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PPP versus MER
Comparison of real incomes across nations

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Is PPPE a better measure than MER to compare real incomes across nations? Would emissions projections necessarily depend on which measure of exchange rates we use to compare real incomes? This paper seeks to answer these questions. It examines the conceptual and empirical basis of the PPP theory and concludes that PPPE is based on a set of very restrictive assumptions which (except one) are relaxed in MER. In fact, MER is a generalisation of PPPE. One can make a consistent comparison of real incomes by using the real exchange rate, which is a ratio of MER to PPPE, not by using just the PPPE or MER. MER, however, can be used to convert nominal current incomes from different currency units into units of a reference currency and the prices in reference currency units can be used to deflate the nominal incomes into constant price incomes to make valid real income comparisons across nations. Finally, it is argued that comparison of real incomes is not always necessary in making emissions projections.

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1 Introduction

In its Special Report on Emission Scenarios (SRES), the Intergovernmental Panel on Climate Change (IPCC) projected global emissions under alternative scenarios of the world economy (Nakićenović, et al. 2000). In some of the scenarios it assumed, consistent with the convergence hypothesis, that the real per person income of developing countries would grow at a much faster rate than that of the OECD region to generate the growth paths of developing regions. This approach required real income comparison and it relied on market exchange rates (MER) for that purpose. Since purchasing power parity has also been considered as a theory of long run exchange rate determination for some 400 years,[1] the choice of MER instead of the PPP based exchange rate needed some explanation. As PPPE and MER do not always agree and price levels, expressed in common currency terms, are found to be positively correlated with real per person incomes, PPP based exchange rate (PPPE) always implies higher base year real incomes for poorer countries than these calculated using MER. Based on this stylised fact, Castles and Henderson (2003a, 2003b) claimed that the SRES methodology is flawed, because it led to higher than justified growth rates for non-OECD regions and hence led to emissions projections that are biased upward. Their argument can be presented as in figure 1.

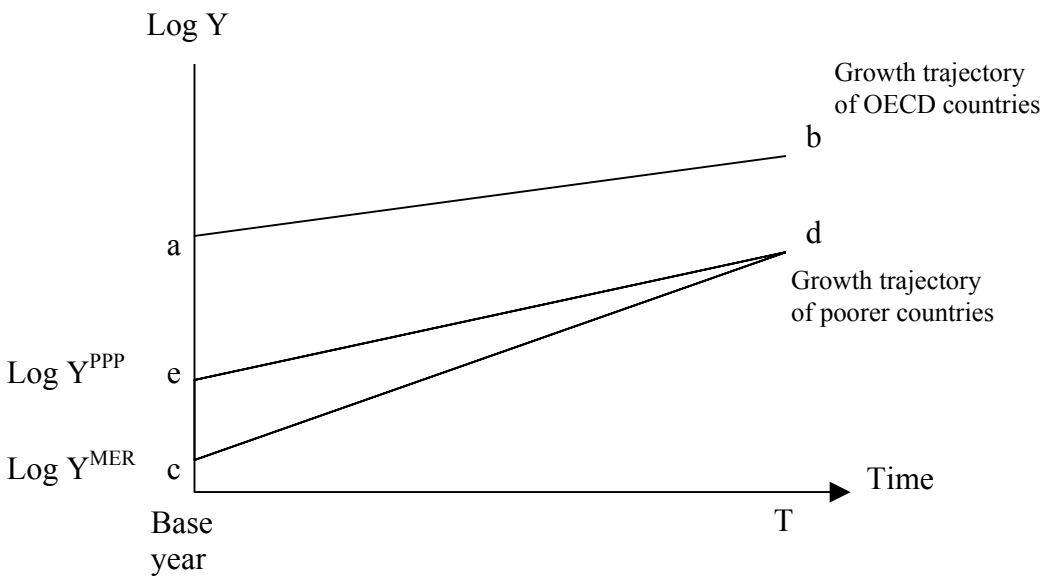

Figure 1: Growth paths of OECD and non-OECD regions in units of OECD output

[1] See Dornbusch (1987) for an illuminating historical account of the PPP versus MER controversy.

In figure 1 the line ab represents the growth trajectory of OECD countries. If d is the point at time T, that poorer nations are expected to attain, then their uniform growth path would be cd under MER and ed under PPPE, where the point c represents the per person real income of non-OECD regions based on MER and the point e represents the per person real income under PPP, all real quantities measured in units of OECD output. As the growth rate implied by the path ed is lower than that by cd, the use of MER instead of PPPE implies a higher economic growth rate and hence higher emissions.

C&H (2003b) write:

'Our main single criticism of the SRES is not that it projects rates of growth for GDP in the developing regions which are impossibly high … Our argument is that (1) other things being equal, emission growth and GDP growth are positively related, and (2) the GDP growth for developing regions shown in the SRES scenarios, since it is based on closing an overstated MER-based gap between the rich and poorer countries, is greater than it would have been if a lower and more accurate estimate of the initial gap, based on PPP valuations, had been taken as a point of departure.'

Particularly C&H are concerned about the use of nominal exchange rates, as they write:

'Just as it is not legitimate, whenever 'real' comparison are in question, to compare national accounts items for different years for a single country at current prices, without taking into account estimated price changes between the periods concerned, so it is inadmissible to compare these items across countries at nominal exchange rates only, without allowing for estimated price differences. The cases are parallel.'

It is clear from the above that at the heart of Castles and Henderson's (2003b) critique lies the choice of exchange rate. The main aim in this paper is to consider the rationale for using exchange rates defined in different ways and then examine whether Castles and Henderson's claim is valid.

The rest of this paper is divided into seven sections. In section 2 we describe the concept of real exchange rate with three interpretations, which helps to link the three commonly used forms of exchange rate - nominal exchange rate, real exchange rate and PPP based exchange rates. In section 3 we attempt to answer the question about which exchange rate should be used for real income comparison. In section 4 we relate the concept of market exchange rate to the nominal equilibrium exchange rate. In section 5 we discuss in short the role of exchange rates in general equilibrium models and describe, conditions under which MER can be used to compare real incomes. In section six we show with the help of a diagram why the choice of exchange rate becomes important in the SRES approach used in generating scenarios. We conclude the paper in section 7.

2 A General Model of LR Equilibrium Exchange Rates

Consider two trading economies – home (h) and foreign (f). Let P^f and P^h be the prices of the goods in the foreign and home country respectively. Let $E^N_{h/f}$ be the long-run equilibrium *nominal* exchange rate between the currencies of the two countries, defined as number of home currency units per unit of the foreign currency. Then the *real* exchange rate of the home currency, E^R_h, is defined as:

(1) $$E^R_h = E^N_{h/f}\frac{P^f}{P^h}$$

The real exchange rate, E^R_h**,** defined in (1) can be interpreted in three interrelated ways: (a) as a real price index; (b) as an indicator of arbitrage possibility; or (c) as a barter terms of trade.

(a) Real Exchange rate as a real price index

Writing equation (1) in its reciprocal form as

(2) $$\frac{1}{E^R_h} = \frac{\left(\frac{P^h}{P^f}\right)}{E^N_{h/f}}$$

the right hand side of equation (2) expresses the price of home goods in units of foreign currency relative to the price of foreign good. Dornbusch (1985) refers to this as the Kravis real price index, which is used by International Comparison Project (ICP) and reported in the Penn World Table (Heston, Summers and Aten, 2002). In other words, the Kravis real prices (or the price levels reported in the Penn World Table) are nothing but the inverse of the real exchange rates as defined in (1).

(b) RER as in indicator of arbitrage possibility

Let us write equation (1) in a convenient way as follows:

(3) $$E^R_h = \frac{1}{P_h} * P_f * E^N_{h/f} = \chi\ .$$

Equation (3) can be read to mean - buy a dollar's worth of commodity bundle in the home country, which is $1/P_h$, and take it to the foreign country and sell in the foreign market that yields (P_f / P_h) units of foreign currency units and finally convert this amount into home currency units using the market exchange rate $E^N_{h/f}$ to obtain $E^N_{h/f} * P_f / P_h$. Say this amount is χ. Then χ is the real exchange rate of the home

currency expressed in home currency units (so it is unit free). If $\chi > 1$ then it provides an incentive for traders to take home goods into the foreign country, sell there and bring back the money. This way they can make a profit of (χ-1) per transaction per unit of home currency invested. As a result, the supply of foreign currency and the demand for home currency in the foreign exchange market will rise which will lower the value of $E^N_{h/f}$. This incentive will disappear as soon as $\chi = 1$. Similarly, if $\chi < 1$, this provides an incentive to importing foreign goods, which will increase the supply of home currency and demand for foreign currency in the foreign exchange market. This will force the nominal exchange rate of the home currency vis a vis the foreign currency up and the process will continue until χ=1. The consequence is that when goods and foreign exchange markets are in simultaneous equilibrium we must have E^R_h=1. In other words, the real exchange rate in equilibrium is always unity. Therefore it follows from equation (1) that we have, in equilibrium,

(4) $$E^N_{h/f} = P_h / P_f = E^{PPP}_{h/f}$$

where $E^{PPP}_{h/f}$ is the nominal exchange rate that maintains the purchasing power parity between the currencies.

Equation (4), thus, shows that purchasing power parity holds at the general equilibrium of goods and foreign exchange markets. This means that the general equilibrium exchange rate is given by the relative prices of the commodities across countries. In a relative sense, percentage change in the nominal exchange rate is fully explained by the difference in the inflation rate in the two countries. Thus the PPPE is a very attractive concept not because it is real and the MER is nominal (they are both nominal in the sense that the price of one currency is expressed in units of another currency) but because it is the value to which the market exchange rate has to converge in equilibrium. The observed market exchange rate at any point in time may not be the equilibrium value or may have been influenced by various interventions.

Empirical support, however, is not unequivocal. For example, The Kravis Real Price, which is the reciprocal of the RER, as defined by equation (3), has not been found to be unity. We have examined the real exchange rates of various countries against the US dollar for the year 2000 using data from Heston, Summers and Aten (2002). The scatter plot is presented in chart 1. It shows that RERs are not unity for many countries and that there appears to be an inverse relationship between real exchange rates and the real per person GDP relative to the US. This relationship between RERs and relative per person real income was observed by Kravis and Lipsey (1983) for the year 1975.

We then investigated whether these real exchange rates have remained more or less constant over time, so that some support can be obtained for the weaker version of PPP, called the relative PPP theory. Trajectories of the RERs for a selected group of countries that have data for the past 50 years in Penn World Table 6.1 are given in charts 2-6. These charts show that over the past 50 years some currencies have shown continuously appreciating real exchange rates against the US dollar, while some others have shown a

persistent depreciation in their real exchange rates. There are some currencies, whose RERs have shown some tendency toward convergence to unity while others have shown indications toward a u-turn and still others showing no sign of convergence – they are maintaining a constant trend deviation from unity.

These charts clearly indicate that the real exchange rate is an endogenous variable that changes with economic conditions in each country and the global environment. But the question still remains whether this observed deviation of the RER from its equilibrium value is because of continuous shocks to the system and so is just a temporary phenomenon. Studies on whether RER is mean reverting in the long run have remained at best inconclusive (Taylor, 2003). On the other hand, there are strong empirical and theoretical grounds to believe that RER has a time trend.

The reason behind the divergence between the prediction of the PPP theory and the empirical evidence remains a vexing question. To answer this question we may have to look into the assumptions underlying interpretation (b) of the real exchange rate.

Note that effective arbitrage is the mechanism behind the assertion that the real exchange rate will remain unity in general equilibrium. In order to have effective arbitrage between the goods and foreign exchange markets of countries we must have at least the following conditions satisfied:

(i) The home bundle of good must be salable in the foreign market at price P_f and vice versa. In other words, the bundle of goods must be homogenous from the point of view of buyers in all countries;

(ii) There should be no cost and barriers to trade in goods and services between countries; and that

(iii) All markets are competitive in all countries.

It is easy to see that the above conditions that underpin PPP theory can be violated easily. First, let us consider condition (i). It is well known that not all goods are produced and consumed everywhere. Despite this, to construct a comparable price index, we must include identical commodities with identical weights in the reference bundle of goods across all countries. Suppose we did this. Does this guarantee that the prices of the bundle in different countries will be the same when expressed in the same currency units provided all other conditions are satisfied? Not at all. Consider the price of a coffee, which can be different, in two different outlets on the same street in a given city. We cannot always guarantee that the price of a cup of coffee of a given flavor will be the same. Naturally, then what would explain the price difference remains a valid question. The standard answer would be that there are some non-traded components such as the standard of the outlet, the quality of service, location, etc that make up for the price differences (Okun, 1981 Ch 5). If this is so, then how differences in prices in local currency units quoted in different countries can be used to determine the exchange rates between the currencies becomes another vexing question. This question simply

highlights the fact that homogenous commodities sold at different places may lose their homogeneity because of the presence of non-traded attributes attached to the sale, such as service quality, location and location specific characteristics - provision of safety and hygiene, enforcement of law and order and provision of other non-traded goods. Hence the assertion that commodities of the same name or description sold at different parts of the world should command the same price in a given currency unit contains a logical flaw. It ignores the presence of other scarce attributes, particularly non-traded, bundled with the commodities when they are sold to customers. This means that goods sold at different places are imperfect substitutes hence the difference in their prices in local currencies cannot be fully explained by exchange rates.

It is obvious that condition (ii) is always violated in real life. There are transport costs and there are trade barriers. As trade barriers and transport costs change the real exchange rates derived from market exchange rates and market prices may also change. The absence of competition in some markets may also contribute to the failure of the law of one price.

Moreover, even if all of the above conditions are satisfied, the arbitrage process may take a very long time to force RER to unity once it has been perturbed. One condition that guarantees full arbitrage without much effect on commodity prices is very high values for the elasticity of substitution for commodities supplied from various sources. Whether these elasticities for all commodities can be sufficiently large remains an empirical question.

Hence the interpretation of RER as an indicator of the arbitrage condition is not very insightful; it is based on unrealistic assumptions. Let us consider the third interpretation.

(c) Real Exchange Rate as the barter terms of trade

Alternatively, E_h^R defined in (1) can be interpreted as the barter terms of trade between the home good and the foreign good. It may be viewed as the number of home goods commanded by a unit of foreign good irrespective of whether the bundles of the two countries are homogenous or not and whether there are any barriers to trade or not. To see this we rewrite equation (1) as

$$(5) \qquad E_h^R = P_f * E_{h/f}^N * \frac{1}{P_h}.$$

In this case, equation (5) is read as follows. Take one unit of foreign reference bundle of goods and sell it to obtain P_f units of foreign currency. Change this money into $P_f * E_{h/f}^N$ units of home currency units using the market exchange rates. Spend the money on home goods to obtain $(P_f * E_{h/f}^N)/P_h$ units of home reference bundle of goods. Thus using market prices and market exchange rates one unit of foreign good can command $(P_f * E_{h/f}^N)/P_h = E_h^R$ units of home goods. Hence E_h^R gives the barter

terms of trade in units of home goods per unit of foreign goods. Note that, viewing the RER this way frees us from the requirement that the bundle of goods be actually moved from one country to the other. As a result the reference bundle can contain any items. They do not need to be viewed by the buyers as homogenous in both countries. We just sell the commodities in the country of its origin and take the proceeds to the other country, use the market exchange rate to convert the currencies and then purchase the foreign bundle at its local price. By doing so, we need not assume that there are no trade barriers and transport costs. However, it is necessary to assume that all markets are competitive.

If the goods produced in the two countries *are not perfect substitutes*, for whatever reasons, then the barter terms of trade between a given bundle of home goods and that of the foreign goods is not always necessarily unity and the interpretation given in (c) becomes relevant. The RER can, however, be made to equal unity in any reference (or base) year by the choice of units. However, once the units have been so chosen the terms of trade between the bundles *over time* becomes an *endogenous* variable. For example, if one country grows much faster than the other because of rapid technical progress, then it may have to ship more of its products for a given quantity of foreign products, just to clear the markets. In other words, faster growth may cause a real depreciation of the currency (or terms of trade loss) of the rapidly growing country – take the case of immiserising growth (Bhagwati, 1958) as an extreme example. Alternatively, the possibility of a real appreciation associated with a faster growth in the traded goods sector in a small open economy has also been discussed in the literature (the so called Harrod-Balasa-Samuleson effect). So E_h^R, in general, is not a constant over time and its direction of change cannot be predicted *a priori*. As we allow E_h^R to deviate from unity it follows from (1) that the nominal exchange rate is given by:

(6) $$E_{h/f}^N = E_h^R \frac{P^h}{P^f},$$

whereas the purchasing power parity based exchange rate, $E_{h/f}^{PPP}$, is given by

(7) $$E_{h/f}^{PP} = \frac{P^h}{P^f}.$$

It must be clear by now that the PPP based exchange rate is also a *nominal* exchange rate with a particular value attached to the real exchange rate. The PPP based exchange rate, $E_{h/f}^{PPP}$, is not a real exchange rate.

It follows from (6) and (7) that

(8) $$E_h^R = E_{h/f}^N / E_{h/f}^{PPP}.$$

Thus equation (8) provides a neat relationship among the nominal exchange rate, the real exchange rate and the PPP based *nominal* exchange rate. As mentioned above, the real exchange rate as defined in (1) measures the units of home bundle of goods

commanded by a unit of foreign bundle of goods. A rise in the value of E_h^R implies a real depreciation and vice versa. As mentioned earlier, equation (8), if expressed in reciprocal terms, will show the number of units of the foreign bundle of goods commanded by a unit of home bundle of goods, which is the intertemporal price index referred to in the paragraph 16.83 of the SNA 1993 and the so-called Kravis price index (Dornbusch, 1987) used by the ICP to make international comparison of real incomes and prices and reported in the Penn World Table.

3 Which exchange rate is to be used for real income comparison?

This is the main question surrounding the MER versus PPP controversy in generating growth scenarios contained in the SRES of the IPCC. To resolve this issue we first see how do the three exchange rate measures perform in converting real and nominal incomes of one country into the units of another.

(a) Conversion of nominal (current dollar values) GDP: Let Q_h^h and P^h be the quantity and price measures of home GDP whose nominal value is Y_h^h such that $Y_h^h = Q_h^h * P^h$, where the subscript denotes the country of residence and the superscript denote the units of the country in which the variable is expressed. That is, Y_h^h is the nominal income of the home country in home currency units and Y_h^f is the nominal income of home country in foreign currency units. Then we have:

$$(9) \qquad \frac{Y_h^h}{E_{h/f}^N} = \frac{Y_h^h}{E_h^R(P^h/P^f)} = \frac{1}{E_h^R}\frac{Y_h^h}{P^h}.P^f = \frac{1}{E_h^R}Q_h^h P^f = Q_h^f.P^f = Y_h^f$$

Thus the nominal GDP of the home country is converted into the current price value of foreign GDP if the nominal exchange rate is used for the conversion. If, however, we use the PPP based exchange rate to make the conversion we obtain:

$$(10) \qquad \frac{Y_h^h}{E_{h/f}^{PPP}} = \frac{Y_h^h}{(P^h/P^f)} = \frac{Y_h^h}{P^h}.P^f = Q_h^h P^f .$$

But, we know that $Q_h^h P^f = Q_h^f.P^f = Y_h^f$ only if $E_h^R = 1$ (and therefore $Q_h^h = Q_h^f$). Hence the use of the PPP based exchange rate yields the *correct* conversion of nominal GDP *only if* the real exchange rate is constant at unity.

(b) Conversion of real (or constant dollar values) GDP:
Furthermore, if we want to convert real GDP of home country, Q_h^h, into units of real foreign GDP then the appropriate scaling factor is the real exchange rate, E_h^R, since, by definition, we have $Q_h^h = E_h^R Q_h^f$.
However, if we use MER or PPPE to make the conversion we obtain:

(11a) $$\frac{Q_h^h}{E_{h/f}^N} = \frac{Q_h^h}{E_h^R(P^h/P^f)} = \frac{Q_h^f}{P^h}.P^f = \beta Q^f \text{, where } \beta = \frac{P^f}{P^h}$$

and

(11b) $$\frac{Q_h^h}{E_{h/f}^{PPP}} = \frac{Q_h^h}{(P^h/P^f)} = Q_h^f \frac{P^f}{P^h}.E^R = \alpha Q_h^f \text{ where } \alpha = \frac{P^f}{P^h}E^R.$$

Clearly, the use of MER or the PPP based exchange rates do not yield the correct conversion of real incomes of the home country into units of foreign real income unless β =1 and α =1 respectively. Thus the conversion or comparison of real incomes should be based on the real exchange rate, which is the ratio of MER to PPPE.

In summary, it follows from the above discussion that it is appropriate to use the nominal exchange rate to convert nominal GDP of home country into its equivalents in foreign currency units, which can then be deflated using a foreign GDP price deflator to obtain home GDP in units of foreign real GDP. The real income thus obtained provides a valid basis for real income comparison whenever such a comparison needs to be made. The only condition for this is that the prices should reflect the marginal values, a condition that is always maintained in all modelling exercises. The use of a PPP based exchange rate does not necessarily provide the appropriate conversion particularly when the real exchange rates are not constant such as in the case of a hundred year long real income projection with rapid income growth, and so care needs to be taken in the cases where further income comparisons need to be made in long term projection exercises.

4 Market Exchange Rate versus the Nominal Exchange Rate

So far we have been using the term market exchange rate (MER) and the equilibrium nominal exchange rate synonymously. The distinguishing features of the market exchange rate, referred so far, are that it clears the foreign exchange market and that it is not directly observable. It can be obtained, however, at the equilibrium solutions of the models and is thus only theoretically (or numerically via model simulations) observable. In the real world, what we observe, however, are spot rates and forward rates, which, unlike the equilibrium rates, may fluctuate quite wildly. It is generally understood that such day to day events do not represent equilibrium phenomena, they will die out as time goes by and the spot rates converge to the long run equilibrium value of nominal exchange rate, provided there are no recurring shocks. Hence to make an unambiguous sense of the term we need to identify the market exchange rates not with spot rates or forward rates but with the equilibrium nominal exchange rate – the market-clearing rate. As long as the market exchange rates are defined to mean the long-run equilibrium nominal exchange rates, solved by models, their empirical equivalent can be obtained from some sort of moving average of the spot rates. In this case the use of market exchange rate in translating income of one country into income units of another country

to facilitate real income comparison will be valid and consistent with equilibrium solutions and be preferable to the use of the PPP based exchange rate.

5 Exchange rates in general equilibrium models of real economy

In a world as described by a general equilibrium model of the global economy with flexible prices, we do not have the problem in observing the various types of exchange rates. Typically, in such models, one price in each country has to be set exogenously, unless the money market is explicitly modelled. It is, therefore, possible to hold PPP exchange rate constant over the entire simulation horizon of the model by the choice of numeraire. Moreover, a shock to the numeraires results in equi-proportionate change in the nominal exchange rates, displaying the PPP property with pure nominal shocks. It would be instructive to see how market and real exchange rates change with time in these models when the pure nominal shocks are absent.

To examine this issue we linearise equation (6) to get:

(12) $$e^N_{h/f} = e^R_h + (p^h - p^f),$$

where the lower case letters represent the percentage change of the corresponding upper case variables. Assume that nominal exchange rates and prices are all set to one initially, which also implies that the real exchange rates are also unity initially.

Equation (12) clearly shows that the percentage change in the nominal exchange rate is the sum of the percentage change in the real exchange rate and the difference between the percentage change of the price of the bundle of home goods and the price of the bundle of foreign goods (relative inflation rate). The bundle of goods could very well be the ones that define GDP in each country. Note that the bundles are not required to be homogenous – one can contain potato chips and the other may have computer chips. In this case the prices are GDP deflators and the real exchange rate is the terms of trade between the GDP units of the two countries. Note here that which price index is being chosen to define the exchange rates remains ambiguous. But whichever price index is chosen, the real exchange rate should be interpreted accordingly to mean the barter terms of trade between the commodity bundles associated with the respective price indices.

If the relevant prices in both regions were held fixed by appropriate monetary policy, then it follows from (12) that the percentage change in the real and nominal exchange rates will be identical while the percentage change in the PPP exchange rate would be zero. In this case the nominal exchange rate behaves like the real exchange rate - a 'real' variable. *Therefore under this condition use of MER to convert real incomes measured in local units into real income measured in foreign units to make real income comparisons in commensurable units is valid.* However, if the numeraires are different from the bundles that are used for comparison, then price changes needs to be taken into account as well.

If the model does not make explicit representation of exchange rates, such as in the case with GTAP (Hertel, 1997), and the database is benchmarked in units of a reference currency, then the implicit assumption in such models is that the market exchange rate between the national currencies is always maintained at unity. In this situation the real exchange rate would be an inverse of the PPPE. So when the model is solved over time, we would have

(13) $$e_h^R = -(p^h - p^f)$$

holding at all points in time. Equation (13) means that the real exchange rates would be changing endogenously as the prices change. They cannot be held fixed by the choice of numeraire. In this case, a direct deflation of the national nominal incomes by the price index of the reference region would convert the real incomes into commensurable units. The use of PPPE would be incorrect.

It is useful to note that if the real exchange rate has remained stable (because there was no real shock to the system) the nominal exchange rate moves with the relative inflation rate, determined by the nominal shock, and thus behaves like a 'monetary variable'. When the prices are fixed by the choice of the numeraire, the nominal exchange rate moves with the real exchange rate. Thus the nominal exchange rate, which is a price of one currency in terms of another, when viewed in an intertemporal sense when real shocks are likely to take place, is more like an income variable that has both real and nominal components. If viewed in a static sense, when economic fundamentals do not change in a relative sense and there is no change in the real exchange rate (meaning the terms of trade are not changing), the nominal exchange rate behaves more like a price – a purely monetary -variable. In the case of pure nominal shocks, the PPPE is valid.

6 Choice of exchange rate and emission projection

Now, finally, we ask whether the choice of exchange rates matter in projecting global emission levels? We answer this question by examining the behavior of regional outputs (or real incomes) in local units rather that in units of OECD real income as we did in section 1.

As in figure 1, let the line ab describe the assumed path of the per person real income of the OECD region. Again the y-axis measures real quantity in logarithms. Assume that at time T, the per person real income of the non-OECD region converges to say 60 pere cent of that of the OECD region and let that be represented by the point e. Also assume that all prices and nominal exchange rates were initially calibrated to unity for the base year and therefore the PPPE and the real exchange rate were all unity. Now under the PPPE the projected uniform growth path for the non-OECD region would be given by the line ce, which passes through the point e as the real exchange rate is assumed to be unity all the way through. But with MER, there is no *a priori* basis to identify where the terminal point would lie for the per person real income of the non-OECD region. It could be at points like d, if the real exchange rate of the non-OECD region is expected to depreciate all the way through and it could be at points like f, if the real exchange rate is expected to appreciate via the Samuelson-Balasa effect.

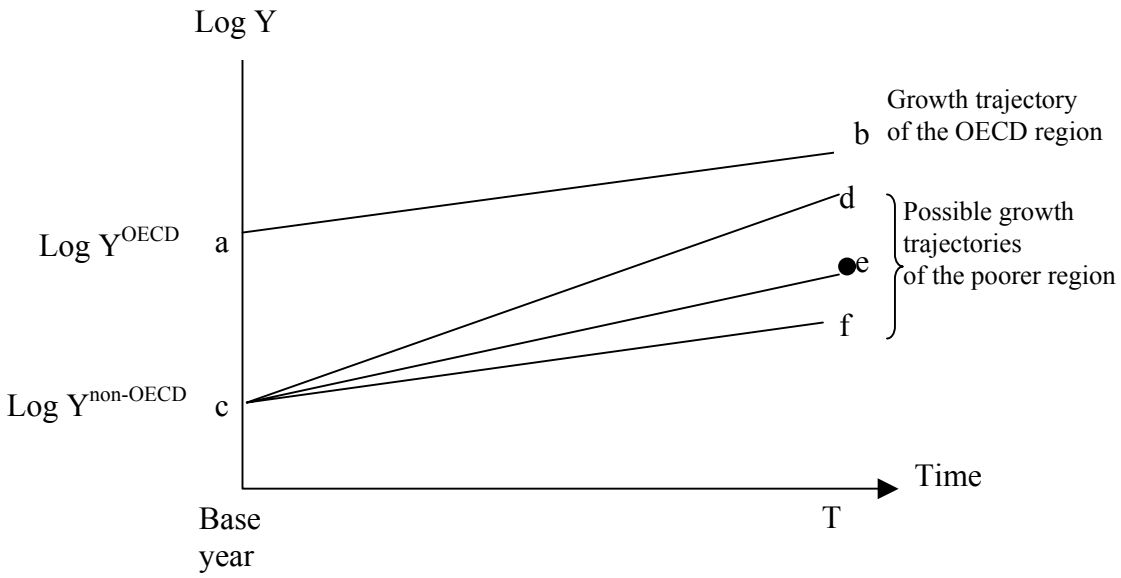

Figure 2: Growth paths of OECD and non-OECD regions in units of local output

In the absence of biased emission efficiency gain, the level of emission would be proportional to the real output growth and hence whether the emission level under PPP will be higher or lower than under MER would depend on the behavior of the RER. In the absence of the Samuelson-Balasa effect, it is natural to expect that countries that grow at relatively faster rates will have depreciating real exchange rates. In this case emissions projection under MER will be higher than emissions projections under the PPP.

Even with the Samuelson-Balasa effect, in which case the RER appreciated with the increase in real per person income, Manne and Richels (2003) have observed with MERGE simulations that the total emissions projection under MER will be higher than that under the PPP. It is so because countries will grow at a faster rate under MER than under PPP when their per person real income is very low. Manne and Richels have, however, also concluded that the difference in emissions level caused by the change of exchange rate is not enough to make a significant impact on the global mean temperature.

7 Conclusion

In this paper, we took recourse to the definition of the market exchange rate, PPP based exchange rate and the real exchange rate to examine their roles in real income comparison across countries. It was clearly seen that the PPPE is a particular case of the MER and therefore the use of MER cannot be considered incorrect whenever PPPE can be used. But the converse is not true. Use of PPPE can be justified only when the real exchange rate can be deemed as a constant over time. As the real exchange rate is just the barter terms of trade of the commodity bundle (of the price indices considered), it can change with change in economic fundamentals, such as policies, technologies, taste and resource endowment. Hence, in a scenario covering a very long term, such as 100 years, there is no reason other than simple faith in the PPP theory to expect that the real exchange rate will remain unchanged over time. History has not been kind to PPP theory either. The use of MER by IPCC, provided it is meant to correspond to the long run equilibrium nominal exchange rate, in the SRES remains valid and the critique by Castles and Henderson cannot be sustained.

It is also possible that the real exchange rates of non-OECD countries will depreciate over the next century as they grow quickly, and the projected emission level under MER will be higher than the projected emissions under PPPE. But this is not a reason to choose PPP as against MER in making international income comparisons.

As a passing remark, however, it can be said that it may be more logical to describe the growth trajectories of nations by assigning values to the country-specific drivers of economic growth in the feasible domain rather than to rely on the absolute convergence hypothesis. For example, economic growth of each region can be projected by specifying the trajectories of their respective exogenous variables, such as their policy profile, technological path, taste changes and changes in exogenous factor supplies.

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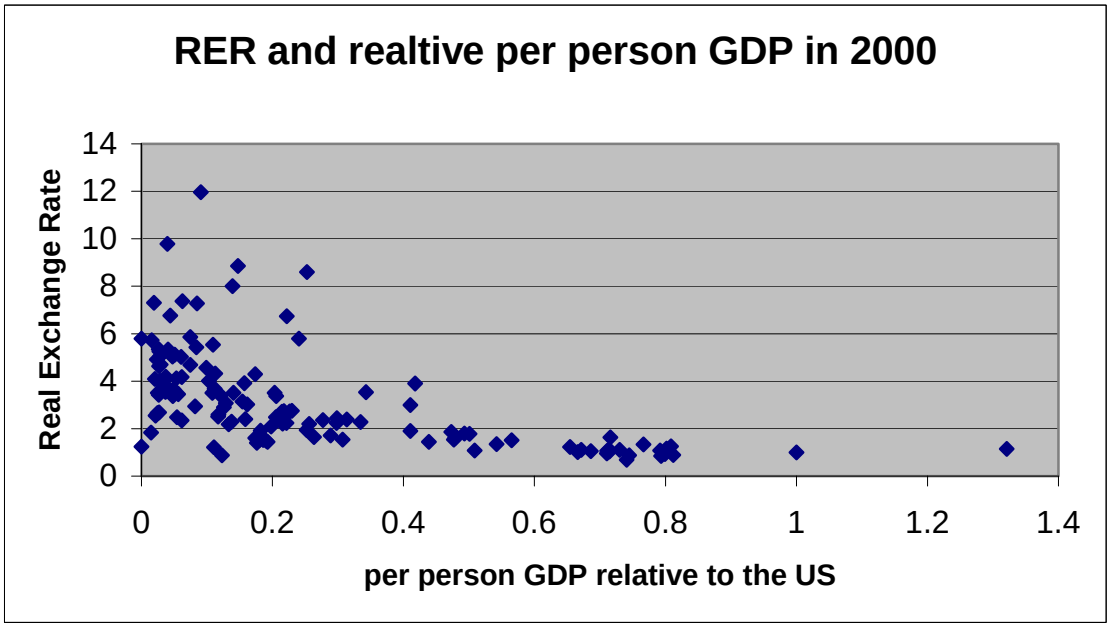

Chart 1: Real exchange rate and real per person income relative to the US.

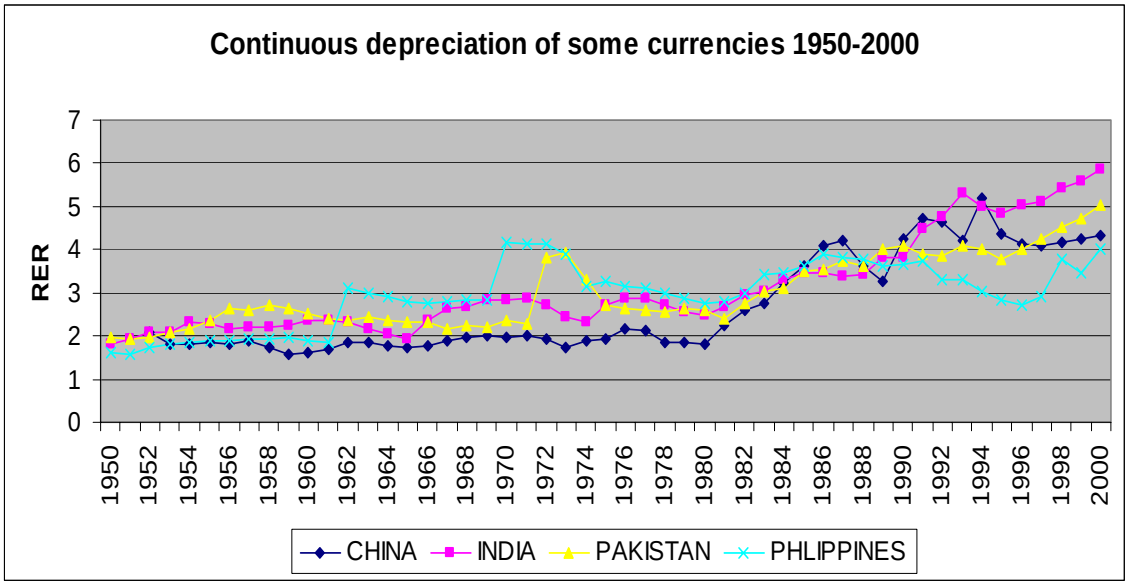

Chart 2: Continuous real depreciation of some currencies over the past fifty years

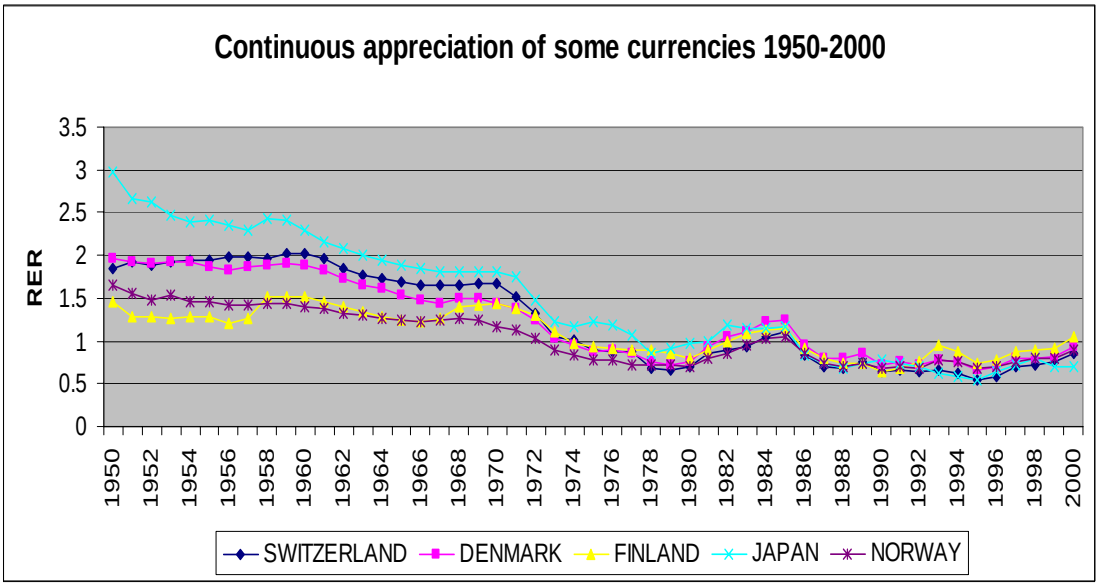

Chart 3: Continuous real appreciation of some currencies over the past fifty years

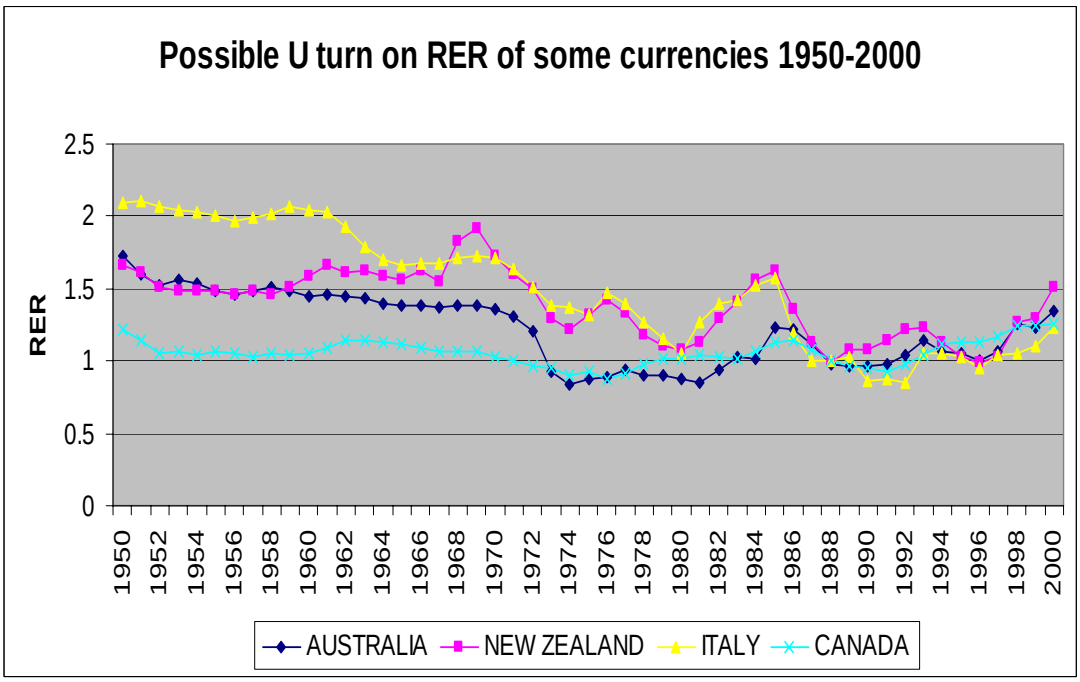

Chart 4: Possible U turn on RER of some currencies over the past fifty years

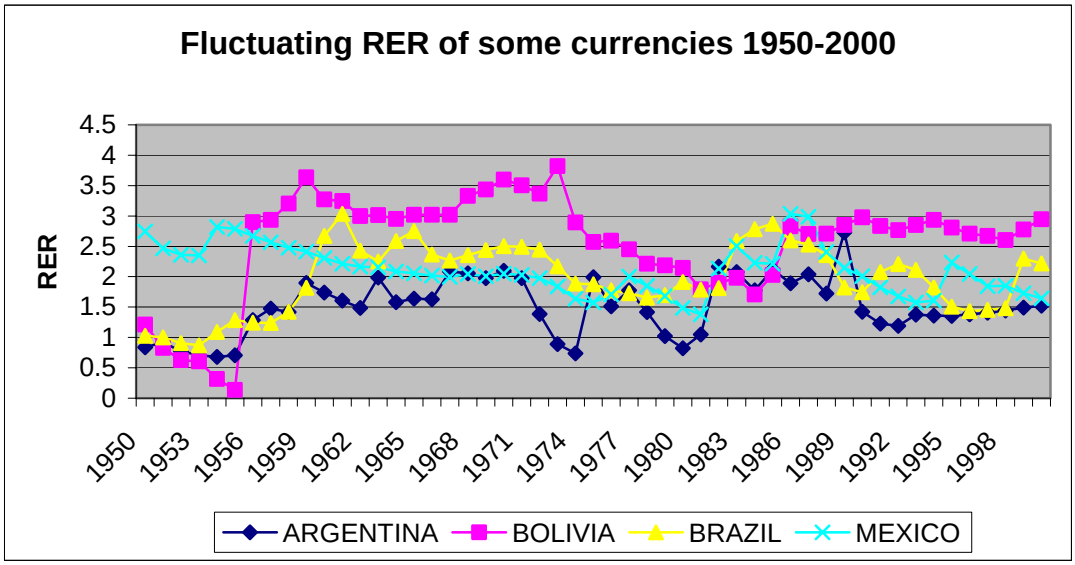

Chart 5: Some currencies may maintain 'under valued' RER with some fluctuations

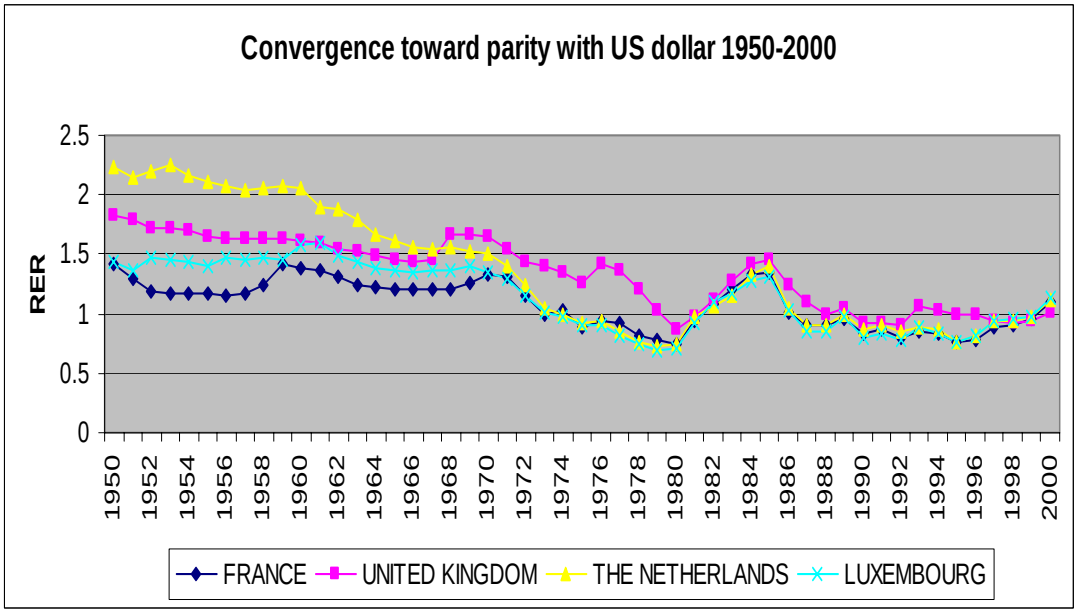

Chart 5: Some currencies may show sign of convergence to PPP (RER=1)