INTERNATIONAL AND INTERTEMPORAL COMPARISONS OF REAL PRODUCT IN THE OECD: 1960-1990*

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En el cuarto trimestre de 1991 la Dirección General de Planificación abrió una línea de estudio sobre el crecimiento comparado de la economía española y la convergencia con las economías más desarrolladas. Los trabajos elaborados dentro de esta línea se publican en inglés para que puedan ser leídos por los estudiosos de esta materia más allá de nuestras fronteras. En breve tiempo estará disponible una traducción castellana.

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D-93005: "Tecnological Differences and Convergence in the OECD."Javier Andrés y José E. Boscá.

ABSTRACT

This paper aims to compare the results obtained using Summers and Heston's *Penn World Table (Mark 5)* with two different alternatives in international comparisons of *real* income per capita. The first alternative consists in using OECD 1990 purchasing power parities (PPP), extrapolated backward until 1960 with national price indices. The second one fixes PPPs to the estimates of different benchmark years, and interpolates these parities applying also national price indices. To accomplish this objective, we discuss the relationship between the exchange rate and the PPP and provide some reasons why it is not convenient to approximate PPPs by exchange rates, and we analize different methods which are usually employed by international organizations to estimate PPPs and to link the benchmark estimates. As an illustrative example of the consequences of using these different PPPs we estimate convergence equations with both cross-section and pooled data for OECD countries, in the way suggested by recent empirical papers that use the human capital augmented Solow model. Estimations based on Summers and Heston's data affect the rate of convergence and yield a worse fit than those obtained using OECD data.

INDEX

I. INTRODUCTION

There is a vast literature devoted to international comparisons of *real* income[1]. From the very begining, there has been a great concern about procedures to convert nominal magnitudes to a common currency which makes the original information comparable among different countries. As a result of this concern, international institutions (OECD, Eurostat or United Nations) have promoted the use of **purchasing power parities**, PPPs thereafter. These have been calculated for groups of countries in order to make international comparisons of GDP levels. For two particular countries, the PPP of a specific commodity, a good or a service, is the exchange rate that equals the price of this commodity in both countries. In this sense, the PPP for the total set of goods and services consumed is a weighted average of the PPPs of each of the different commodities in these countries.

OECD countries have been included, from the begining of the International Comparaisons Project of United Nations (ICP), in the estimation of PPPs in different benchmark years. As different benchmark estimates are available, it is of interest to take advantage of this fact to improve not only the spatial comparisons, but also the temporal ones. This is the reason why Summers and Heston (1991) in their Penn World Tables Mark 5 (*PWT5*) apply a consistentization procedure between national accounts data and benchmark estimates from 1975, 1980 and 1985. However, as a result of this procedure, and also for application of aggregation methods with non OECD countries, the final PPPs for OECD countries do not maintain the original parities in benchmark years.

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1 See Gilbert and Kravis (1954 and 1958), Kravis, Heston and Summers (1978 and 1982), Summers, Kravis and Heston (1980), or Summers and Heston (1984 and 1991). The more popular data set in international comparisons of real income is the Penn World Table, Mark 5, published by Summers and Heston (1991).

This paper aims to compare the results obtained using Summers and Heston's *PWT5* with two different alternatives in international comparisons of *real* income per capita. The first alternative consists in using OECD 1990 PPPs[2], extrapolated backward until 1960 with national price indices. The second one fixes PPPs to the estimates of different benchmark years, and interpolates these parities applying also national price indices. As an illustrative example of the consequences of using these different PPPs we estimate convergence equations with both cross-section and pooled data for OECD countries, in the way suggested by recent empirical papers that use the human capital augmented Solow model[3]. After analyzing alternative estimates of *real* GDP per capita using Summers and Heston's data, OECD 1990 PPPs, and different available benchmark parities maintaining the *fixity* convention as far as possible, there are some significant differences comparing *PWT5* and OECD data set. Estimations based on *PWT5* data affect the rate of convergence and yield a worse fit than those obtained using OECD data, being the differences more important when pooled data are employed. When comparing OECD data sets the results suggest that, when at looking growth for long periods, differences in OECD estimates of real income seem to be of small importance, but when we are interested in analyzing medium term economic growth, the use of different benchmark parities can introduce some additional information.

The structure of the paper is the following. First of all, we discuss the link between the exchange rate and the PPP and provide some reasons why it is not convenient to approximate PPPs by exchange rates. The third and fourth sections of the paper are devoted to discuss PPP estimation methods in time series and cross sections. These sections discuss different methods which are usually employed by international organizations to estimate PPPs and to link

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2. See Purchasing Power Parities and Real Expenditures, 1990 Results (OECD, 1992).

3 See Barro and Sala-i-Martín (1991), Mankiw, Romer and Weil (1990), and Andrés, Doménech and Molinas (1993).

the benchmark estimates. In the last sections of the paper, using the estimated PPPs for OECD countries in several benchmark years, we discuss in detail the interpolation of these data, providing PPPs series of GDP, Private Consumption, Public Consumption and Investment for the twentyfour OECD members in the 1960-1990 period. We also illustrate the importance of using different PPPs estimates making a sensitivity analysis, comparing the results of estimated convergence equations with our data set and the ones provided by Summers and Heston (1991).

II. EXCHANGE RATES AND THE PPPs

The PPP of two currencies is the exchange rate which makes equal the purchasing power of these currencies, i.e., given an amount of money expressed in different currencies using the PPP, it would permit to acquire the same basket of goods and services in the countries for which the PPP was defined. Therefore, the PPP of a country is the exchange rate of its currency which eliminates the differences in the price level of this country with regard to the rest of the countries. For example, let us assume that we want to estimate the PPP for two regions in a country. The price level in region A, P_a, is 10% higher than the price level in B, P_b. Given that there exists the same currency in both regions, the ratio $P_a/P_b = 1'1$ is the quantity by which we have to divide the current income in A, in order to have the same purchasing power of the currency in regions A and B.

When we have GDP data for a group of countries, each of them is expressed in its own national currency, we cannot make any comparisons between these countries GDPs without having measured them in a common unit. In international comparisons, traditionally the GDP of a country is expressed in dollars, this currency being the most usual numerary.

However, there exists a more appropriate way of converting these quantities from different countries into a common unit that consists in using PPPs instead of exchange rates.

The application of the PPP permits to compare the GDP of different countries taking into account the existence of different price levels in each country. The PPP between country j and the *USA* is given by the following expression:

$$PPP_{j,USA} = \frac{\sum_{i=1}^{m} P_{ij}\, q_{ij}}{\sum_{i=1}^{m} P_{i,USA}\, q_{ij}} \qquad (1)$$

where Q_j is the basket of m goods (q_{ij}) and services taken as base, and P_{ij} and $P_{i,USA}$ are the prices of the components of the basket in both countries.

Operating with this expression we get:

$$PPP_{j,USA} = \sum_{i=1}^{m} \left[\frac{P_{ij}}{P_{i,USA}}\right] \frac{e_{i,USA}}{\sum_{i=1}^{m} e_{i,USA}} = \sum_{i=1}^{m} \left[\frac{P_{ij}}{P_{i,USA}}\right] w_{i,USA} \qquad (2)$$

where $e_{i,USA}$ is the expenditure in good i at USA prices. Thus the $PPP_{j,USA}$ would be a weighted average of the prices ratios of the components of the basket for the two countries.

To get a good estimation of the PPP of a set of countries is a difficult task because very detailed information is needed, while the exchange rates are quit easy to observe. Nevertheless, there exist a lot of reasons for the existence of deviations between the PPP and the exchange rate: tariffs, capital flows restrictictions, nontraded goods and services,...,etc..

In **Figure 1** we present the Spanish GDP per head with regard to the United States one for the period 1960-1990, using both, the exchange rate and an estimation of the PPP for the GDP. It can be observed that the comparison

using the exchange rate depends upon the fluctuations in the currency market. Besides the volatility, the level of both series is very different and, as various authors have corroborated, there is a clear relation between income per capita and the ratio of a country's PPP to its exchange rate (the comparative price level). As an example, in **Figures 2.1** to **2.4** we present the deviations of the PPP and the exchange rate against the GDP per head, expressed as a percentage of the United States GDP, for the OECD countries in 1975, 1980, 1985 and 1990.

This effect was identified by D. Ricardo (1821) and more recently by B. Balassa (1964), P. Samuelson (1964), Bhagwati (1984), Kravis and Lipsey (1983) and in the large amount of papers by Kravis, Summers and Heston. These authors give alternative explanations of this correlation between income per head and the comparative price level.

Balassa and Samuelson assume that labour in countries with a low income per head is less productive, in the production of the traded goods, than in countries with high income per head. However their differences in productivity of nontraded goods are small. If prices of traded goods are aproximately equal in both countries, the lower productivity in poorer countries implies lower wages and lower production costs for the nontraded goods sector. On the other hand, the rich countries, with higher labour productivity in the traded goods sector will have higher prices for the nontraded goods and, thus, a higher general prices level.

Alternately, Bhagwati, Kravis and Lipsey give an explanation based on the different capital and labour endowments of the poor and rich countries. They conclude that the relative prices of nontraded goods in a country will rise with income per head. The rich countries usually have a higher capital to labour ratio and them a higher marginal labour productivity, which means higher wages. Nontraded goods, which are mainly services, are in general more intensive in labour than traded ones. Since labour is cheaper in poor countries, nontraded goods will be cheaper in these countries than in the rich ones.

Concerning the question about whether the exchange rates tend to converge to the PPPs, there is a vast literature, both empirical and theoretic. The **absolute PPPs theory** states that in a world with free trade, no trade barriers, no capital flow controls, etc., the exchange rate converges to the PPP. But there exists a modified version, the **relative PPP Theory**, according to which, there are some factors, such as tariffs, that generate deviations between the PPP and the exchange rate. Nevertheless, if these factors are constant, the ratio of the exchange rate to the PPP will be constant as well.

The PPP theory was first formulated by Cassel as an intent of developing a theory of the behaviour of the exchange rate in the long run. After the Second World War arose a great interest on international comparisons of per capita income. Gilbert and Kravis (1958) promoted the research into the direct estimation of the PPP. That meant an implicit rejection of the previous theories, i.e., if the exchange rate converged to the PPP it would not be necessary to calculate the latter separately.

If all the goods were tradable to the same extent, one would expect prices to converge to a unique world price, in any of the currencies, for all of the goods and services. This convergence process will give rise to changes in national prices in each country or to changes in the exchange rate so that this one will equal its corresponding PPP.

In fact, not all of the goods are tradable to the same extent. Balassa (1964) studied the theoretic implications of this question using a model in which the economy is divided into two sectors, one producing the nontraded good, and the other the traded ones. Balassa (1964) says that because the exchange rates are the result of international trade, they are not affected by the prices of nontraded goods. But the PPP of the GDP includes prices of all of the goods demanded in a country. Then if nontraded goods represent a high proportion with respect to total expenditure in the country, there is an important reason to find some deviations between the PPP and the exchange rate, which usually is systematic. Besides that, there is empirical evidence

about the existence of a negative correlation between the income per head of a country and nontraded goods relative prices. This correlation is mainly provoked by the services, which are intensive in labour and nontraded, and so they are cheaper in countries with lower wages (i.e., in the poor countries) than in the rich countries where services are very expensive.

An example of this is showed in **Figures 3.1** to **3.4** where the ratio of the PPP for investment to the PPP of the GDP is represented against income per head for all of the countries belonging to the OECD in 1975, 1980, 1985 and 1990. **Figures 4.1** to **4.4** represent income per head against a similar ratio, but now using the PPP for public consumption. We can conclude that there exists a systematic correlation between the deviation of the exchange rate to the PPP and the income per head of a country. Thus, as a result, the income per head of the poor countries is systematically underestimated when the exchange rate is used, instead of the PPP, to make international comparisons.

III. PPPs ESTIMATION METHODS

Let us assume that we want to calculate the PPP for the GDP in one year. In order to obtain these PPPs we have price levels data for a high amount of goods and services, $i=1,\ldots,k$. Data collection is assumed that has been done in all countries of the sample and for a set of goods and services with similar characteristics. There exist two kind of methods which can be used to obtain the PPPs for this set of countries, that will be discussed in the following sections of the paper. A more detailed description of these methods is provided by Kravis, Heston and Summers (1982).

III.1 Methods for binary comparisons

We start with a set of binary comparisons, in which each of the countries is compared with the base country, for example the nth country. The methods chosen for the binary comparisons should be judged on the basis of the following considerations:

1. Characteristicity. Each binary comparison should be optimal for that pair of countries. This requires that the comparison between each pair should be based on the best sample of representative items that can be obtained for that pair, making prices directly comparable, and that the weights of these items should be representative of the spending patterns in that countries.

2. Country-reversal test. Besides that, the method must be consistent. This means that in a given binary comparison, it should not matter which country is used as the base country. That is,

$$PPP_{j,k} \; PPP_{k,j} = 1 \qquad \forall\, k,j \text{ countries} \tag{3}$$

where $PPP_{j,k}$ represents the PPP for countries j and k. This requirement is important because it is very desirable to obtain an unique set of estimates.

The first step in making binary comparisons is to calculate the ratios between the prices of the different countries and the base country for every good and service. Thus, we obtain $(P_{\alpha j}/P_{\alpha n})$, which, is the ratio which corresponds to the commodity α. But, once these ratios have been calculated they must be aggregated within detailed categories. There are different methods of averaging these price ratios, the easiest one is to use a simple geometric mean of the relative prices. That is, for category **i**:

$$\left(\frac{P_j}{P_n}\right)_i = \left(\prod_{\alpha=1}^{A} \frac{P_{\alpha j}}{P_{\alpha n}}\right)^{\frac{1}{A}} \qquad (4)$$

where:

$\frac{P_j}{P_n}$: PPP of the jth country relative to the nth country.

$P_{\alpha j}$: Price of αth item in the jth country stated in the jth country's currency.

$P_{\alpha n}$: Price of αth item in the numeraire country, which usually is the United States.

A: Number of items within the ith category.

The geometric mean was preferred to an arithmetic one because the former meets the country-reversal test whereas the latter does not.

$$\left(\frac{P_j}{P_n}\right)_i \left(\frac{P_n}{P_j}\right)_i = 1 \qquad (5)$$

After this averaging process within detailed categories we obtain PPPs for each of the n-1 other countries relative to the nth for each of the detailed categories. We can used these results to make two kinds of **binary comparisons**:

1. Original-country comparisons. These comparisons consist of a straight-forward comparison of each of the n-1 other countries with the nth, and no data from a third other country is involved in any binary comparison. To compute these original-country comparison, standard index number formulas can be used. Thus, we can calculate the PPP for GDP, or for other aggregates, averaging the PPP for detailed categories. Using the nth country's weights we obtain a *Laspeyres index* and using the country's own weights we get a *Paasche index*.

   The formula for the Laspeyres index is:

$$PPP_{j,n} = \sum_{i=1}^{m} \left(\frac{P_j}{P_n}\right)_i w_{in} \; ; \; w_{in} = \frac{e_{in}}{\sum_{i=1}^{m} e_{in}} \qquad (6)$$

   where m is the number of detailed categories in the desired aggregate, for example the GDP, and e_{in} is the per capita expenditure in national currency in the nth country and in the ith category.

   The Paasche index responds to the following formula:

$$PPP_{jn} = \frac{1}{\sum_{i=1}^{m} \left(\frac{P_j}{P_n} \right) w_{ij}} \quad ; \quad w_{ij} = \frac{e_{ij}}{\sum_{i=1}^{m} e_{ij}} \qquad (7)$$

Each of the two indices provides a biased estimate of the true PPP_{jn}: one biased in favour of the *j*th country (Paasche index) and the other in favour of *n*th country (Laspeyres index). We also can calculate a Fisher index with both, Laspeyres and Paasche indices, that corresponds to the geometric mean of these two indices. Although this index is not easy to justify in theoretical terms, it is a compromise between the index reflecting the consumption pattern in the *j*th country and the index reflecting that of the *n*th country.

The advantage of the original-country comparisons is that they represent the best comparison that can be made for each pair of countries. They have the maximal degree of characteristicity. But this method has some problems because the number of binary pairs will be high if *n* is large and, beyond the problems of index numbers, these comparisons will not yield a transitive system of comparisons.

2. Binary comparisons via a bridge country. Within this method, transitivity can be achieved, but the main objection is that the use of any bridge country imposes its prices and goods as weights, neither of which is necessarily characteristic of either of the countries in a binary comparison. In this case we have that:

$$\left(PPP_{jk}^{n} \right)_i = \left(\frac{P_j}{P_k} \right)_i^n = \left(\frac{P_j}{P_n} \right)_i \div \left(\frac{P_k}{P_n} \right)_i \qquad (8)$$

That means that the PPP_{jk} is derived from each countries PPP relative to the bridge country, i.e., the nth country. The problem is that there is no reason for $\left(PPP_{jk}^{n} \right)_i$ to be equal to the binary $\left(PPP_{jk} \right)_i$. Once we have these PPP for the detailed categories they may be aggregated, first with the Laspeyres' formula and then with the Paasche's formula.

To conclude, these methods involving binary comparisons cannot achieve genuine transitivity. In addition they suffer from the disadvantage that they are not efficient in the sense that they do not use all the relevant price information available and they depend upon the choice of a base, or bridge, country. If only two countries are going to be compared, this does not matter, but when the objective is to calculate a set of multilateral comparisons, the lack of efficiency and dependence upon the choice of the base country are important shortcomings.

III.2 Multilateral comparisons methods

In this section we will discuss several ways of achieving efficiency and base-country invariance. In some aspects, the desired properties we are looking for these methods are similar to those we claimed from binary methods, specially characteristicity. In other respects, however, we will add some new properties or we will change some others. The properties of the multilateral methods which are used when many countries are to be compared jointly, rather than merely in pairs, are the following:

1. Base-country invariance. It should make no difference which country is chosen as the base. That means that the country selected as the base should serve as nothing else as numeraire.

2. Equality of treatment of countries.

3. Transitivity. Each PPP should be a number on a continous scale in the sense that

$$PPP_{jk} = PPP_{jl} \div PPP_{kl} \quad \forall j,l,k \ \ countries \qquad (9)$$

4. Statistical Efficiency. Because the data collected are subject to sampling errors, the multilateral methods used should give PPPs that are relatively insensitive to the underlying sampling errors, i.e., the aggregation methods should provide estimates of PPPs that have minimum variance.

As in the case of the binary comparisons, two stages in making multilateral comparisons may be distinguished: first, combining items data at the detailed category level for all the countries in the sample to obtain transitive PPPs for each category, and second, averaging in a suitable way the PPPs for the different categories to obtain PPPs at various levels of aggregation, as for example the GDP level.

There is no consensus about the best aggregation method when multilateral comparisons are to be done because there exists a conflict between the characteristicity and the transitivity properties. We can distinguish, and this applies for the two stages of the aggregation, two different approaches. One school of thought proposes to use a common set of international prices that automatically ensures that the calculated PPPs are transitive at every level of aggregation. Thus, this school argues that the natural choice of **international prices** for a set of multilateral measures is simply the average prices within the whole group of countries and, in this sense, the PPP of each country could be referred to this international prices. This approch is preferred to that of chosing an arbitrary base country. By using these international prices, transitivity is ensured, but that means to sacrify the characteristicity requirement, because there is no reason for these international prices to be similar to relative prices structure of each country in the sample.

There is a second school of thought, however, which relegates the international prices to a secondary role, and seeks to evaluate multilateral measures in terms of their relationship to binary measures. It is argued that a binary measure between two countries taken in isolation from the rest of the group is the best measure for this pair of countries, and so, a very high degree of characteristicity is achieved.

In the following sections we will discuss the different aggregation methods to obtain PPPs that are usually proposed by these different approaches in the two stages framework stated before.

III.2.1. *Estimation of PPPs for detailed categories*

The objective in the first stage is to obtain transitive PPPs for the detailed categories using data about prices, which have been previously collected for each item in every country. Transitivity of results is generally required as a necessary condition and we will examine the different methods applied to achieve it.

The starting point will be to collect prices, P, in the way summarized in the price tableau:

Country (j)

Item(α)	*Country 1*	*Country 2*	.....	*Country n*
1	P_{11}	P_{12}	.....	P_{1n}
2	P_{21}	P_{22}	.....	P_{2n}
				⋮
A	P_{a1}	P_{a2}	.....	P_{an}

where $P_{\alpha j}$ is the price of the αth commodity in the jth country expressed in the jth country's national currency and A is the number of items in the category considered.

The first thing we could do is to compute geometric means based upon the data of the tableau as following:

$$\left(PPP_{jk} \right)_i = \left(\frac{P_{1j}}{P_{1k}} \cdots \frac{P_{Aj}}{P_{Ak}} \right)^{\frac{1}{A}} \qquad (10)$$

$$\left(PPP_{jl} \right)_i = \left(\frac{P_{1j}}{P_{1l}} \cdots \frac{P_{Aj}}{P_{Al}} \right)^{\frac{1}{A}} \qquad (11)$$

$$\left(PPP_{kl} \right)_i = \left(\frac{P_{1k}}{P_{1l}} \cdots \frac{P_{Ak}}{P_{Al}} \right)^{\frac{1}{A}} \qquad (12)$$

and we would obtain:

$$\left(PPP_{jk} \right)_i = \left(PPP_{jl} \right)_i \div \left(PPP_{kl} \right)_i \qquad (13)$$

Category PPPs that are geometric means based upon binary comparisons of prices have a high degree of characteristicity. But if, for any reason, the matrix P of prices contains some holes, this transitivity result will disappear.

As long as transitivity is essential, one possibility to overcome the problem is to use a bridge country. In this case, we would choose a country, for example, the *n*th country and we would compute all of the PPP_{jn} in order to obtain:

$$\left(PPP_{jk}^{n} \right)_i = \left(PPP_{jn} \right)_i \div \left(PPP_{kn} \right)_i \qquad (14)$$

where $\left(PPP_{jk}^{n}\right)_i$ is the PPP_{jk} for the *i*th category computed using the *n*th country. But in general, if there are some missing values in the *P* matrix (because some goods are not available in some countries), them $\left(PPP_{jk}^{n} \right)_i \neq \left(PPP_{jk} \right)_i$, achieving transitivity but in an artificial way. In addition, the results are not independent of the country used as bridge and this method is not statistically efficient, because it fails to make use of all the information contained in *P*.

Two methods are usually proposed to overcome these problems. First, we shall discuss the *EKS method* used by Eurostat and the OECD in 1985 PPPs. Given that not all of the items of the category *i* have been priced in every country the first step is to compute the following binary non-transitive PPPs between pairs of countries:

$$\left(PPP_{jh}^{h} \right)_i = \left(\prod_{\alpha=1}^{A} \frac{P_{\alpha j}^{h}}{P_{\alpha n}^{h}} \right)^{\frac{1}{A}} \quad \text{Laspeyres PPP} \quad \forall\ h,j \text{ countries} \qquad (15)$$

$$\left(PPP_{jh}^{j} \right)_i = \left(\prod_{\alpha=1}^{A} \frac{P_{\alpha j}^{h}}{P_{\alpha n}^{h}} \right)^{\frac{1}{A}} \quad \text{Paasche PPP} \quad \forall\ h,j \text{ countries} \qquad (16)$$

where the supra-index indicates that we are comparing the prices of the most representative items of expenditure patterns in the *h*th country (in the Laspeyres case) or in the *j*th country (in the Paasche case). Each of the PPPs we get are biased estimates of the true PPPs, in favour of country *j* or country *h*, except for cases where all the items in category *i* are consumed in the two countries compared. After computing these binary PPPs the Fisher index is calculated in order to compute the best possible unbiased estimate between country *h* and *j*. The Fisher index is defined as the geometric average of the Laspeyres and Paasche indices:

$$\left(F_{jh}\right)_i = \left[\left(PPP^{h}_{jh}\right)_i \left(PPP^{j}_{jh}\right)_i\right]^{1/2} \qquad (17)$$

This Fisher PPP has equal characteristicity for both countries but these indices are not transitive and thus should therefore be transformed. The *EKS method* is known as a procedure to provide transitive parities for a group of countries starting from the Fisher indices. The EKS parities for country *h* and *j* for the *i*th category are calculated in such a way that the deviations from the original Fisher type indices are minimized, i.e. for the *n* countries we have:

$$Min\ D = \sum_{h=1}^{n} \sum_{j=1}^{n} \left[ln\left(PPP^{EKS}_{h,j}\right)_i - ln\left(F_{h,j}\right)_i \right]^2 \qquad (17)$$

where $\left(PPP^{EKS}_{h,j}\right)_i$ is the EKS PPP between the *h*th and the *j*th countries for the *i*th category. From this minimization procedure the following expression for the EKS index can be derived:

$$\left(PPP^{EKS}_{h,j}\right)_i = \left[\prod_{k=1}^{n} \frac{\left(F_{j,k}\right)_i}{\left(F_{h,k}\right)_i}\right]^{1/n} \qquad (19)$$

That means that the EKS PPPs can be written as the geometric average of all *n* "indirect" Fisher estimates, $\left(F_{h,k}\right)_i / \left(F_{j,k}\right)_i$.

The second multilateral method we shall discuss is the *Country-Product-Dummy* (CPD) method, thas is mainly the method used by United Nations and OECD in 1990 PPPs. The CPD takes advantage of all the information of the tableau P in estimating each of the PPPs. First, this method estimates the prices corresponding to the holes in *P*, and then, transitive PPPs are derived as geometric averages of all the binary PPPs calculated for every pair of countries.

The method assumes that:

$$ln\ P_{\alpha j} = \beta_j + \gamma_\alpha \qquad (20)$$

That is, the price of the αth item in country h, is the result of two forces: one corresponding to the own characteristics of the jth country, represented by β_j, and the other corresponding to the special characteristics of this good, represented by γ_α. Considering the matrix P, we obtain:

$$\begin{bmatrix} lnP_{11} \\ \cdot \\ \cdot \\ \cdot \\ lnP_{A1} \\ lnP_{12} \\ \cdot \\ \cdot \\ \cdot \\ lnP_{A2} \\ \cdot \\ \cdot \\ \cdot \\ \cdot \\ \cdot \\ lnP_{1n} \\ \cdot \\ \cdot \\ \cdot \\ lnP_{An} \end{bmatrix}_{n\,A\times 1} = \begin{bmatrix} 1\,0\cdots\cdots 0 \\ \cdot\ \cdot \\ \cdot\ \cdot \\ \cdot\ \cdot \\ 1\,0\cdots\cdots 0 \\ 0\,1\cdots\cdots 0 \\ \cdot\ \cdot \\ \cdot\ \cdot \\ \cdot\ \cdot \\ 0\,1\cdots\cdots 0 \\ \cdot\ \cdot \\ \cdot\ \cdot \\ \cdot\ \cdot \\ \cdot\ \cdot \\ \cdot\ \cdot \\ 0\,0\cdots\cdots 1 \\ \cdot\ \cdot \\ \cdot\ \cdot \\ \cdot\ \cdot \\ 0\,0\cdots\cdots 1 \end{bmatrix}_{nA\times n} \begin{bmatrix} \beta_1 \\ \cdot \\ \cdot \\ \cdot \\ \beta_n \end{bmatrix}_{n\times 1} + \begin{bmatrix} 1\cdots\cdots 0 \\ 0\,1\cdots\cdots 0 \\ 0\,0\,1\cdots 0 \\ \cdot\ \cdot\ \cdot \\ \cdot\ \cdot\ \ \cdot \\ \cdot\ \cdot\ \ \cdot \\ 0\,0\cdots\cdots 1 \\ 1\,0\cdots\cdots 0 \\ 0\,1\cdots\cdots 0 \\ 0\,0\,1\cdots 0 \\ \cdot\ \cdot\ \cdot \\ \cdot\ \cdot\ \ \cdot \\ \cdot\ \cdot\ \ \cdot \\ 0\,0\,1\cdots 1 \\ 1\,0\cdots\cdots 0 \\ 0\,1\cdots\cdots 0 \\ 0\,0\,1\cdots 0 \\ \cdot\ \cdot\ \cdot \\ \cdot\ \cdot\ \ \cdot \\ \cdot\ \cdot\ \ \cdot \\ 0\,0\cdots\cdots 1 \end{bmatrix}_{nA\times A} \begin{bmatrix} \gamma_1 \\ \cdot \\ \cdot \\ \cdot \\ \gamma_A \end{bmatrix}_{A\times 1} \qquad (21)$$

To estimate the prices of the items for which there were no price in all of the countries (represented by a zero in price matrix), we have to estimate the following linear regression equation:

$$ln\,P_{\alpha j} = \beta_1 x_{\alpha 1} + \ldots + \beta_n x_{\alpha n} + \gamma_1 y_{1j} + \ldots + \gamma_A y_{Aj} + \nu_{\alpha j} \qquad (22)$$

whose two sets of involved dummy variables are:

$$x^*_{\alpha j} = \begin{cases} 1 \text{ if } j^* = j \\ 0\text{therwise} \end{cases} \tag{23}$$

$$y^*_{\alpha j} = \begin{cases} 1 \text{ if } \alpha^* = \alpha \\ 0\text{therwise} \end{cases} \tag{24}$$

we shall also assume that

$$v_{\alpha j} \sim N(0, \sigma^2_v) \tag{25}$$

If we impose j to be 1:

$$\sum_{\alpha=1}^{A} ln\ P_{\alpha 1} = \beta_1 \sum_{\alpha=1}^{A} x_{\alpha 1} \tag{26}$$

but as $\sum_{\alpha=1}^{A} x_{\alpha 1} = A$ by definition of $x_{\alpha 1}$, then

$$\beta_1 = (1/A) \sum_{\alpha=1}^{A} ln\ P_{\alpha 1} \tag{27}$$

As we can see $\beta_1, \ldots, \beta_2$ are geometric averages of items prices. So, we have made comparisons that are transitive:

$$\beta_1 = \left(\prod_{\alpha=1}^{A} P_{\alpha 1} \right)^{\frac{1}{A}} \tag{28}$$

$$\beta_2 = \left[\prod_{\alpha=1}^{A} P_{\alpha 2} \right]^{\frac{1}{A}} \qquad (29)$$

$$\frac{\beta_1}{\beta_2} = \left[\prod_{\alpha=1}^{A} \frac{P_{\alpha 1}}{P_{\alpha 2}} \right]^{\frac{1}{A}} = \left[PPP_{1,2} \right]_i \qquad (30)$$

A possible disadvantage of this generalized bridge-country method is that a country for which there are many price observations within the given category will have more influence upon the regression coefficients than a country for which there are few price observations.

III.2.2. *Estimation of the PPP for aggregates: Geary-Khamis and EKS Methods*

We now are at the second stage of the estimating procedures stated before. Having a suitably calculated set of PPPs for the different categories, we shall discuss the methods usually proposed to combine the various category PPPs to estimate the PPP at the level of both GDP and their components. In aggregating up the PPPs from the category levels we shall need some weights. These weights assigned to each category's PPP, are obtained by assessing the average importance of the category, relative to all other categories across the countries, measured by expenditures data of the different countries in each category.

There are a large number of aggregation methods and, as we shall see, the different international organizations which make international comparisons have showed diverse preferences for these methods, sometimes due to the characteristic of the data, other for computational problems.

One of the most used and known method is the Geary-Khamis method, proposed by Geary (1958) and subsequently, improved by Khamis (1967, 1970, 1972). This method was used by the ICP and the OECD until 1990. An alternative method to this one, was suggested by Gerardi (1974) and was used until not many years by EUROSTAT. Other method is the Walsh method, recommended by Ruggles (1967) and very used by the ECIEL in the Latinamerican comparisons. Prasada-Rao (1972) suggested a method alternative to the Geary-Khamis which is based in a log-linear equations system.

All these methods are basically country invariant and have the transitivity property, and they permit to calculate multilateral PPPs in a group of countries for the GDP or, for any of its components, relative to a set of international prices of goods and services. Thus, as outlined earlier, these indices have not a high degree of characteristicity.

However, there are other aggregation methods that permit to obtain transitivity without sacrificing the characteristicity requirement. Thus, we

have the Eltetö-Köves-Szula method, normally referred as EKS method[4] that, as we explained before, can also be used to get PPPs at the detailed categories level from the prices data of goods and services. The main characteristic of this method is that it preserves a very high degree of characteristicity. Others methods which share this property with the EKS method are those suggested by Van Yzeren (1956) which consider that the binary parities are very relevant[5]. As the Geary-Khamis and EKS methods are the most used, we only discuss these methods in the following sections[6].

Geary-Khamis Method

If each country's price for a particular good or service were adjusted for the known purchasing power of the country's currency, it would be easy to find an international price, denoted Π_i, for the good or service. Similarly, if the international prices were known for each good or service, it would be a simple matter to compute for each country the deviation of its prices from the international prices and, thereby, to obtain the corresponding purchasing power, denoted PPP_j, of its currency. Geary suggested the use of a system of homogeneous linear equations that would make it possible to find the Π_i and PPP_j simultaneously from the prices and quantities data of a set of goods and services for a group of countries, p_{ij} and q_{ij}. Subsequently, Khamis demonstrated that the equations system generates non negative Π_i's y PPP_j's[7].

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4 The original publications describing these methods are not in English, but Dreschler analyzed this method in an article in the Review of Income and Wealth in 1973.

5 We will not discuss the Van Yzeren methods because have not been used frequently in the estimations of PPPs in the last years . This method, however, was used by the European Coal and Steel Community.

6 The Gerardi (1974) and Rao (1972) methods can be considered as deviations from the Geary-Khamis method.

7 These aggregation methods for prices or for parities are basically ad hoc statistical procedures with some intuitively appealing interpretation, but they have often been criticized as a mechanical procedure with little

The Geary-Khamis equation system is as follows:

$$\Pi_i = \sum_{j=1}^{n} \frac{P_{ij}}{PPP_j} \left[\frac{q_{ij}}{\sum_{j=1}^{n} q_{ij}} \right] \quad , \quad i=1,\ldots,m \quad \textit{(categories)} \qquad (31)$$

$$PPP_j = \frac{\sum_{i=1}^{m} P_{ij}\, q_{ij}}{\sum_{i=1}^{m} \Pi_i\, q_{ij}} \quad , \quad j=1,\ldots,n \quad \textit{(countries)} \qquad (32)$$

The first equation says that the international price of the *i*th category for the *n* countries considered, Π_i, is the weighted average of the prices of the ith category in this group of countries where the prices p_{ij} are adjusted by its corresponding PPP_j and the weights are given by the quantities of *i*th category's goods and services consumed in each country, q_{ij}, with respect to the total amount of this *i*th category demanded in all of the countries, $\sum_{j=1}^{n} q_{ij}$.

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or no economic theoretic foundations. Caves et al (1982) highlight this problem and conclude that alternative methods, specially those based on EKS method, should be considered, because, at least, these methods are based on some minimization criteria. Prassada Rao and Salazar-Carrillo (1988) analyze which utility function for the different countries in the sample could justify the application of the Geary-Khamis method.

The second equation says that the purchasing power of a country's currency is equal to the ratio of the cost of its total demand of goods and services at national prices, $\sum_{i=1}^{m} p_{ij} q_{ij}$, to the cost at international prices.

The system consists of (n+m) equations in (n+m-1) unknowns because $PPP_j = 1$ for the country used as numeraire, so one equation is redundant. After suitable manipulation, is easy to show that the sum over i of the first equation is equal to sum over j of the second equation, and the system is homogeneous.

Given that we want the Geary-Khamis procedure to be used as an aggregation method of the PPPs previously calculated for the detailed categories[8] , the data that we have are these $[PPP_{jn}]_i$ for each of the $i=1,\ldots,m$ categories. But the inputs that the Geary-Khamis method requires are prices and physical quantities for the sets of good and services to be covered. The only information that we have, except for the $[PPP_{jn}]_i$, are the expenditure data of each country in each category. That is, the starting point is a set of transitivity parities $[PPP_{jn}]_i = \frac{P_{ij}}{P_{in}}$, where the nth country is used as a reference. Let us define the expenditure or the jth country in the ith category as $e_{ij} = p_{ij} q_{ij}$. In this case, the Geary-Khamis equations will be:

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8 An example of this is the work of Ward, M. (1985) for the OECD countries, which provides PPPs for 1980 derived using the EKS method in the first stage of the aggregation procedure, i.e., to obtain transitive PPPs at a detailed category level from the item prices, and then, using the Geary-Khamis method in the second stage. This procedure is similar in OECD publication of 1985 PPPs.

$$\bar{\Pi}_i = \sum_{i=1}^{n} \frac{[PPP_{jn}]_i}{\overline{PPP_j}} \left[\frac{e^n_{ij}}{\sum_{i=1}^{n} e^n_{ij}} \right] , \quad i=1,\ldots,m \quad \textit{(categories)}$$

$$\overline{PPP_j} = \frac{\sum_{i=1}^{m} [PPP_{jn}]_i e^n_{ij}}{\sum_{i=1}^{m} \bar{\Pi}_i e^n_{ij}} , \quad j=1,\ldots,n \quad \textit{(countries)}$$

where $e^n_{ij} = (p_{ij}q_{ij})/(p_{ij}/p_{in}) = q_{ij}\ p_{in}$. It is easy to show that $\bar{\Pi}_i = \Pi_i/p_{in}$ and $\overline{PPP_j} = PPP_j$. Thus this aggregation method ensures that PPP_j for the different aggregates will be independent of the country used as a base.

The advantages of the Geary-Khamis method are the following:

1) It assumes that there is a unique PPP for each country and that this can be measured in terms of the weighted average deviations of its prices from average international prices.

2) Besides that, it defines international prices in a straightforward and appropriate way. It is the availability of these international prices that enables us to achieve additivity and transitivity at the same time.

3) Finally, the method makes it possible to pick a base country that will be no more than a numeraire country.

An essential aspect of the Geary-Khamis method is, that the international price of any category is equal to the weighted average of the individual country prices for that category after the country prices have been adjusted by its corresponding PPP_j, as it can be seen in the first equation. But the weight for any country is its share of the total quantity of the category goods and services demand for all the countries belonging to the sample. Thus, the "international prices" calculated by this method will depend upon which countries are been included in the sample.

EKS method

EKS method[9] was discussed earlier in this paper when the methods usually suggested to compute PPP_j at the detailed category level were analyzed. It is also possible to use this method to compute PPPs at the GDP level and for its components. In this sense, for each pair of countries, *h* and *j*, we should first calculate the Laspeyres type index and the Paasche type index, but taking into account the relative importance of the ith category in the total expenditure:

$$PPP^{h}_{jh} = \prod_{i=1}^{m} \left[PPP^{h}_{jh} \right]_{i}^{w_{ih}} \quad ; \textit{Laspeyres type index}$$

9 This is the method used in the last publication of the OECD about PPPs for 1990, as regards the aggregation in the second stage, whereas for the first one, i.e., to obtain PPPs for the detailed categories, CPD method is used in this publication.

$$PPP^{j}_{jh} = \prod_{i=1}^{m} \left[PPP^{j}_{jh} \right]_i^{w_{ij}} \quad ; \quad Paasche \ type \ index$$

where the $\left[PPP^{j}_{jh} \right]_i$ is the PPP for countries j y h for the ith category calculated using the most representative items prices in the jth country, and the same for $\left[PPP^{h}_{jh} \right]_i$ but now using the prices of the hth country. The weights w_{ih} and w_{ij} were defined before. Having these PPPs for an aggregate, we can calculate the Fisher type index as follows:

$$F_{jh} = \left[PPP^{h}_{jh} \ PPP^{j}_{jh} \right]^{1/2} \qquad (37)$$

and as before:

$$Min \ D = \sum_{h=1}^{n} \sum_{j=1}^{n} \left[ln \ PPP^{EKS}_{hj} - ln \ F_{jh} \right]^2 \qquad (38)$$

and thus, we would obtain that:

$$PPP^{EKS}_{jh} = \left[\prod_{k=1}^{n} \frac{F_{hk}}{F_{jk}} \right]^{1/n} \qquad (39)$$

as we did for each of the categories in the fist stage of the aggregation procedure.

Recently, the OECD, who has been using the Geary-Khamis method for the second stage for a long time, has opted for the EKS method. The reasons given by the OECD to justify this change are the following:

1) With the EKS method, countries are treated as a set of independent units and each country is assigned an equal weight, so the PPPs obtained are equi-characteristic of the prices of all countries, because they are calculated by minimizing the differences between multilateral binary PPPs and bilateral binary PPPs. As a result, the EKS method provides PPPs for each pair of countries that are closer to the PPPs that would be obtained if each pair of countries had been compared separately. With the Geary-Khamis method, countries are treated as members of a group, that is, as parts of a whole. Each country is weighted according to its share of the GDP for the group and common prices are defined as prices which are characteristic of the group overall. They are obtained by averaging prices across the countries in the group. Thus, a change in the composition of the group can change the average prices as well as the relationships between countries.

2) Besides that, when the Geary-Khamis method is used, the "Gerschenkron Effect" appears, because when the price structure of a country is very different from the structure of the average prices used in the aggregation process ("international prices"), this country will appear as having higher volume levels that it would have had if the average prices used had been more characteristic of its prices. This is not a problem when EKS method is used, because this method calculate some average prices that are "equi-characteristic".

3) On the other hand, the Geary-Khamis method provides results which are additive, that is, the real values of aggregates are the sum of the real values of their components and this not the case with the EKS method.

In any case, comparisons of both methods suggest that differences are very small, as Kravis, Heston and Summers (1982) have shown with numerical examples.

IV. INTERNATIONAL AND INTERTEMPORAL COMPARISONS OF PPPs

The calculation of PPPs and quantity comparisons for a given year provides interesting information about the relative importance of countries. However, it would be very convenient to have annual estimates of these PPPs in order to permit users to apply these parities for international comparisons of annual data of the GDP or other aggregate expressed in national currency. In this section of the paper we shall comment the problems related to combining space and time comparisons of prices for a group of countries, following the works of Krijnse Locker and Faerber M.D. (1984), Summers-Heston (1988, 1991) and Kravis-Summers-Heston (1982).

The use of PPPs for comparisons of final domestic expenditure or GDP, within a group of countries, must be done in a framework in which space and time are simultaneously involved. In this framework, temporal indices and parities should be transitive in time and space. It is assumed that the starting point is a set of PPPs (calculated on the basis of special price surveys, such as those elaborated by the United Nations[10] , the EC or the OECD) and that national price indices are available. The objective is to obtain PPPs time series for a set of countries, in such a way that the implicit prices evolution resulting of comparing two benchmark of this time series is consistent with the explicit evolution of prices that can be observed in the national price indices, and that the PPPs derived by extrapolating the original PPPs using these prices indices be transitive between countries.

However, when the PPPs are extrapolated using a price index there is an important source of errors: international comparisons of prices are made using data and methodologies which are different from those used in the calculations of the national price indices. These intertemporal prices indices are computed using the price data corresponding to a basket of goods

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10 That refers to the "International Comparison Project" of the United Nations.

and services which is different in the different countries of the sample. In addition, this basket could be, and normally this is the case, very different from the basket used in the estimation of the PPPs. In general, these errors will depend on the differences between the expenditure pattern of the countries to be covered, and on the length of the period over which data are extrapolated: the longer this period the stronger the errors. Presumably the errors also will depend not only on the number of years but on the characteristics of the period as well. In periods such as the beginning of the seventies or during the eighties, when drastic changes in the world economy affected the international prices structure, PPP extrapolated are less reliable[11].

It would be possible to extrapolate the PPPs at a disaggregated level if we had national price indices for the different subaggregates. Once these PPPs for subaggregates had been extrapolated, they could be aggregated to obtain the PPP of the aggregate, for example the GDP. But, the PPP for the GDP obtained in this way would not be necessarily equal to the PPP extrapolated with an aggregated approach.

The global approach is one of the main reasons for errors and desaggregation seems to be an effective method of limiting errors, because this detailed extrapolation would permit us to take into account the changes in the price structure at the detailed categories level. However, this desaggregated approach will require a high volume of detailed information which is only disposable for some international organizations.

H. Krijnse Locker and Faerber M.D. (1984) proposed three methods to obtain price indices and parities which will be transitive and consistent in the space and in the time.

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11 Szilagyi (1981) presents a similar discussion, but referred to the extrapolation of quantities and volume indices.

IV.1. Unchanged price indices

One possibility consists in remaining unchanged price indices while the parities of a base year are extrapolated with this indices. The simplest method of extrapolation consists in:

$$PPP_{jh}^{t^*} = PPP_{jh}^{t_o^*} \frac{I_{t_0,t}^{j}}{I_{t_0,t}^{h}} \quad , \quad \forall\, h,j \quad , \quad \forall\, t \qquad (40)$$

This method is very convenient if we want to estimate, either future PPPs or past PPP from the last PPP which is available.

IV.2. Unchanged Purchasing Power Parities

If we want that the observed parities remain unchanged, it is possible to obtain new price indices in such a way that the parity change is explained. The change of parities over time will be due to the relative change in price level in the countries concerned. Let us assume that we have the transitive parities observed in periods t_o and t_1 for countries j and h. Suppose the change in the parity from t_o to t_1 will no correspond to the price change over time of the countries. In order to determine space and time transitive parities and indices it will be necessary to re-estimate the indices. In general, we will have that:

$$\frac{I_{t_0,t_1}^{j^*}}{I_{t_0,t_1}^{h^*}} = \frac{PPP_{jh}^{t_1}}{PPP_{jh}^{t_0}} \frac{I_{t_0,t_1}^{j}}{I_{t_0,t_1}^{h}} \quad \forall\, h,j \quad , \quad \forall t_0,t_1 \qquad (41)$$

where $PPP_{jh}^{t_1}$ is the PPP between country j and h in period t_1, I_{t_0,t_1}^{j} is the original price index of country j between period t_o and period t_1, and I_{t_0,t_1}^{j*} is the new transitive price index, which is obtained in such a way that the deviations of this index from the original one are minimal. The distance to be minimized will be:

$$D = \sum_{j=1}^{n} \left[\log \frac{I_{t_0,t_1}^{j*}}{I_{t_0,t_1}^{j}} \right]^2 \qquad (42)$$

By introducing the consistency property between parities and indices it is possible to get the following expression for country h:

$$D_h = \sum_{j}^{n} \left[ln \frac{PPP_{jh}^{t_1}}{PPP_{jh}^{t_0}} \frac{I_{t_0,t_1}^{h*}}{I_{t_0,t_1}^{h}} \right]^2 \qquad (43)$$

and so, the new transitive price index for country h becomes:

$$I_{t_o t_1}^{h*} = \left[\prod_{j=1}^{n} \left[\frac{PPP_{jh}^{t_1}}{PPP_{jh}^{t_o}} \right] I_{t_o t_1}^{j} \right]^{1/n} \qquad \forall\ t_o,\ t_1 \qquad (44)$$

If parities are observed in different years and we want to estimate parities for the intermediate periods, the interpolation procedure is carried out on

the basis of the available national price indices. An appropriate interpolation formula is given by the following nonlinear equation:

$$PPP_{jh}^{t^*} = \left[PPP_{jh}^{t_0} \frac{I_{t_o,t}^{j}}{I_{t_o,t}^{j}} \right]^{\frac{t_1-t}{t_1-t_0}} \left[PPP_{jh}^{t_1} \frac{I_{t_1,t}^{j}}{I_{t_1,t}^{j}} \right]^{\frac{t-t_o}{t_1-t_0}} \quad \forall\, h,j\ ,\ \forall\ t,\ t_o \le t \le t_1 \qquad (45)$$

In this model if $t=t_o$ and $t=t_1$ the observed parities $PPP_{jh}^{t_0}$ and $PPP_{jh}^{t_1}$ are obtained. The influence of these parities depends on the distance from the considered period t.

IV.3. Consistentization between PPPs and price indices

The third possibility consists in the adaptation of parities and indices. In many practical situations observed parities and national price indices will be given the same priority for the calculation of the change in the price levels between countries. It will be useful under these circumstances to use both types of information, the national price indices as well as the parities. Let us see three different methods for the adaptation of prices and indices.

IV.3.1. *Forward smoothing system.*

With this system the parity between countries h and j is fixed for the base year. For all the other years t the parities are defined as the geometric average of the space transitive parities observed in year t and the space

transitive parities at year t extrapolated by means of price indices and parities of year t_o:

$$\overline{PPP}_{jh}^{t_o} = PPP_{jh}^{t_o} \quad \forall\, h,\, j \tag{46}$$

$$\overline{PPP}_{jh}^{t} = \left[PPP_{jh}^{t}\, PPP_{jh}^{t_0}\, \frac{I_{t_o,t}^{j}}{I_{t_o,t}^{j}} \right]^{1/2} \quad \forall h,\, j\,,\ \forall t \tag{47}$$

The corresponding space and time transitive indices $I_{t,t_1}^{j^*}$ are obtained as indices between two parities:

$$I_{t_o,t}^{j^*} = \left[\prod_{j=1}^{n} \frac{PPP_{jh}^{t}}{PPP_{jh}^{t_o}}\, I_{t_o,t}^{j}\, I_{t_o,t}^{h} \right]^{1/2n} \quad \forall\, h,\ \forall\, t \tag{48}$$

IV.3.2. *Backward smoothing system*

This systems is just the opposite to the first one space and time transitive parities of year t are kept unchanged, and all the other are calculated as the geometric mean of the space transitive parities observed in year t and the space and time transitive parities at year t extrapolated by means of price indices and parities of t_1:

$$\overline{PPP}_{jh}^{t_1} = PPP_{jh}^{t_1} \quad \forall\, h, j$$

$$\overline{PPP}_{jh}^{t} = \left(PPP_{jh}^{t}\, PPP_{jh}^{t_1}\, \frac{I^{j}_{t_1,t}}{I^{j}_{t_1,t}} \right)^{1/2} \qquad \forall h, j\ ,\ \forall t \qquad (49)$$

Space and time transitive parities for t are calculated each time a new observed parity becomes available.

IV.3.3. *General Smoothing.*

The third system permits a general revision of parities and price indices instead of fixing parities of a given year. In this case, parities for each year t result from the geometric average of transitive parities obtained in the two previous system.

$$\overline{PPP}_{jh}^{t} = \left[\left(PPP_{jh}^{t}\, PPP_{jh}^{t_o}\, \frac{I^{j}_{t_o,t}}{I^{j}_{t_o,t}} \right)^{1/2} \left(PPP_{jh}^{t}\, PPP_{jh}^{t_1}\, \frac{I^{j}_{t_1,t}}{I^{j}_{t_1,t}} \right)^{1/2} \right]^{1/2} \quad \forall t, \forall h, j \qquad (50)$$

IV.3.4. *Chained Forward Smoothing System.*

The systems explained in the previous paragraph takes the base year at t_o or t_1 on the average of the two as a basis of the annual estimation of the parities and time indices. It is possible that between t_o and t_1 the distance is very great. That means that estimated parities are influenced by parities observed in years which are very far away, and this seems to be undesirable. It is possible to improve this situation by introducing a system of chain indices in which the transitive parities of a given year are mainly influenced by parities of very close years by a shift of the base year. By introducing this idea of chain indices is possible to define three new methods. The *Chained Forward Smoothing System* uses for the base year the original parities:

$$PPP_{jh}^{t_o*} = PPP_{jh}^{t_o} \quad \forall\, h,j \tag{51}$$

For all other years a recursive definition of parities is necessary:

$$PPP_{jh}^{t*} = \left[PPP_{jh}^{t-1*} \frac{I_{t-1,t}^{j}}{I_{t-1,t}^{h}} PPP_{jh}^{t} \right]^{1/2} \quad \forall\, h, j\ , \forall t \tag{52}$$

In this chained system, as was the case in the original forward smoothing system, the results do not need any revision because of new information.

IV.3.5. *Chained Backward Smoothing System*

The parities of the last benchmark year will be kept constant and chaining will work backwards

$$PPP_{jh}^{t_1 *} = PPP_{jh}^{t_1} \quad \forall\ h,j \tag{53}$$

$$PPP_{jh}^{t*} = \left[PPP_{jh}^{t+1*} \frac{I_{t+1,t}^{j}}{I_{t+1,t}^{h}} PPP_{jh}^{t} \right]^{1/2} \quad \forall\ h,\ j\ ,\ \forall t \tag{54}$$

IV.3.6. *Chained General Smoothing System*

This system is only the geometric average of systems IV.3.4. and IV.3.5.:

$$PPP_{jh}^{t*} = \left[\left[PPP_{jh}^{t-1*} \frac{I_{t-1,t}^{j}}{I_{t-1,t}^{h}} PPP_{jh}^{t} \right]^{1/2} \left[PPP_{jh}^{t+1*} \frac{I_{t+1,t}^{j}}{I_{t+1,t}^{h}} PPP_{jh}^{t} \right]^{1/2} \right]^{1/2} \quad \forall h,j,\ \forall t$$

(54)

Once these different methods to obtain intertemporal transitive parities have been analyzed, we can conclude that the choice depends on the relative quality of parities or indices

V.- PPPs ESTIMATES FOR OECD COUNTRIES: 1960-1990

V.1.- International Comparisons Research: A Brief Historical Survey

The aim of this section is to obtain a new set of real products and its composition in major aggregates (private and public consumption, and investment) for OECD countries relying on OECD national accounts and taking into consideration different PPP estimates from the *International Comparison Project* (ICP), Eurostat and OECD. These parities between currencies permit comparisons of GDP aggregates for different countries. As an example of the importance of the availability of PPPs one should notice that the homogenization of aggregates expressed in different currencies is always a previous work in any empirical study in which real variables are involved. This is the case, for example, in empirical economic growth literature.

OECD, United Nations, Eurostat, World Bank and IMF have promoted the use of PPPs in international comparisons of real income. The first study in this area was due to Gilbert and Kravis (1954) who estimated PPPs for USA, United Kingdom, France, Germany and Italy. In the late 60s, United Nations in collaboration with Pennsylvania University designed a wide project to undertake comparisons of real incomes. The first results of this project, known as Phase I were published by Kravis, Kenessey and Summers in 1975 with data of six countries for 1967 and ten countries for 1970, among them USA, Germany, France, United Kingdom, Japan and Italy.

ICP Phase II results were published by Kravis, Heston and Summers in 1978, with data of 16 countries for 1970 and 1973. United States, Germany, Belgium, Netherlands, United Kingdom, Japan and Italy are included among these 16 countries. Following these results, Summers, Kravis and Heston (1980) estimated PPPs for 84 countries, making comparisons in real terms from 1950 to 1977.

In 1978 Eurostat published their first results, comparing national accounts aggregates (following the European System Account classification) for 9 EC countries in 1975. These results were followed by ICP Phase III -Kravis, Summers and Heston (1982)- with data of 34 countries for 1975, among them the 9 EC countries (Germany, France, Belgium, Denmark, Luxembourg, United Kingdom, Ireland, Italy and Netherlands) and USA, Japan, Austria and Spain.

Results of ICP Phase IV where published simultaneously by Eurostat and United Nations in 1987, including 60 countries with 1980 as benchmark year. Among them there are 18 OECD countries, while Sweden, Turkey, Switzerland, Iceland and New Zealand were not included. Ward in 1985 published some preliminary results for OECD countries, and Summers and Heston (1987) used the Phase IV results to estimate parities for other 70 countries, which permits comparisons in real income between 130 countries.

Phase V results were used by Summers and Heston (1991) to produce the *Penn World Table, Mark 5.* Phase V refers to 56 countries using 1985 as benchmark years. The only OECD countries for which benchmark PPPs estimates are not available are Switzerland and Iceland, while for Canada PPPs refer to 1980. However, these results were preceded by OECD 1985 PPPs for 22 members (including Canada).

At the present, there are only some preliminary results for Phase VI, that refers to the 24 OECD countries having 1990 as benchmark year. In contrast to previous studies that use the Geary-Khamis aggregation method[12], these OECD estimates are obtained with the EKS method, while Geary-Khamis results will be published during 1993.

Penn World Table has been extensively used in international comparisons of real incomes, and provide some detailed information for OECD countries. Then

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12 Eurostat used the Gerardi method in 1975 results.

the question is why should we be interested in using a data set for the OECD alternative to the well known *PWT5*. There are several answers to this question. First, it is convenient to use all available information, updating series as much as possible. *PWT5* ranges from 1950 to 1988 and uses the ICP classification, which makes it difficult any effort to assembly with data for recent years from OECD national accounts. Being the result of ICP's Phase V, *PWT5* does not use purchasing power parities estimates for 1990. Therefore, PPPs for Iceland and Switzerland have been estimated from a structural relationship between PPPs and available capital city price surveys in the benchmark countries. However, although this procedure is very appropriate when PPPs are not available, they can produce significant error measurements[13]. Second, Summers and Heston do not maintain the *fixity* convention in PPP agreed by OECD. This convention allows the original Eurostat and OECD results to remain unchanged when these countries are included in a wider sample. When *fixity* is not maintained, the inclusion of countries with different GDP composition and different price structures introduces distortions in original comparisons between OECD countries. Besides that, countries with more than one benchmark have slightly modified national accounts data and PPP in *PWT5*, as a result of what is termed as *consistentization* procedure, that was also used in PWT4[14]. This procedure is based in an errors-in-variables model that estimates adjustment factors in PPP and national accounts data, in such a way that the adjusted real national account data of one benchmark is equal to the adjusted data of the previous benchmark times the adjusted rates of growth. As a result of this consistentization procedure and the inclusion of non-OECD countries when *fixity* is not maintained, real variables in *PWT5* can differ significantly from original OECD estimates. **Table 5.1** provides the original 1985 OECD estimates of GDP per capita compared with the ones obtained from *PWT5*. As it

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13 As an example of these disparities, the ratio of Public Consumption PPP to GDP PPP is equal to 1.965 in PWT5, while it is only 1.134 using OECD 1990 results, that is, a difference of a 73.3%.

14 See Summers and Heston (1988).

can be seen there are very important differences for some countries, specially Spain, Portugal, Turkey, Japan and Luxembourg. Also, for most of the countries these differences are negative, i.e.: *PWT5* estimates of relative GDP per capita to USA are smaller than those of the OECD.

Therefore, when we are interested in international comparisons of real incomes between OECD members, there are some relevant reasons in analyzing the consequences of using a System of Real National Accounts alternative to *PWT5*, with different purchasing power parities that rely on original OECD estimates. It is important to note that *PWT5* aims to facilitate comparisons between 138 countries (industrial countries, developing countries and central planned economies), and it is extremely compelling in achieving this objective. However, this merit is not a guarantee in obtaining the best comparisons when the sample of interest is reduced to a subset of countries. As we have seen in section III.2, there is a trade-off between transitivity and characteristicity: when more countries are included in the sample, gains in the former implies losses in the latter.

V.2.- Alternatives to PWT5 for OECD Countries

When analyzing the possibility of improving comparisons between OECD countries, the main question is how successive benchmark estimates can be used. Taking into consideration the problems we have analyzed in the preceding section, it is convenient to discuss the consequences of using data from different sources. The existence of different classification in national accounts and the attempt to maintain the parities as close as possible to the original estimates in each benchmark year are a limitation in the use of all available information about PPPs.

First of all, one of the characteristics of different PPPs studies is the convention between Eurostat, OECD and United Nation to maintain the original bilateral comparisons between European Community countries, when they are

included in a wider sample as the OECD. This is known as the *fixity convention*. However, in different studies by Summers and Heston, this fixity convention is not applied. The original Eurostat parities between EC countries are changed when other countries are included in the comparisons. In general, the larger the number and the differences in the new included countries relative to EC countries, the larger the divergences between final PPPs estimates and the original ones. By the same reasons, there are divergences for OECD members between the original OECD parities and Summers and Heston estimates, when developing countries of Africa, Asia, America and Oceania are included.

Second, the ICP national accounts classification differs from the *System of National Accounts* (SNA) used by OECD. While ICP classification is done by asking which agents benefit from consumption, the SNA relies on the agents that decide the expenditure. In ICP classification, government expenditures in health, education, social benefits, etc., that benefit households are subtracted from the SNA Government Consumption aggregate in SNA and they are added to SNA Private Consumption, resulting the ICP Consumption category.

Taking into account the limitations just mentioned, we have proceeded as follows. For 1985 and 1990 we have used the original OECD estimates of PPPs for Private Consumption, Government Consumption and Investment, with the exception of Turkey. Turkey's PPPs present cumbersome problems. OECD PPP estimate for GDP in 1985 equals 153 liras per US dollar, while 1990 estimate extrapolation to 1985 equals 232 liras. The difference represents a 51.6.% of the 1985 parity. Heston and Summers (1992) explained that difference arguing problems with Turkish data because 1985 was the first year in which Turkey participated in the OECD studies. Also the OECD suggested that 1985 results for Turkey and Portugal were affected by the *Gerschenkron effect* because of the use of the Geary-Khamis method. However, for Portugal 1985 GDP PPP was 66.2 escudos per US dollar while 1990 extrapolation to 1985 was 64.5 escudos, the difference representing only a -2.6%. As Geary-Khamis results for 1990 are not available yet, we have no estimated bias in using this method instead of the EKS one. After a cautious analysis of 1985 and 1990 results, we have

detected a large discrepancy between the national accounts data used in estimating the 1990 PPPs and those appearing in the OECD *National Accounts, 1960-1991*. While in the later publication Turkey's GDP is equal to 283187 billions of liras, in the former it goes up to 390083 billions. As national account data employed in 1985 estimates are not significantly different to those in *National Accounts*, conditioned by the available information, we have decided to use only the 1985 estimates in the case of Turkey.

For 1980 we have utilized the OECD preliminary results for ICP Phase IV published by Ward (1985), where fixity convention is applied for EC countries and parities for SNA aggregates are available.

For 1975 we have combined Eurostat results for EC countries and those of ICP Phase III. Eurostat estimates for nine EC countries are expressed in terms of the European Account Unit, while ICP results have US dollar as numeraire and uses different national accounts aggregates. To maintain fixity between parities as close as possible we have computed Private and Government Consumption, Investment and GDP for EC countries as a whole, both in ECUs and in 1975 international dollars. From comparisons of both figures we can obtain the associated adjustment factors for each aggregate that permit us to convert the original parities in ECUs for each EC country to 1975 international dollars, without distorting the original Eurostat bilateral comparisons between EC members. Real comparisons between EC countries and Spain, Japan, and Austria have been made using USA as a bridge country. For these four countries national accounts aggregates correspond to ICP ones, while for EC members they correspond to SNA classification. As we are using OECD national accounts data, an error is introduced when using them with 1975 ICP PPPs for these countries. However, comparing PPPs estimates for both systems of classifications in benchmark years where available, differences used to be small if not negligible.

Although ICP Phase I and II results are available we have not employed them for two reasons. First, we are not sure if the advantage of having this additional information compensates possible measurement errors of these

estimates, because for some countries national accounts data are estimated (and in some cases they are far away from successive estimates). Second, ICP classification is applied for GDP aggregates and we are interested in using the SNA one.

Table 5.2 provides, for each benchmark year, the PPPs estimates we have used for Private and Government Consumption, Investment, and GDP, using US dollars as numeraire. Exports and imports parities correspond to current exchange rates. Once PPPs for GDP aggregates are available for different benchmark years we have to decide a method to use these estimates to homogenize national accounts data. To compare different alternatives with *PWT5* results we could apply two extreme solutions.

The first one consists in using only the 1990 OECD PPPs, with the exception of Turkey for which, as mentioned above, we employed the 1985 estimates extrapolated to 1990 using expression (40). By applying price indices to national accounts GDP aggregates we get constant variables expressed in national currencies for all years from 1960 on. Once we have these constant prices series, by dividing them by OECD PPPs we express GDP and its components in 1990 US dollars at international prices[15].

The second alternative consists in maintaining the available OECD PPPs estimates for each benchmark year. For the *j*th aggregate (private consumption, *C*, government consumption, *G*, and investment, *I*) we have interpolated successive PPPs estimates as follows:

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15 By simplicity, we have only deflated GDP, private and government consumption, investment, exports and imports, while the increase in stocks are not considered.

$$PPP^{t}_{USA,h}(j) = \left[PPP^{t_o}_{USA,h}(j) \frac{I^{h}_{t_o,t}(j)}{I^{USA}_{t_o,t}(j)} \right]^{\frac{t_1-t}{t_1-t_o}} \left[PPP^{t_1}_{USA,h}(j) \frac{I^{h}_{t_1,t}(j)}{I^{USA}_{t_1,t}(j)} \right]^{\frac{t-t_o}{t_1-t_o}} \qquad (55)$$

where t_o and t_1 are successive benchmark years, such that $t_o \leq t \leq t_1$, $I_{t_1,t}(j)$ is the price index from t to t_1 of aggregate j, and $I_{t_o,t}(j)$ is the price index from t_o to t. Backward extrapolation from last PPPs estimates (e.g.: from 1960 to 1989 in the cases of Switzerland and Iceland) follows again expression (40).

By interpolation-extrapolation we have obtained PPPs from 1960 to 1990 for *C*, *G* and *I*. At this stage, we can apply Geary-Khamis to these PPPs to obtain current parities for domestic absorption. Once we have these parities for domestic absorption, estimations of PPPs for GDP are straightforward by using current exchange rates for net foreign balance. As a result we have series of national accounts in current international dollars. However we are also interested in time comparisons. As USA is used as numeraire, we can express magnitudes for all countries in international dollars *at USA 1990 prices*, so that, USA variables in real terms are the same as those of national accounts. It is important to note that in this case for all countries, except for USA, national accounts rates of growth are not equal to those obtained from this procedure, which *fixes* all parities in each benchmark year.

In **figures 5.1** to **5.23** we represent the ratio of benchmark extrapolations of GDP parities to current exchange rate -the comparative price level (CPL) following Heston and Summers (1992)-. Apart from the mentioned case of Turkey, there are some important differences between extrapolated comparative price levels, which mean that GDP rates of growth between successive benchmark years are not consistent with those coming from national accounts . The pattern of these differences is not very clear. There is not a significant relationship between these differences and income per capita:

both extremes of poor and rich countries have examples of high differences. However, for most countries, 1985 CPL is above the extrapolations for other benchmark years. This means that 1985 PPPs are, in general, higher than extrapolations from consecutive benchmark years. As a result, income per capita for OECD countries in 1985 relative to the United States tends to be below extrapolations for other benchmarks. As Heston and Summers have pointed out, this fact seems to be related with the appreciation of US dollar in the mid 80s. This probably favoured lower prices in the US and higher in other OECD countries, both forces increasing the purchasing power of US residents. Two questions arise. First, wheater or not this process had only transitory effects. If some hysteresis is present, exchange rate fluctuations can affect countries' purchasing power after the shock has vanished. Second, it is also important to know if this shock has symmetric effects upon countries. If effects are symmetric, dollar appreciation does not affect bilateral comparisons between any other two countries, i.e., it only affects comparisons between US and other OECD countries. If effects are not symmetric, then bilateral comparisons between any two countries can be affected.

Figures 6.1 to **6.24** present different estimations of GDP per capita for OECD countries relative to the OECD average from 1960 to 1991. The first series uses current dollar exchange rates. As figures show for all countries, comparisons based in nominal exchanges rates are incorrect because of exchange rate fluctuations and their systematic deviations from PPPs. The second series is obtained from the *PWT5* variable RGDP (real GDP per capita at 1985 international prices, i.e., a Laspeyres Index). The other two variables use OECD national accounts data and PPPs estimates, and the difference is only that one uses 1990 benchmark estimates while the other fixes benchmark estimates as mentioned above. As we observe in the figures, differences between both series are smaller than those obtained from comparing them with *PWT5* estimates: for some countries differences between OECD estimates and *PWT5* are very important.

V.3.- A Sensitivity Analysis of Cross-country Growth Regressions: The Importance of PPPs

We have just seen the importance of using different PPPs estimates in international comparisons of real income. Differences between estimates are higher enough to justify the use of original OECD multilateral comparisons results. However, we can even question how these differences can affect other macroeconomic research. To illustrate the consequences of using different data sets we have performed a sensitivity analysis of how cross-country growth regressions results are affected by the choice of PPPs.

The theoretical model we have been working with is the well known **"Solow model", augmented with human capital.** This model starts with a constant returns production function in three accumulable factors, physical capital, human capital and efficient labour:

$$Y_{it}=\theta_i(K_{it})^{\alpha_i}(H_{it})^{\gamma_i}(A_{it}L_{it})^{\beta_i} \qquad (56)$$

$$\alpha_i+\gamma_i+\beta_i=1$$

$$A_{it} = A_{io}e^{\phi_i t}$$

$$L_{it} = L_{io}e^{n_i t}$$

where ϕ is the exogenous rate of technical progress. Accumulation equations for the factors of production are given by the following expressions:

$$\text{Accumulation of physical capital: } \frac{dK_t}{dt} = s_k Y_t - \delta_k K_t$$

$$\text{Accumulation of human capital: } \frac{dH_t}{dt} = s_h Y_t - \delta_h H_t$$

Solving the model we obtain a unique steady state input combination, that determines the steady state per capita income equation[16]. Taking into account that every country converges to its own steady state at a constant rate λ (the speed of convergence) we get the conditional convergence equation that has been the focus of a great amount of empirical work in the last years:

$$ln y^{i}_{T+\tau} - ln y^{i}_{T} = \phi_i \tau + (1-exp\{-\lambda_i \tau\})\left(B_{i2} + \phi_i T - ln y^{i}_{T} + ln y^{i*}_{T+t}\right) \qquad (57)$$

This equation states that the rate of growth of per capita income of an economy depends positively on its starting conditions relative to its steady state, that is, the longer the distance of initial GDP per capita relative to its steady state, the higher its rate of growth will be. Each countries own steady state depends on deep parameters, such as saving rates or population growth:

$$ln y^{i*}_{T+t} = B_{i1} + \phi_i T + \beta_i^{-1}\left(\alpha_i ln(s^{i*}_{k}) + \gamma_i ln(s^{i*}_{h}) - (\alpha_i + \gamma_i) ln(n^{i*} + \phi_i + \delta_i)\right) \qquad (58)$$

It should be noticed that the usual procedure in the literature has been to estimate the conditional convergence equation in a linear version using cross country data. In this paper we estimate the non linear version, using both time series and cross section data. This pooled data procedure permits us to include as many theoretical restrictions as possible, and also to deal with the problem of endogeneity of the regressors, using instrumental variables estimators. Another advantage of using this kind of information is that it would permit us to estimate jointly the steady state and convergence equations, imposing cross equation restrictions.

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[16] For a detailed exposition of this model see Sala-i-Martín (1990a and 1990b) and Andrés, Doménech and Molinas (1993).

We have estimated equation (57) for three different data sets. One consists of *PWT5* variables, using *RGDP*, *i* and *POP* . The other two use OECD national accounts data but different parities: the first employs 1990 OECD parities (with the exception of Turkey that uses 1985 PPPs), and the second uses different benchmark estimates as mentioned above. Human capital data comes from Kyriacou (1991) and corresponds to average years of schooling in the labour force. Data is available for 1965, 1970, 1975, 1980 and 1985, although not all benchmarks are disposable for all OECD countries.

Table 5.3 presents cross section estimates of the average rate of growth in GDP per capita from 1960 to 1988, the last year in PWT5. OECD data sets produce better estimates in terms of the fit of the regression. Also, they produce higher convergence rates (a 30% higher in the case of different benchmark parities when parameter λ is estimated) and they accept better the theoretical restriction of $\lambda=(1-\alpha-\beta)[\Sigma_i(n_i+\phi+\delta)]/N$, where N is the number of countries and n the population rate of growth. Parameters estimates are consistent with previous estimates in the empirical literature[17], in particular α and γ are not far from the traditional assumption of equal factor shares, and the rate of convergence is around a 2% per year.

Table 5.4 provides estimates of the convergence equation using pooled data, which consist in five years averages from 1960 to 1980 and a eight years average from 1980 to 1988. Estimation method is nonlinear instrumental variables with time dummies, and instruments are lagged variables except for the case of human capital. Now differences are even larger: the regression fit with OECD data is much better than for *PWT5*. When parameter λ is estimated, human capital is not significant with *PWT5* data and the rate of convergence is half of that estimated with OECD data and different benchmark parities. Again, OECD data accept better the theoretical restriction imposed.

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17 See Andrés, Doménech and Molinas (1993).

How do both OECD data sets compare?. **Tables 5.3** and **5.4** show a slightly better performance when only 1990 PPPs are used. However, notice that when we use a eight years average from 1980 to 1988, we are missing some information contained in 1985 PPPs, and in 1989 and 1990 national accounts data. **Table 5.5** shows the results of cross-section estimation of the average rate of growth of GDP per capita from 1960 to 1990. Now differences are negligible, although data with different benchmark estimates perform slightly better, and there are some small differences in estimated parameters (rate of convergence is a 15% higher in col.3 respect to col.1, where parameter λ is estimated). However differences are much higher with five years averages pooled data. The fit of the regression is higher than in **table 5.4**, and now data with different benchmark parities produce a significant better fit. These results suggest that when looking at growth for long periods, differences in OECD estimates of real income seem to be of small importance, as we can deduce from **figures 6.1** to **6.24**; but when we are interested in analyzing medium term economic growth, the use of different benchmark parities introduces some additional information.

VI. Conclusions

International comparisons of GDP per capita using exchange rates have been subject to criticisms for a long time. As a result of this concern, it has been promoted the use of purchasing power parities, which account for different price levels between countries, in the estimation of *real* products. In this paper, we have surveyed the criticisms to the use of the exchange rates in international comparisons, illustrating with OECD data how comparisons using exchange rates differ in a systematic way from *real* comparisons in PPPs. As it is well known in the literature, there is a positive relationship between the comparative price level and the GDP per capita comparisons using exchange rates. Also we have provided some empirical evidence for OECD countries of how price structures depend upon GDP per capita, as different authors have noted.

We have surveyed the literature on PPPs estimation methods, making distinction between binary and multilateral comparisons. As we have shown there are different aggregation methods, which deal with the conflict between charasteristicity and transitivity in multilateral comparisons.

When we are interested in comparisons across countries for a particular year, we have different benchmark PPPs estimates available; therefore, it is only a matter of choice of benchmark estimates depending upon their distance to that particular year. However, the problem is more complicated when we are interested in performing those comparisons across countries but also across time. In section IV we present a survey of alternative methods of combining information from different benchmark estimates and national accounts data.

As a result of the discussion of alternative aggregation methods of estimating PPPs, we have concluded how the outcome can be affected by the sample of countries included in price surveys. In particular, because we are interested in comparisons between OECD countries, we have analyzed alternative estimations of *real* GDP per capita using the popular *PWT5* from

Summers and Heston (1991), OECD 1990 PPPs, and different available benchmark parities maintaining the *fixity* convention as far as possible. As data show, there are some significant differences comparing *PWT5* and OECD data sets.

Finally, we have performed a sensitivity analysis of growth regressions as an illustrative example of how the use of different purchasing power parities can affect the results of macroeconomic researches. Estimations based on *PWT5* data affect the rate of convergence and yield a worse fit than those obtained using OECD data, being the differences more important when pooled data are employed. When comparing OECD data sets the results suggest that, when looking growth for long periods, differences in OECD estimates of real income seem to be of small importance, but when we are interested in analyzing medium term economic growth, the use of different benchmark parities can introduce some additional information.

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TABLES AND FIGURES

Table 5.1: Comparisons of PWT5 and OCDE results for 1985

	Real GDP per capita relative to USA		
	OCDE (a)	*PWT5* (b)	(b-a)/a (%)
Australia	71.1	74.8	5.2
Austria	66.1	61.3	-7.2
Belgium	64.7	62.3	-3.7
Canada	92.5	89.5	-3.3
Switzerland		85.8	
Germany	73.8	69.4	-5.9
Denmark	74.2	71.4	-3.8
Spain	46.0	38.3	-16.7
Finland	69.5	66.9	-3.7
France	69.3	67.8	-2.2
United Kingdom	66.1	63.6	-3.7
Greece	35.7	34.0	-4.6
Ireland	40.6	35.8	-11.8
Iceland		70.9	
Italy	65.7	63.1	-3.9
Japan	71.5	64.3	-10.2
Luxembourg	81.4	73.8	-9.3
Netherlands	68.3	65.2	-4.5
Norway	84.4	80.4	-4.7
New Zealand	60.9	60.4	-0.8
Portugal	33.8	27.0	-20.0
Sweden	76.9	73.8	-4.0
Turkey	21.8	19.1	-12.5
United States	100.0	100.0	0.0

Sources:
(a) *Purchasing Power Parties and Real Expenditures*, OECD (1987)
(b) Summers and Heston (1991)

TABLE 5.2: Benchmark Purchasing Power Parities, 1975-1990

Country	Year	Source	GDP	Private Consumption	Public Consumption	Investment	Exports Imports
AUSTRALIA	1975						
AUSTRIA	1975	Summers-Heston (1984)	17.59	16.02	16.02	24.21	17.42
BELGIUM	1975	Eurostat (1978)	42.58	41.07	48.04	45.31	36.78
CANADA	1975						
SWITZERLAND	1975						
GERMANY	1975	Eurostat (1978)	2.89	2.87	3.10	2.98	2.46
DENMARK	1975	Eurostat (1978)	7.20	7.27	7.34	7.06	5.75
SPAIN	1975	Summers-Heston (1984)	42.48	41.33	39.04	52.81	57.41
FINLAND	1975						
FRANCE	1975	Eurostat (1978)	4.88	4.92	4.78	5.09	4.29
UNITED KINGDO	1975	Eurostat (1978)	0.39	0.39	0.33	0.53	0.45
GREECE	1975						
IRELAND	1975	Eurostat (1978)	0.38	0.38	0.35	0.48	0.45
ICELAND	1975						
ITALY	1975	Eurostat (1978)	567.28	589.80	477.07	604.47	652.85
JAPAN	1975	Summers-Heston (1984)	273.05	278.98	281.95	296.79	296.79
LUXEMBOURG	1975	Eurostat (1978)	40.61	37.81	49.77	45.39	36.78
NETHERLAND	1975	Eurostat (1978)	2.85	2.62	3.60	3.15	2.53
NORWAY	1975						
NEW ZEALAND	1975						
PORTUGAL	1975						
SWEDEN	1975						
TURKEY	1975						
USA	1975	Summers-Heston (1984)	1.00	1.00	1.00	1.00	1.00
AUSTRALIA	1980						
AUSTRIA	1980	Ward (1985)	15.38	15.24	13.73	16.95	12.94
BELGIUM	1980	Ward (1985)	36.61	36.48	34.92	39.04	29.24
CANADA	1980	Ward (1985)	1.09	1.07	1.22	1.08	1.17
SWITZERLAND	1980						
GERMANY	1980	Ward (1985)	2.37	2.42	2.14	2.53	1.82
DENMARK	1980	Ward (1985)	7.43	7.90	5.66	7.88	5.64
SPAIN	1980	Ward (1985)	63.65	64.13	60.69	68.64	71.70
FINLAND	1980	Ward (1985)	4.52	4.81	3.58	4.79	3.73
FRANCE	1980	Ward (1985)	5.24	5.36	4.64	5.50	4.23
UNITED KINGDO	1980	Ward (1985)	0.49	0.49	0.34	0.67	0.43
GREECE	1980	Ward (1985)	35.05	36.06	31.70	42.91	42.62
IRELAND	1980	Ward (1985)	0.46	0.48	0.37	0.57	0.49
ICELAND	1980						
ITALY	1980	Ward (1985)	758.72	759.07	619.39	896.89	856.45
JAPAN	1980	Ward (1985)	240.09	245.42	218.82	239.34	226.74
LUXEMBOURG	1980	Ward (1985)	34.03	33.37	36.06	38.52	29.24
NETHERLAND	1980	Ward (1985)	2.53	2.41	2.51	2.96	1.99
NORWAY	1980	Ward (1985)	6.15	6.62	4.84	7.16	4.94
NEW ZEALAND	1980						
PORTUGAL	1980	Ward (1985)	31.74	33.84	16.68	53.75	50.06
SWEDEN	1980						
TURKEY	1980						
USA	1980	Ward (1985)	1.00	1.00	1.00	1.00	1.00

TABLE 5.2: Benchmark Purchasing Power Parities, 1975-1990 (Cont.)

Country	Year	Source	GDP	Private Consumption	Public Consumption	Investment	Exports Imports
AUSTRALIA	1985	OECD (1987)	1.24	1.24	1.12	1.35	1.43
AUSTRIA	1985	OECD (1987)	16.60	17.60	14.40	16.30	20.69
BELGIUM	1985	OECD (1987)	44.60	46.40	38.60	44.60	59.38
CANADA	1985	OECD (1987)	1.22	1.23	1.24	1.20	1.36
SWITZERLAND	1985						
GERMANY	1985	OECD (1987)	2.48	2.57	2.32	2.48	2.94
DENMARK	1985	OECD (1987)	9.80	10.67	7.70	9.83	10.60
SPAIN	1985	OECD (1987)	95.30	94.00	77.60	119.40	170.04
FINLAND	1985	OECD (1987)	5.97	6.87	4.62	5.66	6.20
FRANCE	1985	OECD (1987)	7.27	7.52	6.43	7.48	8.98
UNITED KINGDO	1985	OECD (1987)	0.57	0.59	0.43	0.67	0.78
GREECE	1985	OECD (1987)	77.30	79.80	67.50	98.40	138.12
IRELAND	1985	OECD (1987)	0.72	0.76	0.60	0.73	0.95
ICELAND	1985						
ITALY	1985	OECD (1987)	1302.00	1345.00	1013.00	1489.00	1909.44
JAPAN	1985	OECD (1987)	222.00	218.00	171.00	275.00	238.54
LUXEMBOURG	1985	OECD (1987)	43.10	42.90	46.20	42.50	59.38
NETHERLAND	1985	OECD (1987)	2.55	2.53	2.31	2.84	3.32
NORWAY	1985	OECD (1987)	8.63	9.78	7.11	8.24	8.60
NEW ZEALAND	1985	OECD (1987)	1.35	1.35	1.12	1.77	2.02
PORTUGAL	1985	OECD (1987)	66.20	77.90	29.00	101.00	170.39
SWEDEN	1985	OECD (1987)	8.15	8.89	6.46	8.82	8.60
TURKEY	1985	OECD (1987)	153.00	186.00	63.00	162.00	521.98
USA	1985	OECD (1987)	1.00	1.00	1.00	1.00	1.00
AUSTRALIA	1990	OECD (1990)	1.39	1.40	1.17	1.47	1.28
AUSTRIA	1990	OECD (1990)	14.09	13.94	11.79	15.84	11.37
BELGIUM	1990	OECD (1990)	39.43	38.68	32.91	46.49	33.42
CANADA	1990	OECD (1990)	1.31	1.33	1.28	1.26	1.17
SWITZERLAND	1990	OECD (1990)	2.20	2.19	2.16	2.38	1.39
GERMANY	1990	OECD (1990)	2.09	2.02	1.94	2.51	1.62
DENMARK	1990	OECD (1990)	9.40	9.52	7.36	10.42	6.19
SPAIN	1990	OECD (1990)	109.55	106.91	79.76	137.92	101.93
FINLAND	1990	OECD (1990)	6.39	6.63	4.94	6.43	3.82
FRANCE	1990	OECD (1990)	6.61	6.47	5.93	7.60	5.44
UNITED KINGDO	1990	OECD (1990)	0.60	0.57	0.43	0.84	0.56
GREECE	1990	OECD (1990)	140.91	133.78	114.93	200.00	158.51
IRELAND	1990	OECD (1990)	0.69	0.67	0.55	0.84	0.60
ICELAND	1990	OECD (1990)	82.61	86.29	60.71	81.69	58.28
ITALY	1990	OECD (1990)	1421.59	1347.83	1367.39	1767.53	1198.10
JAPAN	1990	OECD (1990)	195.45	196.21	151.28	218.18	144.79
LUXEMBOURG	1990	OECD (1990)	39.66	36.79	42.44	51.04	33.42
NETHERLAND	1990	OECD (1990)	2.17	2.07	1.78	2.74	1.82
NORWAY	1990	OECD (1990)	9.74	10.19	7.77	9.68	6.26
NEW ZEALAND	1990	OECD (1990)	1.61	1.59	1.21	1.92	1.68
PORTUGAL	1990	OECD (1990)	103.75	99.11	62.48	154.16	142.55
SWEDEN	1990	OECD (1990)	9.34	9.30	8.05	10.31	5.92
TURKEY	1990	OECD (1990)	1313.00	1404.00	804.00	1540.00	2608.64
USA	1990	OECD (1990)	1.00	1.00	1.00	1.00	1.00

TABLE 5.3: Nonlinear Model

Dependent Variable: Average Rate of Growth in GDP per capita 1960-1988
Estimation Method: Nonlinear Least Squares

	1	2	3	4	5	6
Constant	-7.34	-8.53	-7.31	-8.31	-7.78	-8.27
	(5.27)	(7.28)	(4.34)	(5.93)	(3.82)	(4.44)
α	0.35	0.34	0.36	0.36	0.43	0.42
	(4.08)	(3.90)	(6.00)	(5.75)	(5.81)	(5.33)
γ	0.27	0.32	0.28	0.30	0.22	0.24
	(3.73)	(4.05)	(5.81)	(5.75)	(3.70)	(3.55)
λ	0.017		0.020		0.022	
	(4.64)		(6.13)		(5.04)	
ϕ	0.02[r]	0.02[r]	0.02[r]	0.02[r]	0.02[r]	0.02[r]
$\bar{R}^2$	0.561	0.583	0.746	0.777	0.701	0.723
N.Obs.	24	24	24	24	24	24
λ_{imp}		0.019		0.019		0.020
$\chi(1)$	1.051		0.030		0.068	
(Sig.level%)	(30.52)		(85.79)		(79.38)	

Cols. 1 and 2 use PWT Mark 5 data. Summers and Heston (1991)
Cols. 3 and 4 use extrapolated 1990 OECD PPPs and OECD National Accounts Data
Cols. 5 and 6 use 1975, 1980, 1985 and 1990 Eurostat-OECD PPPs and OECD National Accounts Data

r = restricted parameter
t-statistics in parenthesis
$\chi(1)$ corresponds to the restriction: $\lambda=(1-\alpha-\beta)(\overline{n_i+\phi+\delta})$, where $\phi=0.02$, $\delta=0.03$

TABLE 5.4: Nonlinear Model

Dependent Variable: Average Rates of Growth in GDP per capita
Period: 1965-70, 70-75, 75-80 and 80-88
Estimation Method: Nonlinear Instrumental Least Squares
(Equation includes time dummies)

	1	2	3	4	5	6
Constant	-7.65	-8.58	-7.01	-7.66	-6.55	-5.79
	(1.94)	(3.20)	(3.54)	(4.29)	(2.71)	(2.90)
α	0.44	0.38	0.41	0.41	0.39	0.37
	(3.42)	(4.50)	(5.62)	(5.80)	(4.24)	(3.23)
γ	0.19	0.27	0.23	0.24	0.22	0.22
	(1.25)	(3.58)	(3.09)	(3.99)	(2.61)	(2.54)
λ	0.014		0.021		0.027	
	(3.31)		(5.08)		(4.30)	
ϕ	0.02[r]	0.02[r]	0.02[r]	0.02[r]	0.02[r]	0.02[r]
$\bar{R}^2$	0.191	0.140	0.342	0.350	0.336	0.334
N.Obs.	96	96	96	96	96	96
λ_{imp}		0.020		0.021		0.024
$\chi(1)$	1.417		0.0004		0.0952	
(Sig.level%)	(23.39)		(98.48)		(52.88)	

Cols. 1 and 2 use PWT Mark 5 data. Summers and Heston (1991)
Cols. 3 and 4 use extrapolated 1990 OECD PPPs and OECD National Accounts Data
Cols. 5 and 6 use 1975, 1980, 1985 and 1990 Eurostat-OECD PPPs and OECD National Accounts Data

r = restricted parameter
t-statistics in parenthesis
$\chi(1)$ corresponds to the restriction: $\lambda=(1-\alpha-\beta)(\overline{n_i+\phi+\delta})$, where $\phi=0.02$, $\delta=0.03$

TABLE 5.5: Nonlinear Model

Dependent Variable: Average Rate of Growth in GDP per capita 1960-1990
Estimation Method: Nonlinear Least Squares

	1	2	3	4
Constant	-7.28	-8.02	-7.88	-8.01
	(3.94)	(5.27)	(4.55)	(4.92)
α	0.37	0.37	0.44	0.44
	(5.47)	(5.29)	(6.87)	(6.26)
γ	0.27	0.29	0.21	0.22
	(5.47)	(4.98)	(4.73)	(3.75)
λ	0.020		0.023	
	(5.76)		(5.03)	
ϕ	0.02[r]	0.02[r]	0.02[r]	0.02[r]
$\bar{R}^2$	0.775	0.797	0.791	0.799
N.Obs.	24	24	24	24
λ_{imp}		0.020		0.020
$\chi(1)$	0.001		0.267	
(Sig.level%)	(97.20)		(60.56)	

Cols. 1 and 2 use extrapolated 1990 OECD PPPs and OECD National Accounts Data
Cols. 3 and 4 use 1975, 1980, 1985 and 1990 Eurostat-OECD PPPs and OECD National Accounts Data

r = restricted parameter
t-statistics in parenthesis
$\chi(1)$ corresponds to the restriction: $\lambda=(1-\alpha-\beta)(\overline{n_i+\phi+\delta})$, where $\phi=0.02$, $\delta=0.03$

TABLE 5.6: Nonlinear Model

Dependent Variable: Average Rates of Growth in GDP per capita
Period: 1965-70, 70-75, 75-80, 80-85 and 85-90
Estimation Method: Nonlinear Instrumental Least Squares
(Equation includes time dummies)

	1	2	3	4
Constant	-6.60	-7.45	-4.94	-5.57
	(3.60)	(4.49)	(2.99)	(2.93)
α	0.40	0.41	0.40	0.38
	(5.80)	(5.77)	(5.24)	(3.72)
γ	0.23	0.24	0.22	0.23
	(3.34)	(4.05)	(2.78)	(2.48)
λ	0.022		0.029	
	(5.60)		(4.93)	
ϕ	0.02[r]	0.02[r]	0.02[r]	0.02[r]
$\bar{R}^2$	0.452	0.449	0.606	0.596
N.Obs.	120	120	120	120
λ_{imp}		0.020		0.022
$\chi(1)$	0.036		1.171	
(Sig.level%)	(84.95)		(27.92)	

Cols. 1 and 2 use extrapolated 1990 OECD PPPs and OECD National Accounts Data
Cols. 3 and 4 use 1975, 1980, 1985 and 1990 Eurostat-OECD PPPs and OECD National Accounts Data

r = restricted parameter
t-statistics in parenthesis
$\chi(1)$ corresponds to the restriction: $\lambda=(1-\alpha-\beta)(\overline{n_i+\phi+\delta})$, where $\phi=0.02$, $\delta=0.03$

FIGURE 1
SPANISH GDP PER CAPITA RELATIVE TO OECD

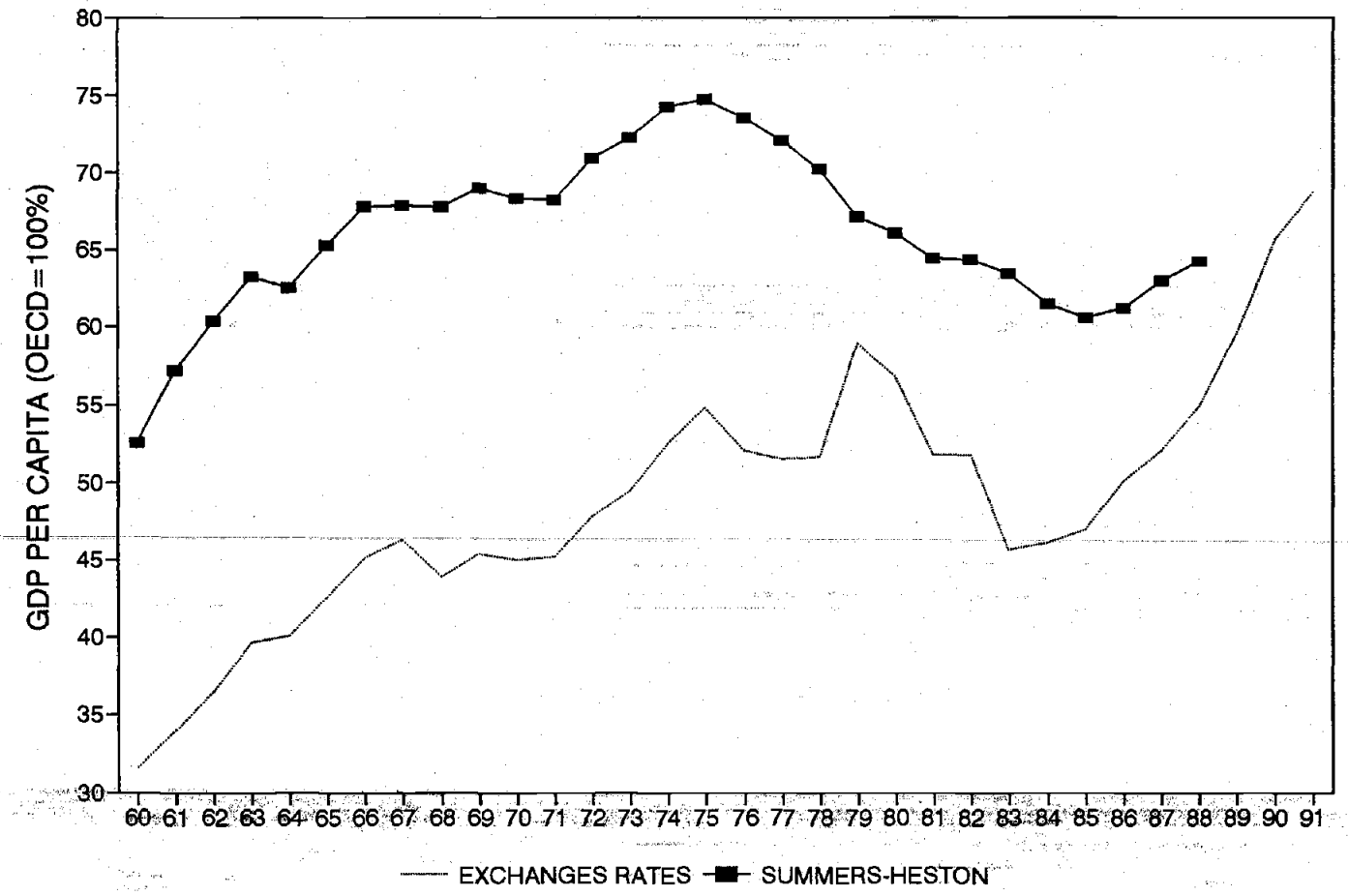


FIGURE 2.1: COMPARATIVE PRICE LEVEL VERSUS GDP PER CAPITA (USA=1). 1975

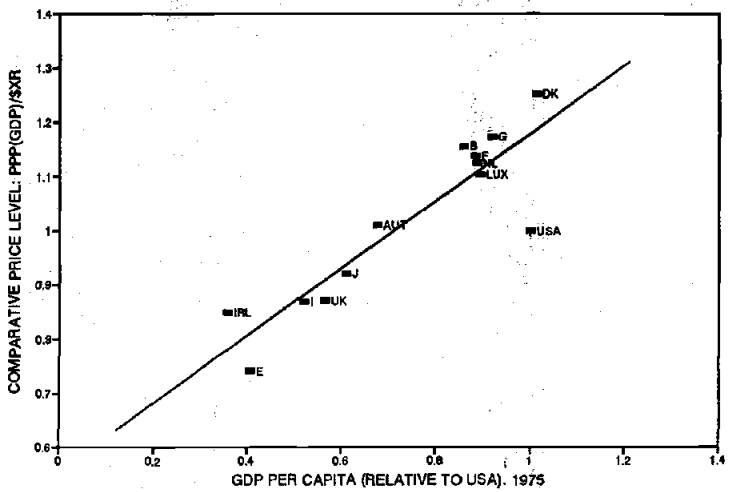


FIGURE 2.2: COMPARATIVE PRICE LEVEL VERSUS GDP PER CAPITA (USA=1). 1980

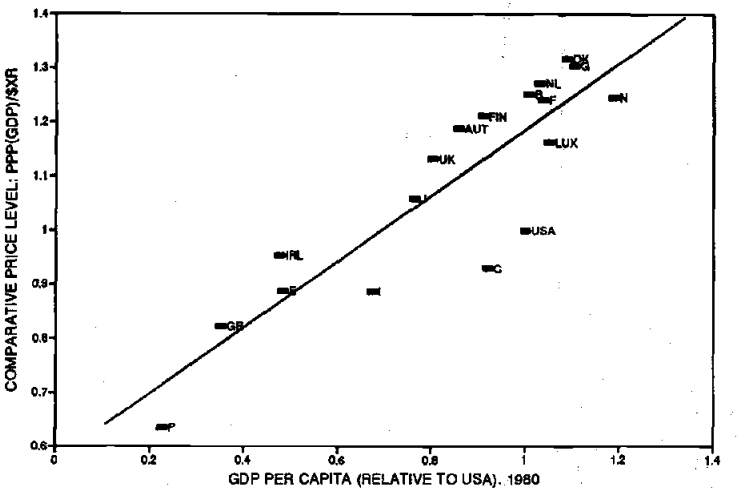


FIGURE 2.3: COMPARATIVE PRICE LEVEL VERSUS GDP PER CAPITA (USA=1). 1985

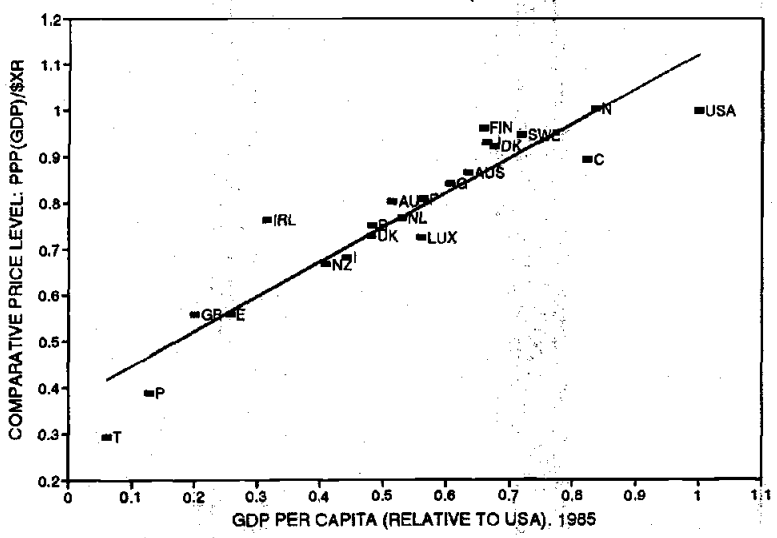


FIGURE 2.4: COMPARATIVE PRICE LEVEL VERSUS GDP PER CAPITA (USA=1). 1990

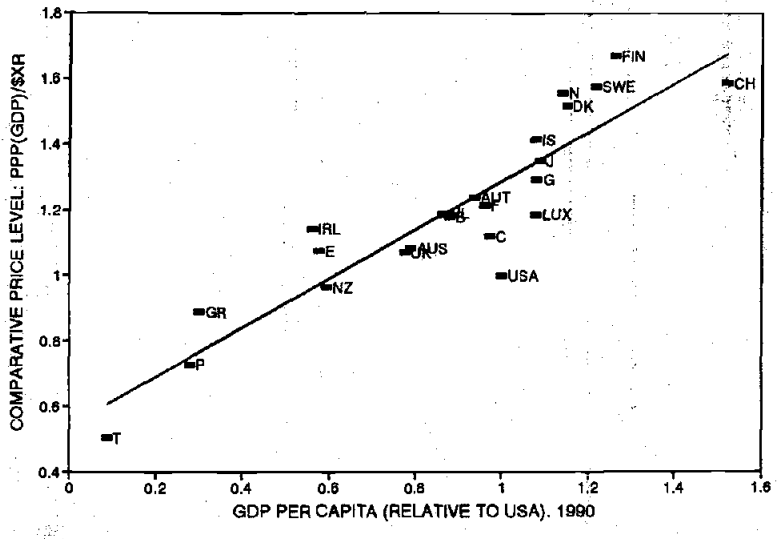


FIGURE 3.1: GROSS FIXED CAPITAL FORMATION PPP AND GDP PER CAPITA IN $US

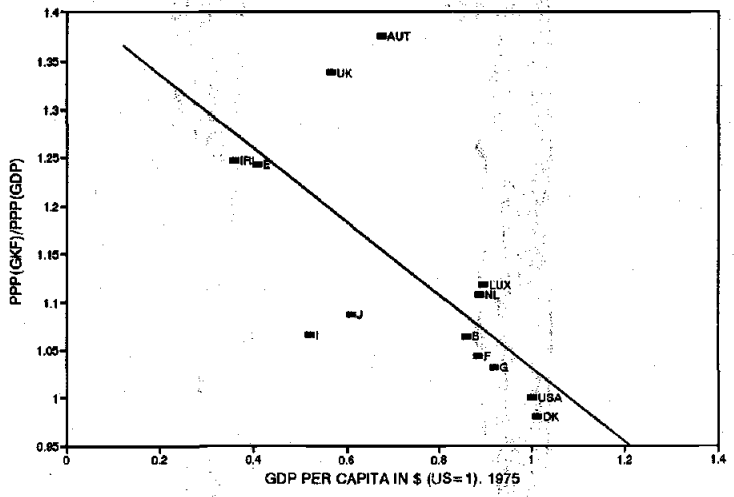


FIGURE 3.2: GROSS FIXED CAPITAL FORMATION PPP AND GDP PER CAPITA IN $US

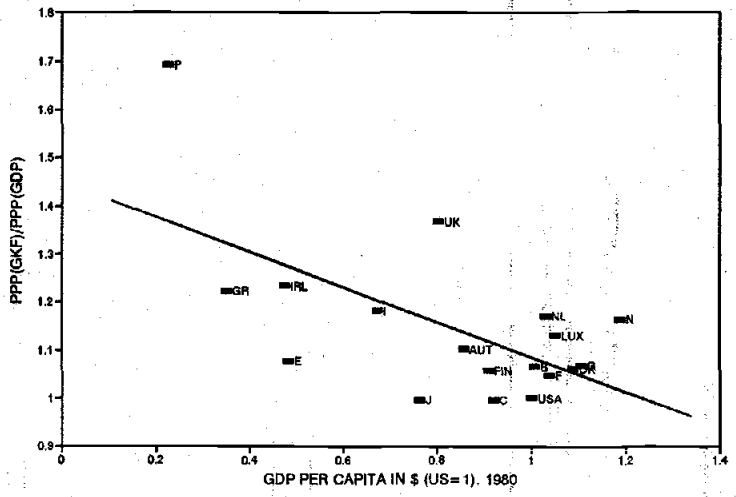


FIGURE 3.3: GROSS FIXED CAPITAL FORMATION PPP AND GDP PER CAPITA IN $US

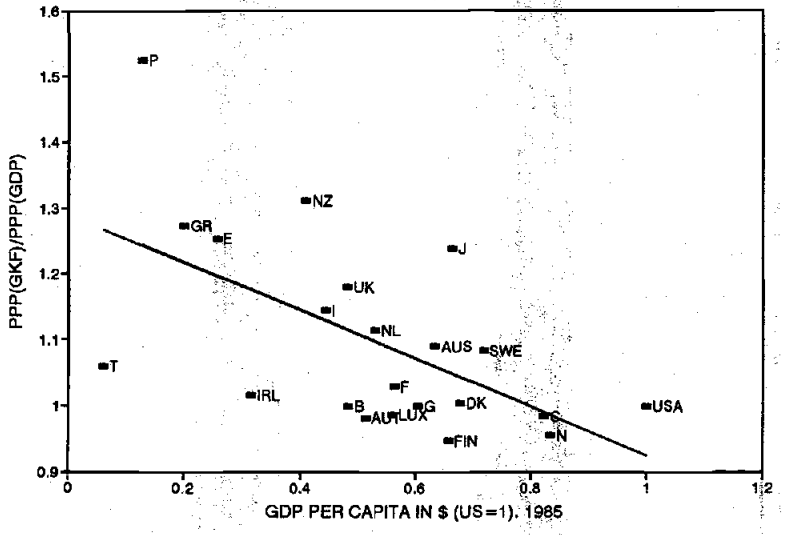


FIGURE 3.4: GROSS FIXED CAPITAL FORMATION PPP AND GDP PER CAPITA IN $US

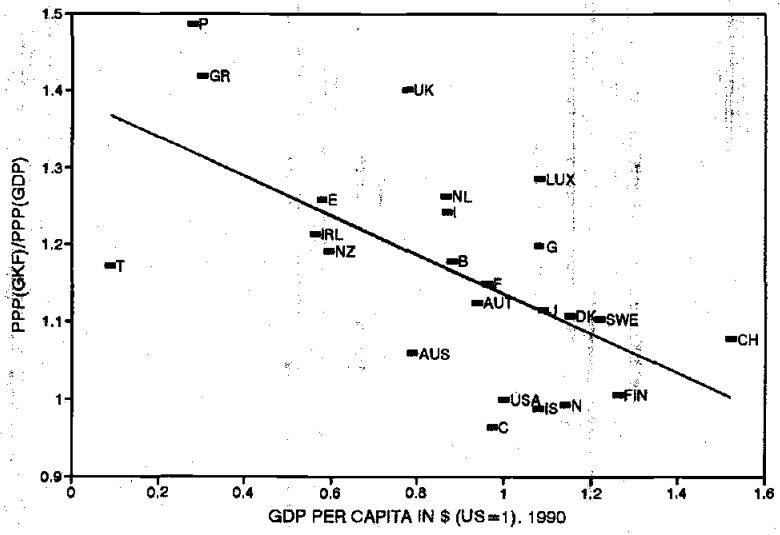


FIGURE 4.1: GOVERMENT FINAL CONSUMPTION
PPP AND GDP PER CAPITA IN $US

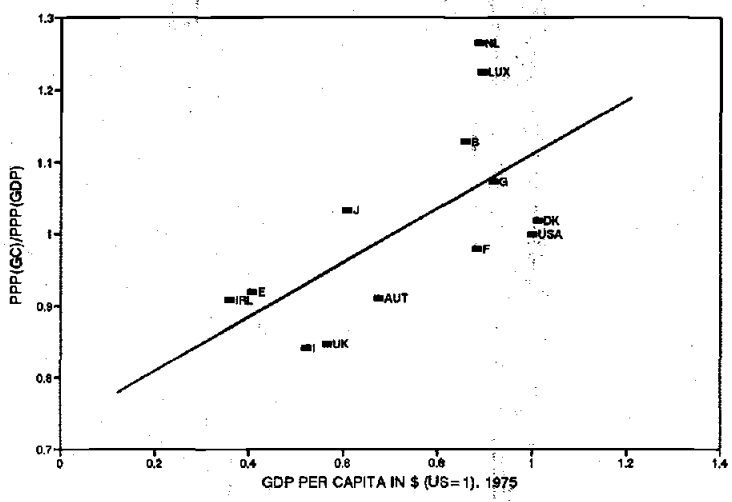


FIGURE 4.2: GOVERMENT FINAL CONSUMPTION
PPP AND GDP PER CAPITA IN $US

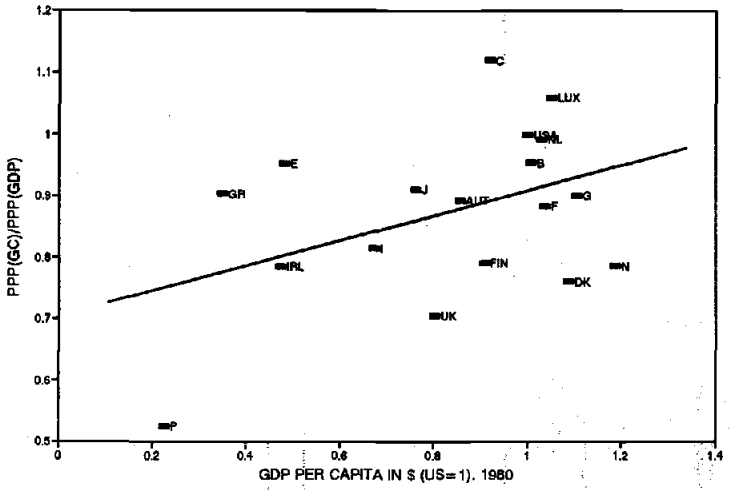


FIGURE 4.3: GOVERMENT FINAL CONSUMPTION
PPP AND GDP PER CAPITA IN $US

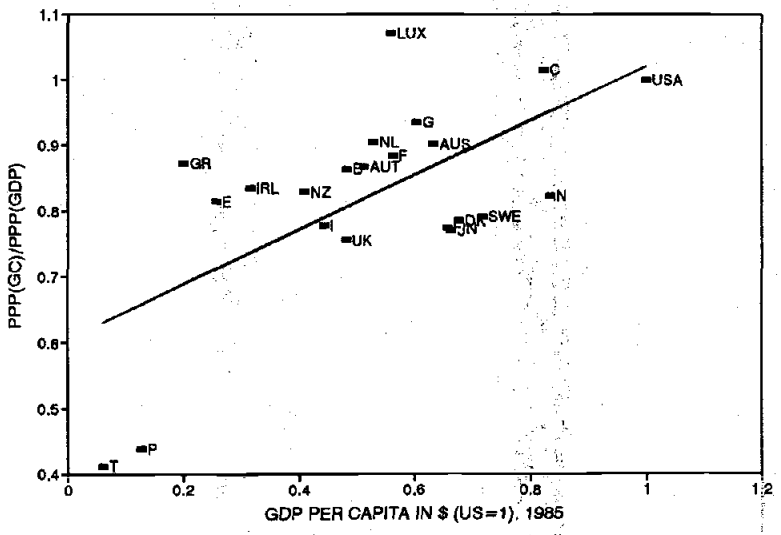
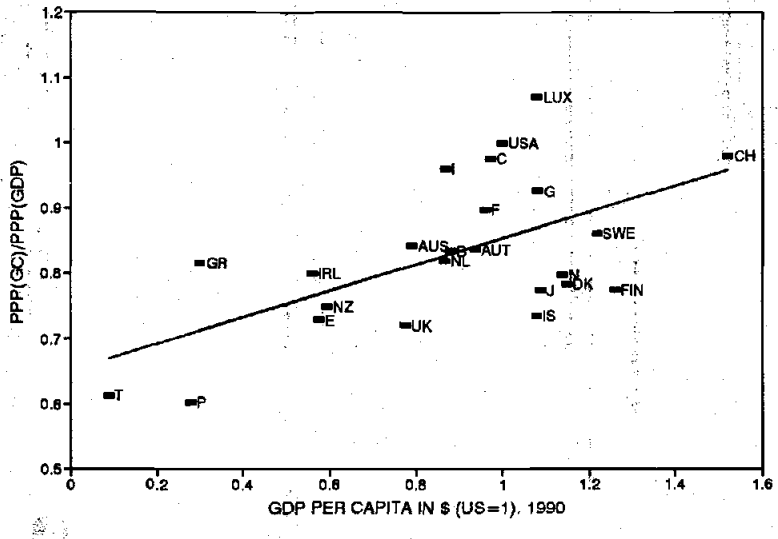


FIGURE 4.4: GOVERMENT FINAL CONSUMPTION
PPP AND GDP PER CAPITA IN $US



Weighted CPL of 13 OECD countries as numeraire (USA,Spain,Ireland,UK,Netherlands,Italy,Belgium,Austria,Denmark,France,Japan,Germany and Luxembourg)

FIGURE 5.1: AUSTRALIA
COMPARATIVE PRICE LEVELS EXTRAPOLATIONS

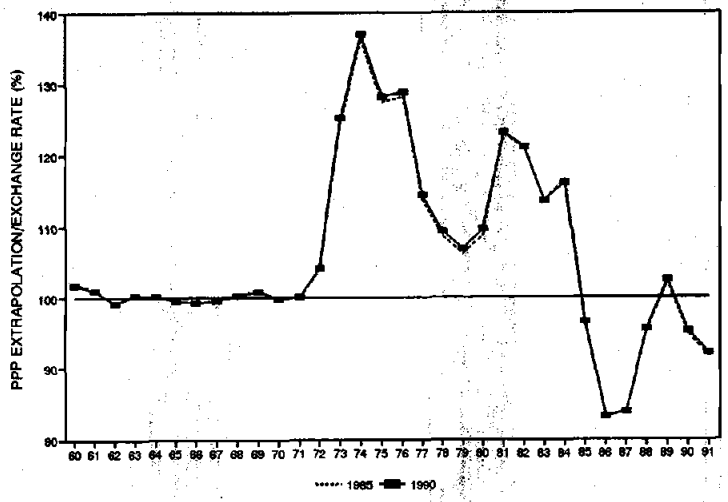
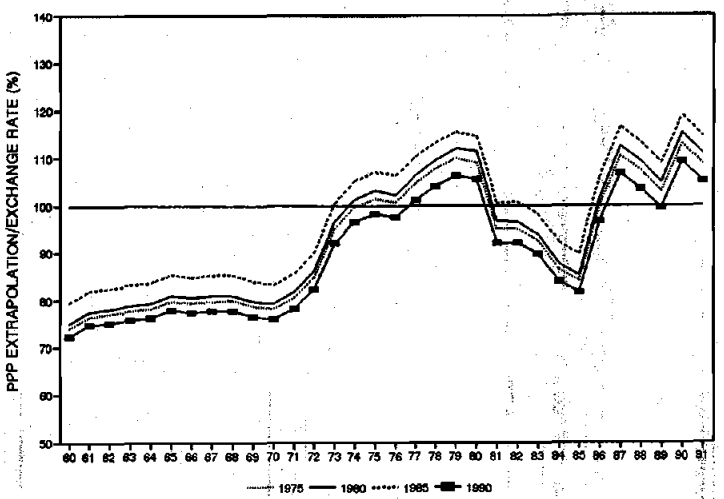


FIGURE 5.2: AUSTRIA
COMPARATIVE PRICE LEVELS EXTRAPOLATIONS



BELGIUM
COMPARATIVE PRICE LEVELS EXTRAPOLATIONS

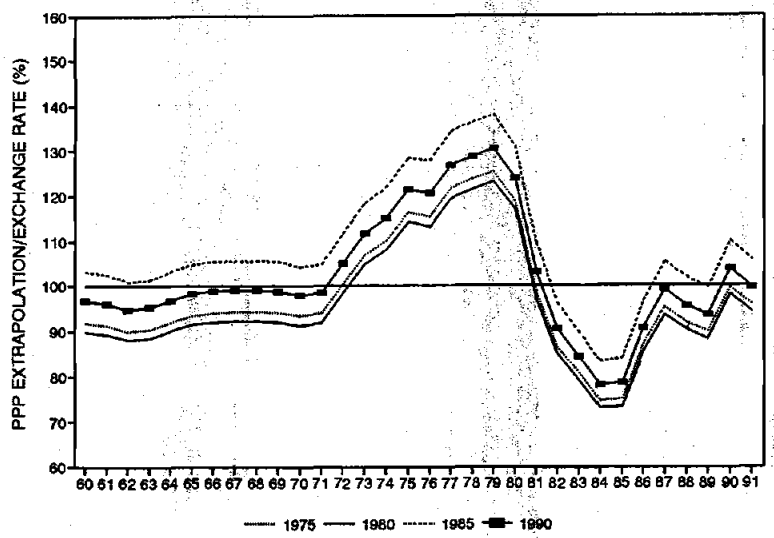
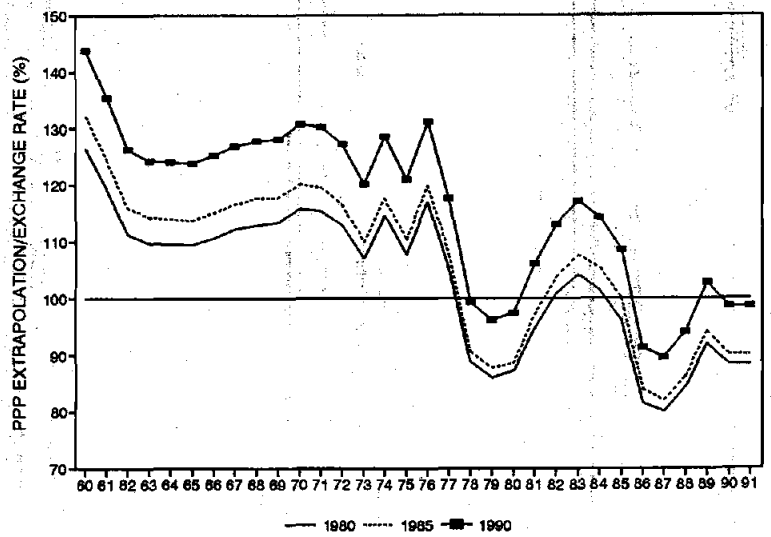


FIGURE 5.4: CANADA
COMPARATIVE PRICE LEVELS EXTRAPOLATIONS



Weighted CPL of 13 OECD countries as numeraire (USA,Spain,Ireland,UK,Netherlands,Italy,Belgium,Austria,Denmark,France,Japan,Germany and Luxembourg)

FIGURE 5.5: SWITZERLAND
COMPARATIVE PRICE LEVELS EXTRAPOLATIONS

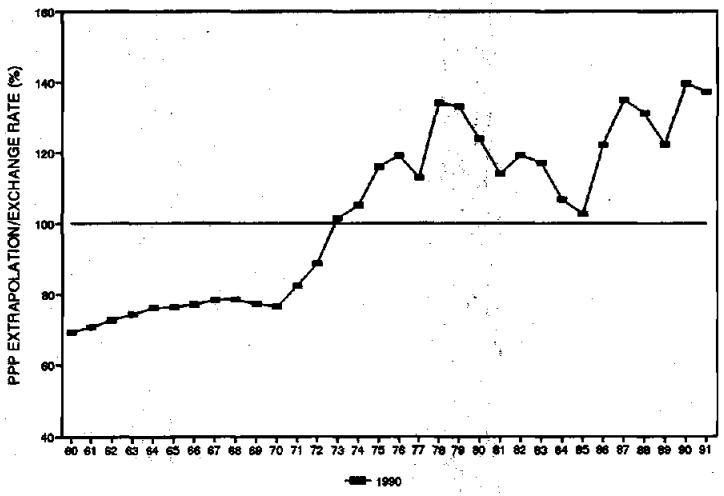


FIGURE 5.6: GERMANY
COMPARATIVE PRICE LEVELS EXTRAPOLATIONS

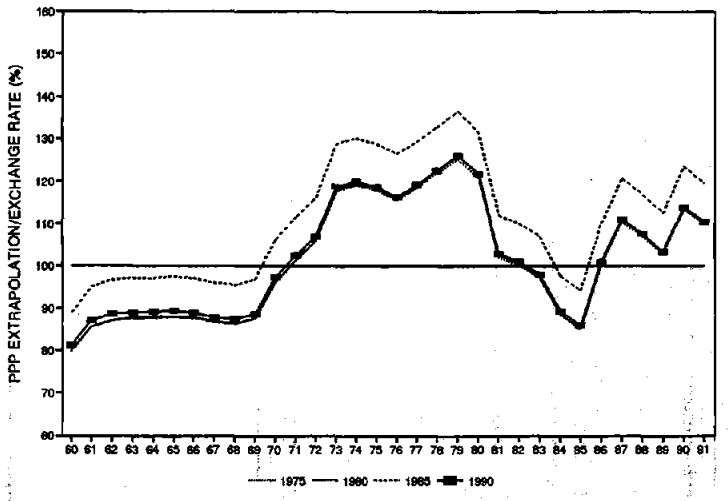


FIGURE 5.7: DENMARK
COMPARATIVE PRICE LEVELS EXTRAPOLATIONS

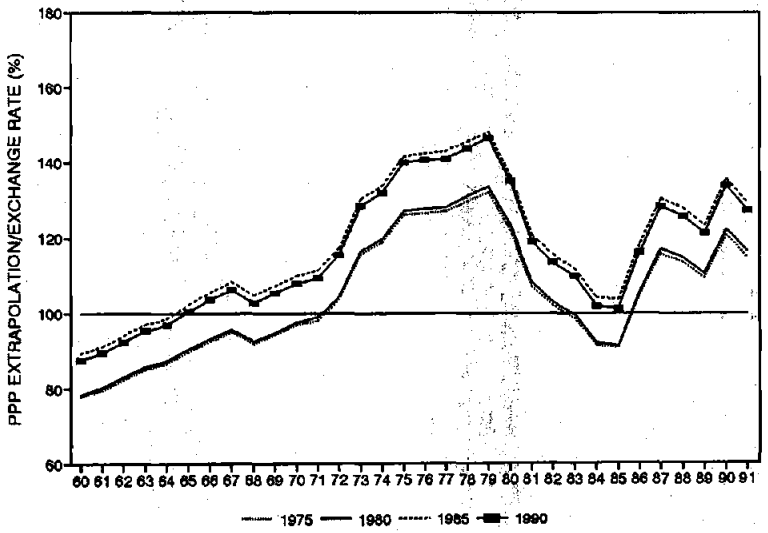
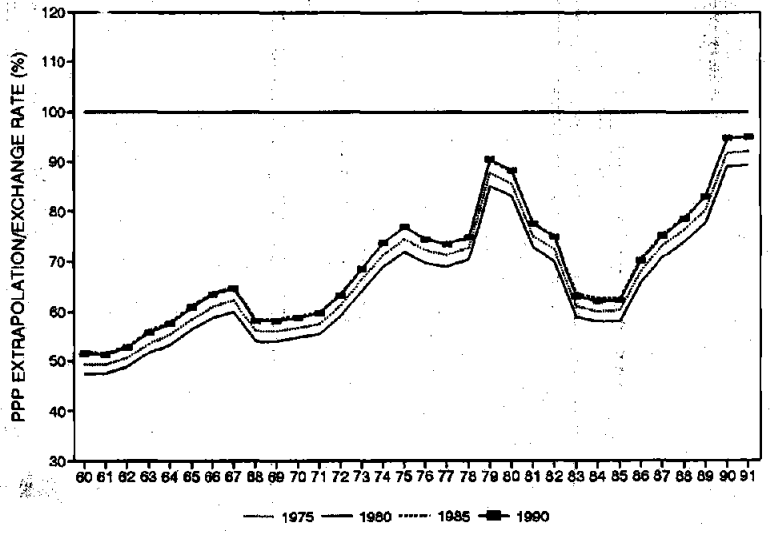


FIGURE 5.8: SPAIN
COMPARATIVE PRICE LEVELS EXTRAPOLATIONS



Weighted CPL of 13 OECD countries as numeraire (USA,Spain,Ireland,UK,Netherlands,Italy,Belgium,Austria,Denmark,France,Japan,Germany and Luxembourg)

FIGURE 5.9: FINLAND
COMPARATIVE PRICE LEVELS EXTRAPOLATIONS

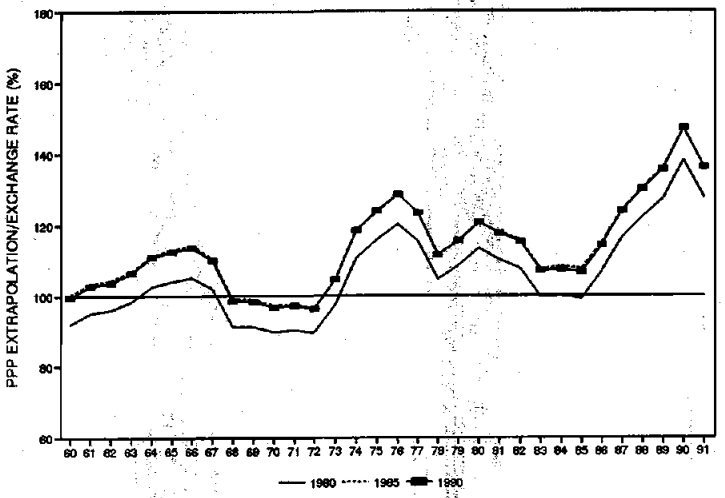
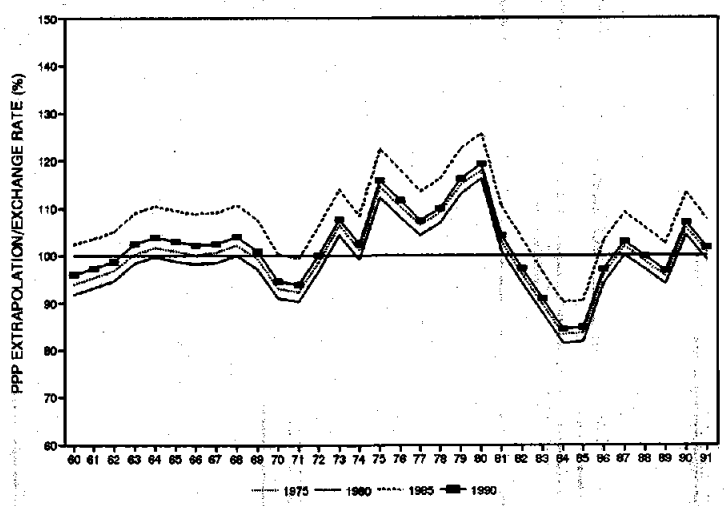


FIGURE 5.10: FRANCE
COMPARATIVE PRICE LEVELS EXTRAPOLATIONS



UNITED KINGDOM
COMPARATIVE PRICE LEVELS EXTRAPOLATIONS

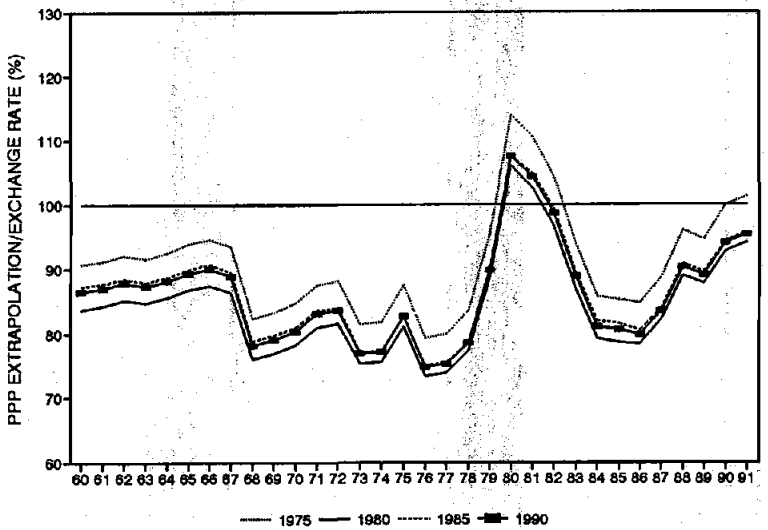
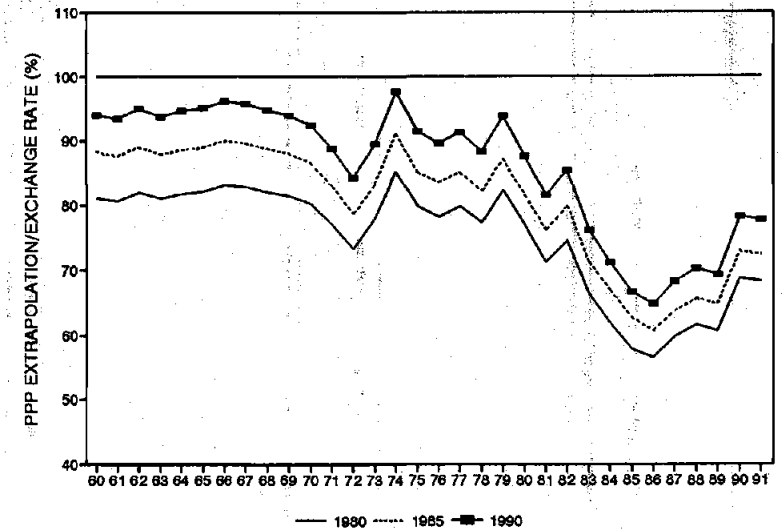


FIGURE 5.12: GREECE
COMPARATIVE PRICE LEVELS EXTRAPOLATIONS



Weighted CPL of 13 OECD countries as numeraire (USA,Spain,Ireland,UK,Netherlands,Italy,Belgium,Austria,Denmark,France,Japan,Germany and Luxembourg)

FIGURE 5.13: IRELAND
COMPARATIVE PRICE LEVELS EXTRAPOLATIONS

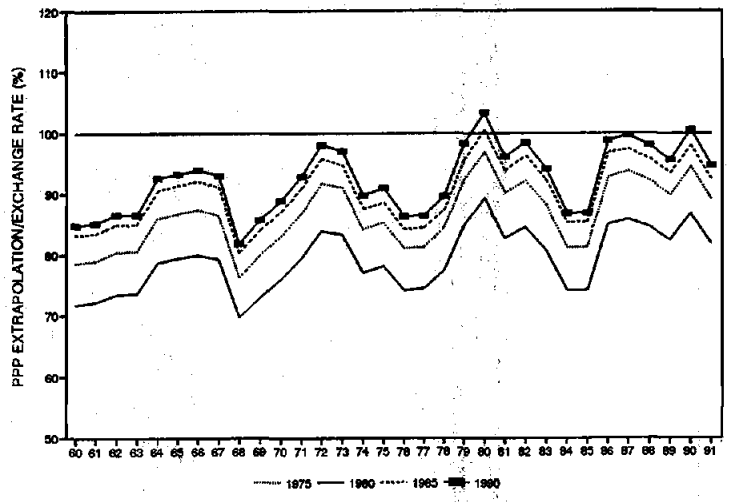


FIGURE 5.14: ICELAND
COMPARATIVE PRICE LEVELS EXTRAPOLATIONS

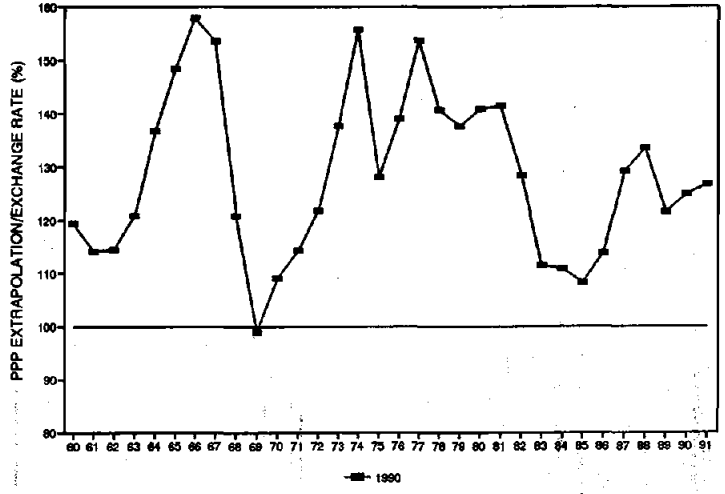


FIGURE 5.15: ITALY
COMPARATIVE PRICE LEVELS EXTRAPOLATIONS

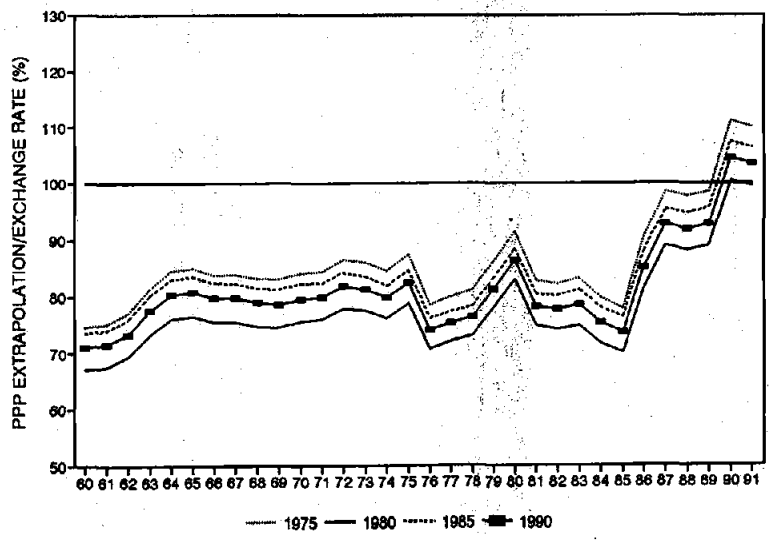
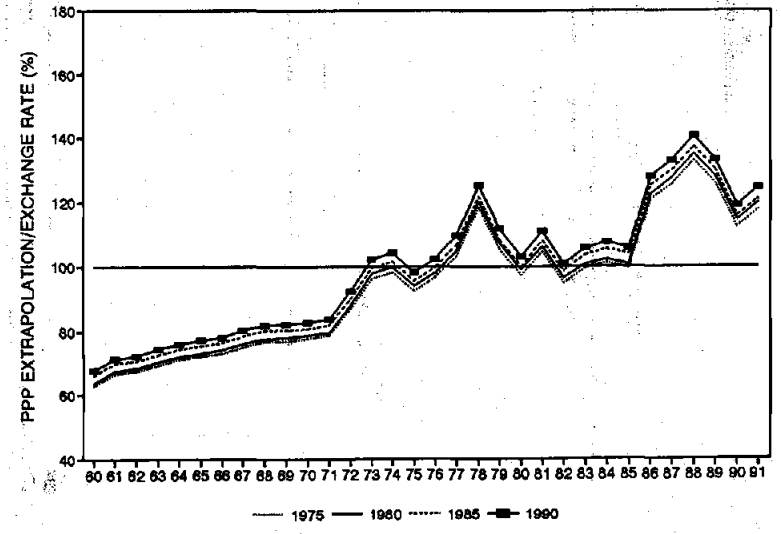


FIGURE 5.16: JAPAN
COMPARATIVE PRICE LEVELS EXTRAPOLATIONS



Weighted CPL of 13 OECD countries as numeraire (USA,Spain,Ireland,UK,Netherlands,Italy,Belgium,Austria,Denmark,France,Japan,Germany and Luxembourg)

FIGURE 5.17: LUXEMBOURG
COMPARATIVE PRICE LEVELS EXTRAPOLATIONS

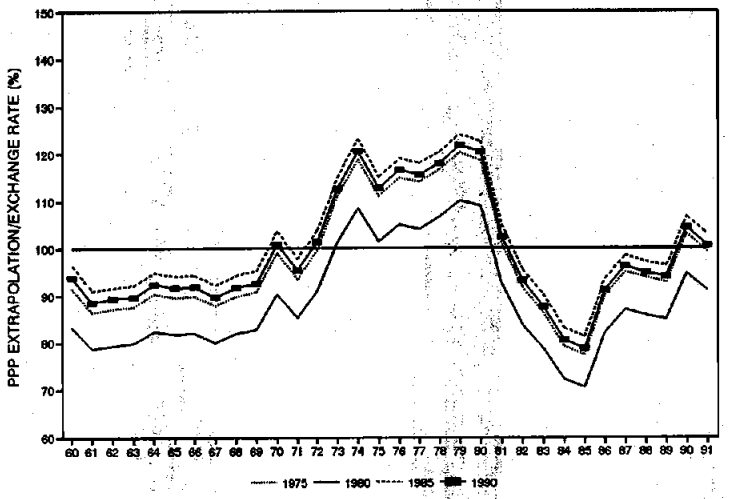


FIGURE 5.18: NETHERLANDS
COMPARATIVE PRICE LEVELS EXTRAPOLATIONS

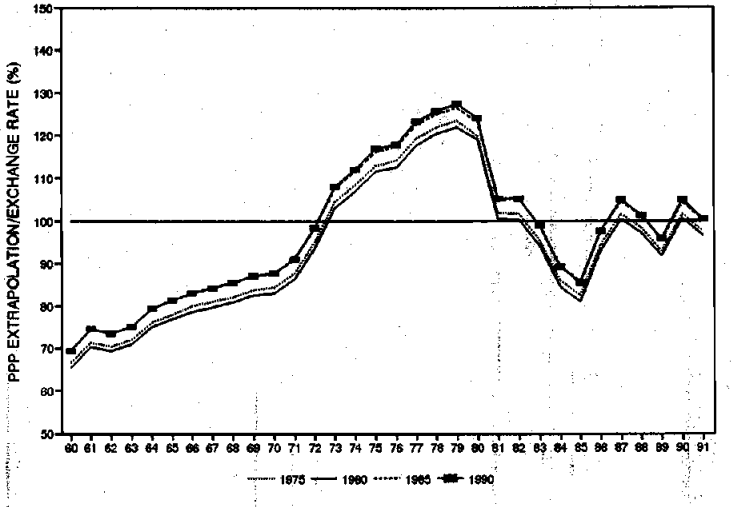


FIGURE 5.19: NORWAY
COMPARATIVE PRICE LEVELS EXTRAPOLATIONS

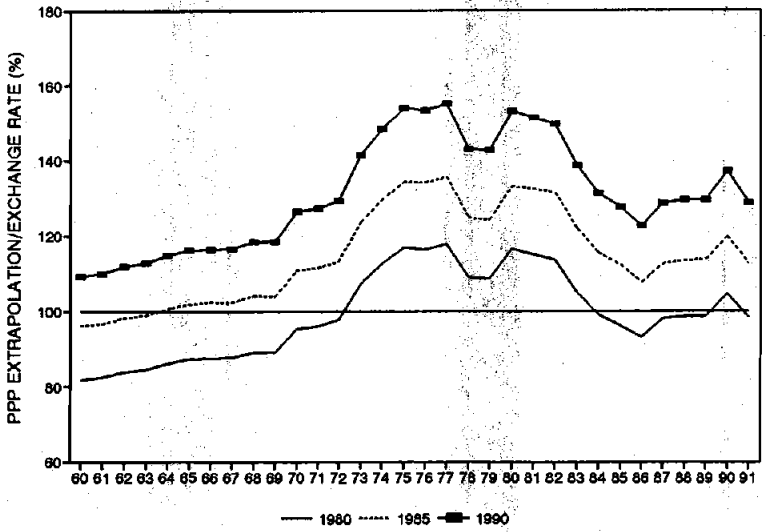
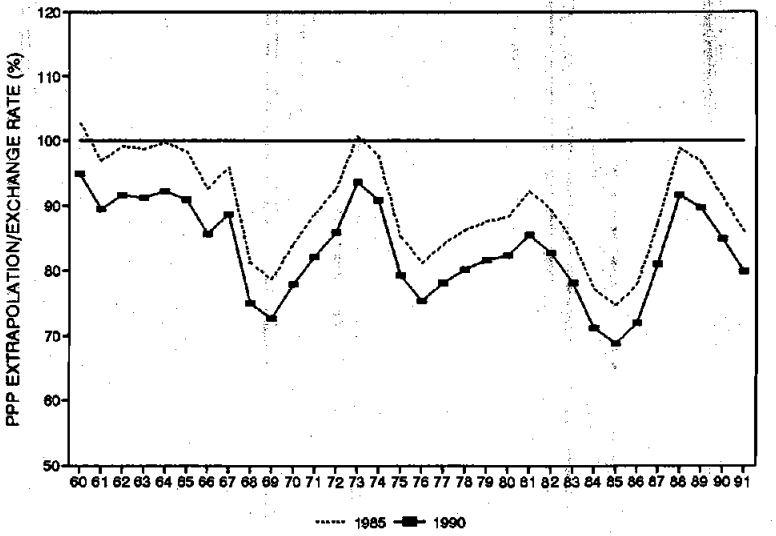


FIGURE 5.20: NEW ZEALAND
COMPARATIVE PRICE LEVELS EXTRAPOLATIONS



Weighted CPL of 13 OECD countries as numeraire (USA,Spain,Ireland,UK,Netherlands,Italy,Belgium,Austria,Denmark,France,Japan,Germany and Luxembourg)

FIGURE 5.21: PORTUGAL
COMPARATIVE PRICE LEVELS EXTRAPOLATIONS

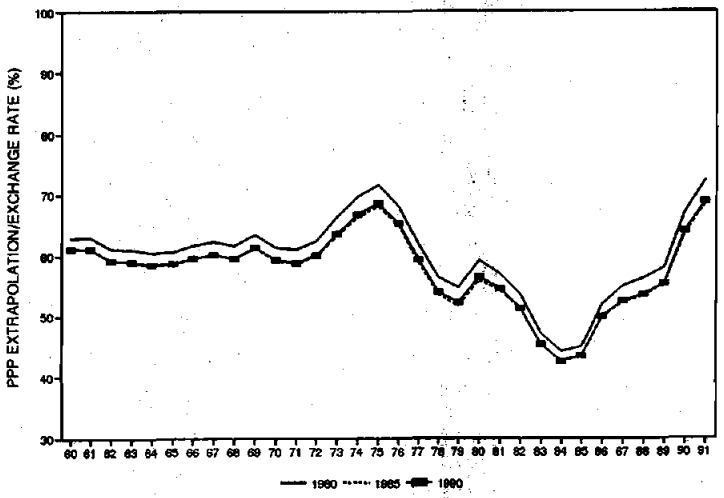


FIGURE 5.22: SWEEDEN
COMPARATIVE PRICE LEVELS EXTRAPOLATIONS

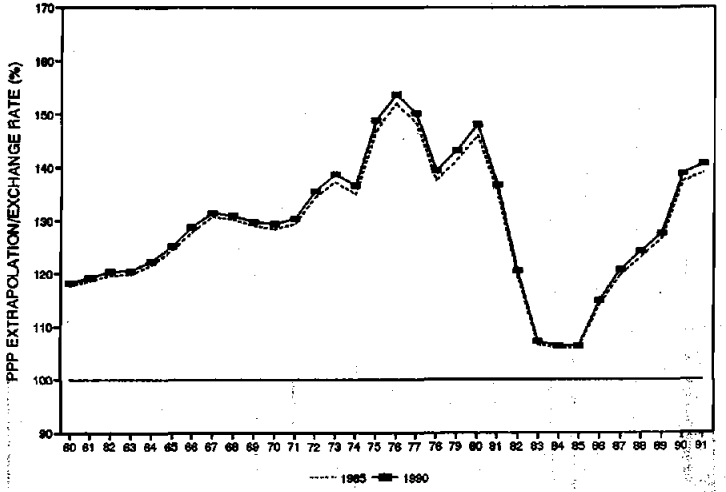


FIGURE 5.23: TURKEY
COMPARATIVE PRICE LEVELS EXTRAPOLATIONS

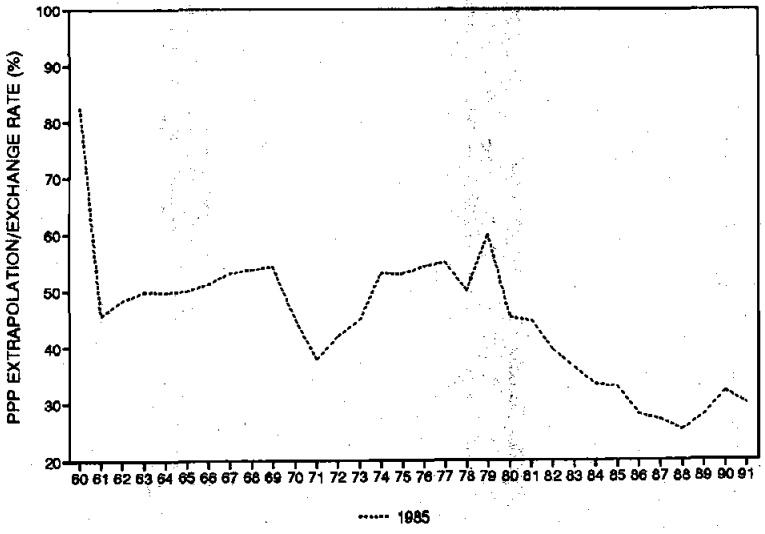


FIGURE 5.18: UNITED STATES
COMPARATIVE PRICE LEVELS EXTRAPOLATIONS

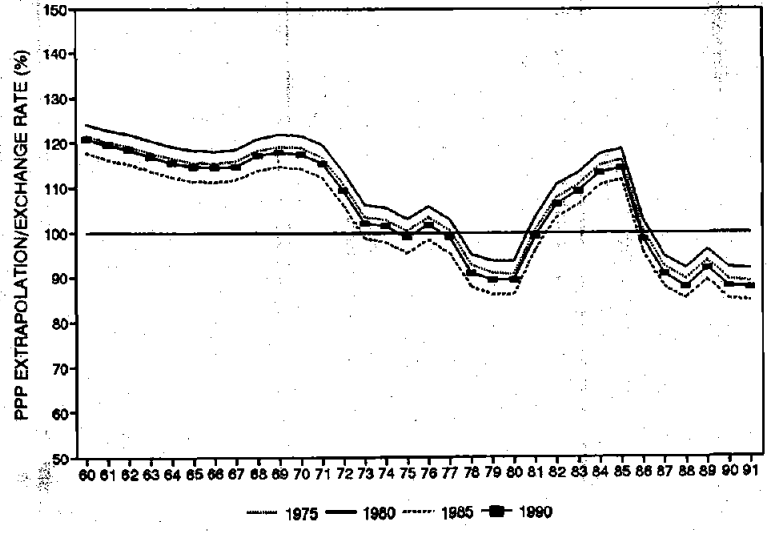


FIGURE 6.1: AUSTRALIA
GDP PER CAPITA RELATIVE TO OECD AVERAGE

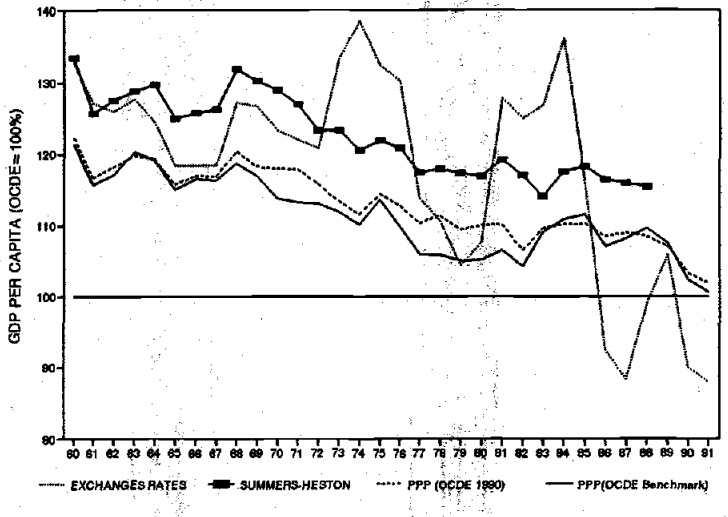


FIGURE 6.2: AUSTRIA
GDP PER CAPITA RELATIVE TO OECD AVERAGE

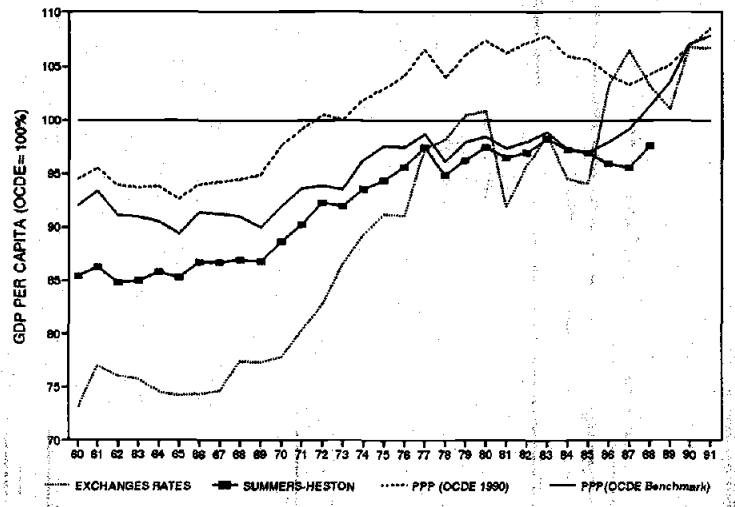


FIGURE 6.3: BELGIUM
GDP PER CAPITA RELATIVE TO OECD AVERAGE

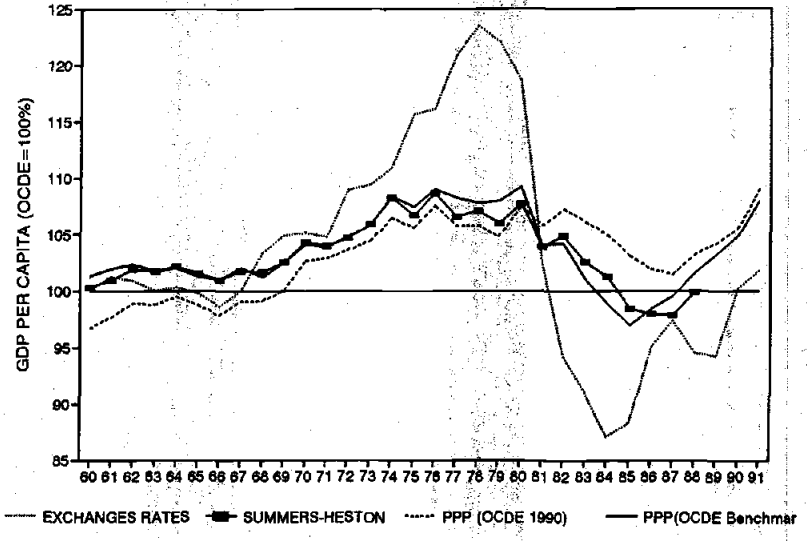


FIGURE 6.4: CANADA
GDP PER CAPITA RELATIVE TO OECD AVERAGE

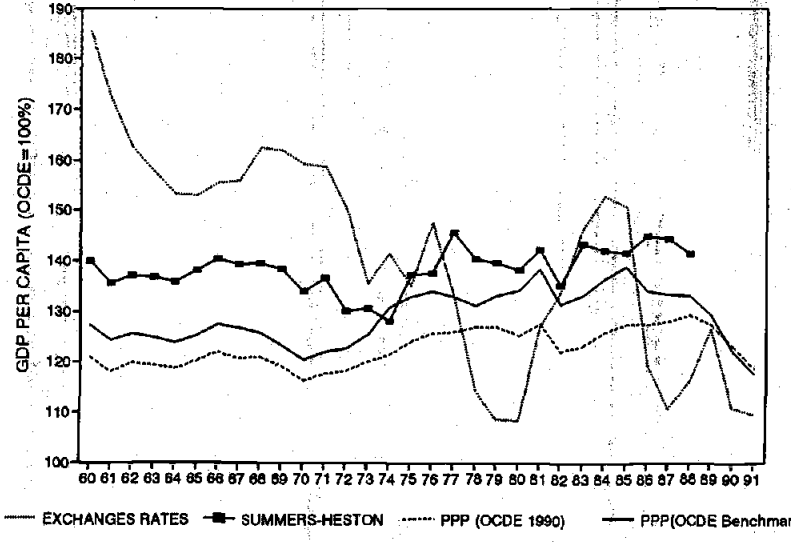


FIGURE 6.5: SWITZERLAND
GDP PER CAPITA RELATIVE TO OECD AVERAGE

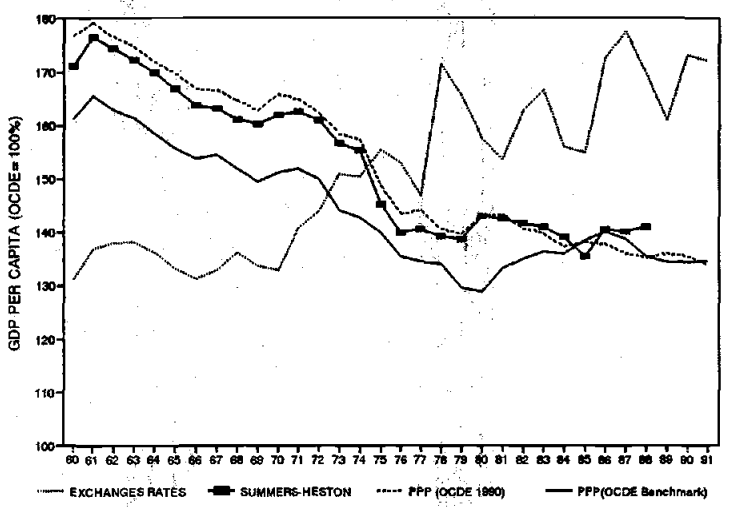


FIGURE 6.6: GERMANY
GDP PER CAPITA RELATIVE TO OECD AVERAGE

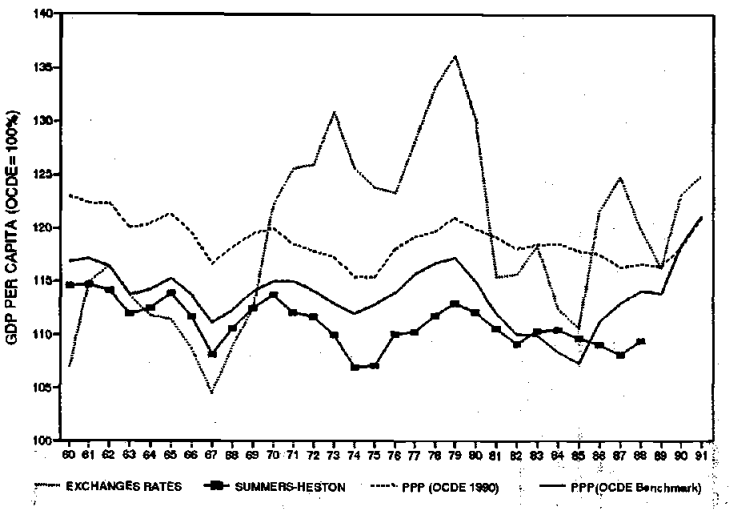


FIGURE 6.7: DENMARK
GDP PER CAPITA RELATIVE TO OECD AVERAGE

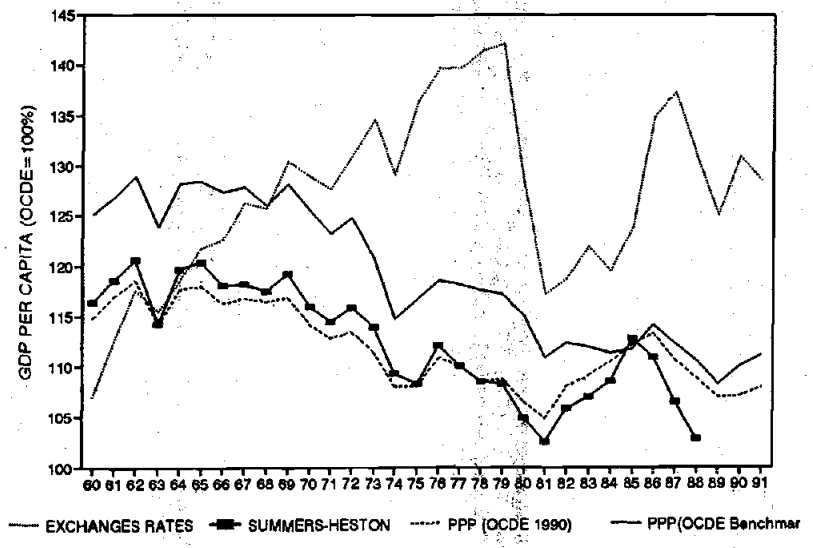


FIGURE 6.8: SPAIN
GDP PER CAPITA RELATIVE TO OECD AVERAGE

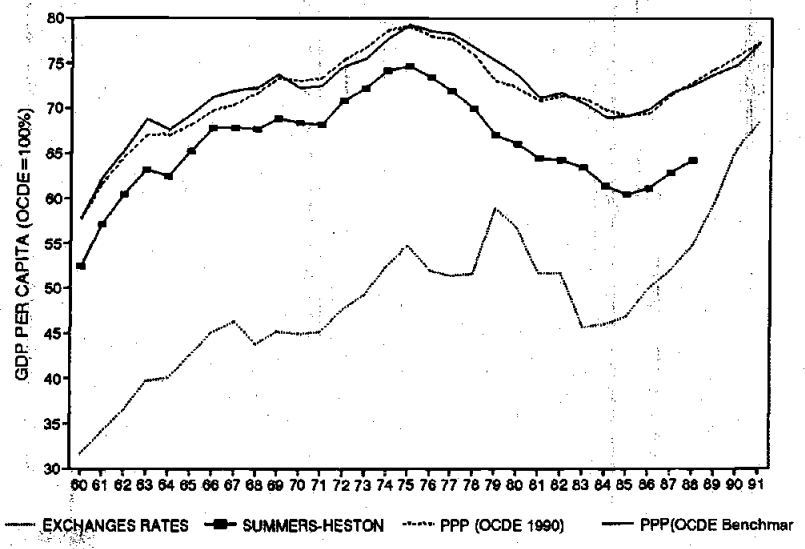


FIGURE 6.9: FINLAND
GDP PER CAPITA RELATIVE TO OECD AVERAGE

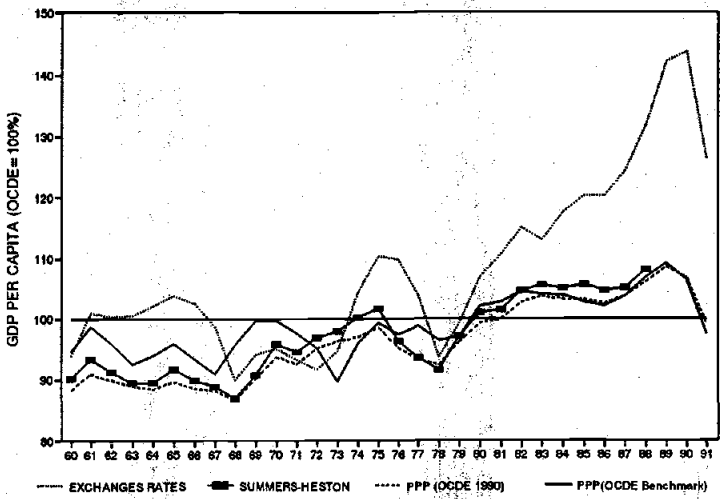


FIGURE 6.10: FRANCE
GDP PER CAPITA RELATIVE TO OECD AVERAGE

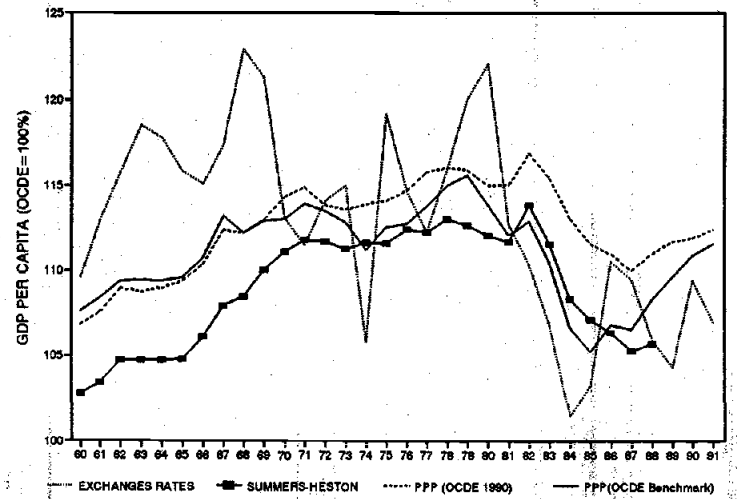


FIGURE 6.11: UNITED KINGDOM
GDP PER CAPITA RELATIVE TO OECD AVERAGE

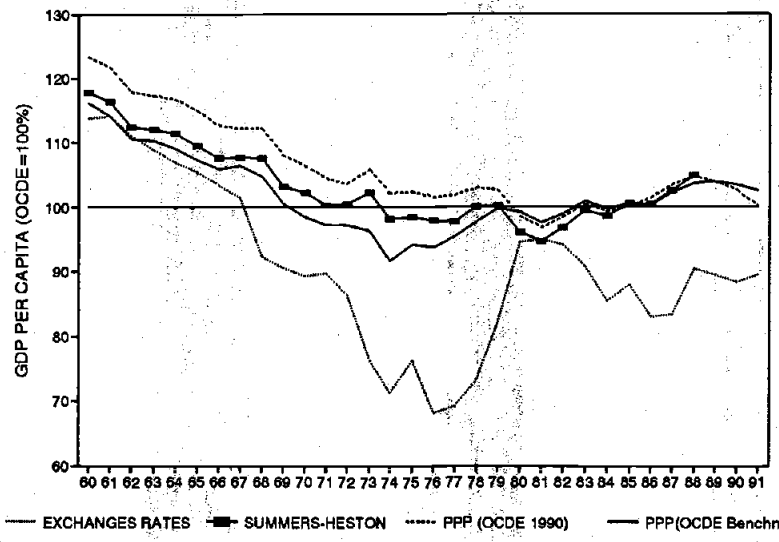


FIGURE 6.12: GREECE
GDP PER CAPITA RELATIVE TO OECD AVERAGE

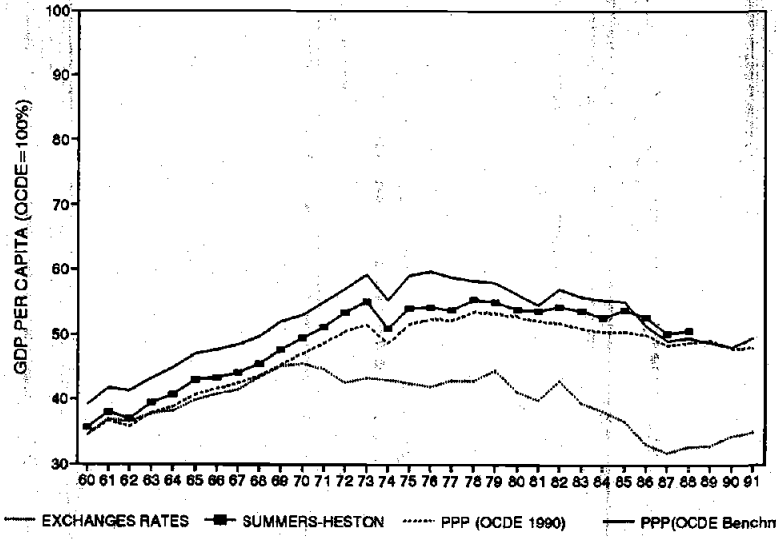


FIGURE 6.13: IRELAND
GDP PER CAPITA RELATIVE TO OECD AVERAGE

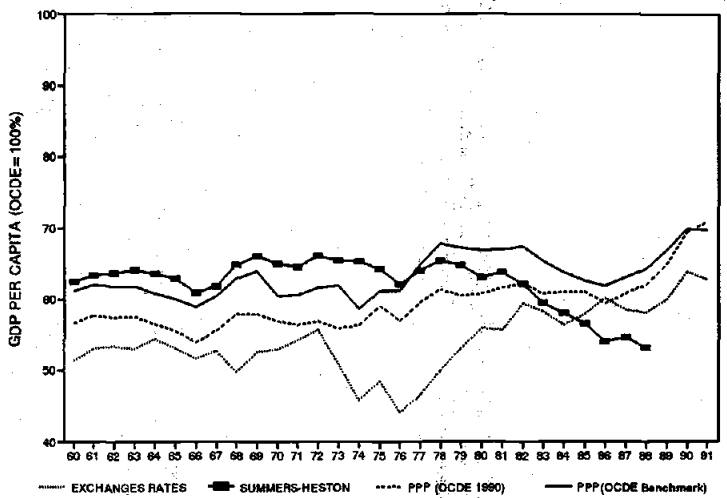


FIGURE 6.14: ICELAND
GDP PER CAPITA RELATIVE TO OECD AVERAGE

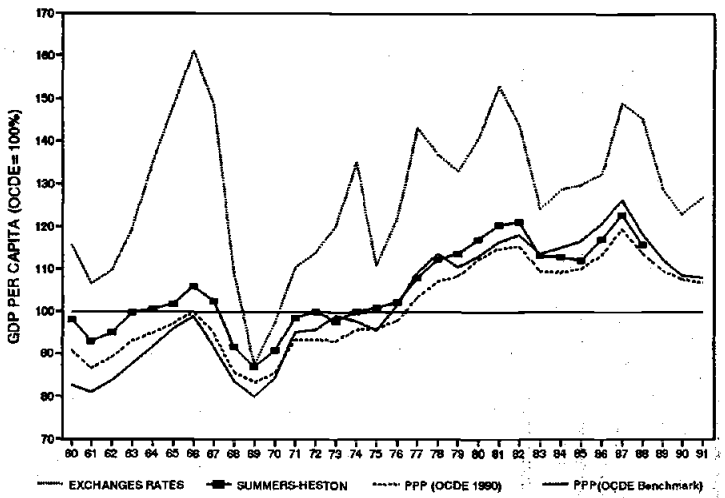


FIGURE 6.15: ITALY
GDP PER CAPITA RELATIVE TO OECD AVERAGE

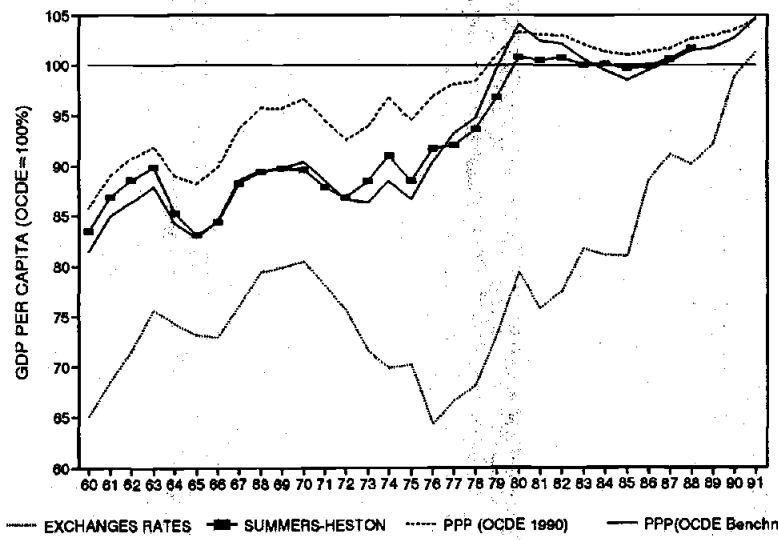


FIGURE 6.16: JAPAN
GDP PER CAPITA RELATIVE TO OECD AVERAGE

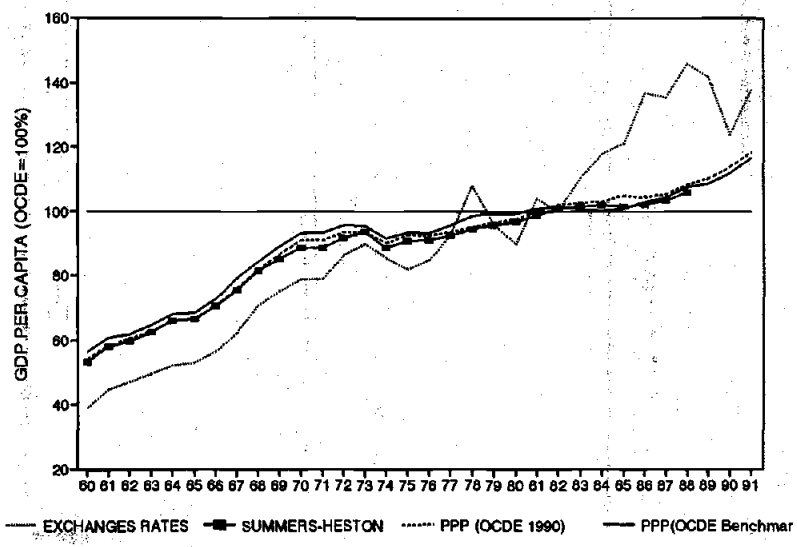


FIGURE 6.17: LUXEMBOURG
GDP PER CAPITA RELATIVE TO OECD AVERAGE

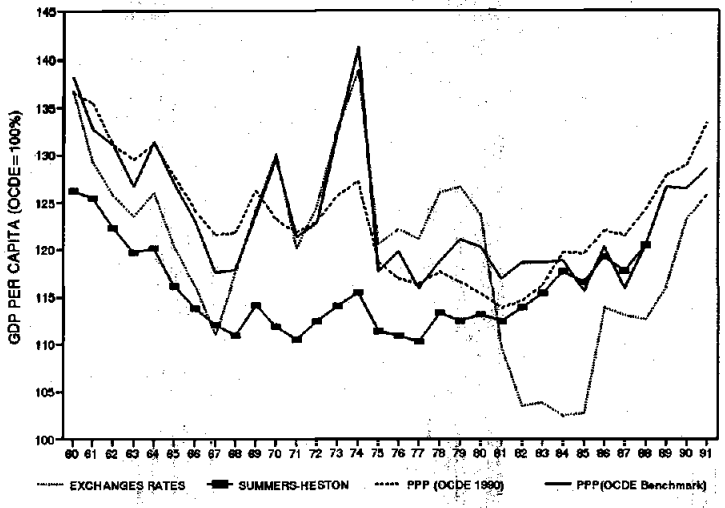


FIGURE 6.18: NETHERLANDS
GDP PER CAPITA RELATIVE TO OECD AVERAGE

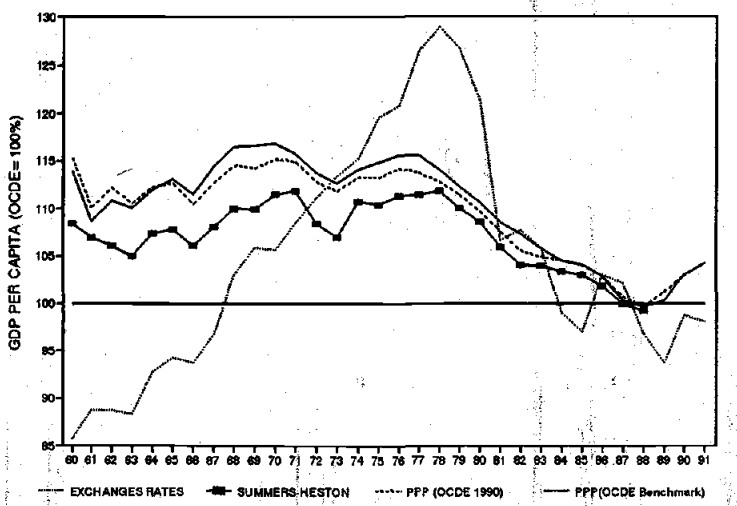


FIGURE 6.19: NORWAY
GDP PER CAPITA RELATIVE TO OECD AVERAGE

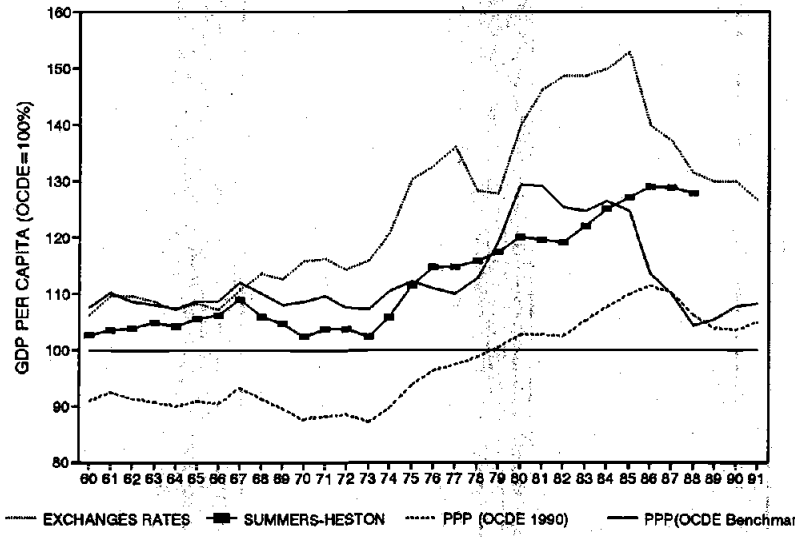


FIGURE 6.20: NEW ZEALAND
GDP PER CAPITA RELATIVE TO OECD AVERAGE

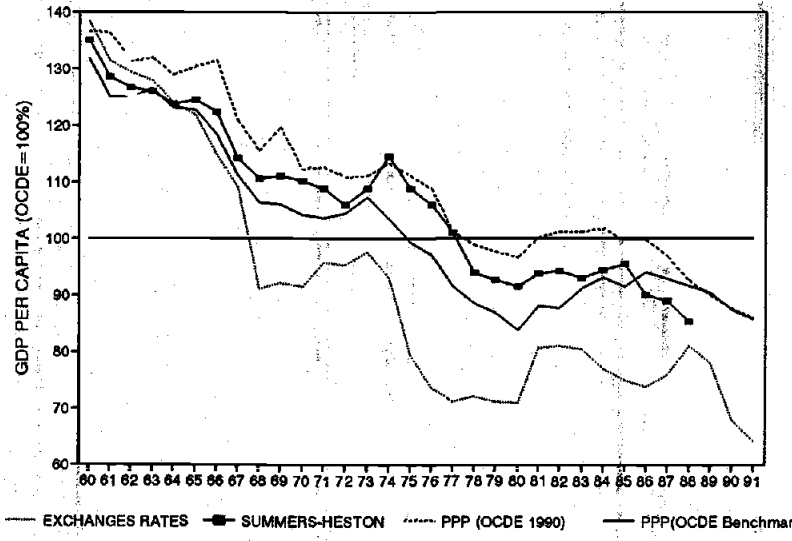


FIGURE 6.21: PORTUGAL
GDP PER CAPITA RELATIVE TO OECD AVERAGE

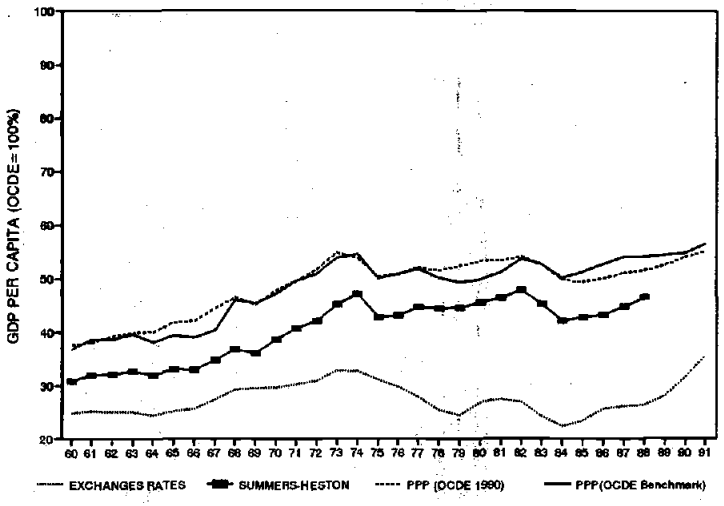


FIGURE 6.22: SWEDEN
GDP PER CAPITA RELATIVE TO OECD AVERAGE

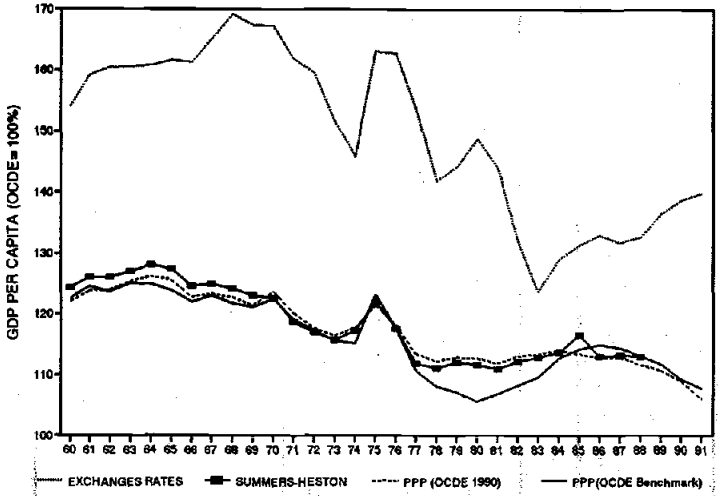


FIGURE 6.23: TURKEY
GDP PER CAPITA RELATIVE TO OECD AVERAGE

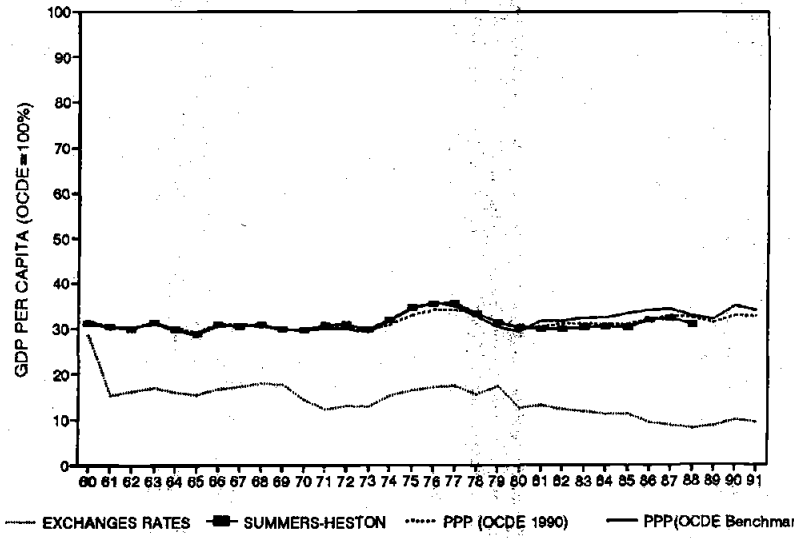
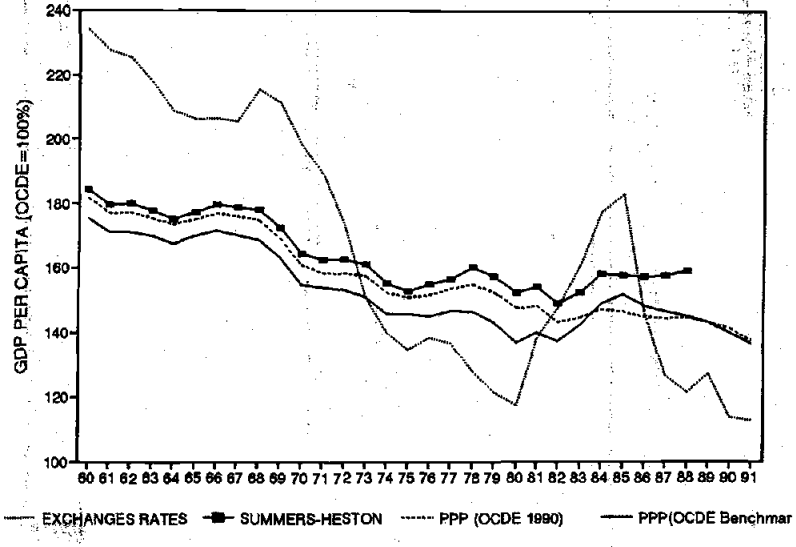


FIGURE 6.24: USA
GDP PER CAPITA RELATIVE TO OECD AVERAGE



DATA APPENDIX

Cross-country growth regression data

	n	GDP/L 1960	GDP/L 1988	GDP/L 1990	i	Human capital
PWT5 (1985 international $)						
AUSTRALIA	1.71	7.24	13.35		28.21	6.07
AUSTRIA	0.25	4.64	11.28		27.52	5.90
BELGIUM	0.28	5.44	11.55		22.97	6.61
CANADA	1.36	7.60	16.32		22.89	7.18
SWITZERLAND	0.72	9.29	16.31		30.22	4.77
GERMANY	0.35	6.22	12.65		26.89	7.30
DENMARK	0.41	6.32	11.88		27.81	6.03
SPAIN	0.89	2.85	7.44		26.22	4.93
FINLAND	0.39	4.90	12.50		34.22	5.61
FRANCE	0.72	5.58	12.22		25.88	7.49
UNITED KINGDO	0.29	6.40	12.13		18.13	6.01
GREECE	0.67	1.93	5.85		25.41	5.84
IRELAND	0.84	3.39	6.15		26.45	6.02
ICELAND	1.25	5.32	13.41		25.84	5.84
ITALY	0.48	4.53	11.77		27.92	6.10
JAPAN	0.95	2.90	12.27		30.95	6.42
LUXEMBOURG	0.58	6.85	13.92		26.53	4.72
NETHERLAND	0.90	5.89	11.48		23.98	6.51
NORWAY	0.58	5.58	14.75		32.79	6.97
NEW ZEALAND	1.22	7.32	9.85		21.96	6.60
PORTUGAL	0.46	1.67	5.38		23.66	4.90
SWEDEN	0.40	6.75	13.07		22.65	6.17
TURKEY	2.42	1.69	3.59		20.99	3.17
USA	1.11	10.02	18.39		17.16	8.84

n=rate of growth of population, i=(Investment/GDP). Averages 1960-1988

Cross-country growth regression data

	n	GDP/L 1960	GDP/L 1988	GDP/L 1990	i	Human capital
OCDE (1990 international $)						
AUSTRALIA	1.62	8.33	16.12	15.98	22.74	7.82
AUSTRIA	0.30	6.44	15.48	16.54	21.98	7.61
BELGIUM	0.29	6.60	15.33	16.31	16.52	8.48
CANADA	1.33	8.25	19.19	18.99	18.82	9.17
SWITZERLAND	0.80	12.04	20.09	20.96	21.05	6.24
GERMANY	0.44	8.39	17.32	18.28	18.68	9.36
DENMARK	0.39	7.82	16.18	16.56	19.21	7.41
SPAIN	0.81	3.93	10.85	11.73	17.07	6.87
FINLAND	0.40	6.01	15.75	16.52	27.73	7.77
FRANCE	0.73	7.28	16.48	17.30	18.58	9.40
UNITED KINGDO	0.31	8.40	15.55	15.87	12.62	7.71
GREECE	0.66	2.35	7.25	7.40	16.41	7.52
IRELAND	0.71	3.87	9.23	10.74	17.62	7.79
ICELAND	1.24	6.20	16.93	16.67	23.34	7.56
ITALY	0.46	5.85	15.26	16.01	18.31	7.92
JAPAN	0.94	3.70	16.12	17.63	24.72	8.32
LUXEMBOURG	0.64	9.31	18.45	19.93	20.78	6.10
NETHERLAND	0.88	7.86	14.82	15.91	18.44	8.41
NORWAY	0.56	6.20	15.77	16.02	29.06	8.82
NEW ZEALAND	1.18	9.30	13.75	13.53	14.55	8.46
PORTUGAL	0.57	2.57	7.65	8.36	18.12	6.20
SWEDEN	0.45	8.33	16.60	16.87	17.94	8.09
TURKEY	2.40	2.16	4.84	5.11	18.94	4.43
USA	1.09	12.38	21.48	21.87	16.69	11.26

n=rate of growth of population, i=(Investment/GDP). Averages 1960-1988

Cross-country growth regression data

	n	GDP/L 1960	GDP/L 1988	GDP/L 1990	i	Human capital
OCDE (Current international prices at 1990 US $)						
AUSTRALIA	1.62	8.56	16.21	15.98	20.48	7.82
AUSTRIA	0.30	6.49	14.98	16.71	17.57	7.61
BELGIUM	0.29	7.15	15.02	16.37	16.93	8.48
CANADA	1.33	8.97	19.67	19.04	18.38	9.17
SWITZERLAND	0.80	11.37	20.04	20.98	21.70	6.24
GERMANY	0.44	8.24	16.86	18.48	18.85	9.36
DENMARK	0.39	8.83	16.36	17.19	18.29	7.41
SPAIN	0.81	4.08	10.74	11.70	16.83	6.87
FINLAND	0.40	6.68	15.79	16.63	22.84	7.77
FRANCE	0.73	7.59	16.02	17.31	18.54	9.40
UNITED KINGDO	0.31	8.20	15.33	16.15	12.32	7.71
GREECE	0.66	2.76	7.30	7.52	16.36	7.52
IRELAND	0.71	4.32	9.50	10.92	16.05	7.79
ICELAND	1.24	5.84	17.55	16.98	22.53	7.56
ITALY	0.46	5.74	15.02	16.04	19.22	7.92
JAPAN	0.94	3.98	15.90	17.46	24.44	8.32
LUXEMBOURG	0.64	9.75	17.81	19.74	21.20	6.10
NETHERLAND	0.88	8.04	14.73	16.08	17.52	8.41
NORWAY	0.56	7.59	15.42	16.81	21.97	8.82
NEW ZEALAND	1.18	9.29	13.54	13.63	15.45	8.46
PORTUGAL	0.57	2.60	7.99	8.57	14.17	6.20
SWEDEN	0.45	8.65	16.73	17.07	16.45	8.09
TURKEY	2.40	2.19	4.87	5.47	18.16	4.43
USA	1.09	12.38	21.48	21.87	16.69	11.26

n=rate of growth of population, i=(Investment/GDP). Averages 1960-1988