Purchasing power parity theory economics essay

Economics

Originated by Cassel (1918), Purchasing power parity (PPP) is considered as one of thefoundations of exchange rate behavior. 1. DefinitionThe theory is based on the simple idea of the law of one price which states that in thepresence of a competitive market, the absence of transport costs and other barriers to trade, arbitrage will lead to the same goods having the same price in different markets. The law isbased on the idea of perfect goods arbitrage which occurs where economic agents figure outthe differences so as to provide a riskless profit. Springing from this law, the PPP doctrine states that a relationship between exchange rateand prices holds between pairs of countries. It comes in two forms: absolute PPP andrelative PPP. The absolute PPP which relies strictly on the law of one price implies that the equilibriumexchange rate between two national currencies equals the ratio between the domestic andforeign price level. Algebraically, it can be expressed as: S =(1)Where S is the exchange rate defined as domestic currency units per unit of foreigncurrency, P and P* are the domestic price level and foreign price level respectively. According to this version of the hypothesis, a fall in the domestic price level in comparisonto the foreign price level will lead to a proportional appreciation of the domestic currencyagainst the foreign currency. The Relative PPP, the ﬀweakerﬀ variation, states that the exchange rate will adjust by theamount of inflation differential between two economies. Algebraically it can be expressedas:%. S = %. P - %. P* (2)Where: %. S is the percentage change in the exchange rate, %. P is the domestic inflation rate, and %. P* is the foreign inflation rate. If the inflation rate in the home country is x% higherthan that in the foreign country, the exchange rate should be expected to depreciate byapproximately x%Absolute PPP is argued to be unlikely to hold since the

conditions needed are strict andunrealistic. Isard (1977) says: "In reality the law of one price is flagrantly andsystematically violated by empirical data". Meanwhile, the relative PPP can be expected tohold even in the presence of distortions such as transport costs or trade impediment. In addition, most empirical work has focused on the validity of PPP in the long-run than inthe short-run, which basically due to the greater volatility of the short-run exchange rate. Dornbusch (1976) argues that in short run goods prices can be regarded as stable, while theexchange rate is rapidly driven by news like announcements about interest rate changes orother economic policies. For example, political uncertainty (the election of a PartiQuebecois government in Quebec on 15 November 1976) and a substantial current accountdeficit are two important causes for the depreciation of Canadian dollar by the end of1970s. Meanwhile, PPP is based on only goods arbitrage, but says nothing about the role ofcapital movements. Therefore, exchange rate deviations from PPP are substantial andprolonged in the shot-run. Instead, PPP is supposed to describe the long-run behaviour ofexchange rates. The economic forces behind PPP will eventually equalize the purchasingpower of currencies. Furthermore, methodology used to calculate PPP in the short-runmakes the volatility readily. Whereas, it seems appropriate to use cointegration technique toexplain the concept of PPP as a long-run equilibrium. Long-run relationship in this sensedenotes the equilibrium to which a system converges over time, indicating that there is noneed for PPP to hold at every point in time. Instead, the PPP rate is thought to indicate atarget toward which the spot exchange rate is adjusted. 2. The limitations of PPPAlthough considered as one of the foundations of exchange rate behavior, PPP is one of thetheories facing the heaviest criticism. In the

following we discuss some main problemsmaking it difficult for the long-run PPP to hold in practice.. Transport costs and trade impedimentsAccording to Keith Pilbeam (1998), the absolute PPP is likely to not hold exactly due to theexistence of transportation cost and the distorting effects of protectionism. For instance, abundle of goods costs C$900 in Canada and $1000 in the US, the exchange rate is supposedto be C$0. 9/$1 under PPP. If the transport cost exists, say C$20, then the exchange rate willfluctuate within C$0. 7/$1 and C$1. 1/$1.. Imperfect competitionThe key assumption of the PPP theory is that there is sufficient international competition tokeep the prices of a good equal no matter in any countries. Nonetheless, such competition isnot a case in reality. Different countries have been in different economic stages andgenerally establish different sets of consumers. And with their price strategies, multinationalcorporations obviously charge different prices in different countries. This argument canpartly explain why PPP is likely to perform better for a pair of industrial countries likeCanada and the US in our paper.. Productivity differentialsBalassa (1964) and Samuelson (1964) argue that productivity differentials in the tradedsector between countries are one source causing deviation from PPP. They complain thatpoor countries have lower price of non-tradables than rich countries because poor countrieshave lower productivity only in traded sector than rich ones. Therefore, the aggregate priceindices which are set up by converting prices of similar baskets of both traded and non-traded goods into a common currency are likely to be higher in rich countries than in poorones2. 2 see Balassa (1964) and Samuelson (1964) for more detail. Statistical problemsThe assumption of PPP that all goods are internationally traded is obviously unrealistic. There is a kind of goods called nontraded

goods, including services, properties. Nonetheless, some authors argue this does not matter much in testing PPP because there isa close relationship between two kinds of goods. Some nontradable goods serve as inputsfor tradable ones and vice versa. Also, under the PPP hypothesis, the exchange rate isdetermined by comparing the price of identical bundles of goods in two countries. However, different countries tend to put different weigh to various classes of goods andservices. CPIs in developing countries have higher weigh on basic consumption such asfood and clothing than that in developed countries, making it difficult for PPP to hold. Bearing in mind these limitations of PPP, we proceed to the expectation of the performanceof PPP in the countries examined. 3. Expectations of the performance of PPPIn this part of the thesis, we will analyze many conditions of the countries examined inorder to make a prediction for the performance of long-run PPP among these countries. Before analyzing, we give a brief note about the exchange rate characteristics of theselected countries in the sample period. The Canadian Dollar (CAD) was floated since June1970 while until 1976 Mexican Peso (MXN) was allowed to switch to the managed floatingexchange rates. Then the exchange rates have been determined largely on the basis ofdemand and supply conditions in the exchange markets. However, the Bank of Canada andthe Bank of Mexico intervened when necessary to maintain orderly conditions in theexchange markets. Whilst the Peso is always much weaker than the USD, The CAD is quitestrong against the USD. It was worth more than the USD for part of the 1970s. After twoseries of downward pressures during the technological boom of the 1990s that was centeredin the US, its value has risen against the USD because of the continued strength of theCanadian economy. Two of the factors causing the

poor performance of PPP in general or long-run PPP inspecific are transport costs and trade impediments. These factors partly explain for theargument of Frankel (1981) that PPP performs better for countries that are geographicallyclose to one another and where trade linkages are high. In our case, it is reasonable toexpect PPP to hold between Canada, Mexico and the US. They are neighboured countries, so the transport costs are no longer much matter to the performance of PPP hypothesis. Furthermore, these North-America nations share the most comprehensive tradingrelationship around the world. On January 1, 1994, the North American Free TradeAgreement (NAFTA) between the United States, Canada, and Mexico entered into force. Such agreements help to reduce trade impediments, making a good condition for PPP totake place in the countries. According to US Commercial Service, Canada and Mexico are two of the largest tradingpartners of the US. Canada is the leading export market for 36 out of 50 U. S. States, andranked in the top three for another 10 States. On its turn, International Trade Administrationreports that Mexico-US trade has increased by over 225% since the NAFTA of 1994. Meanwhile, IMF international statistics reports that the US is the largest trading partner ofboth Canada and Mexico. Trading with the US accounts for about 73% of exports and 63%of imports of Canada since 2009, while these numbers are 65% and 68% respectively forMexico. Furthermore, previous studies support for the statement that high-inflation countriesprovide good conditions for PPP to hold. Figure 1 presents Canadian inflation rate from1977: I to 2010: IV. High inflation occurred in Canada during 1973 through 1979, but therate declines sharply since 1980s. It has fluctuated around 2 percent from 1992 up to now. On average, Canada is considered as a low-inflation country, with

an average annualinflation rate of 4. 49%. Inversely, Mexico is a well-known high inflation country. Figure 2presents Mexican inflation rate from 1977: I to 2010: IV. According to Bank of Mexico, theaverage inflation rate in Mexico was 29. 47% from 1977 until 2010. The rate reached anhistorical high of 179. 73 percent in February of 1988. Therefore, evidence of inflationsuggests PPP is likely to perform better for the case of Mexico-US than for the case ofCanada -US. Nonetheless, the case of Canada and the US owns a condition which makes it easier forlong-run PPP to hold than the case of Mexico-US. In the previous part, we can see that thetwo limitations of PPP, imperfect competition and productivity differentials, can be partlyovercame if we test PPP for two developed countries. Jayendu Patel (1990) supports forthis argument by stating that PPP is likely to hold only among developed relatively free-market economies. The US is obviously the largest economy in the world, and Canada is inthe top of 10 world's largest economies3. Since the two countries are ranked as developedones, there is not a large gap in income or living standard between them; they establishsimilar sets of consumers. Therefore, the multinational corporations tend to charge samelevel of price on the two countries. On the other hand, Mexico is classified by the World Bank as an upper-middle-incomecountry. It is still considered as a developing country although by GDP it is ranked as thethirteenth largest economy in the world in 20113. According to IMF, the Gross NationalIncome (per capita) of the US and Canada are about $33, 000 and $21, 000 respectively, while that of Mexico is about only $5, 000. Thus, an identical good often costs a lower pricein Mexico than in Canada and the US. All dresses belong to the 2011 summer collection ofMango, for example, cost the same price for Canada and the US, but about 10% lower pricein

Mexico. Moreover, it is reasonable for the US to put same weighs with Canada, but different weighswith Mexico to different classes of goods in constructing the price indices. However, according to Someshwar Rao et al. (2004), although Canada and the US are bothranked as developed countries, Canada's labour productivity has grown slowly than theUS's since 1995. In 2003, the US's labour productivity was about 23 percent higher thanthat of Canada's. Therefore, when converting into a common currency, the prices of similarbaskets are still somehow higher in the US than in Canada, making difficulties for PPP tohold. For the case of Mexico-US, there is still a quite large labor productivity differentialbetween two nations although the NAFTA agreement has helped to push up the technologytransfers, reducing the gap in productivity. 3 see World Development Indicators database, World Bank, 1 July 2011In addition, both the Canadian and Mexican exchange markets are quite crowed. StockExchange and TSX Venture Exchange of Canada are home to the largest number ofpublicly traded companies of any exchange in North America. Likewise, the Mexican StockExchange (Bolsa Mexicana de Valores) is the second largest stock exchange in LatinAmerica and the fourth largest in North America. Therefore, although the capitalmovements are argued to affect the short-run PPP much more, it still makes the deviationspersistent and prolonged so as PPP cannot converge to the long-run equilibrium given theimportant role of the capital market to these countries. In short, both Mexico and Canada provide certain favorable backgrounds for PPP to hold incomparison to other groups of countries. However, the previous studies have stilldemonstrated mix findings as discussed in the next section. III. LITERATURE REVIEWSo far, the validity of long-run PPP has remained an open question no matter whicheconometric

approaches are employed, which price indices are used or for which countriesPPP is tested. At the beginning, PPP is often tested by traditional regression technique. Frankel (1981)uses OLS to test PPP for the UK pound, German Mark and French Franc against the USdollar and concludes that the hypothesis worked well in the 1920's, but not during the1970's. Even he argues that PPP should not be considered as a theory of exchange ratedetermination due to the fact that it specifies the relationship between endogenous variableswithout providing the details about the process generating them. On the other hand, using standard 2SLS and GLS Davutyan and Pippinger (1985) provideevidence supporting for PPP during 1970's. These papers are excellent in their choice oftested countries. The authors test PPP hypothesis for the group of developed countrieswhich have the approximately equal productivity. Moreover, it also figures out manyproblems in testing PPP such as standard error or unequal weights constituting price levelsand complains such problems as the reasons for the Frankel's argument of the collapse ofthe theory. However, Dean Corbae (1991) argues that in case exchange rates and prices arenonstationary, standard regression may be biased towards rejection because of the serialcorrelation. After the introduction of cointegration and error-correction analysis, most recent studieshave adopted them in testing the PPP hypothesis in the long-run. This approach is said to bemore advanced than previous approaches in studying PPP since it deals with non-stationarytime series. Those who employed OLS-based cointegrating technique of Engle and Granger (1987)mostly reject PPP. Taylor (1988) conducts the Engle and Granger test for the long-run PPPfor five major exchange rates, including CAD/USD. The paper collected seasonallyadjusted data on relative prices and

nominal exchange rate from 1973 through 1985 andconcluded that cointegrating relationship between exchange rate and relative prices doesnot exist for any of the countries examined. Flynn and Boucher (1993), Mohsin (2004)reject the hypothesis as well. According to Muzafar Shah et al. (2006), nevertheless, the residual-based Engle-Grangermethod tends to provides inconsistent results. Furthermore, they argue that Johansen'smultivariate framework would overcome some weaknesses from bivariate co-integration. And often the Maximum-Likelihood based cointegration method of Johansen (1988) hasmore support for the validity of PPP. Islam and Ahmed (1999) tested the PPP hypothesisfor Korean-US exchange rate and prices for the period from 1971 to 1996. The studyapplied both the Engle-Granger method and the Johansen method. The paper providessupport for long-run PPP, and stronger support came from the Johansen method. Furthermore, the paper also estimates the ECM and concludes that the exchange rate is astable function of the relative prices with a speed of adjustment of about 24% over a year. Even those who used most recent developed techniques have provided mixed results. Applying non-linear URTs, Cuestas (2009) rejected the hypothesis. Meanwhile, Telatar andHasanov (2009) who also use non-linear URTs for twelve CEE countries find evidencesupporting for it. Turning to the researches for the case of North America, we also see mix findings about thelong-run PPP although there are only a few studies analyzing both the exchange rates ofCanada and Mexico against the US. According to Taylor (2002), PPP holds well for boththe cases of Canada-US and Mexico-US in the long-run over the 20th century. The paperapplies both the Johansen likelihood ratio JLR as Multivariate Test as well as ADF and DF-GLS test as Univariate Tests. One of

the outstanding points the author made is that hecollected data for a group of twenty countries over 100 years, a larger historical panel ofannual data than has ever been studied. He argues since PPP is likely to hold in the longrun, it is better to test the theory with long time dimension of the data. The findings aresupported by Wallace (2010) who reuses Taylor (2002) data set. The paper also claims theimportant role of the instrument variables as reinforcement to the tests since they help toeliminate nuisance parameters. The author concludes: "The ECM and ADL model, with orwithout instrumental variables, and the traditional EG two-step approach provide somesupport for the PPP hypothesis". The ECM estimates that deviations move down in order toadjust to long-run equilibrium with the speed of 21. 7% and 58. 9% respectively for Canadaand Mexico. Nonetheless, Lopez at el (2005) argues that if Taylor (2002) had used an accurate lagselection criterion, PPP just performs well for no more than 9 out of 16 cases. Specifically, the authors fail to provide support for both Canada and Mexico. The previous literature also provides evidence for the argument that PPP holds better forthe high-inflation countries. Mahdavi and Zhou (1994) apply the Johansen framework toanalyze PPP in a sample of less-developed countries (LDCs) using quarterly data for1973Q2 onwards. They conclude that PPP holds more frequently among high inflationcountries, including Mexico. This finding is supported by Su Zhou (1997) who examinesthe long-run PPP for four high-inflation countries, including Mexico. The co-integrationtests in this paper are conducted with the correction of the finite sample bias and theadjustment for trend breaks. Like the previous, the paper concludes that: "The results areconsistent with the argument that, during the recent floating exchange-rate period, PPPholds well, at least in a

weak form, in high-inflation countries where the general price levelmovement overshadows the factors causing deviations from PPP.�On the other hand, Holmes (2002) testing PPP for a sample of thirty LDCs over the period1973-2001 finds evidence against long-run PPP for the case of Mexico-US. Turning to the case of Canada-US, there are numerous researches about this pair ofindustrial countries. Johnson (1990) applying both Eagle-granger cointegration techniquesand ECM framework finds supportive evidence for PPP as a long-run equilibriumrelationship for the case of Canada-US. Furthermore, the study concludes that estimates ofthe ECM depend on exchange rate regimes. If exchange rates are fixed, adjustment towardsPPP occurs mainly through the adjustment of the domestic price level. If exchange rates areflexible, then both the domestic price level and the level of the exchange rate can do theadjustment to reach the long-run PPP equilibrium. Investing the validity of long-run PPP between Canada and the US in the 1980s and 1990s, Beiling Yan (2002) generally rejected the theory. This paper is very professional atCommodity Groups Classification. The paper finds some support only from homogeneousgoods within the tradables. Yan (2002)�s findings raise a notice that it should be careful to distinguish betweendifferent commodity groups as well as which price index should be used as the proxy forthe price level when testing PPP. On one hand, some authors argue the WPI is morefavorable to PPP than CPI. Su Zhou (1997) states: "That PPP often holds better for the WPIpairs than the CPI pairs could be explained by the fact that the CPI does not includeexported goods and thus is weighted more toward nontraded goods than is the WPI."According to McNown and Wallace (1989), cointegration between the exchange rate andthe WPIs occurs in two out of four high-

inflation countries, but the relationship between theexchange rate and the CPIs does not exist in any of the four cases. Kim (1990) alsosupports for this argument. On the other hand, some authors argue that PPP should beapplicable to CPI since such general price index can represent the whole mass ofcommodities in the economy. Johnson(1990) finds evidence supporting for long-run PPPbetween Canada-US exchange rate and CPI's. Bearing in mind the advantages of co-integration technique as well as the facts that theconditions needed for PPP to hold in short-run are strict and unrealistic, the main purposeof our paper is testing the validity of PPP as a long-run relationship using co-integrationmethods. Furthermore, we will give more detail about the ECM interpretation. For the firsttime, our paper will focus on the three countries: The US, Canada, and Mexico in anattempt to check the predictions that PPP holds better for high-inflation countries (Mexico-US) and a pair of developed countries (Canada-US). Finally, we also test the theory usingboth CPI and WPI for comparison. In the next section we discuss the analytical model, the methodology as well as the sampleof data used to test the validity of long-run PPP. IV. METHODOLOGY AND DATA1. Econometric methodologyThe long-run PPP implies the following relationship between the nominal exchange rateand the price levels: st = a0 + a1pt + a2pt* + . t (3)Where st, pt, pt* are the logarithms of the exchange rate, domestic price level and foreignprice level respectively. . t is the disturbance term. In the cointegrating context, the proposition that PPP holds in the long run implies that thethree variables st, pt and pt* are cointegrated. The first requirement for a cointegrationrelationship is that three variables are integrated of the same order. 1. 1. Tests for unit rootTo determine if the nominal exchange rate and domestic/foreign price level are integratedof the

same order, we apply the augmented Dicky-Fuller (ADF) test for a unit root. Thegeneral form of ADF test is:. yt = □ + . yt-1 + dt + S+ . t (4)Where . yt is the first difference of the variable yt, □ is the drift term, t stands for the trendterm, m is the number of required lags so as to achieve non autocorrelation of the errorterm, and . t represents the error term. The null hypothesis of the test is that the series has aunit root. Lag length is one important part of the ADF test. Enders (1948) claims that too few lagsmay cause the estimates incorrect, while using too many lags for argumentation lowers theperformance of the test. Therefore, to ensure the power of the test we apply the general-to-specific approach presented in Schwert (1987) to choose the most appropriate number oflags. We start to run the test with a long lag length, then gradually decrease the lags whichare shown insignificant by the t or F values. Finally, we have to make sure the residuals arewhite noise once the tentative lag length has been chosen. If the variables are found to have a unit root at the same level or to be integrated of sameorder, we will apply two tests, the Engle-Granger and Johansen, for co-integration whichrepresents long-run equilibrium relationship of non-stationary variables. 1. 2. Tests for co-integrationFollowing the Engle-Granger (1987), we first estimate the cointegrating regression(equation 3) by the standard regression method OLS. Then the residuals from the regressionwill be tested by the ADF test for a unit root. If the residuals have no unit root or arestationary, the variables are co-integrated and vice versa. Following the Johansen (1988) approach, 5 Information Criterions: LR, FPE, AIC, HQICand SBIC are first applied to specify the appropriate lag length of the VAR system in orderto make sure the residuals uncorrelated. Within the Johansen's maximum likelihoodprocedure, the matrix notation of the Vector

error correction model is specified as follow:. Xt = A0 + . Xt-1 + A1. Xt-1 + A2. Xt-2 + ... + Ap. Xt-p + Et (5)Where Xt is a (nx1) vector of I(1) processes, A0 is the (nx1) vector of intercepts, Ai is thematrix of coefficients, Et is the vector of error term. And . is the matrix of parameters suchas at least one element is non-zero. Johansen test is a test for the rank of matrix.. Denoterank (.) = r. Johansen (1995) suggests a tests statistic to determine the cointegration rankknown as the trace statistic: trace(r0/k) = -TS

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) (6)Where^ are the estimated eigenvalues . 1 > . 2 > . 3 > ﷺ > . k and r0 ranges from 0 to k-1depending on the stage in the sequence. This is the relevant test statistic for the nullhypothesis r < r0 against the alternative r > r0 + 1. If r = 0, we have no co-integration. If 0 < r < n, then we have r co-integration vectors. Onthe other hand, if r = n, all series in vector Xt are stationary. As long as the variables are found to be co-integrated, they share a common trend eventhough they are individually non-stationary. Thus, one can lead to the conclusion that PPPrelationship holds in the long-run. 1. 3. The Error-Correction ModelIf the variables are found to be co-integrated, there must exist an associated error-correctionmodel (ECM) which provides the short-run dynamics or how the system converges to thelong-run equilibrium. Generally, an ECM for 3 variables can be expressed as:. st = a10 + Sas(j)CEj+ Sa11(i) . st-i + Sa12(i) . pt-i + Sa13(i) . p*t-i + est (7)Where CEj are the error correction terms and are the residuals from the cointegratingregression equations. If this term is larger than zero, yt in the previous period overshoots theequilibrium and yt will fall unless yt-1 = ﷺ + ﷺxt-1. . denotes the first differential. a11(i), a12(i) and a13(i) are the

coefficients representing the short-run dynamics of . st with respectto . pt-1, . p*t-1 and . st-1, and eyt is a white noise process. as is the speed-of-adjustment parameter. Larger as is, greater is the response of st to theprevious period's deviation from the long-run equilibrium and vice versa. For an ECM toexist at least one of the speed-of-adjustment parameters must be different from zero. 2. DataAs discussed in the literature review, we follow Taylor (2002) who argues that empiricaltests of long-run relationship require considerable amounts of data over a long period4. Ourpaper tests the hypothesis for a sample of quarterly data of thirty-four years. 4 Frankel (1986) and Kim (1990) also support this argumentThe data examined are quarterly series taken from IMF's International Financial Statisticscovering the floating period from 1977: I to 2010: IV. The exchange rate series includenominal Canada-US exchange rate (CAD/USD) and Mexico-US exchange rate(MXN/USD). Finally, both the WPI and CPI are used as the proxy for the price level inorder to ascertain if the choice of price index matters. The data used are described in thetable 1and graphs 1. Table 1: Price Indices Summary StatisticsSample period: 1977: I to 2010: IVVariableConsumer priceWholesale PriceExchange RateCADMXNUSDCADMXNUSDCAD/USDMXN/USDMaximum109. 808126. 047112. 282111. 717130. 304127. 3611. 59314. 332Minimum21. 7440. 05222. 48624. 0590. 14240. 3440. 9680. 023Mean70. 93944. 12369. 06875. 16444. 09378. 0261. 2435. 475Std. Deviation25. 84943. 68026. 19423. 60843. 90719. 1200. 1624. 702The first 6 columns summarize the price indices of Canada (CAD), Mexico (MXN) and theUS (USD). As we can see, the greatest deviations are in the Mexico prices, indicatingMexico is the most inflationary country. Furthermore, Canadian dollar and US dollar arequite

similar, indicating the similar purchasing power of the two Dollars. Finally, theexchange rate columns show that the more stable currency is the Canadian Dollar. Given this set of data, we proceed to the empirical results. V. EMPERICAL RESULTS1. Graphical evidenceBefore conducting cointegrating tests, we give graphical evidence to present firstdiagrammatically if the PPP hypothesis holds among the selected countries. Graph 2 plots the actual exchange rates and PPP rates for the countries examined. Thefigure shows significant divergences of the exchange rate from that suggested by PPP. Graph 2(a) shows the prolonged divergence of PPP from the real exchange rate of CanadianDollar-US Dollar when the CPI is the proxy. Between mid 1979 and early 1981 there was adramatic depreciation of the Canadian Dollar while PPP would have predicted anappreciation. Thereafter, the Canadian Dollar has a brief period of undervaluation inrelation to PPP. After mid 1986, PPP provided the contrast predictions to the movements ofthe actual exchange rate. For example, between mid 1986 and last 1989 while CanadianDollar appreciated, PPP would have shown a slight depreciation. On the other hand, although the PPP rates which are computed by the WPI indicateprolonged overvaluation of the Canadian Dollar in the whole period examined, the PPPperforms well in predicting the movements of the actual exchange rate since exchange ratesgenerally move in the same direction with PPP rates. Furthermore, it appears that themagnitude of the divergence has been getting small and small. In short, WPI's do a better job at tracking the Canadian Dollar- US Dollar parity than theCPI's. Graphs 2(c) and 2(d) tell us the performance of PPP for the case of Mexico-US. Differentfrom the previous cases, the PPP rates made up from WPI and CPI behave similarly. Thechoice of the price indices does not matter. Both cases show that the

Mexican Peso hasbeen undervalued in relation to PPP in the whole period, but the PPP is useful in predictingthe movement direction of the exchange rate. It is noticeable in all plots, especially for the case of Canada-US, that although theexchange rate is frequently far from PPP it has a propensity to come back towards the PPPrates over the longer term. Therefore, PPP may be useful to determine the long-runexchange rate. In the next part, we present co-integrating tests and ECM estimation to give econometricevidence for the existence of the long-run PPP. 2. Econometric results2. 1. Unit root testsThe results of ADF tests are reported in tables 2. Almost previous studies run the ADF testsonly with the trend and without trend specifications, but nothing about the constant or thedrift term. Our paper runs the F-test for the need of not only trend but also the constant. We then choose the most appropriate specifications for the ADF tests and only report theADF test statistics for these specifications. ADF tests reveal that the null hypothesis of a unit root cannot be rejected for all variables intheir levels but rejected in their first differences. These variables are thus found to be non-stationary in their levels (or integrated of order one, I(1)). The results allow us to proceed tocointegrating tests. 2. 2 . Cointegration testsThe results of the cointegrating Eagle- Granger tests are presented in the table 3. Two casesare considered. First we test whether there is a cointegrating relationship between exchange rates and CPIs. Due to the fact that all the variables are non-stationary, the estimated coefficients areinvalid; therefore, we have to test the unit roots of the residuals. The ADF test statistics ofthe residuals for the cases of Canada-US and Mexico-US are -1. 119 and -2. 377respectively. They are both smaller than the critical value at 5% significant level (-3. 785) inabsolute value; the null hypothesis of a unit root

cannot be rejected. Therefore, one canconclude that the cointegrating relationship does not exist or the long-run PPP does nothold in case CPI is used as the proxy for the price level. Even when WPI is employed, the residuals are still non-stationary. The deviations fromPPP have no tendency to converge to a long-run equilibrium path. Our paper providesevidence consistent with Taylor (1988), Flynn and Boucher (1993), and Mohsin (2004)who also apply Engle-Granger method and reject the hypothesis, but contrary to theconclusions reached in some other studies such as Johnson (1990) and Kim (1990) whichsupport for the long-run PPP. In the followings we analyze the results of Johansen co-integration tests as shown in thetable 4. In contrast to Eagle-grange tests, the Johansen tests show evidence supporting forthe long-run PPP relationship for two pairs of countries no matter CPI or WPI are in use, but with different numbers of cointegrating vectors. The exchange rate and the CPIs of Canada and the US share 1 cointegrating vector whilethere are 2 vectors for the case of Mexico-US. On the other hand, there are 2 cointegratingvectors exist for the case of Canada-US and only 1 vector for the case of Mexico-US whenWPI is employed. However, no matter how many cointegration vectors are found, theJohansen tests are supportive for the validity of long-run PPP. This result is against Lopezat el (2005), but consistent with almost previous studies such as Mahdavi and Zhou (1994), Su Zho (1997), Islam and Ahmed (1999) or Taylor (2002) and provides more evidence forthe argument of Muzafar Shah et al. (2006) that Johansen test will give stronger support forthe long-run PPP relationship than the Eagle-Granger method. Furthermore, findings from the cointegrating tests provide the evidence that both the CPIand WPI bring about similar results for the existence of long-run PPP relationship

betweenthe exchange rate and the price levels. Therefore, one should keep suspect eyes on theargument of McNown and Wallace (1989) or Kim (1990) about the advantage of WPIsover CPIs in testing PPP. 2. 3. The Error-Correction ModelTables 5-6 represent the results of the ECM estimation. Table 5 shows how the systemconverges to the long-run equilibrium implied by the speed-of-adjustment parameters. Thecondition that at least one speed-of-adjustment parameter is different from zero is satisfiedin all cases. Therefore, the ECMs exist and PPP holds in the long-run in all cases. For the pair of Canada and the US, there exists 1 error correction term (CE) when CPI isemployed. The p-values of the speed-of-adjustment parameters a11, a21, a31 are equal to0. 294, 0. 000 and 0. 000 respectively, so only the speed-of-adjustment parameters inequations of . p and . p* are significant. Therefore, most of the adjustment to reach thelong-run equilibrium path is done by the two price levels. The magnitude and the sign ofthe parameters are almost the same (-0. 0055). Intuitively, if there are depreciations orappreciations in the exchange rate in previous period, the US CPI and the Canadian CPIwill play almost equally important roles in adjusting the exchange rate to fall back again tothe equilibrium with a slow speed of 0. 55%. On the other hand, the exchange rate and WPIs of the 2 nations are cointegrated through 2vectors. For the first CE, only the speed-of-adjustment parameter in the equation of . p* issignificant, meaning that the US WPI plays the most important role in adjusting theexchange rate. Furthermore, the parameter is equal to -0. 035, meaning that deviations willmove down with the speed of 3. 5%. Otherwise, deviations in the second CE move down toeliminate disequilibrium with faster speed of 5. 3% mainly through the Canadian WPI. For the case of Mexico-US, there are two CE as CPI is the proxy. In the first

CE, adjustment to reach the long-run PPP equilibrium path is done by the exchange rate andMexico CPI. However, the signs of the parameters are opposite, indicating oppositemovement directions of the convergence. The absolute value of the parameter in theexchange rate equation is 24% which is much larger than that of 5. 7% in the Mexico CPIequation. Therefore, one can lead to the conclusion that the deviations made up through theexchange rate donate those through the Mexico price in the convergence process. On theother hand, in the second CE, all speed-of-adjustment parameters are significant. Deviations move down with speed of 5. 9% through Mexico CPI and 1. 2% through US CPI, but move up with much faster speed of 24% by the lagged exchange rate. The exchange rate and the WPIs of Mexico and the US share only 1 cointegrating vector. Through Mexico WPI, deviations will move up with a speed of 13% while they will movedown with a slower speed of only 3. 3% through the US WPI. In short, for the case of Canada-US, both the ECMs with CPI and WPI indicate deviationsmove down mainly through the two price levels with a low average speed of 2. 4% towardsthe long-run equilibrium. On the other hand, while the ECM with CPI shows that all 3variables can make deviations towards equilibrium, the other with WPI indicates only the 2price levels can do in case of Mexico-US. The average upward speed is 14. 2% and theaverage downward speed is 8. 6%. In comparison with previous findings, our results show some difference in detail. Johson(1990) concludes the domestic price level and the level of the exchange rate can dothe adjustment for the case of Canada-US while our paper shows the two price levels. Also, the speed of adjustment in our paper is much lower than in Wallace (2010). Another interest finding is about the interaction between the variables as presented in table6. The p-values of the

estimated coefficients in the . s equation are 0. 398, 0. 294, 0. 755, 0. 917 and 0. 056 respectively. They are all larger than the critical value, so they are allinsignificant, indicating no variables have impact on the future value of the exchange ratein case CPI is used as the price levels of Canada and the US. However, when the WPI isemployed, one-period past difference of exchange rate has effects on predicting the futurevalues of the exchange rate. For the case of Mexico-US with CPI, only lag 1 and lag 3 of the exchange rate firstdifference are significant, thereby having impact on the exchange rate future values. Meanwhile, lag 1, 3, 6 of the exchange rate first difference and lag 4, 5 of the Mexico WPIdo impact in case WPI is employed. In summary, while the Eagle-Granger cointegrating test rejects the long-run PPP, theJohansen and the ECM are supportive for it. According to Duasa (2004), Johansen�sapproach has several advantages over the more traditional Eagle-Granger procedure. Unlikethe Eagle-Granger test, the Johansen test can work in the multivariate framework andenables one to determine the number of cointegrating relations. Furthermore, the maximumlikelihood Johansen does not depend on arbitrary normalization rules, whereas results ofthe OLS-based Eagle-Granger depend on the normalization implicit in the choice of theregress and in the cointegrating regression. Given these advantages, our paper follows theresults of the latter ones5. Therefore, one can lead to the conclusion that long-run PPP holdsamong these countries as expected in the previous section. Our results are in line withJohnson (1990), Mahdavi and Zhou (1994), Su Zhou (1997), Islam and Ahmed (1999), Taylor (2002) or Wallace (2010). 5 Harris and Sollis (20003) discusses more detail about the problems of Eagle-Granger method. Table 2: Unit root Tests in nominal exchange rates and price indicesF-test

statistic ADF test statisticTrend Constant Level First differencesExchange rateCAD/USD 2. 60 1. 83 -0. 904*** -9. 801***(1) (1)MXN/USD 2. 36 3. 88 -1. 350*** 0. 029***(3) (3)Price indexCAD - CPI 10. 35 11. 76 0. 143* 0. 000*(3) (1)MXN – CPI 3. 97 5. 67 0. 058** 0. 002**(5) (5)USD – CPI 12. 80 14. 56 0. 471* 0. 000*(3) (1)CAD – WPI 12. 76 14. 23 0. 058** 0. 006**(5) (5)MXN – WPI 1. 71 5. 46 0. 361** 0. 000**(1) (1)USD – WPI 5. 21 7. 24 0. 472** 0. 000**(1) (1)Note: F-test for trend: the null hypothesis: there is no trend. The critical value at 5% is 6. 49. F-test for the constant: the null hypothesis: there is no constant. The critical value at 5% is 4. 71. ADF test statistic: *, ** and *** denote the specifications with both trend and the constant, specifications with only theconstant and the ones without both trend and the constant respectively. The null hypothesis of the ADF and PP test is that: the series has a unit root. The critical value for the first 2 specifications at 5% significance level is 0. 05 while that for thelatter is -2. 888. The lag length is chosen using the general-to-specific approach and reported in parentheses. Table 3: The cointegrating Eagle- Granger testsPeriod: 1977: I - 2010: IVCPI WPICanada-USst = - 0. 122+ 0. 798pt – 0. 720p*t st = 0. 553+ 1. 282pt -1. 362p*t(0. 327) (0. 001) (0. 003) (0. 000) (0. 000) (0. 000)R2 = 0. 0969 F-statistic = 7. 13 R2 = 0. 788 F-statistic = 246. 79Unit Root Test in the Residuals Unit Root Test in the ResidualsADF test statistic -1. 119 [-3. 78] - 0 lag ADF test statistic -2. 985 [-3. 785] – 0 lagMexico-USst = 4. 371 + 1. 044pt – 1. 46p*t st = -0. 788+ 0. 983pt – 0. 251p*t(0. 703) (0. 023) (0. 177) (0. 453) (0. 000) (0. 328)R2 = 0. 993 F-statistic = 10092. 41 R2 = 0. 976 F-statistic = 2713. 45Unit Root Test in the Residuals Unit Root Test in the ResidualsADF test statistic -2. 377 [-3. 785] - 2 lags ADF test statistic -2. 021 [-3. 785] – 1 lagNote: t-statistics in parentheses and critical values at

the 5% S. L. for the ADF tests in [ ]. Table 4: The cointegrating Johansen testsPeriod: 1977: I - 2010: IVr Eigenvalue Trace statistic 5% critical valueSeries: ln(CAD/USD), ln(Canadian CPI), ln(US CPI) Maximum lag in VAR = 1None - 145. 3597 29. 68At most 1 0. 6458 1. 8564 * 15. 41At most 2 0. 01344 0. 0300 3. 76Series: ln(CAD/USD), ln(Canadian WPI), ln(US WPI) Maximum lag in VAR = 1None - 78. 8852 29. 68At most 1 0. 34719 21. 3113 15. 41At most 2 0. 14410 0. 3058* 3. 76Series: ln(MXN/USD), ln(Mexican CPI), ln(US CPI) Maximum lag in VAR = 4None - 58. 0980 29. 68At most 1 0. 20109 28. 4638 15. 41At most 2 0. 17471 3. 1179* 3. 76Series: ln(MXN/USD), ln(Mexican WPI), ln(US WPI) Maximum lag in VAR = 6None - 38. 4430 29. 68At most 1 0. 16394 15. 1666* 15. 41At most 2 0. 09129 2. 7224 3. 76Note: r is the number of cointegration vectors under the null hypothesis. The appropriate lag length is based on 5information criteria: LR, FPE, AIC, HQIC and SBIC. The stars denote the rank of the matrix . where the trace statisticsare smaller than the critical values at 5% significant level. Table 5: The Speed of adjustmentEquation Speed of adjustmentCPI WPICanada-US Mexico-US Canada-US Mexico-US. s CE1(a11) □ 0. 0096 - 0. 244 -0. 034 0. 083(0. 109) (0. 021) (0. 547) (0. 055)CE2(a21) 0. 242 0. 005(0. 023) (0. 947). p CE1(a21) □ 0. 0056 0. 058 0. 018 0. 130(0. 000) (0. 032) (0. 365) (0. 004)CE2(a22) - 0. 059 -0. 053(0. 031) (0. 033). p* CE1(a31) □ 0. 0055 0. 013 -0. 035 -0. 033(0. 000) (0. 064) (0. 006) (0. 000)CE2(a23) - 0. 012 0. 022(0. 048) (0. 550)Note: . s, . p and . p* are respectively the equations of the first difference of exchange rate, domestic price level and theforeign price level in the ECM estimation. CEs denote the cointegrating vectors. The p-values are in parentheses and thecritical value at 5% significant level is 0. 05Table 6: the Error Correction ModelCanada-US -

CPIEstimates of regression. s = -0. 003 – 0. 0020CE1 – 0. 169. pt-1 + 0. 054. p*t-1 + 0. 164. st-1(0. 398) (0. 294) (0. 755) (0. 917) (0. 056)R2 = 0. 155Normalized Cointegrating VectorCE1= st-1 + 21. 671 – 9. 581pt-1 + 5. 029p*t-1(0. 059) (0. 313)P > Chi2 = 0. 000Mexico-US-CPIEstimates of regression. s = -0. 002 - 0. 244CE1+ 0. 242CE2 + 0. 433. pt-1 – 0. 318. pt-2 + 0. 169. pt-3 + 0. 009. pt-4(0. 991) (0. 021) (0. 023) (0. 229) (0. 412) (0. 658) (0. 976)- 2. 033. p*t-1 + 2. 153. p*t-2 – 1. 842. p*t-3 – 0. 984. p*t-4(0. 212) (0. 196) (0. 272) (0. 535)+ 0. 329. st-1 + 0. 053 . st-2 + 0. 474. st-3 + 0. 016. st-4(0. 008) (0. 684) (0. 000) (0. 900)R2 = 0. 4669Normalized Cointegrating VectorCE1= st-1 + 48. 209 - 9. 445p*t-1(0. 002)P > Chi2 = 0. 0016CE2= pt-1 + 45. 005 – 8. 283p*t-1(0. 005)P > Chi2 = 0. 0049Canada-US - WPIEstimates of regression. s = -0. 003 – 0. 023CE1 + 0. 009CE2 – 0. 208. pt-1 + 0. 158. p*t-1 + 0. 222. st-1(0. 343) (0. 654) (0. 881) (0. 490) (0. 467) (0. 027)R2 = 0. 052Normalized Cointegrating VectorCE1= st-1 + 3. 269 – 0. 658p*t-1(0. 002)P > Chi2 = 0. 0021CE2= pt-1 + 2. 503 + 0. 465p*t-1(0. 002)P > Chi2 = 0. 0017Mexico-US-WPI – 6 lagsEstimates of regression. s = 0. 004+ 0. 083CE1 +0. 083. pt-1– 0. 103. pt-2 +0. 443. pt-3 –0. 095. pt-4 + 0. 111. pt-5 –0. 194. pt-6(0. 782) (0. 055) (0. 358) (0. 646) (0. 399) (0. 000) (0. 044) (0. 677)+ 0. 044. p*t-1 + 0. 479. p*t-2 + 0. 348. p*t-3 – 0. 116. p*t-4 – 0. 108. p*t-5 + 0. 237. p*t-6(0. 925) (0. 355) (0. 518) (0. 830) (0. 835) (0. 610)+ 0. 232. st-1 – 0. 103 . st-2 + 0. 443. st-3 – 0. 095. st-4 +0. 112. st-5 – 0. 194. st-6(0. 030) (0. 353) (0. 000) (0. 359) (0. 254) (0. 048)R2 = 0. 052Normalized Cointegrating VectorCE1= st-1 + 1. 956 + 1. 067pt-1 – 0. 985p*t-1(0. 000) (0. 007)P > Chi2 = 0. 0000Note: In the Estimates of regression, the p-values related to t-statistics are in parentheses. The Normalized CointegratingVector expresses how the

variables are cointegrated. The P > Chi2 denotes the p-value associated with the F-test for thesignificance of the cointegrating vectors; they are all smaller than 0. 05, the critical value at 5% significant level. Thus, theECMs are all meaning.