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TESTING FOR PURCHASING POWER PARITY IN THE TRANSITION ECONOMIES

The case of Czech Republic, Rumania and Estonia.

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Abstract

The main goal of the thesis is to examine the time series properties of the price and exchange rate series for Bulgaria, Rumania and some other Eastern and Central European countries in terms of non-stationarity and cointegration, to determine whether purchasing power parity holds as a long - run constraint (purchasing power parity has been tested in different ways and there seems to be a consensus that purchasing power parity is likely to hold approximately in the long run but not in the short run). I use non-stationarity and cointegration of time series to investigate the validity of long - run purchasing power parity for Czech Republic, Rumania and Estonia. Long - run PPP is examined vis-a vis two countries, the United States and Germany. The results reject the null hypothesis of the presence of PPP for all the countries considered.

I. INTRODUCTION

The theory of purchasing power parity (PPP) is one of the most important relationships in international economics, and the doctrine has been under debate ever since Cassel (1918) first stated the theory formally and named it. The theory simply states that the exchange rate expressed as the domestic currency in units of a foreign currency, will equal the domestic price level in terms of the foreign price level.

The purchasing power parity (PPP) theory concerns the equilibrium relationship between exchange rate and prices of two countries. PPP theory has the exchange rate and relative prices moving proportionately to each other. Views differ concerning the usefulness of PPP theory in explaining actual relative prices and exchange rates. Purchasing power parity has been tested in different ways and there seems to be a consensus that PPP is likely to hold approximately in the long run but not in short run. According to this interpretation, in spite of the possibility of short-term deviations from its purchasing power parity value, the exchange rate will revert to a level consistent with purchasing power parity in the long term. Purchasing power parity thus serves an anchor for the exchange rate. The existence of an equilibrium value of exchange rate is of both theoretical and practical significance. On the theoretical side, more sophisticated models of exchange rate behavior rely on purchasing power parity as their basis and thus implicitly assume it holds (Krugman and Obstfeld 1991). On the practical side, purchasing power parity has several empirical applications. These include the use of purchasing power parity as a conversion factor in intercountry comparisons of data, setting a new exchange rate, measuring the disequilibrium of a fixed or a floating exchange rate (Officer 1982).

The empirical evidence on PPP, mainly based on the post-W.W.II experience of industrialized countries, is not generally favorable (a large number of empirical studies of PPP in the 1960s and 1970s are reviewed by Officer). Copeland (1989) summarizes the general conclusions drawn from the empirical literature as follows: "In the short-run, deviations from purchasing power parity are so frequent as to be more or less the norm." And "there is not even much sign of a tendency towards purchasing power parity in the long run."

The results of more recent studies which have tested PPP as a long-run equilibrium relationship using data from advanced countries are rather mixed. Most of authors who tested different versions of purchasing power parity, relied upon standard econometric procedures (Frenkel, 1978, 1981; Officer, 1978; Dyvutyan and Pippenger, 1985). The development of cointegration technique has shifted the emphasis to the analysis of the residuals of those models. Examples of studies that have used the cointegration technique include Taylor (1988), McNown and Wallance (1989a), Karfakis and Moschos (1989), Layton and Stark (1990), and Kim (1990) with mixed results. In general, purchasing power parity is rejected for countries that experience a relatively low rate of inflation. For countries with high rates of inflation, it is argued, that since monetary growth could overshadow real factors, purchasing power parity could receive empirical support. So, Frenkel (1981) has argued that for countries experiencing high money supply growth and variable rate of inflation, short-run deviations from purchasing power parity will occur, but prices and nominal exchange rate movements will offset each other over time so the long-run purchasing power parity is likely to hold. If, however, the economy suffers real shocks, long-run purchasing power parity will also not hold. For example, Phylaktis (1992) presented evidence that long-run purchasing power parity holds for Greece in the 1920s - a period when the Greek economy was characterized by high money supply growth and a high and variable rate of inflation confirming the view that purchasing power parity performs well when monetary shocks dominate the effects of real shocks'. Mcnown and Wallance (1989a) investigated the experience of four high inflation countries (Argentina, Brazil, Chile, and Israel) and they found some direct evidence favoring purchasing power parity for all except Brazil.

Most of the studies have employed the cointegration technique to test the purchasing power parity. Taylor (1988) used the bilateral exchange rates between the dollar and the currencies of five major industrialized countries and rejected the purchasing power parity in all five cases. Layton and Stark (1990) also rejected the purchasing power parity by relaying on the effective foreign price level which was constructed using the price levels and the bilateral exchange rates of Canada, Germany, France Italy, Japan and the United Kingdom. Kim (1990) on the other hand, who used annual data on the us dollar and currencies of five industrial countries, provided some support for purchasing power parity. As for less developed countries (LDCs), one could cite Mcnown and Wallance (1989a) and Karfakis and Moschos (1989). The former authors tested the purchasing power parity for the bilateral exchange rate of four high inflation countries (Chile, Argentina, Brazil and Israel) using Wholesale Price as well as Consumer Price Indexes. They provided some support for purchasing power parity, only when the Wholesale Price Indexes was used. This finding is an indication that in testing the purchasing power parity, the results could be sensitive to the choice of price index. One must select an index which includes more tradable. The latter authors, who rejected the purchasing power parity, concentrated on the bilateral exchange rate between the Greek drachma and the currencies of six major industrial countries. All these studies have used official exchange rate data to test the purchasing power parity.

II. THE THEORY OF PURCHASING POWER PARITY: THEORETICAL CONSIDERATIONS

1. The purchasing power parity: Alternative interpretations

The originators of the purchasing power parity doctrine Wheatley (1803, 1807, 1819) and Ricardo (1811, 1821) have viewed the doctrine as an extension of the quantity theory of money to the open economy. Thus, exchange rates like prices summarize the underlying monetary conditions. By Wheatley (1803) the course of the exchange rate was determined as the exclusive criterion of how far the currency of one country was augmented above the currency of another.

The purchasing power parity (which was referred to by Wheatley as "the par of produce") was ensured so by fluctuations in the rate of exchange. According to this theory the state of the exchange rate had to uniformly coincide with the state of prices.

The renewed interest in the purchasing power parity doctrine which was stimulated to a large extent by Cassel's writings (e.g. Cassel 1916, 1920, 1921, 1928, 1930), centered around two issues:

1. Determining the usefulness of the purchasing power parity doctrine, and

2. determining the proper price index that should be used in computing the parity[1].

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[1] Cassel 's own views have changed over the years. His original formulation (1916) has stated the purchasing power parity in terms of the relative quantities of money, but later formulations were in terms of the prices. The evolution of Cassel's thinking and exposition led to conflicting interpretations of the doctrine.

Views concerning the usefulness of the doctrine varied widely. On the one extreme, proponents of purchasing power parity viewed its usefulness in describing the "true" equilibrium exchange rate. Following them, the purchasing power parities were representing the true equilibrium of the exchanges, and it was of great practical value to know these parities. At his work Cassel (1921) was pretending that in order to get an idea of the real value of currencies whose exchanges are subject to arbitrary and sometimes wild fluctuations we had to refer to such parities.

Supporting Cassel, Keynes (1923) considered the purchasing power parity as an explanation of the exchanges and he explained that the essence of the purchasing power parity had to be found in its regarding internal purchasing power as being in the long run a more trustworthy indicator of the currency's value the market rates of exchange.

On the other extreme there were those who found the purchasing power parity concept of the equilibrium exchange rate useless. They were pretending that there was no normal or settled rate of exchange based on purchasing power parity.

Most of the writers have concluded that even though the purchasing power parity doctrine in its rigid form is subject to numerous deficiencies and limitations, its usefulness depends on the origin of disturbances. When disturbances are mainly of a monetary origin, the purchasing power parity doctrine may be of some value. So, following Haberler (1936), for one group of phenomena, namely monetary changes, the theory was holding true with a high degree of precision. During the post-war inflation perhaps 99 per cent of the depreciation of the Germany mark was due to the rise in prices and only 1 percent to changes in relative demand.

At this time there were admittedly numerous weaknesses of the purchasing power parity doctrine, as enunciated by Gustav Cassel and others. Still, something of a pragmatic case could be made for its consequences when applied to the dislocated exchange rate situation of

(1) immediate post-World War I period, and (2) the depresses 1930's. Thus, in spite of its deficiencies the value of the purchasing power parity doctrine was basically pragmatic.

The second issue of controversy was related to the question of which price index should be used in computing the parity. One extreme view argued that the proper price index was that of traded goods only. By them, exchange rates were determined not by general price level at all, but by the prices and by quantities of media or international payments and the influence of purely domestic commodity prices was considered distinctly secondary.

The other extreme view argued that the proper price index should pertain to the broadest range of commodities. So, Cassel (1928) was explaining that the whole theory of purchasing power parity essentially was referring to the internal value of the currencies concerned, and variations in this value could be measured only by general index figures representing as far as possible the whole mass of commodities marketed in the country.

The basic difference between these two extreme views reflects fundamentally different interpretations of the role of exchange rates and thereby, of the meaning of purchasing power parity. Those who advocated the use of traded good prices emphasized the role of *commodity arbitrage* as the mechanism which governs the relationship between index emphasize the role of *equilibrium in asset markets* as a major factor governing the relationship between prices and the exchange rate.

The commodity arbitrage view went even further in arguing that no aggregate price index was relevant and only individual commodity prices should be analyzed. By Ohlin (1967) foreign exchange rates had nothing to do with individual prices.

On the other hand, proponents of the asset market approach argued against emphasis on specific commodities that in speaking of the exchange rate and comparative value of money in different countries, we had not in the least refer to the value of money estimated in commodities in either country. The exchange rate was never ascertained by estimating the comparative value of money in corn, cloth or any commodity whatever but estimating the value of the currency of one country, in the currency of another.

Indeed, if the role of exchange rates was to clear asset markets by equating the purchasing power of the various currencies, then the relevant price index should pertain to the broader domain of commodities. The asset view took it for granted that the operation of commodity arbitrage was equating traded goods prices and thus, if the purchasing power parity doctrine only was applied to traded goods it became a truism (Keynes 1923, p.74-5). Moreover, in that case, the purchasing power parity doctrine was presenting but little interest. It simply was stating that prices in terms of any given currency, of some commodity had to be the same elsewhere. Whereas its essence was the

statement that exchange rates were the index of the monetary conditions in the countries concerned

Therefore, proponents of the asset market approach rejected the use of the wholesale price index since it was giving an excessive weight to traded goods (e.g. Ellis 1936, p.28-9), Haberler (1945, p. 312 and 1961, p 49-50).

In fact, since according to the asset market approach, the exchange rate linked purchasing powers of moneys in terms of the broad definition of the price level, one could imagine a situation in which all traded goods prices had been equalized by commodity arbitrage while the exchange rate was in disequilibrium. Analyzing such a situation Hawtrey (1919) mentioned that the equilibrium to which foreign exchange market tends was an equilibrium of the price level. What he argued was that if the currency units of two countries were considered in terms of foreign trade products only, then the rate of exchange between the two currency units would approximate closely to the ratio of their purchasing power so calculated .But that was not the condition of equilibrium As result it was to the price level in general, of home trade products as well as foreign trade products, that the rate of exchange had to adjust.

A complete separation of the analysis of equilibrium exchange rates from commodity arbitrage, leaded to an argument for using price indices of nontraded goods only. Strictly interpreted then, prices of non-internationally traded commodities only should be included in the indices on which purchasing powers pars are based.

This argument yielded an even narrower interpretation of the meaning of purchasing power parity by which the relevant indices were those of the least traded commodity - the wage rate parity. So on 1919 Hawtrey was writing that among industrial countries purchasing power parity was a parity rather of wage levels than of price levels.

Supporting Hawtrey, Cassel (1930) was explaining that in adjusting the value of a country's money, a foreign country would naturally not only go by trade prices but by the height of wages. The level of wages in the country therefore was going to be always a very important factor - in the long run it could be the predominant one - in determining the international value of the country's currency.

This interpretation of the purchasing power parity doctrine was forcefully advocated and implemented by Jacques Rueff in 1926 (reproduced in Rueff 1967).

Whatever the price index used for computations of parities, the question remained of distinguishing between an equilibrium relationship and a causal relationship. Most authors recognized that in analytical matter, prices and exchange rates were determined simultaneously as a function of some exogenous variables. It was not right to pretend that the rise in prices was the primary phenomenon, and that the depreciation of the exchange was merely an effect of this. The two changes beared a functional relation to one another and were both effects of the same cause. So, Angell (1926) was explaining that neither prices nor the exchange rates could properly be regarded as having been the "cause" of the general movement in any specific case. Nor was the level of either, except in a very immediate sense, ever the "result" of the other's fluctuations. Rather, both prices and exchange movement s were common products of a common antecedent condition.

However, it is important to mention that it was a minority that argued that there existed a casual relationship between prices and exchange rates. While Cassel (1921) claimed that the causality goes from prices to the exchange rate, Einzig (1935, p. 40) claimed the opposite. As an empirical matter, however, most of the formal studies of purchasing power parity have involved regressions of exchange rates on price ratios with the implicit assumption that the latter is in some sense exogenous to the former.

2. The absolute and relative versions of purchasing power parity.

The absolute version of the purchasing power parity doctrine (APPP) asserts that economic forces set the nominal exchange rate between currencies of two countries (defined as number of units of domestic currency per unit of foreign currency) equal to the ratio of domestic to foreign price level so that the price of a standard market basket of goods, when expressed in terms of a common currency, would be the same in the two countries.

Let E be the nominal (spot) exchange rate, defined as the number of units of the domestic currency needed to purchase one unit of the foreign currency, let P be the domestic price index and let P* be the foreign price index. In its simplest form, APPP is expressed by the following equation:

$$E = P / P^* \qquad (9)$$

Absolute purchasing power parity relies on the law of one price, which states that the general level of prices, when converted to a common currency, will be the same in every country. Equation 9 clearly holds if there is only one good produced in a perfectly competitive world market with no transportation costs or any other barrier to trade. A more realistic model would be to assume monopolistic competition (Krugman, 1979; Lancaster, 1980 and Ethier, 1982).

If $P > EP^*$, goods will be cheaper to import than to buy at home and imports will rise driving down the domestic price level.

A number of factors may lead to deviations from purchasing power parity particularly in the short run. Melvin (1992) divides these factors into three groups:

1. Transport costs and barriers to trade such as tariffs which may cause permanent deviations from PPP.

2. Differential speeds of adjustment in the exchange rate markets and the goods markets which may lead to the temporary deviations from purchasing power parity. Similar deviations may result if there are changes in relative prices due to real economic events (for example, changes in tastes, technology, government policies and weather conditions) even if exchange rates and goods prices do not vary at different speeds.

3. Differences in the composition of the "market basket" and weights used in constructing the official price index across countries, and comparing prices at the time of order which exchange rates at the time of delivery. These two factors may generate false deviations from purchasing power parity.

Many of the factors mentioned above will diminish in significance in periods which the general level of prices change rapidly. For example, real shocks to the economy often change relative prices and the exchange rate leading to short-term deviations from APPP. However, since most of these real shocks are random their effects on the exchange rate tend to cancel out over time.[2] Even if they do not, the sheer magnitude of increases in the domestic general price level tends to overwhelm the relative price changes and dominate movements in the exchange rates. Accordingly, the larger the changes in the price level and the longer the time frame, the less important are the

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[2] A notable exception is the effect of asymetrical productivity advances in the tradable and nontradable sectors. This phenomenon known as the "productivity bias" lead to a relatively higher nontradable/tradable price ratio in more advanced countries (Balassa 1964). Thus, price parity calculations based on general price levels for these countries yield exchange rates which are below

effects of the random relative price changes on the exchange rates. [The intuition behind this argument is illustrated by Melvin (1992) using the "elevator" analogy. In this analogy, the price level is represented by the distance of a moving elevator from the ground. The elevator contains a load of bouncing tennis balls each representing the price of an individual good. As the elevator moves upward the balls inside are carried with it (individual prices rise). But since some balls are bouncing up and some down the relative prices change at the same time. The faster the elevator moves (the higher is the inflation rate) and the longer the length of time that elapses the less important become the changes in relative prices caused]. Thus, one would expect that the long-run behavior of the exchange rate would follow its purchasing power parity path more closely in high inflation countries than in low- or moderate inflation countries.

Copeland (1989) offers two additional arguments to support the proposition that purchasing power parity may hold better in high inflation countries. He argued that in the case of high inflation environment, the cost of being wrong about any price is potentially so great that agents are forced to invest considerable effort and expense in gathering information. Further more, there tends to be a progressive collapse in the kind of institutional and legal arrangements that in normal times serve to make price sticky, such as long-term contracts, price controls and so on. His conclusion was that both prices and the exchange rate move smoothly along their purchasing power parity paths.

The absolute version of purchasing power parity is rather restrictive, for it requires the exchange rate at a given point in time to be equal to the ratio of prevailing price levels as in Equation (9). The actual exchange rate, however, may deviate from the purchasing power parity exchange rate due to imperfections of published price levels (for example, in reality the price indexes of different countries may not necessarily reflect the costs of

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their corresponding true long-run equilibrium values. Furthermore, this bias is systematic and exactly the same market basket) and / or sensitivity of the purchasing power parity exchange rate to the choice of the base period for the price indexes.

An alternative version of purchasing power parity is called relative purchasing power parity and can be written as

$$E = TP/P^* \qquad (10)$$

where T is the real terms of trade, the quantity of exports needed to purchase a unit of imports. T is usually assumed to be constant. In a single-good world, factors which will influence the terms of trade include transport costs, tariffs, quotas and differences in technology. For a multiple-good world, additional factors influencing the terms of trade include the existence of non-traded goods or services, the monetary and fiscal policy mix and tastes. Note that when T is constant both absolute and relative PPP imply

$$e = p - p^* \qquad (11)$$

where $e = \ln E_t - \ln E_{t-1}$ (or percentage change in E), $p = \ln P_t - \ln P_{t-1}$, $p^* = \ln P^*_t - \ln P^*_{t-1}$, and ln denotes the natural logarithm. Equation 11 says that the rate of change of the exchange rate is equal to the domestic rate of inflation minus the foreign rate of inflation. Equation 11 holds if T, in Equation 10, is constant. Absolute purchasing power parity, Equation 9 holds if T = 1.

The relative version of purchasing power parity requires that, over a given time period, the percentage change in the exchange rate be equal to the inflation rate differential of the two countries. The exchange rate, accordingly, depreciates (appreciates) if the inflation rate in the home country is greater (smaller) than the inflation rate in the foreign country. If price movements dominate changes in the exchange rate in high inflation countries, then percentage change in the exchange rate is primarily a function of differential in inflation rates.

Another type of relative purchasing power parity occurs if the long-run terms of trade change at a constant rate. For example, the Prebisch-Singer

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increases with the overall productivity differentials.

hypothesis is that the long-run terms of trade move against less developed countries. This would imply that Equation 11 can be written as

$$e = \lambda + p - p^* \qquad (12)$$

where for less developed country, the Prebisch-Singer hypothesis implies $\lambda > 0$

It should be pointed out that if absolute purchasing power parity holds for a country relative purchasing power parity should hold as well, for relative purchasing power parity is directly derived from absolute purchasing power parity. However, relative purchasing power parity may hold even if absolute purchasing power parity does not provided that factors which have caused deviations from absolute purchasing power parity remain more or less stable over time.

Indeed, much of economists' faith in PPP derives from a belief that over most of the past century, price level movements have been dominated by monetary factors. If price index movements are dominated by monetary shocks, and if money is neutral in the long run, then it won't matter if the two baskets being compared are not the same; relative purchasing power parity should still hold (approximately). Of course, economists like to use purchasing power parity as a frame of reference not just for hyperinflationary economies, but for any pair of economies.

3. Purchasing power parity and balance of payments theory

Purchasing power parity plays a major role in balance of payments theory. In the monetary approach to the balance of payments (MABP), prices and exchange rates in the very long run, say a year or more tends toward equation

$$E = P / P^*$$

However, in the short run, though asset prices are in continuos equilibrium, commodity prices can be disequilibrated for observably long periods. The disequilibria in commodity prices is the driving mechanism for capital flows, for the creation of a trade imbalance, and penultimately for the interpretational transmission of the inflation and other monetary disturbances. For the MABP, violations of above equation must have a persistent and predictable pattern over time. Short-run disequilibrium coupled with the presumption of long-run equilibrium implies a steady movement of prices or of exchange rates toward the norm of the above equation. If for example, the deviations in the given equation were judged to be purely random, based on empirical observation, there would remain no incentive for producers to direct shipments toward the higher (relative) priced locations nor for consumers to order goods deviations in the given equation might be reversed by the time the goods have arrived, and no capital movements, trade imbalance, nor inflation transmission can be caused by such purely stochastic deviations.

Empirical evidence on these issues is mixed and conflicting. For example, by Isard (1977) the law of one price was flagrantly and systematically violated by empirical data. There were exchange rate changes that were altering the relative dollar equivalent prices of the most narrowly defined domestic and foreign manufactured goods for which prices might be readily matched. Moreover, Isard explained that the relative price effects seemed to persist for at least several years and could not be shrugged off as transitory.

A somewhat different conclusion was reached by Hodgson and Phelps (1975). So they concluded that the major impact of price-level movements (on exchange rates) occurred only within a few months, and in most instances considered by them the lagged effects were largely exhausted within a year's time. By them, the purchasing power parity theory, appropriately specified, might offer a useful explanation of exchange rate behavior over shorter periods than those to which it had generally been applied.

Finally, a diametrically opposite conclusion to Isard's was reached by Rogalski and Vinso (1977). In their work they were pretending that freely floating exchange rate markets were reacting immediately or nearly so to changes in relative inflation rates. Such a finding was consistent with both the purchasing power parity theory and the efficient market hypothesis. In particular they pointed out that no significant lagged relationship had been observed as in previous research by others.

With their findings Rogalski and Vinso seem to have been the first authors to emphasize the conflict between the efficient markets concept and slow adjustments in purchasing power parity. Their tests were quite sophisticated relative to those of Isad and Hodgson and Phelps, and some greater reliance could be placed on Rogalski and Vinso's conclusion for this reason alone. However, Rogalski and Vinso restricted their attention to the early 1920s and to Canada for 1953 -1957 (because these were period of floating exchange rates). The possibility remains that other periods, of fixed or of dirty exchange rates, might display different characteristics for PPP or that commodity and exchange markets are efficient for some pairs of countries but not for others.

III. EVOLVING TESTS OF SIMPLE PPP

There are distinguished three different stages of purchasing power parity tests:

1. older tests in which the null hypothesis is that purchasing power parity holds
2. more recent theories and time series tests in which the null hypothesis is that purchasing power parity deviations are completely permanent; and
3. even more recent cointegration tests in which the null hypothesis is that deviations away from any linear combination of prices and exchanges rates is permanent.

1. Stage one: Simple purchasing power parity as the null hypothesis.

In Cassel (1922) view, purchasing power parity was seen as a central tendency of the exchange rate, subject to temporary offset, and not a continuously-holding equivalence. Much of the work on purchasing power parity through the 1970s recognizes the importance of temporary disturbances to purchasing power parity, in principle. But early formal empirical analyses were limited by the absence of statistical and theoretical tools for distinguishing between short-run and long-run real effects. Thus, typically, the early studies at best only allowed for a disturbance term, and did not specifically allow for any dynamics of adjustment to PPP.

Without doubt, the most positive results in stage-one tests came from data on high inflation economies. Frenkel (1978) ran regressions of the form

$$s_t = \alpha + \beta(p_t - p_t^*) + \varepsilon_t$$

for a number of hyperinflationary economies. He was mot so much interested in the properties of the error term, as in whether the slope coefficient was one. Frenkel indeed found estimates of β quite close to one and, based on these estimates, argued that PPP should be an important building block of any model of exchange rate determination.

Outside of hyperinflation, however, most stage-one tests produced strong rejections of purchasing power parity. Frenkel (1981) reports that purchasing power parity performed poorly for industrialized countries during the 1970s, with β estimates typically far from one (some country-pairs actually yield negative coefficients while for others β estimates exceeded 2.0). Frenkel suggested that the failure of PPP might be attributable to some combination of temporary real shocks and sticky goods prices, implicitly arguing that PPP still holds in the long run even though short-run factors get in the way of finding $\beta = 1$. However, Frenkel made no attempt to model the short-run bias in the coefficients.

Aside from failing to allow for dynamic adjustment, another obvious problem with the given regression is that exchange rates and prices are simultaneously determined, and there is no compelling reason to put exchange rates on the left-hand side, rather than visa-versa. Indeed, many authors ran the reverse regression, projecting relative prices on the exchange rate.

Krugman (1978)was an attempt to explicitly address the endogeneity problem. Krugman offered a flex-price model which had the domestic monetary authorities offsetting the effects of real shocks by expanding the money supply and thereby raising the price level introduces a downward bias in OLS estimates of β. To control for this bias, Krugman (1978) and Frenkel (1981) re-estimated the equation using instrumental variables.[3] Their methodology succeeded in that it yielded coefficients closer to one than under OLS, though one could still soundly reject purchasing power parity. The endogeneity issue can, of course, also be cast as a left-out regressor problem. That is, the bias in the key coefficient β can be removed by conditioning the

[3] Krugman (1978) used a time trend as an instrument, whereas Frenkel (1981) used a time polynominal as well as lagged exchange rates and price levels.

regression on the real exogenous factors that affect both exchange rates and prices and which, according to some model, explain deviations from PPP.

A fundamental flaw in the econometrics of the stage-one tests was the failure to take explicitly into account the possible nonstationarity of relative prices and exchange rates. Today it is well known that if there is a unit root in the error term to the given equation, then standard hypothesis tests of the proposition $\beta = 1$ are invalid. Overall, the main lesson from stage - one tests was that PPP does not hold continuously, but the results provided no perspective on whether purchasing power parity might be valid as a long-run proposition.

2. Stage two: The real exchange rate as a random walk.

Stage-one tests' disappointing results and flawed hypothesis testing led to an alternative approach. In stage-two tests, the null hypothesis becomes that the real exchange rate follow a random walk, with the alternative hypothesis being that PPP holds *in the long run*. These tests stand those from stage-one tests on their head: they impose - rather than estimate - hypothesis that $\beta = 1$, and test - rather than impose - the hypothesis that the (log of the) real exchange rate is stationary.

$$q_t = s_t - p_t + p_t^*$$

Examples of early stage- two tests include Darby (1993), Alder and Lehman (1983), Hakkio (1984), Frankel (1996), Huizinga (1987) and Meese and Rogoff (1988). The main problem with stage-two tests is low power. Given the phenomenal volatility of floating exchange rates, it can be very hard to distinguish between slow mean reversion and a random walk real exchange rate. Much of the evolution of stage-two testing has revolved around finding longer or broader data sets, and implementing more powerful unit roots tests.

Leaving aside the problem of low power, how plausible is the null that the real exchange rate follows a random walk? Roll (1979) argued that a random walk is a sensible null hypothesis because real exchange rate changes, like changes in asset prices, should not be predictable if foreign exchange markets are efficient. Of course, this analogy is inappropriate, since real exchange rates are not traded assets and therefore not subject to the usual efficient capital markets logic. Indeed, there is no reason why even the nominal exchange rate - which is a market variable - should follow a random walk in the presence of nominal interest differentials or risk premia.

Certainly it is possible to find rationales for random walk, or near random walk, exchange rate behavior that are defensible than Roll's. Balassa and Samuelson showed that cross-country sectoral differences in productivity growth can lead to real CPI exchange rate changes. If productivity differential shocks are permanent, sectoral productivity shocks can induce a unit root in the real exchange rate. By Rogoff's (1992) model intertemporal smoothing of traded goods consumption can lead to smoothing of the intratemporal price of traded goods. This in turn implies a unit root in the real exchange rate, even when productivity shocks are temporary. Obstfeld and Rogoff (1995) offer a model in which any shock (even e monetary one) that effects a wealth transfer across countries will lead to potentially long-lasting change in relative work effort, and therefore the real exchange rate.[4]

Econometric techniques to test for random walk real exchange rates

Once the null hypothesis posits that the real exchange rate follows a random walk (or more generally has a "unit root" component),[5] it becomes necessary to negotiate a number of important econometric subtleties. Most importantly, conventional confidence intervals calculated under the null of a stationary real exchange rate are no longer appropriate and, as Dickey and Fuller (1979) emphasized, the correct confidence intervals should be wider.

[4] There is a substantial empirical literature on the effects of wealth re-distributions on the long-run equilibrium exchange rate; [for example, Krugman (1990), and Bayoumi, Clark, Symansky and Taylor (1994)].

[5] If the real exchange rate has one unit root, then its first difference must be stationary though not necessarily serially uncorrelated as in the random walk model.

The modern literature uses three main techniques for distinguishing the real exchange rate from a random walk.[6] The first and most commonly used, is the Dickey-Fuller and augmented Dickey-Fuller tests. These involve a regression of the real exchange rate, q_t, on a constant, a time trend, q_{t-1}, and lagged changes in q_{t-1}:

$$q_t = \alpha_0 + \alpha_1 t + \alpha_2 q_{t-1} + \Phi(L)\Delta q_{t-1} + \varepsilon_t$$

where L is the lag operator, $\Phi(L)$ is the pth order polynomial in L, with coefficients $\phi_1, \phi_2, \ldots \phi_p$, and ε_t is white noise. Under the null hypothesis that q_t has a unit root, $\alpha_2 = 1$. Under the alternative hypothesis that purchasing power parity holds in the long run, $\alpha_1 = 0$ and $\alpha_2 < 1$.[7] The distribution of the OLS estimates for the upper equation is nonstandard under the random walk null, with the appropriate confidence intervals reported by Dickey and Fuller (1979). An example of a study applying the Dickey-Fuller test to floating real exchange rates is Meese-Rogoff (1988), who are unable to reject the unit root hypothesis for monthly dollar/pound, dollar/yen, and dollar/DM floating exchange rate data.

The second commonly-used technique is that of variance ratios. The idea here is that under the null hypothesis of a random walk, the variance of the real exchange rate should grow linearly over time. This implies that the statistic

$$k(i) = (T/T - i + 1) \,.\, var\,[(1-L)q_t]i/var[(1 - L^i)q^t], \quad i = 2,3,\ldots T - 1$$

should be one for all i. For a stationary series, on the other hand, the k statistic converges to zero as k increases.

A third technique is that of fractional integration, which encompasses a broader class of stationary process under the alternative hypothesis. A fractionally integrated process allows the real exchange rate to evolve according to:

[6] Some of the very early efforts to test the random walk real exchange rate hypothesis, including Darby (1983), and Adler and Lehman (1983), did not use modern root testing methodologies, but nevertheless illustrated the difficulties in rejecting the random walk model.

[7] Some of the studies test only $\alpha 2 < 1$, and do not jointly apply the restriction $\alpha 0 = 0$. Also, many studies lok only at the straight Dickey-Fuller test and do not augment the regression with the lagged changes. There is no problem with this simplification as long as the residuals are not autocorrelated.

$$\Phi(L)\,(1 - L)^d q_t = \chi(L)\,\varepsilon_t,$$

where $\Phi(L)$ and $\chi(L)$ are polynomial lag operators with roots outside the unit circle and ε_t is white noise. If the parameter $d = 0$, then the real exchange rate is confined to the class of stationary ARMA processes described by $\Phi(L)$ and $\chi(L)$. If $d = 1$ the $\Phi(L) = \chi(L) = 1$, then the real exchange rate follows a random walk. The advantage of this class of processes is that it allows for fractional integration, $0 < d < 1$. Because fractionally integrated process are stationary, but have autocovariance functions that die off more slowly than ARMA processes, encompassing them under the alternative hypothesis may enhance one's chances of rejecting the random walks null.

3. Stage three tests: Cointegration

At first glance, purchasing power parity testing would seem to provide the perfect context for Engle and Granger's (1987) work on cointegration. The techniques are designed to test for long-run equilibrium relationships, for which the adjustment mechanism remains unspecified. Cointegration tests are thus liberated from stage-one concerns about endogeneity and left-out variables. Moreover cointegration tests hold forth the promise of testing weaker versions of purchasing power parity, since they require only that some linear combination of exchange rates and prices be stationary. In other words, stage-two tests ask whether the real exchange rate $q_t = s_t - p_t - p_t^*$ is stationary. Stage-three tests ask only whether

$$s_t - \mu p_t + \mu^* p_t^*$$

is stationary for any constant μ and μ^*. Any incremental power from stage-three test over stage-two tests must therefore come from relaxing the symmetry and proportionally restrictions that $\mu = \mu^* = 1$. In the discussion below, we will distinguish between trivariate tests that place no restrictions on the coefficients in the equation, and bivariate tests that impose the symmetry restriction $\mu = -\mu^*$.

Why might μ not equal one? Consider the following model used by Taylor (1988), Fisher and Park (1991), and Cheung and Lai (1993). First, assume purchasing power parity holds exactly for traded goods so that

$$s_t = p_t^T - p_t^{*T} \qquad (1)$$

where p_t^T is the time t (log) home price of traded goods. Second, assume that the overall price index consists of a weighted average of traded and nontraded goods prices:

$$p_t = \gamma p_t^T + (1 - \gamma)p_t^N \qquad (2)$$

where p_t^N is the time t home price of nontraded goods, for which purchasing power parity does not necessarily obtain. the price index abroad is similar to (2), with weights γ^* and $1 - \gamma^*$. Finally, the price of nontraded goods is assumed to be proportional (in the limit) to the price of traded goods:

$$p_t^N = \alpha_0 + \phi p_t^T + \varepsilon_t \qquad (3)$$

$$p_t^{*N} = \alpha_0 + \phi p_t^{*T} + \varepsilon_t^* \qquad (4)$$

where the residuals ε and ε* are stationary. Given eqs. (1) - (4), a regression of the form

$$s_t = \mu p_t + \mu^* p_t^* + \varepsilon_t \qquad (5)$$

yields coefficients

$$\mu = 1 / [\gamma + \phi(1 - \gamma)] \qquad (6)$$

$$\mu^* = 1 / [\gamma + \phi^*(1 - \gamma^*)] \qquad (7)$$

One possible explanation of why the slope coefficients in eqs. (3) and (4) might not equal one is simply that there is a trend in the relative prices of traded and nontraded goods. Another explanation, offered by Taylor (1988), Fisher and Park (1991), and Cheung and Lai (1993) is that errors in measuring nontraded goods prices can imply ϕ, $\phi \neq 1$. But can measurement error interfere with the proportionality of p_t^N and p_t^T? One possibility is to think of p^N as an index of nontraded goods prices that is subject to either "fixed-weight" or " new goods" bias. Fixed-weight bias results when fixed weight price indices confront changing relative prices. Bryant and Cecchetti (1993) show

how these effects can generate permanent upward index movements when relative prices change, and therefore bias measured inflation upward. A second source of bias comes from the introduction of new goods, which one can think of having high implicit prices prior to their introduction.

V. SOME OF THE RECENT EMPIRICAL STUDIES CONCERNING PPP

Recently a increasing consideration in the articles that are testing for the presence of the PPP is present. Most of them didn't get any positive result. I would like to mention some of them.

Conejo and Shields (1993) applied the cointegration technique to examine a relative version of purchasing power parity for Brazil, Mexico, Costa Rica, Columbia and Venezuela. They got that relative purchasing power parity holed for Brazil and Mexico but not for the remaining countries. The exchange rate and price variables were cointegrable and the cointegrated coefficient between the exchange rate and relative prices were close to one for Brazil and Mexico for both price indexes. Furthermore, the constant term was close to zero for both Brazil and Mexico indicating no long run trend in the real terms of trade.

Bahmani-Oskooee (1993) tested the purchasing power parity theory between Iran rial and 19 other currencies using the concept of effective foreign price and the cointegration technique. Using two different concepts weighted averaging, he showed that when official exchange rate data are used, purchasing power parity receives no empirical support. However, when black market exchange rate are used, after incorporating the effects of the Iranian revolution and the Iran-Iraq war, enough evidence was provided supporting the long-run purchasing power parity.

Serletis (1994) used recent developments in the theory of nonstationarity repressors, to investigate the purchasing power parity relation during the floating exchange rate period for seventeen OECD countries using quarterly data (form 1973.1 to 1992.1). He used Johansen's powerful maximum-likelihood method for estimating and testing steady-state relations in multivariate vector outoregressive models. By the test he got that although in many cases there existed a long-run relationship between exchange rates and international price differentials, likelihood ratio tests rejected in most instances the null hypothesis that purchasing power parity relation was stationary. The results were quite different from previous studies, particularly from those of Kugler and Lenz (1993) who applied exactly the same methodology using, however monthly data. With respect to this Sarletis was arguing that the power of such tests was primarily a function of the length of the time period, not the number of observations.

Hokue *(1995)* tested for the presence of the PPP for the countries in the South Asia. The results of the cointegration tests of the purchasing power parity as a long-run relationship provided rather weak support for the hypothesis Bangladesh, Pakistan and Sri Lanka provide no evidence in support for cointegration and therefore no support for the purchasing power parity hypothesis. India provided mixed support. The error cointegration equations for India showed that the price level hardly adjusted in response to deviations from long-run path. Most of the adjustments that took place to correct the deviation came through exchange rate devaluation by the government. What is important to say is that all these countries were protected by tariff and quota systems and were subject to domestic market distortions although relative more liberalized in recent times. The foreign exchange market was under government regulation and was subject to intervention by the central banks from time to time.

Henricsson and Lundback (1995) were able to reject the null hypothesis of the presence of purchasing power parity and at the same time they couldn't reject the null hypothesis of the absence of purchasing power parity. They showed that the low support for the purchasing power parity should not simply be interpreted as the failure to prove purchasing power parity, but rather as a counter evidence against purchasing power parity. Purchasing power parity appeared to fail as a proper description of the long-run relationship between exchange rates and price levels.

Thacker (1995) examined the hypothesis of long-run purchasing power parity for Poland and Hungary *vis-á-vis* the United Kingdom, Germany and the

United States for the period January 1981 to February 1993. Both the cointegration tests and the tests for unit roots in the real exchange rates were used to test the purchasing power parity proposition. The results indicated that purchasing power parity failed to hold irrespective of weather the consumer price index or the wholesale price index were used as the measure of the prices. Even though both Poland and Hungary had experienced large monetary shocks and frequent devaluation of their currencies, purchasing power parity was rejected.

V. THE EMPIRICAL ANALYSIS

1. Empirical methodology

To test purchasing power parity, a cointegration technique is applied which is a technique that asks whether a group of nonstationary variables can be combined to produce a stationary variable.

First, we test for cointegration between exchange rate (E_t), domestic price(P_t) , and foreign price (P_t^*) using the Engle and Granger methodology. Briefly, following Engle and Granger (1987) a non-stationary time series X_t is said to be integrated of order *d* if it achieves stationarity after being differenced *d* times denoted by $X_t \sim I(d)$. Now consider two series X_t and Y_t that are both integrated of the same order, *d*. According to Granger (1986) and Engle and Granger (1987) it will generally be true that a linear combination $Z_t = X_t - gY_t$ will also be $I(d)$. However, if a constant like g exists, such that $Z_t \sim I(d - b)$ where $b > 0$, then X_t and Y_t are said to be cointegrated. Therefore, we began cointegration tests by examining the order of integration of the natural logarithms of the domestic price ($\ln P_t$) and the sequence formed by the sum $\{\ln E_t + \ln P_t^*\}$ for each country with the United States and Germany serving as the standard countries. To this end, we perform Augmented Dickey-Fuller (ADF) tests. In general, for a variable such as Xt these tests involve estimating the following regression equation:

$$(1 - L)X_t = c + ft + dX_{t-1} + \Sigma e_i(1 - L)X_{t-i} + V_t \qquad (1)$$

where L is the lag operator; *v* is an error term; *d* and *e* are the parameters to be estimated t is the time trend and c is the intercept. The null hypothesis to be estimated is the estimate of $d = 0$ against the alternative that $d \neq 0$. Thus, after fitting OLS to the regression, we form the "t-ratio" for *d* and compare its value to the appropriate value. The rejection of the null hypothesis implies that the X_t series is non-stationary. The cumulative distribution of the ADF test statistic is provided by Fuller (1976). If the calculated statistic is less than its critical value from Fuller's table, then X is said to be stationary.

The next step is to estimate the long-run equilibrium relation by regressing each $\{lnE_t + lnP_t^*\}$ on lnP_t:

$$lnE_t + lnP_t^* = \beta_0 + \beta_1 lnP_t + \mu_t \qquad (2)$$

Absolute PPP asserts that $lnE_t + lnP_t^* = lnP_t$, so that this version of the theory requires $\beta_0 = 0$ and $\beta_1 = 1$. The intercept β_0 is consistent with the relative version of PPP requiring only that domestic and foreign price levels move proportionately to each other. Unless there are compelling reasons to omit the constant, the recommended practice is to include an intercept term in the equilibrium regression. In fact, Engle and Granger's (1987) Monte Carlo simulations all include intercept terms.

The second step in the methodology entails testing the hypothesis of a unit root in the residuals. If this unit-root hypothesis cannot be rejected, then we cannot rule out the possibility that the "disequilibrium error" is nontationary, in which case there is no long-run relationship between between variables. The test is an ADF test. The following equation has to be estimated using the residuals from each long-run equilibrium relationship:

$$\Delta\mu_t = a_1\mu_{t-1} + \Sigma a_i + 1\Delta\mu_{t-i} + \varepsilon_t \qquad (3)$$

where the value of p is chosen so as to make the error term in regression (3) a white noise process. Note that it is not necessary to include all the laged values of $\Delta\mu_t$ from 1 to p; we can include only the lags that are significant, e.g, only $\Delta\mu_{t-1}$ and $\Delta\mu_{t-3}$ omitting $\Delta\mu_{t-2}$. Note also that we do not include a constant term in regression (3) because we included it in the cointegrating regression; had we not included one in the cointegrating regression, however, we should have included one in (3). The null hypothesis is $H_0{:}a_1 = 0$. Thus after fitting OLS to (3), we form the "t-ratio" for a1 and compare its value to the appropriate critical value. Critical values have been constructed by Engle and Yoo (J. of Econometrics 35, May 1987, pp.143-159) for $2 \leq N \leq 5$. Note that Engle and Yoo do not include a time trend in either cointegrating regression or in their ADF regression.

The second approach that we employ to test the empirical validity of PPP for the three considered countries is Johansen's maximum likelihood approach.

Following Johansen and Juselius (1992), we consider the following p(=3)-dimensional vector autoregresive model

$$X_t = \Sigma \Pi_i X_{t-i} + \mu + \varepsilon_t \qquad (t = 1,\ldots,T) \quad (1)$$

where $X_t = [\ln S_t, \ln P_t, \ln P_t^*]$ and ε_t is an independently and identically distributed p-dimensional vector of intonations with zero mean and covariance matrix O. Letting $\Pi = -(I-\Pi 1 - \ldots - \Pi k)$ be the p x p total impact matrix, we consider the hypothesis of the existence of at most r (< p) cointegrating relations formulated as

$$H_1(r): \Pi = \alpha\beta',$$

where α and β are p x r matrices of full rank. The β matrix is interpreted as a matrix of cointegrating vectors, that is, the vectors in β have the property that $\beta' X_t$ is stationary even though X_t itself is nonstationary. The α matrix is interpreted as a matrix of error -correction parameters.

The maximum likelihood estimation and likelihood ratio test of this model has been investigated by Johansen (1988), and can be described as follow. First, letting $\Delta = 1 - L$, where L is the lag operator, Johansen and Juselius (1992) suggest writing (5) as

$$\Delta X_t = \Sigma \Gamma_i \Delta X_{t-1} + \alpha\beta' X_{t-k} + \varepsilon_t \quad , \qquad (t = 1,\ldots,T)$$

where

$$\Gamma_i = -(I - \Pi_1 - \ldots - \Pi i), \qquad (i = 1,\ldots,k-1).$$

In (7), the matrix Π is restricted as $\Pi = \alpha\beta'$, but the parameters vary independently. hence the parameters $\Gamma_1,\ldots,\Gamma_{k-1}$ can be eliminated by regressing

ΔX_t and ΔX_{t-k} on lagged differences, $\Delta X_{t-1}, \ldots, \Delta X_{t-k+1}$.. This gives residuals R_{ot} and R_{kt} and residuals product matrices

$$S_{ij} = T^{-1} \sum R_{it} R'_{jt} \qquad (i,j = o,k).$$

The estimate of β is found by solving the eigenvalue problem

$$|\lambda S_{kk} - S_{ko} S_{00}^{-1} S'_{ko}| = 0$$

for eigenvalues $\lambda_1 > \ldots > \lambda_p > 0$, eigenvectors $V = (v_1, \ldots, v_p)$ normalized by $V' S_{kk} V = I$. the maximum likelihood estimators are given by

$$\beta = (v_1, \ldots, v_r), \qquad \alpha = S_{ok}\beta, \text{ and } \qquad O = S_{oo} - \alpha\alpha'.$$

Finally the maximized likelihood function is found from

$$L_{max} = |O| = |S_{oo}| \Pi (1 - \lambda_I)$$

and the likelihood ratio test of the hypothesis $H_1(r)$ is given by the trace test statistic

$$-2\ln Q[H_1(r) \mid H_0] = -T \sum ln(1-\lambda_i).$$

An alternative test (called the maximum eigenvalue test, λ_{max}) is based on the comparison of $H_1(r-1)$ against $H_1(r)$

$$-2\ln Q[H_1(r-1) \mid H_1(r)] = -T \; ln(1-\lambda_{r+1}),$$

The approach proposed by Johansen has several advantages over the frequently employed residual-based tests of cointegration suggested by Engle and Granger (1987) . First, instead of assuming that there exists a unique cointegrating vector between the variables, Johanson's approach explicitly test for the number of cointegrating vectors. These tests are based on maximum eigenvalue and trace of the stochastic matrix. Second, it treats all the variables as endogenous and, thus avoids an arbitrary choice of the dependent variable as in the cointegrating equations of the Engle-Granger tests. Finally, unlike the two-step procedure of the Engle-Granger method, the Johansen approach provides a unified framework for estimating and testing cointegrating relations within the framework of vector error correction model.

For the Johansen's cointegration tests the null hypothesis r = 0 is tested against the alternative r = 1, r = 1 against the alternative r = 2, etc. Critical values have been constracted from Osterwald-Lenum(1990) under the assumption thet there is a linear trend in the data generating process.

In cases where the evidence suggests that there is a cointegrating relationship between variables , the likelihood ratio tests will be employed to test (a) the significance of the cointegrating parameters and (b) the "homogeneity condition" imposed by PPP.

2. Data

The data used are monthly ones and they are obtained from various issues of the International Financial Statistics and from Short -Term Economic Statistics Central and Eastern Europe published by the OECD. For all countries included in this test, we test PPP *vis-a-vis* the United States, and Germany and using the consumer price index . The data cover the period January 1991 to December 1995 for Czech Republic, January 1991 to October 1995 for Rumania, and June 1992 to December 1995 for Estonia. The time intervals are relatively short ones but this is because of difficulties in finding data for these countries.

3. Empirical Results

The methodology outlined above is implemented as a test of the long run purchasing power hypothesis for the Czech economy, Rumanian economy, and Estonian economy .

For both Czech Republic and Rumania, we test PPP *vis-á-vis* the United States and Germany and for Estonia we test PPP *vis-á-vis* United States using the consumer price index. All the series are converted to their natural logarithms.

A critical first step in any econometric analysis is to visually inspect the data. The plots of the exchange rate and price levels are shown in Figures 1, 2, 2, 3, 4 and 5 for each country respectively: Czech Republic, Rumania and Estonia.

Fig. 1.*Czech, U.S. price levels and exchange rate*

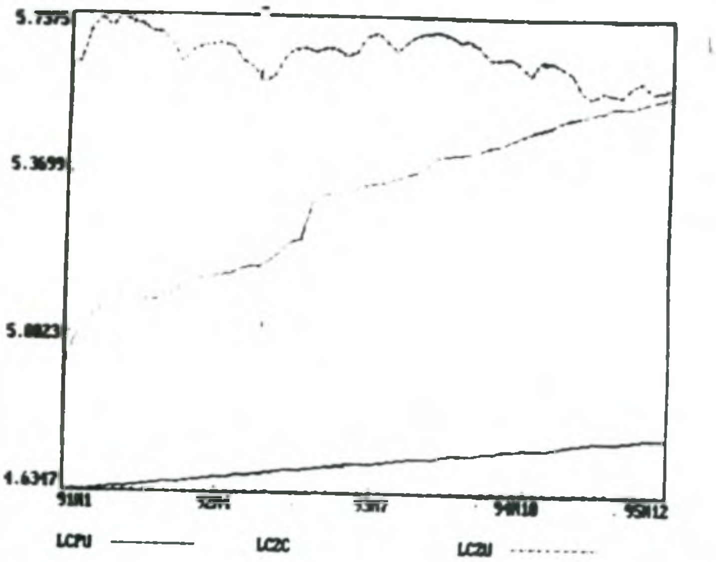


Fig. 2. *Czech, German price levels and exchange rate*

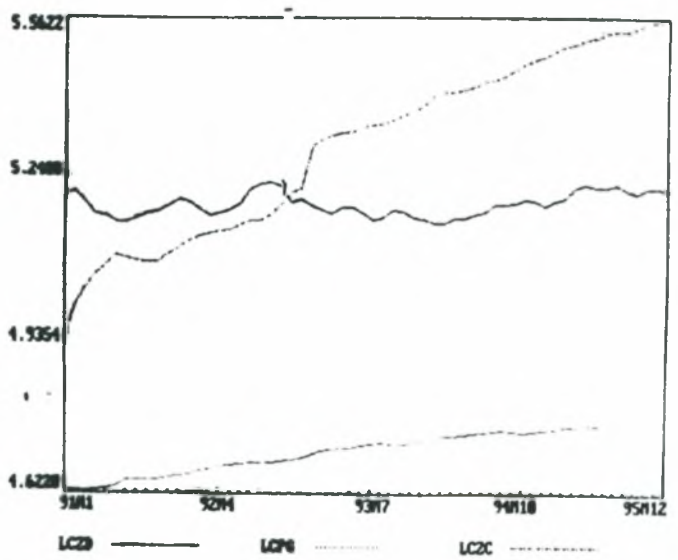


Fig. 3. *Rumanian, U.S. price levels and exchange rate*

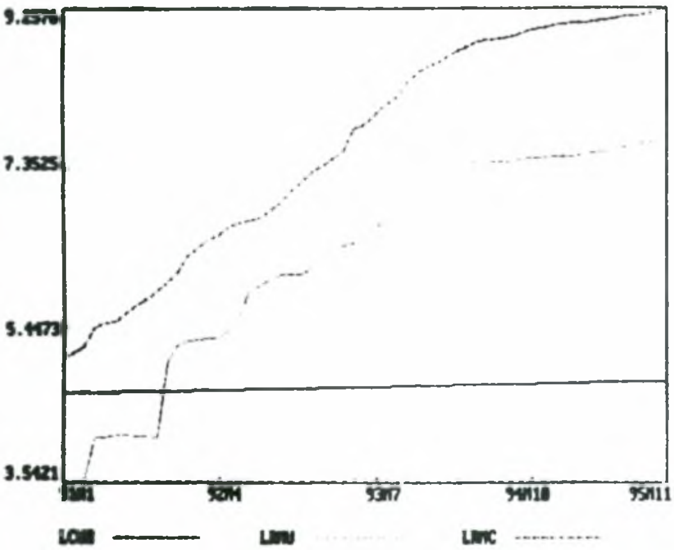


Fig. 4. *Rumanian, U.S. price levels and exchange rate*

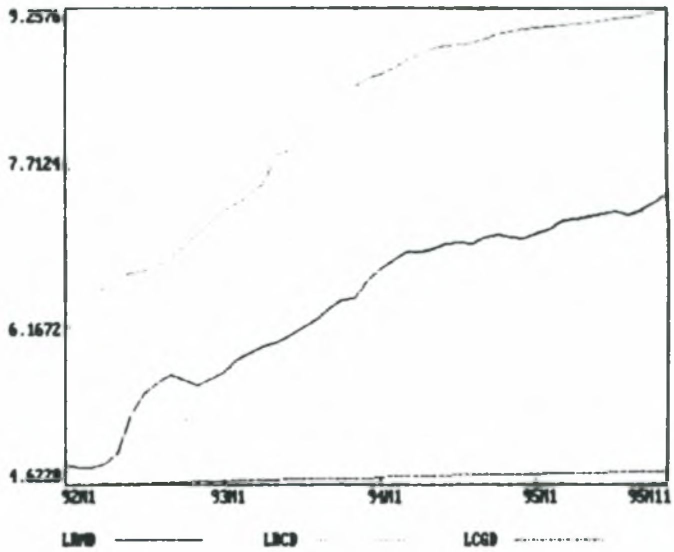
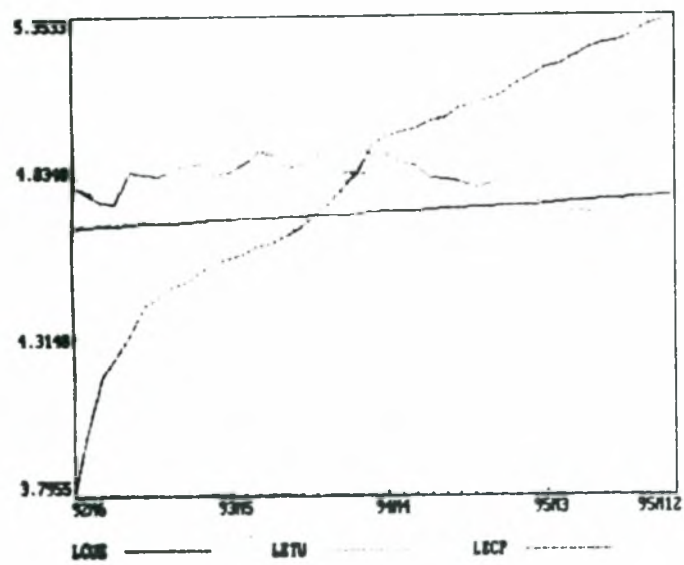


Fig. 5. *Estonian, U.S. price levels and exchange rate*



Each series seems to meander in a fashion characteristic of a random walk process. There is visual evidence of a detrminiistic time trend in most of them.

Tables 1, 2, 3 give the results of the ADF test for the level as well as for the first differenced variables for each of country respectively, Czech Republic, Rumania and Estonia. The null hypothesis is that the series are non-stationary against the alternative hypothesis that they are stationary. The critical values for the test statistics are obtained from the Fullers's (1976) table. An acceptance of the null hypothesis will imply that the corresponding series are non-stationary and have unit roots, while a rejection of the hypothesis will imply that the series are stationary with well-defined mean and variance.

Table 1. *The calculated ADF test statistics for level and first difference data (Czech Republic)*

Variable	Level	First difference
ln of domestic price level	-1.9392 (1)	-5.2937 (0)
critical value	-3.18	-1.61
ln of foreign price level (USA) + ln of exchange rate U.S.$-based	-2.7373 (1)	-5.1731 (0)
critical value	-3.18	-1.61
ln of foreign price level (Germ.) +ln of exchange rate D-mark-based	-2.1695 (1)	-5.2692 (0)
critical value	-3.18	-2.60

Note: The critical value of the ADF statistic are from the Fuller's (1976) table for 50 observations (10% level of significance)
Numbers inside the brackets are the numbers of lags

Table 2. *The calculated ADF test statistics for level and first difference data (Rumania)*

Variable	Level	First difference
ln of domestic price level	1.3553 (2)	-4.6417 (0)
critical value	-1.61	-1.61
ln of foreign price level (USA) + ln of exchange rate U.S.$-based	-2.3267 (0)	-6.5357 (0)
critical value	-2.60	-2.60
ln of foreign price level (Germ.) + ln of exchange rate D-mark-based	-1.9405 (1)	-3.8457 (0)
critical value	-2.60	-2.60

Note: The critical value of the ADF statistic are from the Fuller's (1976) table for 50 observations (10% level of significance)
Numbers inside the brackets are the numbers of lags

Table 3. *The calculated ADF test statistics for level and first difference (Estonia)*

Variable	Level	First difference
log of domestic price level	-2.9009 (1)	-5.9486 (0)
critical value	-3.18	-2.60

log of foreign price level (USA) + log of exchange rate U.S.$-based	-1.7054 (0)	-5.7135 (0)
critical value	-2.60	-1.61

Note: The critical value of the ADF statistic are from the Fuller's (1976) table for 50 observations (10% level of significance)

All the computed statistics lie below the corresponding critical values, implying an acceptance of the null hypothesis and presence of unit roots in the levels series. On the other hand, the test statistics for all the differenced series are significant indicating a rejection of the null hypothesis of non-stationarity. Therefore all these series are first difference stationary or integrated of order one.

Having established that for Czech Republic, Rumania and Estonia all the variables have achieved stationarity after being differenced once, we can now test for cointegration .

So we continue the cointegration tests for Czech Republic, Rumania and Estonia. The estimated values of β_1 and their associated standard errors are reported in Tables 4 and 5. Note that three of the five values are estimated to be quite a bit below unity. But we are making too much of these findings. It is not appropriate to conclude that each value of β_1 is significantly different from unity simply because the values of $(1 - \beta_1)$ exceed two or three standard deviations. The assumption underlying this type of t-test are not applicable here unless the variables are actually cointegrated and p_t (ln of domestic price level) is the independent variable.

Table 4. The equilibrium regressions (dollar values of the foreign price levels)

	Czech Republic	**Rumania**	**Estonia**
Estimated β_1	0.86589	0.86787	0.36215
Standard error	0.029277	0.021082	0.024197

Table 4. The equilibrium regressions (D-mark values of the foreign price levels)

	Czech Republic	Rumania
Estimated β_1	0.27200	0.84683
Standard error	0.018862	0.021644

The residuals from each regression equation are checked now for unit roots. Plotting the regression residuals against time series suggests that the regression residuals are not stationary.

Fig. 6. *Regression residuals for Czech (base country U.S.A.)*

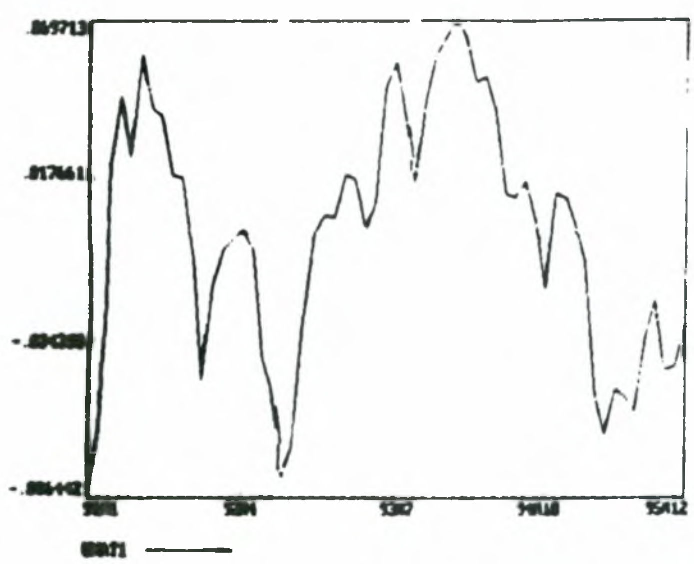


Fig. 7. *Regression residuals for Czech (base country Germany)*

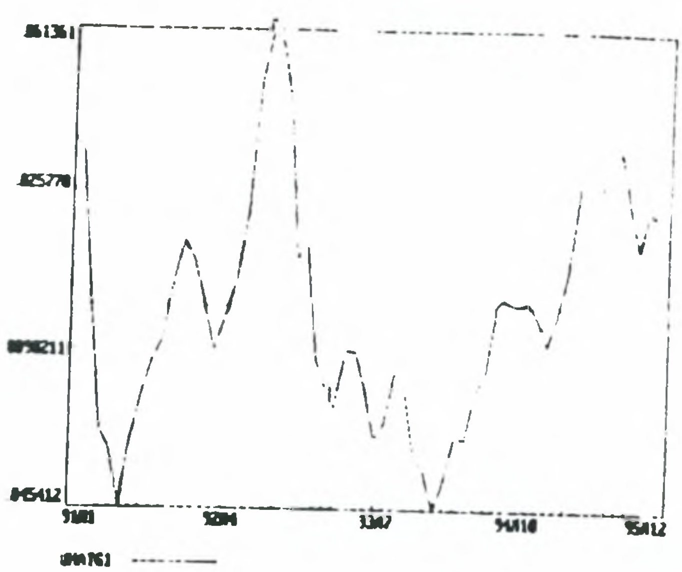


Fig. 8. *Regression residuals for Rumania (base country U.S.A.)*

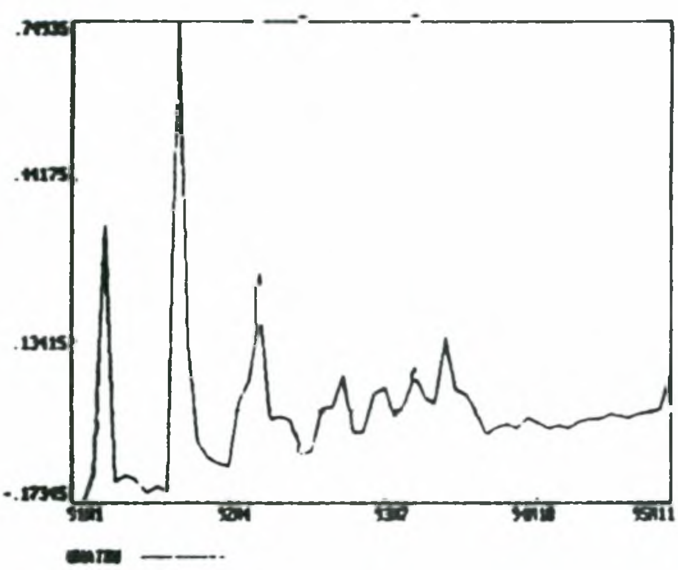


Fig. 9. *Regression residuals for Rumania (base country Germany)*

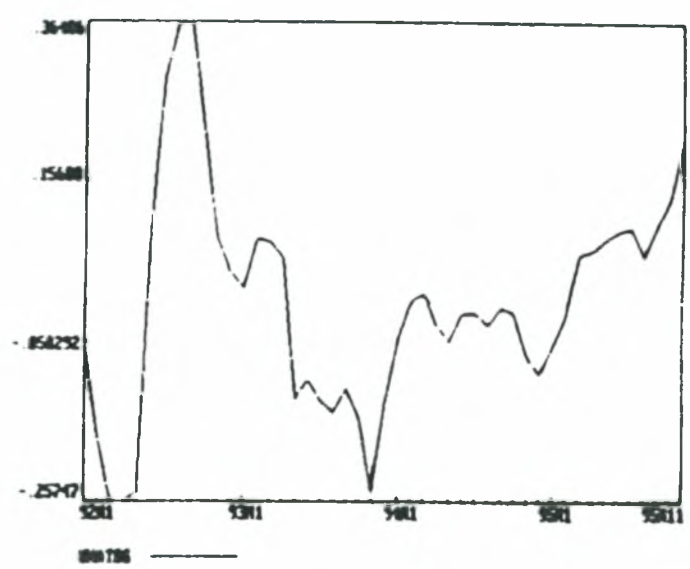
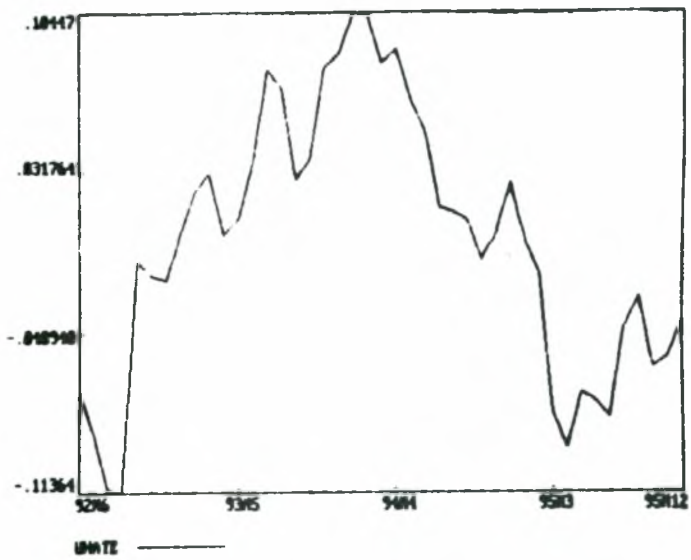


Fig. 10. *Regression residuals for Estonia (base country U.S.A.)*



Tables 6 and 7 reports the estimated values of a_1. It bears repeating that failure to reject the null hypothesis $a_1 = 0$ means we cannot reject the null hypothesis of no cointegration.

Table 6. *Test of the stationarity of the residuals (when we test vis-à-vis* USA*)*

	Czech Republic	**Rumania**	**Estonia**
Estimated a_1	-0.11685	-0.24667	-0.14982
Standatd error	0.067762	0.076587	0.072883
t-statistic for $a_1 = 0$	-1.6938	--2.6008	-2.0557
Critical value	3.28	3.28	3.28

Note: The critical value is from Engle and Yoo (1987) at the 10% level of significance

Table 7. *Test of the stationarity of the residuals (*when we test *vis-à-vis* Germany*)*

	Czech Republic	**Rumania**
Estimated a_1	-0.17559	-0.19907
Standard error	0.056022	0.064949

t-statistic for a_1	-3.1344	-3.0651
Critical value	3.28	3.28

Note: The critical value is from Engle and Yoo (1987) at the 10% level of significance

As the cointegration results indicate, the size of all the computed statistics are below the critical values indicating that the null hypothesis of no cointegration cannot be rejected. This means a rejection of the long-run PPP hypothesis for all the three countries considered: Czech Republic, Rumania and Estonia.

Johansen cointegration tests

Tables 8,9,10 give the results of the ADF test for the level as well as for the first differenced variables for each of country respectively, Czech Republic, Rumania and Estonia.

Table 8. *The calculated ADF test statistics for level and first difference data (Czech Republic)*

Variable	Level	First difference
ln of domestic price level critical value	-1.9392 (1) -3.18	-5.2937 (0) -1.61
ln of foreign price level (USA) critical value	-2.3420 (2) -3.18	-7.0348 (3) -3.18
ln of foreign price level (Germany) critical value	-2.1695 (1) -3.18	-6.5391 (3) -3.18
ln of exchange rate *vis-á-vis* US critical value	-2.9550 (0) -3.18	-5.2937 (0) -1.61
ln of exchange rate *vis-á-vis* Germany critical value	-2.1461 (0) -3.18	-6.5240 (0) -2.60

Note: The critical value of the ADF statistic are from the Fuller's (1976) table for 50 observations (10% level of significance)
Numbers inside the brackets are the numbers of lags

Table 9. *The calculated ADF test statistics for level and first difference data (Rumania)*

Variable	Level	First difference
ln of domestic price level critical value	1.3553 (2) -1.61	-4.6417 (0) -1.61
ln of foreign price level (USA) critical value	-2.9560 (2) -3.18	-6.5254 (2) -2.60
ln of foreign price level (Germany) critical value	-1.8207 (1) -2.60	-3.1623 (2) -2.60
ln of exchange rate *vis-á-vis* US critical value	-2.3287 (0) -2.60	-6.5191 (0) -2.60
ln of exchange rate *vis-á-vis* Germany critical value	-1.9521 (1) -2.60	-4.3506 (2) -2.60

Note: The critical value of the ADF statistic are from the Fuller's (1976) table for 50 observations (10% level of significance)

Numbers inside the brackets are the numbers of lags

Table 10. *The calculated ADF test statistics for level and first difference (Estonia)*

Variable	Level	First difference
ln of domestic price level critical value	-2.9009(1) -3.18	-5.9486(0) -2.60
ln of foreign price level (USA) critical value	-2.6416 (1) -3.18	-5.9486 (0) -2.60
ln of exchange rate *vis-á-vis* US critical value	-1.8188 (0) -2.60	-5.6861 (0) -1.61

Note: The critical value of the ADF statistic are from the Fuller's (1976) table for 50 observations (10% level of significance)

Numbers inside the brackets are the numbers of lags

All the computed statistics lie below the corresponding critical values, implying an acceptance of the null hypothesis and presence of unit roots in the levels series for exchange rate, domestic price and foreign price. On the other hand, the test statistics for all the differenced series are significant indicating a rejection of the null hypothesis of non-stationarity. Therefore all these series are first difference stationary or integrated of order one. This evidence is consistent with prevalent view that most macroeconomic time series are characterized by a stochastic rather than deterministic nonstationary

Now we can perform the Johansen cointegration tests. We begin the cointegration analysis by performing Johansen tests on VARs of various lag lengths and we stop at the smallest lag number for which the normality and autocorrelation diagnostics appeared to be roughly consistent with the Gaussian error term assumption.

The results are presented in Tables 11 - 12.

Table 11- ML Cointegration Tests (U.S. dollar-based exchange rates)

Null Hypothesis	**Trace**	λ_{max}	**Trace**	λ_{max}	**Trace**	λ_{max}
	Czech Rep.	(VAR = 3)	Rumania	(VAR = 3)	Estonia	(VAR = 3)
r = 0	24.0384	16.9733	25.6719	15.0108	26.7053	18.3697
r ≤ 1	7.0651	4.7715	10.6611	9.2453	8.3357	7.0908
r ≤ 2	2.2936	2.2936	1.4258	1.4158	1.2448	1.2448

Note: 95 per cent critical values for the trace and λmax test statistics are (for r = 0, r ≤ 1 and r ≤ 2) 29.680, 15.410 and 3.762 and 20.967, 14.069 and 3.762, respectively

Table 12. ML Cointegration Tests (D-mark-based exchange rates)

Null Hypothesis	**Trace**	λ_{max}	**Trace**	λ_{max}
	Czech Rep.	(VAR = 3)	Rumania	(VAR = 3)
r = 0	26.3034	17.0318	29.2600	18.1709
r ≤ 1	9.2716	5.6320	11.0890	7.8992
r ≤ 2	3.6396	3.6396	3.1899	3.1899

Note: 95 per cent critical values for the trace and λmax tst statistics are (for r = 0, r ≤ 1 and r ≤ 2) 29.680, 15.410 and 3.762 and 20.967, 14.069 and 3.762, respectively

Clearly, the results of the tables indicate that for all the countries the null hypothesis of no cointegrating vectors can not be rejected at the 5% level of significance. This means that there is apparently no coitegrating relationship between the exchange rate, domestic price and foreign price implying no support for PPP as a long-run equilibrium relationship.

CONCLUSION

I attempted to test the empirical validity of purchasing power parity (PPP) as a long-run equilibrium relationship in a sample of three Eastern Countries (Czech Republic, Rumania and Estonia) over the transition period.

I examined the time series properties of the price and exchange rate series for Czech Republic, Rumania and Estonia in terms of non-stationarity and cointegration, to determine whether purchasing power parity holds as a long-run constraint. The results indicate that purchasing power parity fails to hold. Even though these three countries have been experienced large monetary shocks and frequent devaluations of their currencies, purchasing power parity is rejected. This is similar to the results obtained by McNown and Wallance (1989) for Brazil and Israel. Even though both these economies had high inflation and money growth rates, they find that purchasing power parity does not hold. However, they do find that long-run purchasing power parity holds for two other high inflation economies, namely Chile and Argentina. It would seem that dominance of monetary shocks does not always imply that purchasing power parity will hold in the long-run.

Frenkel (1976) has argued that much of the controversy over the usefulness of the purchasing power parity doctrine results from the fact that the purchasing power parity specifies a final, equilibrium relationship rather than a precise theory of exchange rate determination. If we interpret cointegration as an evidence of a long-run equilibrium relationship, then what we found suggests that prices and exchange rates may diverge in the long run.

It should also be emphasized that the points mentioned below can explain why the purchasing power parity hypothesis did not work for the three Eastern countries concerned.

4. Some reasons for failure of PPP

In general, both the cointegration tests and unit root tests indicate that the long-run PPP relation does not hold for each of the considered countries irrespective the country against which it is tested. The following general points are worth mentioning as possible causes of the failure of the PPP.

One of the most common reasons for the failure of purchasing power parity to hold lies in the price index used to test the hypothesis. It is essential that the price index being used in testing PPP be similar across countries. That is to say, first, that the price indices include similar commodities, and secondly that the weights used in compiling the respective price indices are identical. This condition is generally very hard to fulfill. even for industrial countries, because different countries give different weights to commodities based on their individual consumption and production patterns. National price indices include many goods that are not traded, and in so far as the price of non-traded goods change there will be no concomitant change in the exchange rate. For the countries we are analyzing , Czech Republic. Rumania and Estonia, it is likely that the dissimilarity between their price indices and the price indices of Unites States and Germany is a major cause of rejection because until lately their consumption patterns were dictated by central authorities, were not necessarily similar to what would result in a free-market economy, or necessarily similar to those of the industrial countries.

Another assumption made when testing the PPP proposition is that there are no transaction costs (costs associated with shipping goods) and no trade restrictions between the countries. Although this is an analytically convenient assumption, it is not very realistic. Relative prices among tradables can indeed diverge among countries (especially between developed and developing countries) and therefore induce errors in the purchasing power parity. Both transaction costs and trade barriers can cause a divergence in relative prices between countries. This factor is specially important with respect to the East European economies. For example, until 1990 industrial country tariff and non-tariff protective barriers with respect to the East European countries were much higher than those with respect to other areas. Although a lot of these quantitative restrictions are being gradually removed, the historical presence of these trade barriers may well account for the failure of purchasing power parity in our sample.

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