respectively the number of laborers and the number of units of time.

From this good-production function, the marginal physical product of time that I will call the good-marginal product of time (g-MP) can be computed as the derivative of the good-production function with respect to the variable time t :

$$\text{g-MP} = \frac{\partial f(l;t)}{\partial t} \qquad\qquad (6.2)$$

This good-marginal product is the total real wage paid out for the unit of time. It is the total real wage paid out to the entire labor force employed during the unit of time. It expresses how much is produced within each standardized period of time by the entire labor force.

The Production of Money

In any modern economy, the supply of money is regulated by the central bank. Let us assume that it does so in response to the demand for printed money, expressed in the number of units of time employed and worked in the economy.

Any laborer who performs in the economy will expect to be paid in local currency. The private economy, we assume, must borrow this sum of money at a specified rate of interest from the central bank. Because all laborers in the economy are paid in local currency units, all the market prices of the produced goods are expressed in local currency units. Employers and consumers all need to get some units of money denominated in local currency units in order to pay for the labor and for the produced goods. The market prices of the produced goods are expressed in local currency unit simply because the labor that produced all of them was paid a price denominated in local currency unit.

If, by any chance, all the laborers performing in the economy suddenly decided not to accept payment in local currency denominated monies, all market prices would not be expressed in local currency unit, employers and consumers would need something other than the local currency unit to pay for labor and for the produced goods; the

economy would have no reason to borrow some from the central bank. The demand for the local currency denominated money would fall and so would its value. With no demand to respond to, the central bank would have no reason to print more of the local currency denominated money.

As we can see the central bank is simply the structure that prints the money but this money is produced by the number of units of time employed and worked in the economy. As such, the fundamental value of the local currency should depend on the fundamental value of the unit of time.

The unit of time is paid a money wage based on the wage rate determined by law or by contract. The money-production function is linear and depends on both the number of laborers performing and the number of units of time. The money-production function of the economy can therefore be expressed as:

$$M(l;t) = m \cdot l \cdot t \tag{6.3}$$

With M, m, l, and t being respectively the total quantity of local money in circulation in the economy, the money hourly wage rate of the labor, the number of laborers employed, and the number of units of time.

The derivative of the money-production function with respect to the variable time t is the money-marginal product (m-MP) of the unit of time.

$$\text{m-MP} = \frac{\partial M(l;t)}{\partial t}$$

$$\text{m-MP} = \frac{\partial(m \cdot l \cdot t)}{\partial t} \tag{6.4}$$

$$\text{m-MP} = m \cdot l$$

As we can see, the money-marginal product of the unit of time is the hourly wage rate multiplied by the number of laborers employed. It is also the money price or wage of the unit of time. This indicates how many units of money is paid out to all the laborers that have performed during this unit of time; it is the total number of units of money infused in the economy as the result of one unit of time spent laboring.

<p align="center">*The Production of Utility*</p>

The compounding interest equation of money over time suggests that:

$$\text{Future Principal} = \text{Present Principal} \cdot (1+i)^t \qquad (6.5)$$

When dividing both sides by the hourly wage m, this equation becomes function of the total labor that each of these principal sums of money can command. The expression becomes:

$$\frac{\text{Future Principal}}{m} = \frac{\text{Present Principal}}{m} \cdot (1+i)^t$$

$$\qquad (6.6)$$

$$\text{FutureTotal Labor} = \text{PresentTotal Labor} \cdot (1+i)^t$$

But total labor when measured in unit of time is equal to the total number l of laborers multiplied by the total number t of time so that:

$$\text{Total Labor} = l \cdot t \qquad (6.7)$$

Substituting total labor in the above equation gives us:

$$[\text{Future } l \cdot t] = [\text{Present } l \cdot t] \cdot (1+i)^t \qquad (6.8)$$

Because we consider here the utility of the variable time t, it can therefore be substituted for by its utility. For the purpose of the calculus involved, we will make the substitution only on the left hand side of the equation so that:

$$\text{Future Utility} = l \cdot \text{t} \cdot (1+i)^{\text{t}} \tag{6.9}$$

We can therefore express the utility-production function U of the economy as:

$$U(l, \text{t}, i) = l \cdot \text{t} \cdot (1+i)^{\text{t}} \tag{6.10}$$

Because the unit of time is the hour of labor, and the rate of interest is expressed in a per annum basis, t becomes large and we can assume continuous compounding. The utility-production function of the economy can therefore be expressed as:

$$U(l, \text{t}, i) = l \cdot \text{t} \cdot e^{i \cdot \text{t}} \tag{6.11}$$

According to this expression, utility production grows linearly depending on the number of laborers performing and on the number of units of time and simultaneously it grows exponentially depending on the number of units of time.

The utility-marginal product (u-MP) of the variable time is:

$$\text{u-MP} = \frac{\partial U(l; \text{t})}{\partial \text{t}}$$

$$\text{u-MP} = \frac{\partial [l \cdot \text{t} \cdot e^{i \cdot \text{t}}]}{\partial \text{t}}$$

$$\text{u-MP} = l \cdot \frac{\partial [\text{t} \cdot e^{i \cdot \text{t}}]}{\partial \text{t}}$$

$$\text{u-MP} = l \cdot [e^{i \cdot \text{t}} + \text{t} \cdot (i \cdot e^{i \cdot \text{t}})] \tag{6.12}$$

$$\text{u-MP} = l \cdot (e^{i \cdot \text{t}} + i \cdot \text{t} \cdot e^{i \cdot \text{t}})$$

$$\text{u-MP} = l \cdot [e^{i \cdot \text{t}} (1 + i \cdot \text{t})]$$

The expression indicates how much utility is produced in each unit of time by all the laborers performing.

Measurement of Fundamental Values

The utility marginal product u-MP of the variable time is equal to its price which is also the wage paid for it. This wage as seen earlier can be a real wage therefore it is the good marginal product g-MP of time or it can be a nominal wage in such case it is its money marginal product m-MP.

When the unit of time is paid a real wage equal to its good marginal product g-MP, we simply equate its utility marginal product u-MP with its good marginal product g-MP so that:

$$\text{g-MP} = \text{u-MP}$$

$$\text{g-MP} = l \cdot [e^{i \cdot t}(1 + i \cdot t)] \tag{6.13}$$

$$\frac{l \cdot [e^{i \cdot t}(1 + i \cdot t)]}{\text{g-MP}} = 1$$

When the unit of time is paid a nominal wage, we equate its utility marginal product u-MP with its money marginal product m-MP so that:

$$\text{u-MP} = \text{m-MP}$$

$$l \cdot [e^{i \cdot t}(1 + i \cdot t)] = m \cdot l$$

$$\frac{l \cdot [e^{i \cdot t}(1 + i \cdot t)]}{m \cdot l} = 1 \tag{6.14}$$

$$\frac{e^{i \cdot t}(1 + i \cdot t)}{m} = 1$$

These ratios measure the total utility produced in the unit of time by the entire labor force per unit of goods produced in the same period by the same labor force, whether this

produced item is an ordinary consumable good or some money. These ratios express respectively the fundamental value of the produced good and that of the currency. They are function of the number of units of time and of the rate of interest. These fundamental values increase as the rate of interest increases and they decrease as it is cut.

The Money Price of the Produced Good

To find the money price of the produced good, we simply equate the good marginal product g-MP of the labor-time with its money marginal product m-MP. The same result is achieved when equating the fundamental value of the currency to that of the produced good.

$$g\text{-MP} = m\text{-MP}$$

$$g\text{-MP} = m \cdot l \tag{6.15}$$

$$\frac{m \cdot l}{g\text{-MP}} = 1$$

This equation is the expression of the total money wage paid to or produced by the entire labor force during the unit of time per unit of good produced during the same unit of time by the same entire labor force. Since the good marginal product g-MP of the variable time and its money marginal product m-MP are both function of the number of laborers, this variable will cancel out leaving what is the break even money price of the good as a function of the level of the wage rate of the unit of time.

Variation of the Money Price of the Produced Goods

Any variation in rate of interest affects the fundamental value of the produced goods, that of money, and that of the variable time. The money price of the produced

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goods goes up and down depending on whether the interest rate is raised or cut; this occurs because of a time delay.

When the rate of interest is changed this change automatically affects the fundamental value of time and that of the money. However, the fundamental value of the goods that have been produced before the change and that are still being sold in the market is dependent on the old rate of interest. Because of this difference in fundamental values, the money price of these produced goods will be affected. This can be illustrated using the fundamental value ratios.

Let's assume that at time t_0 the prevailing rate of interest is i_0. Equating the fundamental values of the produced good and that of the currency will give:

$$\frac{l \cdot [e^{i_0 \cdot t_0}(1+i_0 \cdot t_0)]}{\text{g-MP}} = \frac{e^{i_0 \cdot t_0}(1+i_0 \cdot t_0)}{m}$$

(6.18)

$$\frac{m}{\text{g-MP}} = \frac{e^{i_0 \cdot t_0}(1+i_0 \cdot t_0)}{l \cdot e^{i_0 \cdot t_0}(1+i_0 \cdot t_0)} = 1$$

This is equal to one because the rate of interest is the same for both the fundamental value of the currency and that of the produced goods. There is an equilibrium that suggests that the quantity of money paid out for the unit of time is equal to the quantity of goods produced in the sane unit of time.

If at t_1 the rate of interest changes say it is increased, the fundamental value of the goods produced before the change is still dependent on i_0 whereas that of the money is now dependent on i_1 (with $i_1 > i_0$). So the above ratio is now greater than one:

$$\frac{e^{i_1 \cdot t_1}(1+i_1 \cdot t_1)}{l \cdot e^{i_0 \cdot t_0}(1+i_0 \cdot t_0)} > 1$$

$$(6.19)$$

$$\frac{m}{\text{g-MP}} > 1$$

The equilibrium is no longer respected. For it to be reestablished, the quantity of goods, the denominator has to be increased. Assuming the first in first out system or first produced first sold is applied in the economy, the same amount of money (*m* is constant over time) will exchange for greater number of units of the produced good. As interest rate is increased, the purchasing power of the currency also is increased. However, the parity will be restored over time as the goods produced under the old interest rate are sold and progressively replaced by the ones produced under the new rate of interest. The new price of the same good will end up being higher compared to the old one. And the reverse will occur as the rate of interest is cut.

Applied Microeconomic Analysis to Exchange Rate Determination

The utility production function of the economy has been expressed as:

$$\text{U}(l, t, i) = l \cdot t \cdot e^{i \cdot t} \qquad (6.20)$$

This simplistic function assumes that the economy considered is self-sufficient or an autarky economy that produces all the goods and services it needs and does not buy any good or service from another economy. In reality there is no such economy. Economies depend on each other for raw materials, for finished goods, for capital, and even for cheap labor whether skilled or unskilled. When a particular domestic economy imports something from a foreign economy, the former is getting some utility from the latter and

is relying on units of time that are not its own and whose utility or fundamental value is measured by the foreign rate of interest.

Overall, the total number of units of time supporting the utility production of the domestic economy originates from two sources, one domestic and the other foreign. The utility production function of the domestic economy is therefore dependent on units of time both domestic and foreign and on rates of interest also both domestic and foreign. The utility production function for a trading economy can therefore be expressed as:

$$U(t, l, i, t^*, l^*, i^*) = (l \cdot t \cdot e^{i \cdot t}) + (l^* \cdot t^* \cdot e^{i^* \cdot t^*}) \tag{6.21}$$

With l, t and i being respectively the domestic number of laborers, time and the rate of interest and l^*, t^*, and i^* those of the foreign economy; l^* and t^* are the foreign number of laborer and units of time that entered into the production of foreign goods and services imported by the domestic economy.

The domestic time is paid a money wage rate of m and the foreign time is paid a money wage rate of m^*, each denominated in local currency unit. The domestic economy which relies on both sources of time is constrained by its budget. It has to pay for these two types of time but it cannot spend more than the total quantity M of domestic currency denominated money in circulation in the system. The domestic budget constraint can be expressed as:

$$M(t; l; t^*; l^*; S) = m \cdot l \cdot t + S \cdot m^* \cdot l^* \cdot t^* \tag{6.22}$$

with S being the prevailing domestic to foreign rate of exchange.

The LaGrange function for this domestic economy is:

$$L = U(t; l; i; t^*; l^*; i^*) + \lambda(M - m \cdot l \cdot t - S \cdot m^* \cdot l^* \cdot t^*)$$

(6.23)

$$L = (l \cdot t \cdot e^{i \cdot t}) + (l^* \cdot t^* \cdot e^{i^* \cdot t^*}) + \lambda(M - m \cdot l \cdot t - S \cdot m^* \cdot l^* \cdot t^*)$$

Taking the partial derivative of the LaGrange function with respect to the domestic time we get:

$$\frac{\partial L}{\partial t} = l \cdot [e^{i \cdot t}(1 + i \cdot t)] - \lambda \cdot m \cdot l = 0$$

(6.24)

$$l \cdot [e^{i \cdot t}(1 + i \cdot t)] = \lambda \cdot m \cdot l$$

Simplifying the l in both sides we get:

$$e^{i \cdot t}(1 + i \cdot t) = \lambda \cdot m$$

(6.25)

When we divide both sides by m we get the formula of the fundamental value of the currency as expressed earlier:

$$\frac{e^{i \cdot t}(1 + i \cdot t)}{m} = \lambda$$

(6.26)

Through the same process we find that:

$$e^{i^* \cdot t^*}(1 + i^* \cdot t^*) = \lambda \cdot S \cdot m^*$$

(6.27)

The marginal rate of technical substitution of t for t^* requires that:

$$\frac{e^{i \cdot t}(1 + i \cdot t)}{e^{i^* \cdot t^*}(1 + i^* \cdot t^*)} = \frac{\lambda \cdot m}{\lambda \cdot S \cdot m^*}$$

(6.28)

$$\frac{e^{i \cdot t}(1 + i \cdot t)}{e^{i^* \cdot t^*}(1 + i^* \cdot t^*)} = \frac{m}{S \cdot m^*}$$

And solving for S the domestic to foreign currency rate of exchange, we get:

$$S \cdot \frac{e^{i \cdot t}(1 + i \cdot t)}{e^{i^* \cdot t^*}(1 + i^* \cdot t^*)} = \frac{m}{m^*}$$

$$S = \frac{m \cdot e^{i^* \cdot t^*}(1 + i^* \cdot t^*)}{m^* \cdot e^{i \cdot t}(1 + i \cdot t)}$$

(6.29)

The number of units of domestic time and that of foreign time in reality might be different. However, for standardization and comparison purpose we set all times, domestic and foreign equal to the unit so that the domestic to foreign currency rate of exchange can be expressed as:

$$S = \frac{m \cdot e^{i^*}(1 + i^*)}{m^* \cdot e^{i}(1 + i)}$$

(6.30)

As expressed above, holding everything constant in the foreign country, the domestic to foreign currency exchange rate S will rise, meaning that the domestic currency will depreciate in value relative to the foreign currency if the domestic labor hourly wage rate m rises with no improvement in productivity, meaning that no additional utility is created. The same depreciation of the domestic currency relative to the foreign currency will occur if the domestic rate of interest i is cut. The reverse will occur whenever the foreign labor hourly wage rate m^* is increased without any improvement in productivity or when the foreign rate of interest i^* is cut, providing everything in the domestic country stays constant. In case where the domestic currency is pegged to the foreign currency, every change in the foreign hourly wage and/or in the foreign rate of interest will be matched by the same kinds of changes in the domestic economy in order to maintain the peg.

This approach offers many advantages compared to the approach of price levels ratio. First, it does not use price levels as proxies for the purchasing power of the currency. Rather the purchasing power of the currency is calculated using the rate of interest and the wage rate, two important determining fundamentals of any economic system. Second, by not using the price levels this approach solves the simultaneous causality that exists between the price levels and the rate of exchange. The rate of interest and the wage rate are both determining variables of prices; and the rate of exchange being itself price, they also determine the rate of exchange without being determined by it. Third, this approach is built upon the commodity of time. In doing so it solves the problems that have been plaguing the law of one price and the ratio of price levels approach. Time, being naturally universal and standardized, is free from any transportation, insurance, or other related costs, and escapes all barriers to free trade.

CHAPTER SEVEN

General Conclusion

In economics it is not the quantity that matters the most, it is the amount of utility. The definition of the purchasing power of the currency as the quantity of goods the money can command suggests that there are as many measures of the purchasing power of the same currency as there are goods it can exchange for in a particular economy. Considering that all goods possess some utility, the argument can be made that, beyond the diverse physical goods it can command, money in fact can command some utility. Measuring its purchasing power is therefore measuring the amount of utility it can command. This shifts the definition of the purchasing power of the currency from the number of goods and services to the amount of utility the money can command. The subjective nature of utility however suggests also that there are as many measures of utility as there are humans and goods. This difficulty of the measure of the amount of utility the money can exchange for can be overcome if we can identify what the money primarily exchanges for.

Adam Smith (1981, 47-48) made clear that the real price we pay for any good is equivalent to the quantity of labor that was required in producing it and that we can spare for ourselves. He identified labor measured in unit of time as the original price that was paid for everything else. It is because the unit of labor is first exchanged for some units of money that all good produced by it are also exchanged for some units of money. Money ends up being a superior good in the economy because it is primarily exchanged for some unit of time spent laboring. It follows form this that behind the observable

phenomena of production, distribution and voluntary exchange of goods and services, we ultimately are trading time. Time as a natural resource is very particular in a sense that it bears singular characteristics.

Time is the most precious and most valuable resource of all. It is also the scarcest of all, but its quantity is nevertheless fixed and known. Everyday, all humans are equally and freely given the same twenty-four hours to invest in whatever activities they choose. No human works to produce it. No human at the end of the day can say that he was able to save n hours so that he will have $24 + n$ hours tomorrow. Likewise, no human can say that he was short of n hours today so he has to borrow them from his next day temporal capital leaving him with only $24 - n$ hours for tomorrow. No matter the nature and number of activities engaged in during the day, at the end all twenty-four hours are spent and are renewed during the following day. This was true before and during the time of Adam Smith, it is true now, and it will be true for eternity. It is also true everywhere on earth. In time, all humans everywhere and all time are equally endowed. The dilemma is that humans need more than twenty-four hours a day to satisfy their infinite number of wants. But time cannot be created, it cannot be saved, it cannot be lost, it is always spent or incested and it can only be traded. How much of this time is invested in labor and how much is accomplished or how much utility is produced within the number of hours invested in labor is what makes the difference between prosperous economies and poor ones.

Time is a standardized and a universal commodity that plays a crucial role in economic activities. Everything else is produced or harvested through human effort except time. Everything is contained within time and is subject to its continuous passing.

Because goods are produced within the boundaries of time, the utility of the unit of time divided by the number of goods produced in the same unit of time will measure their respective fundamental value. Because the unit of time is paid some units of money, the ratio of the utility of the unit of time to the number of units of money paid as wage will measure the fundamental value or the purchasing power of the currency.

The measuring of the utility of the passing time is possible given the principle of interest rate according to which anything invested should grow over time or that any amount of utility forgone over a certain period of time should be rewarded. The derivative of the compound interest function with respect to the variable time measures its marginal product which is what the unit of time can do, in other words its utility. Because labor is some amount of utility invested over time, and because the laborer forgoes some utility for a certain period of time, the same principle of interest rate should be applicable. Because the unit of labor is equivalent to the unit of time, and because the two cannot be dissociated one from the other, the marginal product of the unit of labor, its value or wage should be equivalent to that of the unit of time, namely, the compound interest.

Among economists, Irving Fisher is the one who most explicitly suggested a relation between the wage of the labor and the compound interest. He argued that:

> the capitalists of to-day, are receiving compound interest on the labor of yesterday. (Fisher 1907, 40)

The laborer naturally is the sole proprietor of his labor, therefore that of its fruit, the produced good. This good which is also the real wage of the laborer is produced after a certain elapse of time. When the laborer accepts some amount of money as a nominal wage from the capitalist, he enters into a voluntary exchange in which he gives away the

fruit of his time spent laboring. The capitalist receives the produced good which, as suggested by Irving Fisher is the compound interest on the labor expended in producing the good. Because the produced good is received in exchange for some money wage, the wage of the labor is therefore equivalent to the compound interest on the expended labor. In the aggregate, in one unit of time it is the entire labor force that is working and expending some utility. The labor force comprises not only the economic agents but also all other goods that are consumed. If this labor force is taken out of the system, time alone will produce no additional utility. So time in the aggregate is the entire labor force; the interest is the measure of the additional utility created by the unit of time which is equivalent to the additional utility created by the entire labor force. As for the rate of interest itself, it is simply the ratio of the amount of the additional utility created in the economy to the total amount of the utility invested or put to work initially, in other words, it is the ratio of the amount of additional utility produced to the amount of initial utility that has been used to produce it. This can be shown as follows using the compound interest equation and considering just one period of compounding.

$$\text{Future Utility} = \text{Present Utility} \cdot (1+i)$$

$$\frac{\text{Future Utility}}{\text{Present Utility}} = (1+i)$$

$$\frac{\text{Future Utility}}{\text{Present Utility}} - 1 = i$$

$$\frac{\text{Future Utility-Present Utility}}{\text{Present Utility}} = i \tag{7.1}$$

But Future Utility-Present Utility = Additional Utility and Present Utility is the initial utility put to work or invested. This leaves us with the following ratio:

$$\frac{\text{Additional Utility}}{\text{Initial Utility}} = i$$

(7.2)

An economy that is slowing down is characterized by a decreasing productivity of its labor force; the entire labor force is not producing enough for its size. This situation can be translated to an initial amount of utility invested or forgone that does not produce satisfying amounts of additional utility over time. As the additional utility falls and the initial utility stays constant or increases, the ratio of the additional utility to the initial utility invested decreases and as the conventional wisdom tells us the rate of interest has to be cut. When the economy is growing, the labor force is highly productive. The additional utility created is growing larger that the initial utility invested. The ratio is therefore increasing and the rate of interest has to be raised.

There is probably another reason behind the cutting and the raising of the rate of interest other than speeding up or slowing down the growth of the economy. Cutting the rate of interest is to devalue the additional utility created relative to the initial utility invested. And an increased interest rate is an appreciation in value of the additional utility created relative to the initial utility invested.

If then, in the economy no one and nothing is working, no additional utility is produced and the rate of interest has to be set equal to zero. The marginal product of time, its utility, is equivalent to the marginal product of the entire labor force employed within it; because the latter is paid some units of money as nominal wage equivalent to its marginal product, then the utility of time is equal to the nominal wage of the labor. This equality leads to the determination of the fundamental value or the purchasing power of

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the currency. This measure of the purchasing power is not the number of units of time but some amount of the utility of time the money can command. In determining the exchange rate between currencies, it suffices to set equal their respective purchasing power as measured in the previous chapter and as suggested by the purchasing power parity.

The distinctive characteristic of the present monetary order is the prime role of time as a universal and standardized commodity which was not taken into account in the previous systems and models. The gold standard and the Bretton Woods systems broke down mainly because they were built upon gold, a commodity whose production depended on human effort. As for the flexible-exchange rate system, it is built whether intentionally or not upon time, a commodity whose production is totally independent from human effort. In adopting in the 1970s the flexible-exchange rate system, economies were switching from the US dollar-standard system of exchange rate to the utility-standard system of exchange rate. And the floating currency contrary to the popular conception is not unbacked. Rather, it is backed neither by the law nor by faith nor by any government but by the utility of time. This utility in the aggregate is the measure of the marginal product or the productivity of the entire economy. By productivity I do not mean simply the number of units of good produced but also the utility, the usefulness of both the economic agents and all produced goods within the system.

APPENDICES

APPENDIX A

The CAN$ to US$ Annual Exchange Rate between 1975 and 2005

According to the formula 6.30 derived in chapter six, the random walk of the domestic to foreign exchange rate can be explained using the following formula:

$$S = \frac{m \cdot e^{i^*}(1+i^*)}{m^* \cdot e^i(1+i)}$$

with m and i being respectively the labor wage and the rate of interest of the domestic economy and likewise, m^* and i^* being those of the foreign economy.

In testing this formula I intended to explain the random walk of the annual Canadian dollar to the U.S. dollar exchange rate between 1975 and 2005, namely since theses two countries have adopted the floating rate system and since the PPP exchange rates started being calculated.

The data used in this study are annual data from 1975 to 2005. For consistency purposes, data were gathered from the same source. All data about wages, both for Canada and for the US were gathered from the U.S. Bureau of Labor website. All rates of interest were gathered from the Bank of Canada website. In this study, the particular rate of interest used is the bank rate, the one charged by banks for loans. The wage rate used is the hourly direct pay for production workers in manufacturing.

Judging by the scatter plot in figures A.1 and in figure A.2 there seems to be a better correlation between the CAN$/US$ market exchange rate and the CAN$/US$ estimated exchange rate than there is between the CAN$/US$ market exchange rate the CAN$/US$ official PPP exchange rate.
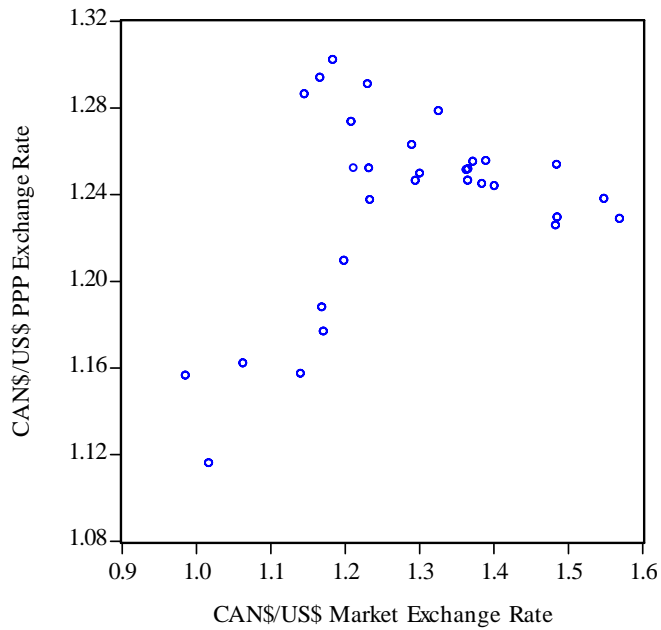
Figure A.1. Scatter Plot of the CAN$/US$ Market Exchange Rate vs. the CAN$/US$ PPP Exchange Rate
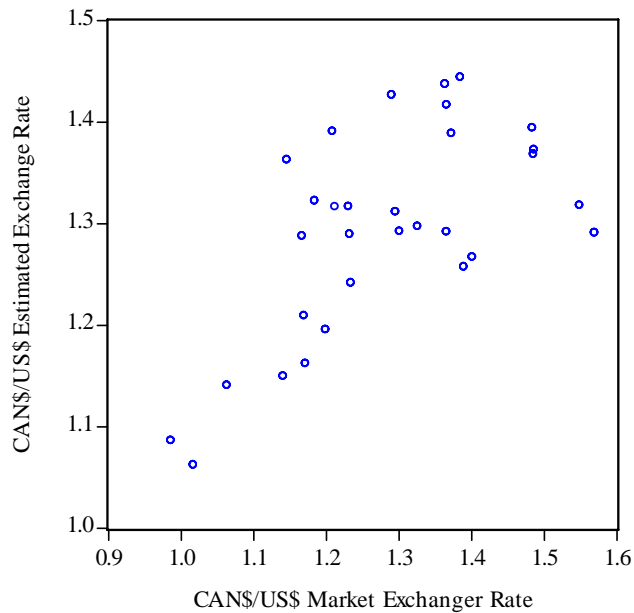
Figure A.2. Scatter Plot of the CAN$/US$ Market Exchange Rate vs. the CAN$/US$ Estimated Exchange rate

The curve of the CAN$/US$ exchange rate calculated using the above formula is graphed against the curve of the CAN$/US$ market exchange rate (Figure A.3.) as shown bellow:
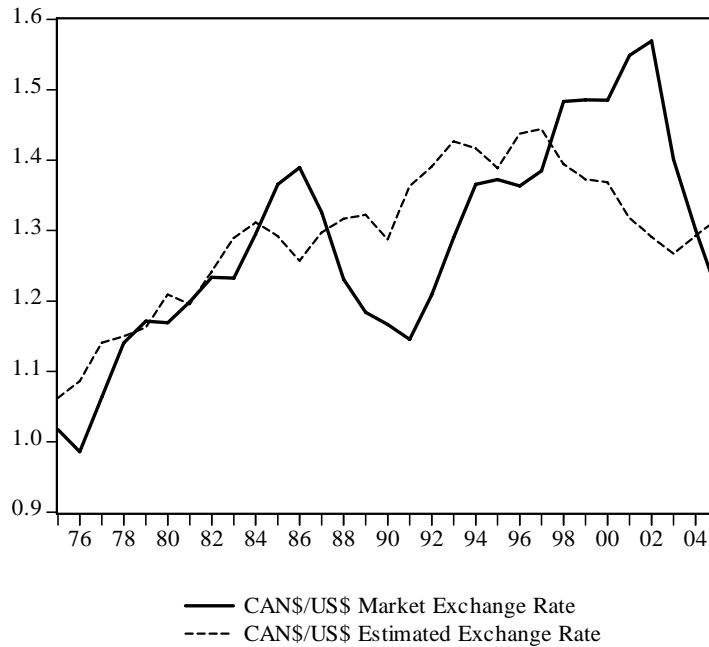
Figure A.3. CAN$/US$ Market Exchange Rate vs. CAN$/US$ Estimated Exchange Rate

For comparison purpose, the graph of the curve of the CAN$/US$ official PPP exchange rate (ratio of price levels) against the curve of the CAN$/US$ market exchange rate is also provided (Figure A.4.).
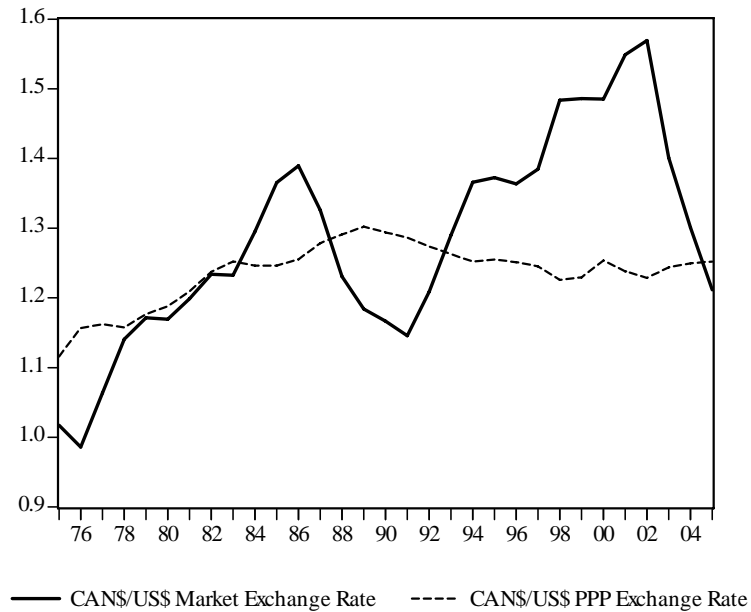
Figure A.4. CAN$/US$ Market Exchange Rate vs. CAN$/US$ PPP Exchange Rate

Comparison of these two figures shows that the curve of the CAN$/US$ estimated rate of exchange seems to follow the path of the curve of the CAN$/US$ market rate of exchange more closely than does the curve of the CAN$/US$ official PPP rate.

I have run two heteroskedasticity-robust (Newly-West) ordinary least squares regressions with the CAN$/US$ market exchange rate as the dependent variable. In regression one, the CAN$/US$ PPP exchange rate is used as the independent variable whereas in regression two, the CAN$/US$ estimated exchange rate is used as the independent variable. The results of the two regressions are compared one against the other in the following table.

Table A.1. Comparative results of regression 1 and regression 2

Independent variables	1	2
Intercept	-0.383114	0.059114
	(1.109511)	(0.278541)
PPP	1.348437*	
	(0.902290)	
Estimated Exchange Rate		0.94628**
		(0.226235)
R-Squared	0.162036	0.411223
Adjusted R-Squared	0.133141	0.390920
N	31	31

Standard errors are given in parenthesis. The individual coefficient is statistically significant at the
***10% level, *5% level and **1% level.

The intercepts in both regressions are not statistically significant. The coefficients of the independent variables are statistically significant; that of the CAN$/US$ PPP rate at 5% whereas that of the CAN$/US$ estimated exchange rate at 1%. When comparing both the R-Squared and the adjusted R-Squared for both regressions we notice that the

CAN$/US$ PPP rate as the ratio of prices explains just 16% of the actual CAN$/US$ market exchange rate whereas the CAN$/US$ estimated exchange rate explains a little over 40% of the same CAN$/US$ market exchange rate.

There is no immediate reaction of the economy to any change in rate of interest and/or in hourly wage rate. A rate of interest and/or a wage rate changed today will have some effects in the future. Because of this shift in time, in figure A.5.a, b, and c the curve of the CAN$/US$ estimated exchange rate has been shifted respectively one, two, and three years ahead to the right.

The more the curve of the CAN$/US$ estimated exchange rate is shifted to the right, the closer it seems to follow the path of the curve of the CAN$/US$ market exchange rate. This suggests that all economies have probably a speed of reaction or adaptation to any change in interest rate and in wage rate. How fast economies adjust to these changes probably influences the rate of exchange between their currencies.

CAN$/US$ Market Exchange Rate
---- CAN$/US$ Estimated Exchange Rate Shifted One Year Forward
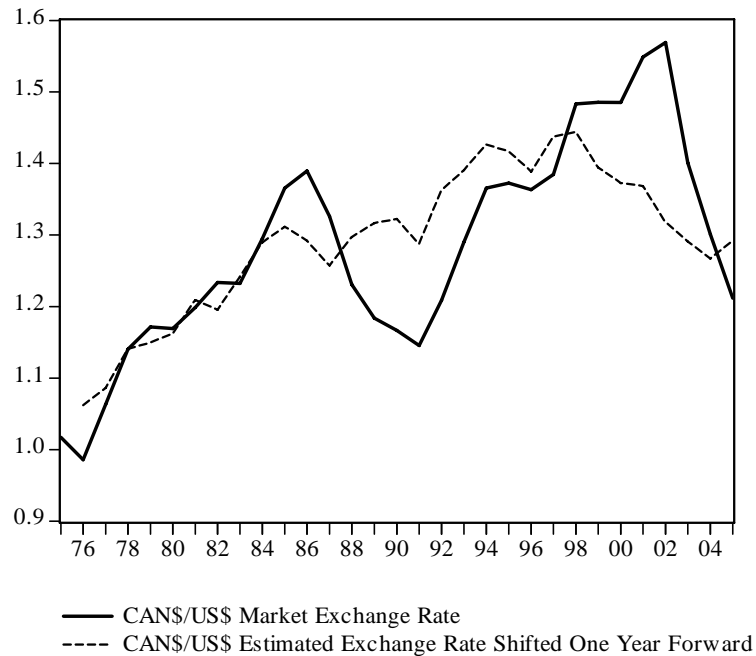
Figure A.5.a. CAN$/US$ Market Exchange Rate vs. CAN$/US$ Estimated Exchange
Rate Shifted One Year Forward
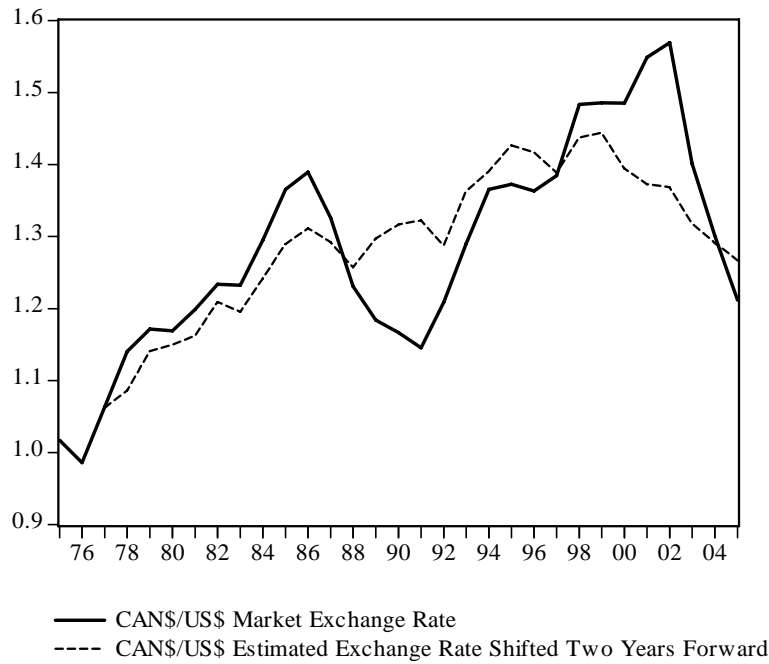
Figure A.5.b. CAN$/US$ Market Exchange Rate vs. CAN$/US$ Estimated Exchange Rate Shifted Two Years Forward
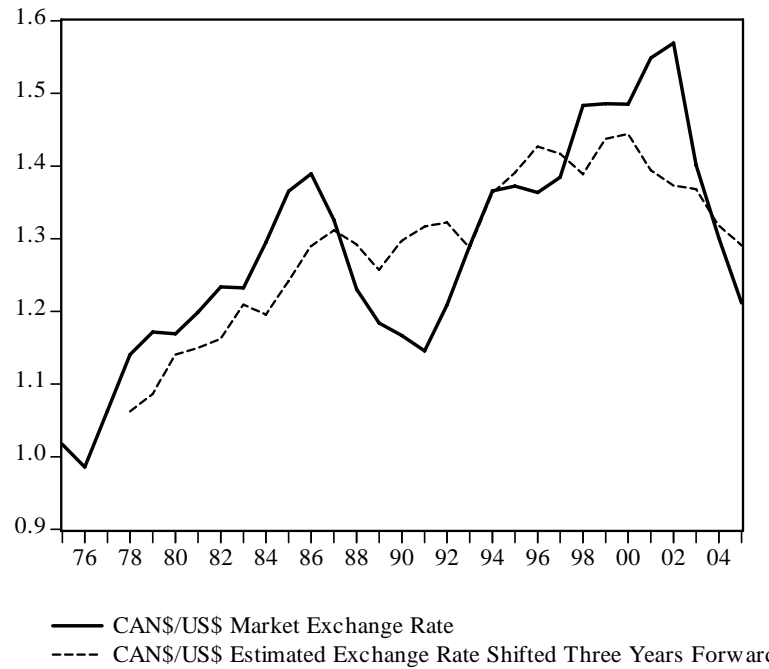
Figure A.5.c. CAN$/US$ Market Exchange Rate vs. CAN$/US$ Estimated Exchange Rate Shifted Three Years Forward

The divergence observed between the curve of the CAN$/US$ estimated exchange rate and the curve of the CAN$/US$ market exchange rate could be the result of various facts.

First in this study, the wage data used is the hourly direct pay for production workers in manufacturing. In the past twenty years the economy of the United States and that of Canada have been shifting from manufacturing to service. This shift from manufacturing economy to service economy has for corollary the shrinking of the employment share of the manufacturing sector in these two economies. The wage data therefore reflect smaller and smaller portion of total labor wage. Second, the model assumed that the United States and Canada have exclusive trade relations between one another excluding all other countries which in reality also are trading with these two countries. A more comprehensive analysis would include variables from all trading partners and the wage data should be the average hourly wage that includes all sectors of each economy.

APPENDIX B

Data

Table B.1. Canada Bank Rate

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
1975	8.25	8.25	8.25	8.25	8.25	8.25	8.25	8.25	9	9	9	9	**8.5**
1976	9	9	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9	8.5	**9.2916667**
1977	8.5	8	8	8	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	**7.7083333**
1978	7.5	7.5	8	8.5	8.5	8.5	9	9	9.5	10.25	10.75	10.75	**8.9791667**
1979	11.25	11.25	11.25	11.25	11.25	11.25	11.75	11.75	12.25	14	14	14	**12.104167**
1980	14	14	14.79	15.67	11.83	10.67	10.18	10.45	11.02	11.76	13.06	17.26	**12.890833**
1981	17	17.14	16.59	17.4	19.06	19.07	19.89	21.03	19.63	18.3	15.4	14.66	**17.930833**
1982	14.72	14.74	15.11	15.32	15.32	16.58	15.6	14.26	13.18	11.53	10.87	10.26	**13.9575**
1983	9.81	9.43	9.42	9.46	9.38	9.42	9.51	9.57	9.52	9.45	9.63	10.04	**9.5533333**
1984	9.98	10.04	10.76	10.82	11.6	11.98	13.24	12.39	12.28	11.71	10.78	10.16	**11.311667**
1985	9.66	10.95	11.18	9.75	9.59	9.57	9.31	9.2	9.31	8.77	8.98	9.49	**9.6466667**
1986	10.33	11.84	10.44	9.27	8.43	8.84	8.63	8.58	8.63	8.62	8.47	8.49	**9.2141667**
1987	7.74	7.59	7.14	8.26	8.54	8.59	8.76	9.24	9.57	8.26	8.48	8.66	**8.4025**
1988	8.63	8.58	8.78	9.06	9.12	9.44	9.53	10.03	10.54	10.51	10.84	11.17	**9.6858333**
1989	11.54	11.7	12.4	12.61	12.4	12.31	12.32	12.4	12.47	12.43	12.47	12.47	**12.293333**
1990	12.29	13.25	13.38	13.77	14.05	13.9	13.59	13.01	12.61	12.66	12.25	11.78	**13.045**
1991	10.88	10.02	9.92	9.66	9.07	8.91	8.94	8.8	8.68	8.17	7.69	7.67	**9.0341667**
1992	7.08	7.56	7.65	6.85	6.5	5.91	5.5	5.11	5.69	7.37	8.82	7.36	**6.7833333**
1993	6.81	6.09	5.36	5.6	5.1	4.79	4.41	4.9	4.9	4.63	4.36	4.11	**5.0883333**
1994	3.88	4.1	5.64	6.07	6.31	6.92	6.04	5.6	5.54	5.62	6.04	7.43	**5.7658333**
1995	8.38	8.38	8.47	8.17	7.64	6.97	6.87	6.59	6.71	7.65	6.07	5.79	**7.3075**
1996	5.37	5.5	5.25	5	5	5	4.75	4.25	4.25	3.5	3.25	3.25	**4.5308333**
1997	3.25	3.25	3.25	3.25	3.25	3.25	3.5	3.5	3.5	3.75	4	4.5	**3.5208333**
1998	4.5	5	5	5	5	5	5	5	5.75	5.5	5.25	5.25	**5.1041667**
1999	5.25	5.25	5	5	4.75	4.75	4.75	4.75	4.75	4.75	5	5	**4.9166667**
2000	5	5.25	5.5	5.5	6	6	6	6	6	6	6	6	**5.7708333**
2001	5.75	5.75	5.25	5	4.75	4.75	4.5	4.25	3.75	3	2.5	2.5	**4.3125**
2002	2.25	2.25	2.25	2.5	2.5	2.75	3	3	3	3	3	3	**2.7083333**
2003	3	3	3.25	3.5	3.5	3.5	3.25	3.25	3	3	3	3	**3.1875**
2004	2.75	2.75	2.5	2.25	2.25	2.25	2.25	2.25	2.5	2.75	2.75	2.75	**2.5**
2005	2.75	2.75	2.75	2.75	2.75	2.75	2.75	2.75	3	3.25	3.25	3.5	**2.9166667**

Pdf document source: http://www.bankofcanada.ca/pdf/annual_page1_page2.pdf
Source: Bank of Canada (http://www.bank-banque-canada.ca/en/rates/sel_hist.html)
Average calculated by the author.

Table B.2. US Prime Rate Charged by Banks

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
1975	9.5	8.5	7.5	7.5	7.25	7	7.5	7.75	8	7.75	7.5	7.25	**7.75**
1976	6.75	6.75	6.75	6.75	6.75	7.25	7.25	7	7	6.75	6.5	6.25	**6.8125**
1977	6.25	6.25	6.25	6.25	6.5	6.75	6.75	7	7.25	7.75	7.75	7.75	**6.875**
1978	8	8	8	8	8.5	8.75	9	9	9.5	10	11.5	11.75	**9.1666667**
1979	11.75	11.75	11.75	11.75	11.75	11.5	11.5	12.25	13.25	15	15.75	15.25	**12.770833**
1980	15.25	16.38	19	19.5	14.5	12	11	11.5	12.5	14.5	17.75	21.5	**15.448333**
1981	20	19	17.5	17.5	20.5	20	20.5	20.5	19.5	18	16	15.75	**18.729167**
1982	15.75	16.5	16.5	16.5	16.5	16.5	16	13.5	13.5	12	11.5	11.5	**14.6875**
1983	11	11	10.5	10.5	10.5	10.5	10.5	11	11	11	11	11	**10.791667**
1984	11	11	11.5	12	12.5	13	13	13	13	12	11.25	10.75	**12**
1985	10.5	10.5	10.5	10.5	10	9.5	9.5	9.5	9.5	9.5	9.5	9.5	**9.875**
1986	9.5	9.5	9	8.5	8.5	8.5	8	7.5	7.5	7.5	7.5	7.5	**8.25**
1987	7.5	7.5	7.5	7.75	8.25	8.25	8.25	8.25	8.75	9	8.75	8.75	**8.2083333**
1988	8.75	8.5	8.5	8.5	9	9	9.5	10	10	10	10.5	10.5	**9.3958333**
1989	10.5	11	11.5	11.5	11.5	11	11	10.5	10.5	10.5	10.5	10.5	**10.875**
1990	10	10	10	10	10	10	10	10	10	10	10	10	**10**
1991	9.5	9	9	9	8.5	8.5	8.5	8.5	8	8	7.5	6.5	**8.375**
1992	6.5	6.5	6.5	6.5	6.5	6.5	6	6	6	6	6	6	**6.25**
1993	6	6	6	6	6	6	6	6	6	6	6	6	**6**
1994	6	6	6.25	6.75	7.25	7.25	7.25	7.75	7.75	7.75	8.5	8.5	**7.25**
1995	8.5	9	9	9	9	9	8.75	8.75	8.75	8.75	8.75	8.5	**8.8125**
1996	8.5	8.25	8.25	8.25	8.25	8.25	8.25	8.25	8.25	8.25	8.25	8.25	**8.2708333**
1997	8.25	8.25	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	**8.4583333**
1998	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.25	8	7.75	7.75	**8.3125**
1999	7.75	7.75	7.75	7.75	7.75	7.75	8	8.25	8.25	8.25	8.5	8.5	**8.0208333**
2000	8.5	8.75	9	9	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	**9.2708333**
2001	9	8.5	8	7.5	7	7	6.75	6.5	6	5.5	5	4.75	**6.7916667**
2002	4.75	4.75	4.75	4.75	4.75	4.75	4.75	4.75	4.75	4.75	4.25	4.25	**4.6666667**
2003	4.25	4.25	4.25	4.25	4.25	4.25	4	4	4	4	4	4	**4.125**
2004	4	4	4	4	4	4	4.25	4.5	4.75	4.75	5	5.25	**4.375**
2005	5.25	5.5	5.75	5.75	6	6	6.25	6.5	6.75	6.75	7	7.25	**6.2291667**

Pdf document source: http://www.bankofcanada.ca/pdf/annual_page66_page67.pdf
Source: Bank of Canada (http://www.bank-banque-canada.ca/en/rates/sel_hist.html)
Average calculated by the author.

Table B.3. Hourly Direct Pay in National Currency for Production Workers in Manufacturing

Year	US	CAN
1975	5.16	5.66
1976	5.58	6.45
1977	6.1	7.18
1978	6.64	7.71
1979	7.21	8.4
1980	7.84	9.27
1981	8.61	10.4
1982	9.18	11.64
1983	9.5	12.34
1984	9.87	12.96
1985	10.24	13.41
1986	10.5	13.79
1987	10.72	14.26
1988	10.95	14.82
1989	11.26	15.6
1990	11.8	16.41
1991	12.24	17.19
1992	12.49	17.79
1993	12.78	18.21
1994	13.16	18.51
1995	13.56	18.77
1996	14.05	19.35
1997	14.42	19.46
1998	14.73	19.87
1999	15.12	20.13
2000	15.69	20.66
2001	16.24	21
2002	16.86	21.57
2003	17.37	22.25
2004	17.81	22.85
2005	18.32	23.28

Source: U.S. Department of Labor, Bureau of Labor Statistics (http://www.bls.gov/)
Document source: ftp://ftp.bls.gov/pub/special.requests/ForeignLabor/ichccpwsuppt08.txt

Table B.4. CAN$/US$ Market Exchange Rate and PPP Rate

Year	CAN$/US$	PPP
1975	1.0171583	1.115985068
1976	0.986025	1.156311228
1977	1.06345	1.162070639
1978	1.140675	1.157292183
1979	1.171425	1.176636419
1980	1.1692167	1.187828983
1981	1.1989083	1.209340384
1982	1.2337333	1.237369204
1983	1.2324167	1.251986244
1984	1.2950667	1.246232873
1985	1.3654833	1.246335395
1986	1.3895	1.255413454
1987	1.3259917	1.278403843
1988	1.2307083	1.290805847
1989	1.1839917	1.302051533
1990	1.166775	1.293815182
1991	1.1457167	1.286260952
1992	1.208725	1.273514547
1993	1.2900742	1.262763351
1994	1.3656383	1.251627378
1995	1.3724408	1.255066976
1996	1.3634683	1.251188258
1997	1.3846167	1.24490032
1998	1.4834631	1.225650616
1999	1.4857317	1.229350807
2000	1.48511	1.253597801
2001	1.5487608	1.237947024
2002	1.5693183	1.228728523
2003	1.4010517	1.243841312
2004	1.3010192	1.249593386
2005	1.2117633	1.252060886

Source: World Bank World Development Indicator
PPP: Purchasing power parity conversion factor (LCU per international $)

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