A Constrained State-Space Approach to the Prediction of Comparable Real Income across Countries

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Abstract:
Studies on growth performance and catch-up and convergence of countries require and make extensive use of internationally and temporally comparable data on real gross domestic product (GDP) expressed in a common currency unit. The International Comparison Program (ICP), a project supported by the World Bank, OECD and a host of other international bodies, provides estimates of purchasing power parities (PPPs) as the most robust and appropriate converter of nominal GDP into a common currency unit reflecting differences in levels of prices of goods and services in different countries. The coverage of the ICP, however, has been limited to a few benchmark years, roughly every five years since 1970, and to only those countries participating in benchmark comparisons. Over the last two decades, the Penn World Tables (PWT) filled this gap by providing extensive tabulations of real GDP data for a large number of countries and for a 50-year period covering both participating and non-participating countries and benchmark and non-benchmark years. The PWT figures are essentially extrapolations based on results from benchmark years and country-specific growth rates with particular emphasis on comparisons from specific benchmark years. The main purpose of the paper is to show how a constrained state-space formulation of the problem can be used to generate PPPs, and real GDP data, that is consistent with data generated by the ICP for the benchmark years. Treating the ICP data as an unbalanced panel, the paper presents a suitable spatially autocorrelated econometric model for PPPs which is reformulated as a constrained state-space form to complete the panel. The empirical illustration focuses on 24 OECD countries from 1971 to 2000 and generates a complete set of predicted PPPs for all the countries and years. Unlike the PWTs figures, it is possible to compute standard errors associated with the predicted figures.

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Introduction

Over the last three decades, studies on growth performance of countries and the issues of catch-up and convergence have been prominent. These studies require and make extensive use of internationally comparable data on real gross domestic product (GDP) and real per capita incomes expressed in a common currency unit which are derived after adjusting for price level differences across countries and price movements over time.

In 1988, the United Nations (UN) embarked on a major project to standardise the way economic aggregates are compiled and assembled in the form of a system of national accounts (SNA) and its recommendations were finalised in leading to the 1993 SNA. But, conceptually and practically, the UN national accounts will only be completed when a common measure of economic aggregates (compiled by different countries and expressed in respective national currency units) can be expressed in a common currency unit. The longstanding recognition of the deficiencies of using nominal exchange rates for these comparisons mainly due to the existence of non-traded goods and services in different countries and due to capital movements and exchange market intervention, gave rise to the International Comparison Program (ICP) which developed purchasing-power parities (PPPs) as the most robust and appropriate converter for accurately reflecting differences in the levels of prices of goods and services in different countries. However, ICP, a project supported by the World Bank, UN, OECD, EU and a host of other international bodies, provides PPPs and real economic aggregates only for specific years when participating countries undertake extensive price surveys and the data collected are used in conjunction with other national accounts data. The coverage of the ICP, however, has been limited and results have been available only for the benchmark years, 1975, 1980, 1985, 1990, 1993, 1996 and 1999. Country coverage also varies greatly across different benchmark years with coverage limited mostly to developed countries and a small proportion of developing countries. Therefore, the limited temporal and spatial coverage of the ICP has limited the applicability of the resulting PPPs and real aggregates.

The ICP benchmark PPPs have been extrapolated to create a complete panel of internationally comparable GDP and its components for a large number of countries spanning over 40 years. Two alternative data sets have resulted, the Penn World Tables (PWT) (currently Mark 6.1 is available) (see Summers and Heston, 1988 and 1991) and the World Bank's tables published in the World Development Indicators (WDI) (see Ahmad 1996). A third set of available tables is that by Maddison (2001), where very long time series are provided for ICP participating countries. The methodology of construction of these tables is relatively similar in that PWT and WDI first, extrapolate *ICP results from a given benchmark* to non-ICP participating countries (spatial extrapolation) using regression techniques[1]. Second, national price level's growth rates are used to interpolate temporally. Maddison does not attempt to extrapolate to non-participating countries. A fundamental problem of consistency arises from these methods. The use of price level's growth rates to interpolate between benchmark years for participating countries results in discrepancies between the interpolated values and the benchmark values. As a consequence, the interpolation is based on a single benchmark year (usually the latest available) and all previous

[1] The PWT series uses a slightly more detailed method that extrapolates consumption, investment and government separately and then aggregates them to form real GDP series.

benchmark observations are discarded. If follows that different benchmark exercises lead to a different data set (ie the data in Marks 5 and 6 of PWT differ).

Our approach is fundamentally different in that the temporal and spatial completion of the panel is achieved jointly. Our econometric method is basically a learning algorithm that moves from one time period to the next incorporating new temporal information (ie new ICP results or country specific growth rates) and spatially predicting incomplete PPPs (non-participating countries during an ICP exercise, all countries for non-benchmark years). The success of the learning algorithm depends on the economic and econometric model formulated to predict PPPs. We review the existing literature on the modeling of national price levels next. Section 3 presents the approached proposed in this study, including both the econometric model and derived state space model. Section 4 discusses the estimation by Kalman filtering techniques. Section 5 presents a small empirical illustration of the method for OECD countries. Section 6 concludes.

2. The problem

Purchasing power parities (PPPs) of currencies are compiled by international organizations on a regular basis. The PPP of the currency of a country compared to a reference currency provides a measure of the number of the currency units of the country that have the same purchasing power as one unit of the currency of the reference country. For example, PPP of Au$ 1.30 = US$ 1.00 shows that 1.30 Australian dollars have the same purchasing power as one US dollar at a given point of time.

Let $PPP_{j,t}$ represent the PPP of currency of country j at a time point t[2]. These PPPs are compiled using extensive price surveys conducted in the countries

[2] Strictly speaking it is necessary to identify the reference currency used in defining the PPP for the country. Without loss of generality, it is assumed that the US dollar is used as the reference currency.

participating in the International Comparison Program. As such surveys and the process involved is very resource intensive, these PPPs are compiled only for selected years, referred to as “benchmark years”, and for only those countries that participate in the ICP. The PPPs are computed using specialized index number methodology designed specifically for the purpose of international comparisons. Kravis et al (1983) and Roberts (2004) provide an excellent exposition of the methodology underlying international comparisons. PPPs are used in the place of exchange rates of currencies for purposes of comparing real incomes and various output aggregates. The World Development Indicators of the World Bank and the Human Development Index (HDI) of the United Nations Development Program make use of per capita real incomes derived by converting gross domestic product of different countries, expressed in respective national currency units, into a common currency unit through the use of PPPs. Availability of PPPs on a regular basis is considered very essential by most international organizations.

As these PPPs are available only for a subset of countries and also for only a few years, the main problem is one of meaningfully extrapolate or predict PPPs for countries not participating in the ICP comparison and for all the years in between benchmark years. These are the two issues considered in the present problem.

Extrapolation of PPPs for the non-participating countries

Suppose there are M participating countries in a given bench mark year. Then we have PPP_j (j = 1, 2, 3, …, M) as the output of the ICP exercise. The problem is one of extrapolating these PPPs to countries outside the ICP. The basic approach used in the literature thus far is to formulate a regression relationship between observed PPPs with a set of explanatory variables. This is achieved through the use of the concept of national price level. If ER_j denotes the exchange rate of currency of country j, then the national price level, PL_j, for country j is defined as:

$$PL_j = \frac{PPP_j}{ER_j} \tag{1}$$

For example, if the PPP and ER for Japan are 155 and 80 yen respectively, then the price level in Japan is 1.94 indicating that prices in Japan are roughly double to that in the United States.

There is considerable literature (Kravis and Lipsey 1983 and 1986; Clague, 1988; Bergstrand, 1996 to select a few papers) focusing on the problem of explaining the national price levels. It has been found that for most developed countries the price levels are around unity and for most developing countries these ratios are usually well below unit. Most of the explanations of price levels are based on productivity differences in traded and non-traded goods across developed and developing countries. There is a general consensus that variables like resource abundance, population, size of the agriculture sector in the economy, trade balance, openness, educational attainment and share of exportable services (such as tourism) are the primary drivers of the price levels. In general it is possible to identify a vector of regressor variables and postulated a regression relationship:

$$PL_j = F(X_1, X_2, X_3, \ldots X_k) + e_j \tag{2}$$

where e_j is a random disturbance with specific distributional characteristics.

Once this regression model is specified properly and estimated, the resulting estimates of the parameters can be used in predicting the "price levels" for non-participating countries. Since the exchange rates, ER_j, are observed it is possible to obtain predictions of the PPPs.

Extrapolation of PPPs for non-benchmark years

In comparison to the prediction of PPPs for non-participating countries discussed in the previous section, the methodology used in the extrapolation of the PPPs is relatively simple. Since $PPP_{j,t}$ represents the PPP for country j in period t relative to the United States (or some other reference country), it is possible to obtain a PPP for country *j* in period *t+1* by adjusting $PPP_{j,t}$ for differential movements of prices in country *j* and the US over the period *t* to *t+1*. National price movements are measured through the gross domestic product deflator (or the GDP deflator) for period *t+1* relative to period *t*. This is due to the fact that PPPs from the ICP refer to the whole GDP, GDP deflators are used in this extrapolation process.[3] The extrapolation of PPP to period *t+1* is given by the formula:

$$PPP_{j,t+1} = PPP_{j,t} \times \frac{GDPDef_{j,[t,t+1]}}{GDPDef_{US,[t,t+1]}} \tag{3}$$

The appropriate extrapolation of the price level is then given by

$$PL_{j,t+1} = \frac{PPP_{j,t+1}}{ER_{j,t+1}} = \frac{PPP_{j,t}}{ER_{j,t}} \times \frac{GDPDef_{j,[t,t+1]}}{GDPDef_{US,[t,t+1]}} \times \frac{ER_{j,t}}{ER_{jt+1}} \tag{4}$$

This extrapolation process can be used in conjunction with the prediction model in equation (2).

The use of equations (2) and (4) in practice can lead to some consistency issues. For example if two different benchmark PPPs, say for years 1985 and 1990, are used in obtaining extrapolations to the year 1997, there will be two different predictions for the PPP in year 1997. Which one should be use? Or is there some way of obtaining a single prediction for 1997 that makes use of all the historical

[3] It is necessary to choose the type of deflator to use for purposes of extrapolation. The choice is intricately connected to the scope and coverage implicit in the PPP that is being extrapolated.

information that is available at a given point of time t? This is the problem that is pursued in the following section.

3. A Unified and Consistent Approach

Our approach starts by considering the ICP benchmark data as an unbalanced data set. This is so as it contains observations (roughly every five years from 1975 to 1999) with varying coverage of countries of PPP conversion factors (PPPs). It is also important to note that growth rates in PPPs for the complete panel can be computed from published national account statistics and the definition in (4) (we discuss the observed growth rates in Section 4). These growth rates are used by previous methods to extrapolate PPPs across time for participating countries as already stated.

Using theoretically based arguments (as discussed in the previous section), an econometric model for the price level ratio ($PL_t=PPP_t/ER_t$) (if observable) for the panel of countries can be specified. This model includes autocorrelated errors to recognize the temporal dimension of PL and spatially correlated errors to incorporate cross-country correlations. Following Doran (1996) and Rambaldi, Hill and Doran (2004), we re-write the model in a state-space form, so that the observation equation is specified as a function either the ***observed*** PLs or an observable function of them (ie their growth rates). We note PLs are observed during benchmark years for participating countries, and the growth rates in PLs are observed for the complete panel.

The Econometric Model

Let $\mathbf{Y}_t$ ($N \times 1$) be the price level (PPP_t/ER_t) for the N countries at time t (if observed). The aim is to produce predictions ($\hat{\mathbf{Y}}_t$), given benchmark observations for some countries in some years, and growth rates for all countries in all years. The starting point is a suitable econometric model:

$$\mathbf{y}_t = \mathbf{X}_t\boldsymbol{\beta} + \mathbf{e}_t \qquad (5)$$

where,

$\mathbf{y}_t$ is the natural log of $\mathbf{Y}_t$

$\mathbf{X}_t$ a N × K matrix of observed related economic variables derived from the theoretical literature of price levels (PL), such us *trade openness, education levels, resource abundance, etc.*

$\boldsymbol{\beta}$ a K × 1 unknown parameter vector

$\mathbf{e}_t$ an N×1 unobserved random error, which is specified to account for autocorrelation and spatial autocorrelation, as follows

$$\mathbf{e}_t = \rho\, \mathbf{e}_{t-1} + \mathbf{u}_t \qquad (6)$$

$$\mathbf{u}_t = (\mathbf{I} - \phi\mathbf{W})^{-1}\zeta_t \qquad (7)$$

where,

ρ a scalar autocorrelation parameter.

ϕ a scalar spatial autocorrelation parameter,

$\mathbf{W}$ a known matrix measuring spatial contiguity of countries.

$\zeta_t \sim MN(\mathbf{0},\ \sigma_1^2\mathbf{I})$

$E[\mathbf{u}_t\mathbf{u}_t'] = \sigma_1^2\boldsymbol{\Omega}_t = \sigma_1^2(\mathbf{I} - \phi\mathbf{W})^{-1}[(\mathbf{I} - \phi\mathbf{W})^{-1}]'$

$E[\mathbf{u}_t\mathbf{u}_{t-s}'] = \mathbf{0} \qquad \forall\ s \neq 0$

The state space representation

We define $\alpha_t = [\mathbf{e}'_t, \mathbf{e}'_{t-1}]'$ as the unobservable "state vector." It follows from (6)

$$\alpha_t = \mathbf{D}\ \alpha_{t-1} + \xi_t \tag{8}$$

where,

$\mathbf{D} = \rho\mathbf{I}_{2N}$

$\xi_t \sim \mathrm{MN}(\mathbf{0}, \sigma_1^2 \mathbf{Q}_t)$ which accounts for spatial autocorrelation arising out of countries' characteristics (this follows from (7)).

$\mathbf{Q}_t = \mathbf{I}_2 \otimes \mathbf{\Omega}_t$

$\boldsymbol{\alpha}_t \sim MN(\mathbf{0}, \mathbf{P}_t)$

Furthermore, there exists at all t, a vector $\mathbf{y}_t^*$ of observations. This vector has dimension $N_1 = N$ in non-benchmark years, and $N_1 = N + N_t$ in benchmark years, where $1 \leq N_t \leq N$ and N_t is the number of countries participating in the benchmark exercise in year t.

In benchmark years we observe:

$$\mathbf{S}_t \mathbf{y}_t = \mathbf{S}_t [\mathbf{I}_N, \mathbf{0}] \boldsymbol{\alpha}_t + \mathbf{S}_t \mathbf{X}_t \boldsymbol{\beta} + \boldsymbol{\eta}_t \tag{9}$$

where,

$\mathbf{S}_t$ is $N_t \times N$, a known selection matrix accounting for PL only being available for <u>some</u> countries

$\eta_t \sim (0,\ \sigma_2^2 \mathbf{V}_t)$ is a random error that acknowledges that benchmark exercises can carry some measurement error.

$\mathbf{V}_t$ is $N_t \times N_t$, diagonal, with elements assumed to be inversely related to the measurement error in the benchmarking exercise for country *j*.

For all years growth rates in PL are observed from national accounts, $\mathbf{Gr}_t = \mathbf{y}_t - \mathbf{y}_{t-1}$, we discuss the definitions below. Our state-space representation will preserve the integrity of these growth rates. That is, the completed panel of PL will be consistent with observed growth rates.

It follows that for all years we observe:

$$\mathbf{Gr}_t = \mathbf{y}_t - \mathbf{y}_{t-1} = [\mathbf{I}_N, -\mathbf{I}_N]\boldsymbol{\alpha}_t + (\mathbf{X}_t - \mathbf{X}_{t-1})\boldsymbol{\beta} \tag{10}$$

Thus,

We then write (9) and (10) as:

$$\mathbf{y}_t^* = \mathbf{Z}_t\boldsymbol{\alpha}_t + \mathbf{G}_t\boldsymbol{\beta} + \boldsymbol{\varepsilon}_t \tag{11}$$

Where,

$\mathbf{y}^* = \begin{pmatrix} \mathbf{S}_t\mathbf{y}_t \\ \mathbf{Gr}_t \end{pmatrix}$ in benchmark years, and $\mathbf{y}^* = \mathbf{Gr}_t$ in non-benchmark years

$\mathbf{Z}_t = \begin{pmatrix} \mathbf{S}_t[\mathbf{I}_N, \mathbf{0}] \\ [\mathbf{I}_N, -\mathbf{I}_N] \end{pmatrix}$ in benchmark years, and $\mathbf{Z}_t = [\mathbf{I}_N, -\mathbf{I}_N]$ in non-benchmark years

$\mathbf{G}_t = \begin{pmatrix} \mathbf{S}_t\mathbf{X}_t \\ \mathbf{X}_t - \mathbf{X}_{t-1} \end{pmatrix}$ in benchmark years, and $\mathbf{G}_t = (\mathbf{X}_t - \mathbf{X}_{t-1})$ in non-benchmark years

ε_t is random with mean zero and variance-covariance $\mathbf{H}_t$,

$\mathbf{H}_t = \begin{bmatrix} \mathbf{V}_t & \mathbf{0} \\ \mathbf{0} & \mathbf{0} \end{bmatrix}$ is $N_1 \times N_1$ in benchmark years and $\mathbf{H}_t = \mathbf{0}_{N\times N}$ in non-benchmark years

Equation (10), and therefore (11) is, in effect, a constraint insuring the predictions of PL's growth rates, $\mathbf{Gr}_t$, will be identical to observed benchmark values. This constrain maps the state vector to the known information. The observation equation (11) together with (8), constitute a conventional state-space model (SSM). SSMs cannot be estimated with ordinary regression techniques, however, it is well known that the Kalman Filter (KF) can be used to estimate (or predict) $\boldsymbol{\alpha}_t$ optimally from the observations $\mathbf{y}^*_1, \mathbf{y}^*_2, ..., \mathbf{y}^*_t$. In addition, the KF produces as outputs the one-step ahead prediction error, $\boldsymbol{\upsilon}_t$ and its covariance matrix $\mathbf{F}_t$ (required to evaluate the likelihood function) and can be used to simultaneously obtain estimates $\hat{\boldsymbol{\alpha}}_t$ and $\hat{\boldsymbol{\beta}}$ with their respective standard errors, as well as the parameters of the covariances $\mathbf{Q}_t$ and $\mathbf{H}_t$. A full discussion of the KF algorithm and maximum likelihood estimation can be found in Harvey (1990, 100-110 and 130-133).

A fundamental property of the Kalman Filter (see Doran (1992)), guarantees $\hat{\mathbf{G}}\mathbf{r}_t = \mathbf{G}\mathbf{r}_t$ for all years, ensuring the consistency of the constructed series (see also Doran (1996) and Rambaldi, Hill and Doran (2004)).

Finally a prediction of PL, $\hat{\mathbf{y}}_t$, at time t for all countries is given by:

$$\hat{\mathbf{y}}_t = \mathbf{X}_t\hat{\boldsymbol{\beta}} + [\mathbf{I}_N, 0]\hat{\boldsymbol{\alpha}}_t \qquad (12)$$

A note on national Price Level's Growth rates

An expression for the growth rate in PL_j= Y_{jt} can be obtained from equation (4):

$$Y_{jt} = \frac{PPP_{jt}}{ER_{jt}} = \frac{PPP_{j,t-1}}{ER_{j,t-1}} \times \frac{GDPDef_{j,[t-1,t]}}{GDPDef_{US,[t-1,t]}} \times \frac{ER_{j,t-1}}{ER_{jt}}$$

$$Y_{jt} = Y_{jt} \times \frac{GDPDef_{j,[t-1,t]}}{GDPDef_{US,[t-1,t]}} \times \frac{ER_{j,t-1}}{ER_{jt}}$$

Then,

$$Gr_{jt} = \frac{Y_{jt} - Y_{j,t-1}}{Y_{j,t-1}} = \left[\frac{GDPDef_{j,[t-1,t]}}{GDPDef_{US,[t-1,t]}} \times \frac{ER_{j,t-1}}{ER_{jt}}\right] - 1$$

An approximation to Gr_{jt} is given by the logged differences of Y_{jt}

$$y_{jt} - y_{j,t-1} = \ln\left[\frac{GDPDef_{j,[t-1,t]}}{GDPDef_{US,[t-1,t]}}\right] + \ln\left[\frac{ER_{j,t-1}}{ER_{jt}}\right] \qquad (13)$$

This is the definition used in the state-space model defined in equation (10).

4. Estimation Method and Computational Issues

The estimation requires two main steps. First, a numerical optimisation of the likelihood function over the parameters, ρ, ϕ, σ_1^2 and σ_2^2. The likelihood function takes the form:

$$\ell nL(\boldsymbol{\beta}, \varphi; \mathbf{y}) = -\frac{1}{2}\ell n(2\pi)\sum_{t=1}^{T} N_{1t} - \frac{1}{2}\sum_{t=1}^{T}\ell n\,|\,\mathbf{F}_t\,| - \frac{1}{2}\sum_{t=1}^{T}\boldsymbol{\upsilon}_t'\mathbf{F}_t^{-1}\boldsymbol{\upsilon}_t \qquad (14)$$

where, φ = [ρ ϕ σ_1^2 σ_2^2].

A concentrated form of the likelihood function can be shown to be:

$$\ell nL(\boldsymbol{\beta}, \gamma; \mathbf{y}) = -\ell n(\sigma_1^2) - \left(\sum_{t=1}^{T} N_{1t}\right)^{-1}\sum_{t=1}^{T}\ell n\,|\,\mathbf{F}_t\,| \qquad (15)$$

where,

γ = [ρ ϕ λ]

λ = σ_1^2 / σ_2^2

$$\sigma_1^2 = \sum_{t=1}^{T}\boldsymbol{\upsilon}_t'\mathbf{F}_t^{-1}\boldsymbol{\upsilon}_t \Big/ \sum_{t=1}^{T} N_{1t}$$

The vector β is estimated by a GLS-MLE routine. That is, at every iteration of the numerical optimisation, a new estimate of β is obtained and used to continue the search. When final estimates of γ are obtained, they are used to obtain the final GLS-MLE estimates of β.

With β**, H** and **Q** replaced by their estimates, the state space in (11) and (8) is run through the Kalman Filter and smoother to obtain N vectors $\hat{\boldsymbol{\alpha}}_t$ of dimension T, and standard errors for $\hat{y}_{it}$ from the square root of the diagonal elements of the estimated covariance matrix, $\hat{\mathbf{P}}_t$ (we discussed the computation of standard errors for PL below). The GLS-MLE estimator of β and the computation of the value of the likelihood function, at every iteration, are obtained through a run of the Kalman Filter[4]. The Kalman filter requires starting values for the state-vector and its covariance matrix, α_0 and $\mathbf{P}_0$, respectively. When the transition equation is non-stationary, the unconditional distribution of the state vector is not defined, and the initial distribution of α_0 must be specified in terms of a diffuse or non-informative prior. $\hat{\mathbf{P}}_0 = \kappa\mathbf{I}$, where κ is a very large positive scalar (see Harvey (1990), Section 3.3.4). A non-stationary transition equation would occur if the autocorrelation parameter, ρ, is equal to one. Alternative algorithms have been proposed for the diffuse prior that do not involve κ (de Jong (1988,1989) and Koopman (1997)). Normally, the effect of a large κ disappears within the first few periods, and has no effect on the GLS-MLE estimator[5].

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[4] This is since the likelihood function in (15) is written as a function of the one-step ahead prediction error which is obtained from the Kalman filter.

[5] An exception is in the case of completing very sparse panels, where observations on the dependent variable for some cross-sections do not eventuate until close of the end of the sample. For a discussion see Rambaldi, Hill and Knight (2003).

Predicted PPP and prediction standard errors

To obtain predicted PPPs we use equation (12) to obtain $\hat{y}_{it} = \ln\left(\frac{P\hat{P}P_{it}}{ER_{it}}\right)$, from which we obtain $P\hat{P}P_{it}$. The prediction standard errors are computed as:

$$\text{se}(P\hat{P}P) = \sqrt{\text{var}(P\hat{P}P_{it})} = \sqrt{\text{var}(\hat{y}_{it})} \times P\hat{P}P \qquad (16)$$

The expression has been derived from a Taylor's expansion:

$$Var(g(\text{x})) \approx Var(\exp(\hat{y}_{it})) \approx Var(\hat{y}_{it})\left[\frac{\partial}{\partial \hat{y}_{it}}\exp(\hat{y}_{it})\right]^2$$

where ER_{it} is assumed known and therefore $Var(\ln(ER_{it}))=0$.

5. An Illustration

We present a small illustration of the method using OECD data. These data can be easily accessed through the OECD and World Bank sites. Several of the countries in the OECD were participants in the ICP project since its first benchmark year. We use 24 countries for the illustration. They are: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, (S.) Korea, Mexico, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Turkey and the United Kingdom.

The data for the empirical example was for the period 1970 to 2000, annual, and we discuss next the *dependent*, *explanatory*, and *covariances related variables*.

Dependent Variable

Benchmark PPP information were collected from the OECD site and the World Bank's Stars data set. Benchmark years were: 1975, 1980, 1985, 1990, 1993, 1996 and 1999. Not all countries in the sample had participated in all the benchmarks (for France, although a participant in all of them, only two benchmarks were available). The results tables presented in the Appendix (see columns 3 and 4 and 9 and 10) show the exchange rate in units of domestic currency per US$ and PPP data available by country (two countries are shown per table). For the purpose of analyzing the performance of our method we assumed that countries had participated only sporadically in the benchmark exercises. Only benchmark years marked with the superscript "K", Column 4 (and 10), were included in the estimation and prediction of the panel. Growth rates in PL were computed as per formula (13).

Explanatory Variables

The following variables were included as explanatory variables in the model:

FDI%: Foreign direct investment, net inflows (% of GDP)

LE: Life Expectance in years

SERV%: Services, value added (% of GDP)

OPEN%: Trade (% of GDP)

School enrollment, secondary (% net), could not be included as the data available from the OECD site were only five-yearly. We believe this variable should be included, and will be in the next iteration of this exercise

Covariances related Variables

a) *Measuring spatial autocorrelation*

A contiguity matrix was constructed were a value of one (1) is given to countries that share a border. For the purpose of this exercise Australia and New Zealand were assumed to share a border, Iceland was assumed to share borders with Denmark and Norway, and Japan with S. Korea. This is the matrix **W** in (7).

b) *Capturing accuracy of benchmark data collection*

We assume that the accuracy of a PPP benchmark is inversely related to a country's GDP per capita. Therefore the matrix $\mathbf{V}_t$ is diagonal (see definitions of equation (9)) with values equal to the inverse of each country's GDP per capita measured in constant US$ of 1995.

Results

As stated in the previous section the Kalman filter requires staring values for the parameters in γ**.** Note that the autocorrelation and spatial autocorrelation parameters are bounded between 0 and 1. The parameter λ is also bounded between zero and one if $\sigma_1^2 > \sigma_2^2$ [6]. Thus a grid search was used first to obtain starting values for the numerical maximization of the log-likelihood function in (15). Grid-search values were used to start a numerical maximization and obtain estimates of γ. Table 1 presents the results of the grid search and resulting maximized values. The estimates of γ were then used to obtain the estimates of β (also shown in Table 1).

[6] This can always be achieved by a simple redefinition of λ

Table 1. Maximum Likelihood Estimates

	Grid Search	MLE Estimate	Std Err
Intercept		-0.3076	0.5691
FDI%		0.00012	0.0026
LE		0.00014	0.00065
SERV%		-0.00056	0.00374
OPEN%		-0.0107***	0.00117
$\hat{\lambda}$	0.9	0.6897***	0.2357
$\hat{\phi}$	0.2	0.1912***	0.0162
$\hat{\rho}$	0.9	0.9812***	0.0400
$\hat{\sigma}_1^2$		0.0114	

*** Significant at the 1% level.

These estimates were used to run the Kalman Filter and smoother and obtain predictions (and prediction standard errors) of $\mathbf{y}_t$ (the natural log of the Price Level ratio) for all years and countries. With these values a prediction of the PPP values and corresponding prediction standard errors for each year and country were computed. The result's tables in the Appendix show the computed values. The model's prediction of the PL's growth rates had to be identical to the actual values for every observation (this is a model's constraint). They were checked to insure the results were time-space consistent.

To gain a visual understanding we have plotted the results for two countries, Australia and Japan, in Figures 1 and 2. In these figures we have included the PPP value published from the ICP benchmark exercises, our model's predictions and 95% prediction intervals (based on two standard errors), as well as PWT 6.1 predicted PPP values. The circles show when, for the purpose of this exercise, each country was assumed to have participated in a benchmark exercise. We assumed Australia and Japan only participated in two benchmark exercises 1980, and 1999.

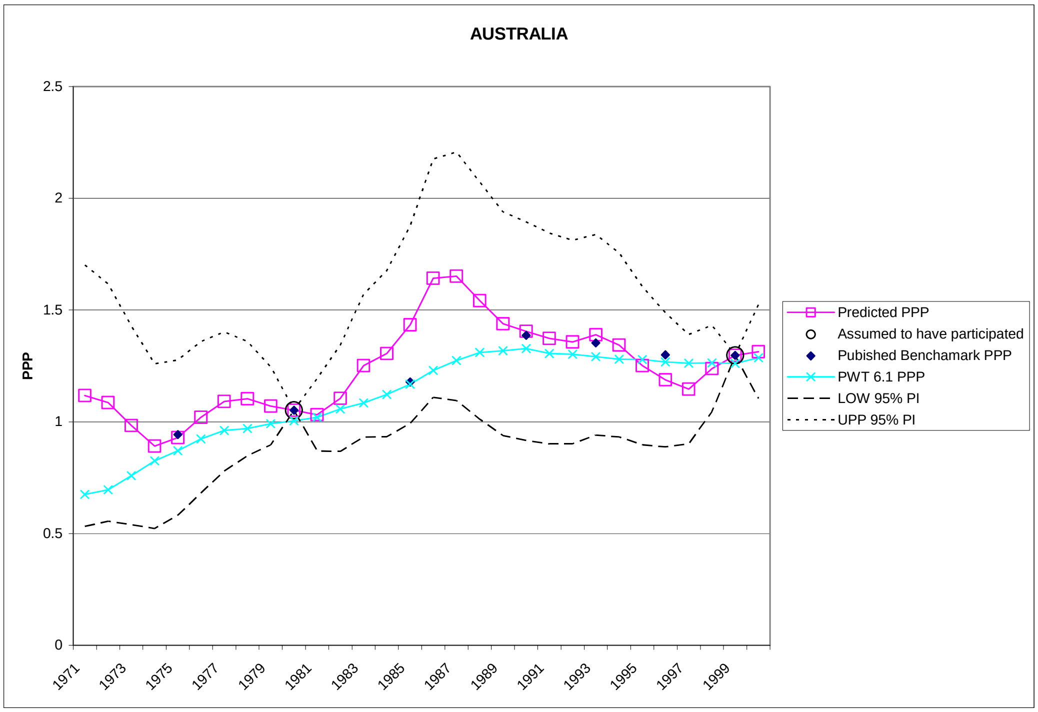

Figure 1. Australia: PPP Predictions, PPP benchmark information available, benchmark information assumed to be available, PWT 6.1 computed PPP AND 95% Prediction Interval.

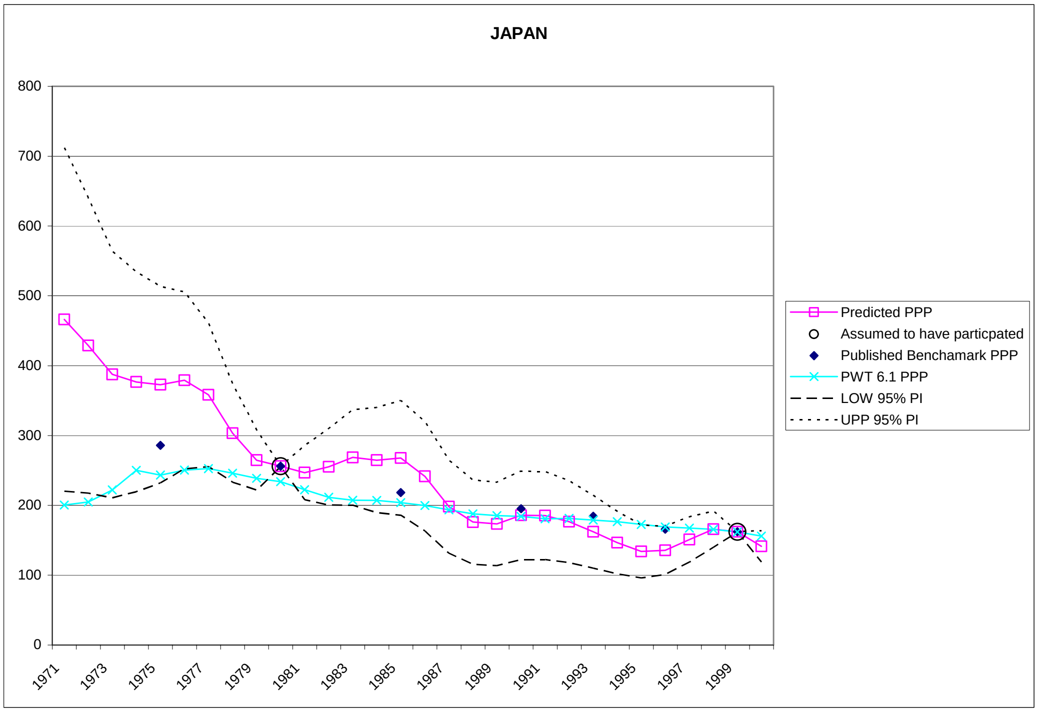

Figure 2. Japan: PPP Predictions, PPP benchmark information available, benchmark information assumed to be available, PWT 6.1 computed PPP AND 95% Prediction Interval.

The complete results of the illustration are in the Appendix tables. These results are very plausible. It is expected that PPPs will be lower than the respective ER for less developed economies. This is clearly observable in the cases of Spain, Portugal, Mexico, S. Korea and Turkey (arguably among the "less" developed economies in the OECD). In Turkey's case, the model has also been able to follow the depreciation of the currency during the periods of high inflation. The results for Australia are as expected since the exchange rate was fixed until 1983 and believed to have been overvalued during this period. This is reflected by the PPPs being considerably higher than the corresponding ER value until 1983.

The prediction of a country's PPP is extremely accurate for years when the benchmark value is used. Overall, prediction errors become generally smaller as more benchmarks have been observed. Thus, in general for any given country, prediction errors are smaller for the later years of the sample. The predictions are more accurate for countries that are contiguous to others in the sample. This is anticipated as the use of a spatially correlated covariance is expected to improve the spatial prediction and highlights the importance of a wide coverage of the benchmark exercises.

These results are very promising, considering it is just an illustration. There are identified improvements that can be made, namely, the economic model, alternative spatial structure and the inclusion of all available benchmark information can only improve the performance of the method and reduce the size of the standard errors.

Conclusions

This paper shows how a constrained state-space formulation can be used to generate time-space consistent comparable PPPs (therefore GDP) from all the available information, namely, benchmark PPP values obtained by the International Comparisons Program (only covering some countries and some years) and national price levels' growth rates (available for all years). We treat the information as an unbalanced panel and constrain the results to preserve national price levels' growth rates. Previous methods are based on extrapolating the results of a single benchmark exercise (usually the latest available) to non-participating countries through a regression framework and through time using of national price levels' growth rates. Our results produce some re-adjustment of some of the benchmark values so that the resulting panel of N countries and T years is consistent with national growth rates.

An illustration is presented for 24 OECD countries which, for the purpose of the exercise, are assumed to have only participated in the ICP benchmarking sporadically. A simple econometric model of the log of national price levels (the ratio of PPP to the exchange rate in domestic currency per US$) is written in a constrained state-space form accounting for autocorrelation and spatial autocorrelation. The results are consistent with general expectations on the behaviour of the PL ratio.

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APPENDIX: RESULTS TABLES

Headings' definitions:
ER: Units of domestic currency per US$
BPPP: Published Benchmark PPPs values
PLPL: Predicted natural logarithm of PPP/ER
SE: Standard Error of Predicted PPP
[K] Country assumed to have participated in the ICP Benchmark exercise in these years

	AUSTRALIA	ER	B PPP	PLPL	Predicted PPP	SE	AUSTRIA	ER	B PPP	PLPL	Predicted PPP	SE
1971		0.883		0.2355	1.1171	0.2925		1.814		0.8218	4.1259	1.9943
1972		0.839		0.2587	1.0863	0.2655		1.680		0.8281	3.8452	1.7880
1973		0.704		0.3340	0.9833	0.2222		1.423		0.8511	3.3326	1.4885
1974		0.697		0.2458	0.8908	0.1842		1.358		0.7332	2.8278	1.2108
1975		0.764	0.943	0.1959	0.9293	0.1736		1.266	1.294	0.6865	2.5146	1.0299
1976		0.818		0.2208	1.0205	0.1693		1.304		0.6083	2.3952	0.9363
1977		0.902		0.1903	1.0908	0.1556		1.201		0.6089	2.2081	0.8216
1978		0.874		0.2331	1.1030	0.1278		1.055		0.6053	1.9331	0.6825
1979		0.895		0.1797	1.0707	0.0873		0.972		0.5130	1.6226	0.5414
1980		0.878	1.051[K]	0.1800	1.0514	0.0009		0.940	1.138	0.3903	1.3891	0.4359
1981		0.870		0.1700	1.0314	0.0808		1.157		0.1949	1.4064	0.4127
1982		0.986		0.1138	1.1047	0.1188		1.240		0.2445	1.5830	0.4312
1983		1.110		0.1196	1.2510	0.1597		1.305		0.2540	1.6829	0.4216
1984		1.140		0.1357	1.3051	0.1861		1.454		0.1806	1.7419	0.3961
1985		1.432	1.178	0.0015	1.4340	0.2207		1.504	1.079	0.1454	1.7389	0.3525
1986		1.496		0.0934	1.6425	0.2666		1.110		0.3372	1.5544	0.2839
1987		1.428		0.1452	1.6514	0.2780		0.919		0.3260	1.2730	0.2028
1988		1.280		0.1863	1.5420	0.2656		0.897		0.2124	1.1096	0.1452
1989		1.265		0.1290	1.4387	0.2504		0.962		0.1171	1.0810	0.1011
1990		1.281	1.387	0.0925	1.4053	0.2445		0.826	1.020[K]	0.2109	1.0203	0.0007
1991		1.284		0.0671	1.3729	0.2361		0.849		0.1043	0.9418	0.0864
1992		1.362		-0.0034	1.3570	0.2278		0.799		0.1545	0.9320	0.1178
1993		1.471	1.353	-0.0568	1.3894	0.2246		0.845	1.008	0.1147	0.9480	0.1426
1994		1.368		-0.0178	1.3437	0.2056		0.830		0.1338	0.9489	0.1657
1995		1.349		-0.0753	1.2511	0.1769		0.733		0.1526	0.8535	0.1665
1996		1.278	1.299	-0.0733	1.1876	0.1497		0.769	0.987	0.0199	0.7849	0.1671
1997		1.347		-0.1619	1.1460	0.1223		0.887		-0.1159	0.7898	0.1806
1998		1.592		-0.2512	1.2382	0.0966		0.900		-0.1368	0.7846	0.1903
1999		1.550	1.297[K]	-0.1782	1.2970	0.0009		0.939	0.946	-0.2150	0.7570	0.1929
2000		1.725		-0.2725	1.3134	0.1048		1.085		-0.3664	0.7524	0.2008

	BELGIUM	ER	B PPP	**PLPL**	**Predicted PPP**	**SE**	**CANADA**	ER	B PPP	**PLPL**	**Predicted PPP**	**SE**
1971		1.211		0.5634	2.1279	0.9339		1.010		0.5275	1.7113	0.6884
1972		1.091		0.5943	1.9768	0.8274		0.990		0.5022	1.6356	0.6336
1973		0.966		0.5224	1.6291	0.6485		1.000		0.4563	1.5783	0.5879
1974		0.966		0.3163	1.3249	0.4998		0.978		0.4393	1.5175	0.5427
1975		0.912	1.111	0.3385	1.2789	0.4553		1.017	1.222	0.3779	1.4843	0.5086
1976		0.957		0.3162	1.3129	0.4391		0.986		0.4272	1.5115	0.4953
1977		0.889		0.3251	1.2299	0.3840		1.064		0.3514	1.5114	0.4723
1978		0.781		0.3367	1.0932	0.3162		1.141		0.3028	1.5441	0.4589
1979		0.727		0.2208	0.9064	0.2404		1.171		0.2725	1.5384	0.4332
1980		0.725	0.999	0.0684	0.7762	0.1861		1.169	1.268	0.2492	1.5001	0.3988
1981		0.920		-0.1589	0.7852	0.1667		1.199		0.2207	1.4950	0.3733
1982		1.133		-0.2615	0.8720	0.1588		1.234		0.2441	1.5747	0.3671
1983		1.268		-0.2970	0.9418	0.1388		1.232		0.2713	1.6164	0.3490
1984		1.432		-0.3854	0.9743	0.1005		1.295		0.1903	1.5665	0.3102
1985		1.472	1.003[K]	-0.3840	1.0026	0.0007		1.366	1.284	0.1322	1.5584	0.2789
1986		1.107		-0.0384	1.0657	0.0974		1.390		0.1260	1.5761	0.2498
1987		0.926		0.0716	0.9942	0.1112		1.326		0.1555	1.5491	0.2107
1988		0.912		0.0426	0.9512	0.1064		1.231		0.1658	1.4526	0.1598
1989		0.977		-0.0001	0.9767	0.0892		1.184		0.1381	1.3594	0.1047
1990		0.828	0.978[K]	0.1659	0.9779	0.0007		1.167	1.303[K]	0.1104	1.3030	0.0010
1991		0.847		0.1120	0.9468	0.0934		1.146		0.1087	1.2772	0.0889
1992		0.797		0.2009	0.9744	0.1310		1.209		0.0484	1.2686	0.1117
1993		0.858	0.925	0.2040	1.0517	0.1663		1.290	1.263	-0.0151	1.2708	0.1186
1994		0.829		0.2332	1.0472	0.1940		1.366		-0.0822	1.2578	0.1107
1995		0.731		0.1945	0.8877	0.1847		1.372		-0.1146	1.2238	0.0852
1996		0.768	0.913	0.0309	0.7916	0.1804		1.364	1.185[K]	-0.1401	1.1853	0.0009
1997		0.887		-0.1209	0.7858	0.1926		1.385		-0.2046	1.1284	0.0852
1998		0.900		-0.1406	0.7818	0.2033		1.484		-0.3050	1.0936	0.1157
1999		0.939	0.934	-0.2021	0.7668	0.2094		1.486	1.191	-0.3164	1.0827	0.1390
2000		1.085		-0.4174	0.7150	0.2048		1.485		-0.3509	1.0456	0.1536

	DENMARK	ER	B PPP	**PLPL**	**Predicted PPP**	**SE**	**FINLAND**	ER	B PPP	**PLPL**	**Predicted PPP**	SE
1971		7.417		0.8030	16.5565	9.8954		0.704		0.3933	1.0430	0.2833
1972		6.949		0.8471	16.2119	9.3841		0.697		0.3984	1.0387	0.2611
1973		6.050		0.8619	14.3224	8.0223		0.643		0.4327	0.9907	0.2280
1974		6.095		0.7094	12.3892	6.7094		0.635		0.3880	0.9355	0.1943
1975		5.746	8.019	0.7152	11.7491	6.1459		0.619	0.777	0.3741	0.8994	0.1649
1976		6.045		0.6806	11.9393	6.0597		0.650		0.3964	0.9661	0.1616
1977		6.003		0.7075	12.1805	5.9873		0.678		0.3930	1.0040	0.1484
1978		5.515		0.7668	11.8724	5.6386		0.693		0.3777	1.0103	0.1242
1979		5.261		0.7268	10.8819	4.9794		0.655		0.3798	0.9578	0.0847
1980		5.636	8.383	0.6030	10.2999	4.5264		0.627	0.859[K]	0.3140	0.8588	0.0006
1981		7.123		0.4401	11.0612	4.6548		0.726		0.1770	0.8664	0.0771
1982		8.332		0.4408	12.9475	5.2056		0.811		0.2105	1.0006	0.1247
1983		9.145		0.4710	14.6470	5.6115		0.937		0.2123	1.1583	0.1752
1984		10.357		0.4336	15.9784	5.8163		1.011		0.2522	1.3007	0.2250
1985		10.596	9.140	0.4470	16.5694	5.7091		1.042	0.977	0.2724	1.3688	0.2623
1986		8.091		0.6362	15.2870	4.9875		0.853		0.4148	1.2909	0.2686
1987		6.840		0.6560	13.1822	4.0515		0.739		0.4062	1.1098	0.2471
1988		6.732		0.5778	11.9959	3.4506		0.704		0.3731	1.0217	0.2410
1989		7.310		0.4998	12.0497	3.2157		0.722		0.3335	1.0073	0.2498
1990		6.189	9.393	0.6051	11.3338	2.7762		0.643	1.074	0.4033	0.9625	0.2493
1991		6.397		0.4760	10.2962	2.2841		0.680		0.3092	0.9265	0.2495
1992		6.036		0.5072	10.0235	1.9732		0.753		0.2308	0.9490	0.2646
1993		6.484	8.786	0.4452	10.1205	1.7087		0.961	1.024	0.0588	1.0188	0.2931
1994		6.361		0.4651	10.1271	1.3827		0.879		0.1375	1.0080	0.2983
1995		5.602		0.4748	9.0066	0.8611		0.734		0.1389	0.8438	0.2563
1996		5.799	8.328[K]	0.3620	8.3278	0.0047		0.773	0.990	-0.0251	0.7535	0.2343
1997		6.605		0.2510	8.4890	0.6574		0.873		-0.1046	0.7864	0.2499
1998		6.701		0.2386	8.5067	0.6588		0.899		-0.0799	0.8298	0.2687
1999		6.976	8.244[K]	0.1670	8.2441	0.0046		0.939	0.996	-0.1080	0.8425	0.2774
2000		8.083		0.0370	8.3874	0.7882		1.085		-0.2112	0.8787	0.2944

	FRANCE	ER	B PPP	**PLPL**	**Predicted PPP**	**SE**	**GERMANY**	ER	B PPP	**PLPL**	**Predicted PPP**	**SE**
1971		0.845		2.2817	8.2749	3.7501		1.785		0.3550	2.5454	1.9008
1972		0.769		2.2741	7.4742	3.2304		1.630		0.3696	2.3592	1.7077
1973		0.680		2.2316	6.3302	2.6015		1.367		0.3934	2.0252	1.4197
1974		0.734		2.0345	5.6133	2.1866		1.323		0.2452	1.6907	1.1467
1975		0.653		2.0774	5.2166	1.9180		1.258	1.566	0.1928	1.5254	1.0001
1976		0.729		1.9522	5.1325	1.7727		1.287		0.1323	1.4695	0.9308
1977		0.749		1.9332	5.1772	1.6690		1.187		0.1492	1.3784	0.8426
1978		0.688		1.9545	4.8574	1.4501		1.027		0.1729	1.2208	0.7191
1979		0.649		1.8962	4.3200	1.1821		0.937		0.1090	1.0450	0.5923
1980		0.644		1.8057	3.9196	0.9696		0.929	1.309	0.0074	0.9363	0.5096
1981		0.829		1.6109	4.1487	0.9093		1.156		-0.1881	0.9574	0.4995
1982		1.002		1.6079	5.0018	0.9399		1.241		-0.1608	1.0564	0.5272
1983		1.162		1.6079	5.8005	0.8813		1.306		-0.1667	1.1051	0.5262
1984		1.332		1.5704	6.4064	0.6818		1.455		-0.2292	1.1570	0.5242
1985		1.370	6.617[K]	1.5750	6.6170	0.0047		1.505	1.142	-0.2389	1.1854	0.5094
1986		1.056		1.8335	6.6056	0.6472		1.110		0.0274	1.1412	0.4792
1987		0.916		1.8765	5.9838	0.7605		0.919		0.0862	1.0018	0.4085
1988		0.908		1.8715	5.9011	0.8276		0.898		0.0755	0.9683	0.3806
1989		0.973		1.8800	6.3737	0.9047		0.961		0.0782	1.0394	0.3902
1990		0.830		2.0494	6.4444	0.8549		0.826	1.068	0.2556	1.0667	0.3781
1991		0.860		1.9772	6.2119	0.7667		0.849		0.2127	1.0496	0.3506
1992		0.807		2.0543	6.2957	0.6094		0.799		0.3160	1.0952	0.3404
1993		0.863	6.570[K]	2.0294	6.5700	0.0043		0.845	1.075	0.3246	1.1695	0.3323
1994		0.846		2.0252	6.4139	0.6699		0.830		0.3584	1.1873	0.3020
1995		0.761		1.9965	5.6028	0.8194		0.733		0.3717	1.0626	0.2359
1996		0.780		1.8670	5.0450	0.8948		0.769	1.037	0.2450	0.9830	0.1825
1997		0.890		1.7259	4.9986	1.0120		0.887		0.1261	1.0058	0.1564
1998		0.899		1.7098	4.9719	1.1103		0.900		0.1171	1.0115	0.1140
1999		0.939		1.6310	4.7951	1.1559		0.939	0.978[K]	0.0407	0.9776	0.0006
2000		1.085		1.4875	4.8038	1.2422		1.085		-0.0972	0.9849	0.1124

	GREECE	ER	B PPP	**PLPL**	**Predicted PPP**	SE	**HUNGARY**	ER	B PPP	**PLPL**	**Predicted PPP**	SE
1971		0.088		0.0676	0.0942	0.0479		59.822		4.1320	0.9602	0.3361
1972		0.088		0.0216	0.0899	0.0443		55.260		4.0957	0.9198	0.3071
1973		0.087		0.0087	0.0877	0.0418		48.966		4.0779	0.8296	0.2635
1974		0.088		-0.0458	0.0841	0.0387		46.752		4.2164	0.6897	0.2076
1975		0.094	0.086	-0.1151	0.0839	0.0373		43.971		4.2907	0.6022	0.1711
1976		0.107		-0.1316	0.0940	0.0404		41.575		4.2175	0.6126	0.1634
1977		0.108		-0.0668	0.1011	0.0418		40.961		4.1902	0.6203	0.1545
1978		0.108		-0.0548	0.1021	0.0406		37.911		4.1381	0.6048	0.1395
1979		0.109		-0.0435	0.1041	0.0398		35.578		4.1299	0.5723	0.1210
1980		0.125	0.121	-0.1717	0.1054	0.0386		32.532		4.0602	0.5611	0.1072
1981		0.163		-0.2807	0.1228	0.0431		34.314		4.0766	0.5821	0.0986
1982		0.196		-0.1694	0.1655	0.0554		36.631		4.0171	0.6595	0.0958
1983		0.258		-0.1316	0.2265	0.0722		42.671		4.0032	0.7790	0.0916
1984		0.331		-0.0606	0.3113	0.0941		48.042		3.9590	0.9168	0.0756
1985		0.405	0.231	0.0100	0.4094	0.1169		50.119	1.020[K]	3.8946	1.0200	0.0016
1986		0.411		0.1404	0.4727	0.1270		45.832		3.8124	1.0127	0.0771
1987		0.397		0.1783	0.4750	0.1193		46.971		3.7896	1.0618	0.1058
1988		0.416		0.1903	0.5036	0.1174		50.413		3.6828	1.2680	0.1411
1989		0.477		0.1770	0.5689	0.1220		59.066		3.6039	1.6077	0.1848
1990		0.465	0.413	0.3032	0.6300	0.1226		63.206		3.3919	2.1265	0.2365
1991		0.535		0.1866	0.6446	0.1148		74.735		3.2903	2.7832	0.2771
1992		0.559		0.1783	0.6686	0.1067		78.988		3.1631	3.3409	0.2542
1993		0.673	0.541	0.0551	0.7109	0.0985		91.933	4.160[K]	3.0955	4.1601	0.0069
1994		0.712		0.0588	0.7551	0.0856		105.160		2.9784	5.3498	0.4314
1995		0.680		0.0264	0.6981	0.0562		125.681		2.9304	6.7086	0.7579
1996		0.706	0.628[K]	-0.1181	0.6277	0.0006		152.647		2.8971	8.4231	1.1546
1997		0.801		-0.1714	0.6751	0.0539		186.789		2.8721	10.5686	1.6572
1998		0.867		-0.1683	0.7329	0.0820		214.402		2.8852	11.9729	2.0793
1999		0.897	0.677	-0.1582	0.7658	0.1039		237.146		2.8966	13.0928	2.4675
2000		1.072		-0.2915	0.8012	0.1244		282.179		2.9869	14.2336	2.8714

	ICELAND	ER	B PPP	**PLPL**	**Predicted PPP**	SE	**IRELAND**	ER	B PPP	**PLPL**	**Predicted PPP**	SE
1971		0.880		-1.6789	0.1642	0.0925		0.522		0.0672	0.5580	0.1919
1972		0.883		-1.5630	0.1849	0.1010		0.508		0.1205	0.5735	0.1879
1973		0.901		-1.4594	0.2094	0.1107		0.518		0.0982	0.5718	0.1781
1974		1.000		-1.4178	0.2421	0.1238		0.543		-0.0895	0.4966	0.1466
1975		1.537	2.012	-1.4969	0.3440	0.1701		0.574	0.521	-0.1203	0.5089	0.1417
1976		1.822		-1.2540	0.5198	0.2486		0.707		-0.1592	0.6026	0.1575
1977		1.989		-1.0813	0.6744	0.3115		0.728		-0.1514	0.6256	0.1524
1978		2.711		-1.0650	0.9346	0.4163		0.662		-0.1462	0.5721	0.1289
1979		3.526		-0.9736	1.3319	0.5710		0.620		-0.2069	0.5045	0.1040
1980		4.798	7.623	-0.8532	2.0441	0.8416		0.618	0.704	-0.2528	0.4799	0.0892
1981		7.224		-0.7563	3.3909	1.3374		0.789		-0.3431	0.5598	0.0925
1982		12.352		-0.6559	6.4102	2.4176		0.895		-0.2192	0.7185	0.1022
1983		24.843		-0.5380	14.5060	5.2184		1.022		-0.1932	0.8422	0.0972
1984		31.694		-0.2853	23.8267	8.1507		1.171		-0.2863	0.8798	0.0714
1985		41.508	38.362	-0.2319	32.9156	10.6700		1.201	0.891[K]	-0.2985	0.8908	0.0009
1986		41.104		0.0037	41.2559	12.6283		0.944		-0.1037	0.8506	0.0676
1987		38.677		0.1415	44.5563	12.8127		0.854		-0.1612	0.7272	0.0807
1988		43.014		0.1700	50.9863	13.6908		0.834		-0.2650	0.6395	0.0857
1989		57.042		0.1489	66.2016	16.4651		0.896		-0.3907	0.6062	0.0926
1990		58.284	82.630	0.3048	79.0570	18.0291		0.768	0.876	-0.3194	0.5578	0.0939
1991		58.996		0.3172	81.0222	16.7084		0.789		-0.4039	0.5267	0.0958
1992		57.546		0.3477	81.4703	14.8881		0.746		-0.4047	0.4979	0.0965
1993		67.603	82.927	0.2382	85.7872	13.4385		0.860	0.831	-0.5651	0.4887	0.0998
1994		69.944		0.2449	89.3535	11.3229		0.849		-0.6019	0.4651	0.0992
1995		64.692		0.2510	83.1525	7.3765		0.792		-0.6928	0.3961	0.0878
1996		66.500	76.755[K]	0.1434	76.7552	0.0500		0.794	0.854	-0.8086	0.3535	0.0810
1997		70.904		0.0710	76.1206	6.4282		0.838		-0.8710	0.3506	0.0836
1998		70.958		0.0730	76.3326	8.7332		0.892		-0.9711	0.3377	0.0835
1999		72.335	81.212	0.0372	75.0801	10.0403		0.939	0.919	-1.0618	0.3246	0.0829
2000		78.616		-0.0148	77.4582	12.1967		1.085		-1.1911	0.3298	0.0867

	ITALY					JAPAN					
		ER	B PPP	**PLPL**	**Predicted PPP**	**SE**	ER	B PPP	**PLPL**	**Predicted PPP**	**SE**
1971		0.320		-0.3329	0.2295	0.1051	349.330		0.2885	466.1599	123.0153
1972		0.301		-0.3285	0.2169	0.0955	303.170		0.3468	428.8469	105.6564
1973		0.301		-0.3685	0.2083	0.0881	271.700		0.3548	387.4134	88.3511
1974		0.336		-0.4448	0.2153	0.0874	292.080		0.2547	376.8124	78.7024
1975		0.337	0.279	-0.4009	0.2258	0.0877	296.790	286.074	0.2279	372.7705	70.3738
1976		0.430		-0.4875	0.2640	0.0979	296.550		0.2452	378.9685	63.3794
1977		0.456		-0.3813	0.3112	0.1099	268.510		0.2882	358.1855	51.3820
1978		0.438		-0.3234	0.3172	0.1063	210.440		0.3658	303.3775	35.2135
1979		0.429		-0.3238	0.3104	0.0984	219.140		0.1888	264.6685	21.5080
1980		0.442	0.427	-0.3188	0.3215	0.0959	226.740	255.893[K]	0.1210	255.8930	0.1628
1981		0.587		-0.4255	0.3837	0.1071	220.540		0.1125	246.7908	19.3241
1982		0.699		-0.3390	0.4977	0.1291	249.080		0.0244	255.2425	27.4217
1983		0.784		-0.2472	0.6126	0.1464	237.510		0.1229	268.5679	34.2263
1984		0.907		-0.2353	0.7172	0.1558	237.520		0.1085	264.7307	37.6575
1985		0.986	0.629	-0.2074	0.8014	0.1557	238.540	218.397	0.1159	267.8501	41.0858
1986		0.770		0.0431	0.8038	0.1402	168.520		0.3597	241.4787	39.2328
1987		0.669		0.0682	0.7166	0.1087	144.640		0.3141	198.0156	33.3620
1988		0.672		0.0401	0.6997	0.0871	128.150		0.3169	175.9254	30.2168
1989		0.709		0.0427	0.7395	0.0654	137.960		0.2286	173.3923	29.9036
1990		0.619	0.734[K]	0.1706	0.7339	0.0006	144.792	195.300	0.2493	185.7885	31.7000
1991		0.641		0.1238	0.7251	0.0627	134.707		0.3184	185.2128	31.3892
1992		0.637		0.1695	0.7541	0.0896	126.651		0.3315	176.4340	29.3264
1993		0.813	0.792	0.0362	0.8427	0.1191	111.198	184.307	0.3762	161.9835	26.0329
1994		0.833		0.1035	0.9236	0.1517	102.208		0.3599	146.4888	22.3707
1995		0.841		0.0610	0.8942	0.1641	94.060		0.3532	133.9029	18.9849
1996		0.797	0.818	0.0781	0.8617	0.1727	108.779	165.615	0.2194	135.4603	17.2233
1997		0.880		-0.0058	0.8745	0.1883	120.991		0.2223	151.1104	16.2110
1998		0.897		0.0048	0.9010	0.2061	130.905		0.2359	165.7381	12.9686
1999		0.939	0.803	-0.0216	0.9186	0.2211	113.907	162.036[K]	0.3524	162.0355	0.0828
2000		1.085		-0.1245	0.9584	0.2416	107.765		0.2705	141.2435	11.2749

	KOREA (S.)	ER	B PPP	**PLPL**	**Predicted PPP**	**SE**	**MEXICO**	ER	B PPP	**PLPL**	**Predicted PPP**	**SE**
1971		347.150		-0.8128	154.0045	52.9666		0.013		-3.4439	0.0004	0.0002
1972		392.890		-0.8062	175.4384	57.5059		0.013		-3.4261	0.0004	0.0002
1973		398.320		-0.8310	173.5177	54.0971		0.013		-3.3987	0.0004	0.0002
1974		404.470		-0.8745	168.7002	49.8359		0.013		-3.3488	0.0004	0.0002
1975		484.000	222.853	-0.9091	194.9995	54.3265		0.013	0.0097	-3.3156	0.0005	0.0002
1976		484.000		-0.7384	231.3011	60.4866		0.015		-3.3519	0.0005	0.0002
1977		484.000		-0.7119	237.5036	57.9091		0.023		-3.3579	0.0008	0.0004
1978		484.000		-0.6438	254.2371	57.3578		0.023		-3.1491	0.0010	0.0004
1979		484.000		-0.5972	266.3633	55.0131		0.023		-3.1104	0.0010	0.0004
1980		607.430	413.376	-0.7241	294.4500	54.8452		0.023	0.0188	-3.0268	0.0011	0.0004
1981		681.030		-0.7132	333.7489	55.2058		0.025		-2.9799	0.0012	0.0005
1982		731.080		-0.6799	370.4131	52.6620		0.056		-3.1702	0.0024	0.0009
1983		775.750		-0.6319	412.3770	47.5372		0.120		-2.8515	0.0069	0.0025
1984		805.980		-0.6089	438.4306	35.5105		0.168		-2.4321	0.0147	0.0051
1985		870.020	472.565[K]	-0.6103	472.5720	0.6921		0.257	0.1364	-2.2567	0.0269	0.0088
1986		881.450		-0.5185	524.8127	37.8221		0.612		-2.2315	0.0657	0.0205
1987		822.570		-0.4587	519.9593	45.8851		1.378		-1.8187	0.2236	0.0665
1988		731.470		-0.3727	503.8799	44.4658		2.273		-1.3460	0.5917	0.1667
1989		671.460		-0.2844	505.2344	36.4096		2.462		-1.0667	0.8471	0.2253
1990		707.764	562.172[K]	-0.2303	562.1658	0.6727		2.813	1.533	-0.9869	1.0483	0.2619
1991		733.353		-0.1748	615.7412	48.9713		3.018		-0.8568	1.2813	0.2988
1992		780.651		-0.1572	667.0685	74.0305		3.095		-0.7596	1.4479	0.3127
1993		802.671	660.590	-0.1134	716.5917	96.0949		3.116	2.122	-0.7137	1.5261	0.3021
1994		803.446		-0.0800	741.6905	113.2943		3.375		-0.7382	1.6132	0.2887
1995		771.273		-0.0797	712.1561	119.9611		6.419		-0.9929	2.3783	0.3769
1996		804.453	744.399	-0.1522	690.8894	125.7248		7.600	3.789	-0.7587	3.5587	0.4838
1997		951.289		-0.2634	730.9838	141.6690		7.919		-0.6381	4.1833	0.4599
1998		1401.440		-0.4853	862.5749	176.1817		9.136		-0.6291	4.8700	0.3751
1999		1188.820	754.893	-0.2707	906.9243	193.6531		9.560	5.634[K]	-0.5289	5.6337	0.0100
2000		1130.960		-0.3630	786.6546	176.3754		9.456		-0.4566	5.9892	0.4525

	NETHERLAND	ER	B PPP	**PLPL**	**Predicted PPP**	**SE**	**NEW ZEALAND**	ER	B PPP	**PLPL**	**Predicted PPP**	**SE**
1971		1.5893		0.7590	3.3949	1.0302		0.8806		0.0538	0.9293	0.1557
1972		1.4564		0.7968	3.2309	0.9148		0.8368		0.0615	0.8899	0.1278
1973		1.2686		0.8007	2.8253	0.7409		0.7368		0.0675	0.7883	0.0913
1974		1.2199		0.6223	2.2730	0.5462		0.7154		-0.0775	0.6621	0.0538
1975		1.1476	1.3889	0.5778	2.0452	0.4440		0.8323	0.6840[K]	-0.1962	0.6840	0.0006
1976		1.1998		0.5412	2.0613	0.3966		1.0049		-0.1743	0.8442	0.0662
1977		1.1137		0.5832	1.9954	0.3292		1.0303		-0.0782	0.9528	0.1027
1978		0.9818		0.6144	1.8148	0.2422		0.9644		-0.0035	0.9610	0.1231
1979		0.9103		0.5107	1.5170	0.1418		0.9785		-0.0476	0.9330	0.1337
1980		0.9022	1.2784[K]	0.3485	1.2784	0.0009		1.0267	0.9643	-0.0868	0.9414	0.1459
1981		1.1323		0.1098	1.2637	0.1161		1.1528		-0.1043	1.0386	0.1710
1982		1.2117		0.1316	1.3822	0.1779		1.3326		-0.1281	1.1724	0.2016
1983		1.2951		0.1079	1.4426	0.2252		1.4968		-0.1082	1.3433	0.2382
1984		1.4560		0.0056	1.4641	0.2615		1.7640		-0.1709	1.4869	0.2689
1985		1.5072	1.1290	-0.0432	1.4435	0.2856		2.0234	1.2359	-0.1353	1.7673	0.3227
1986		1.1118		0.2372	1.4094	0.3012		1.9132		0.0967	2.1075	0.3851
1987		0.9192		0.2952	1.2349	0.2789		1.6946		0.2184	2.1081	0.3819
1988		0.8969		0.2138	1.1107	0.2609		1.5264		0.2402	1.9409	0.3453
1989		0.9623		0.1328	1.0989	0.2651		1.6722		0.1250	1.8948	0.3274
1990		0.8263	0.9824	0.2488	1.0598	0.2597		1.6762	1.6090	0.1247	1.8988	0.3147
1991		0.8484		0.1612	0.9968	0.2561		1.7335		0.0688	1.8569	0.2904
1992		0.7980		0.2146	0.9890	0.2642		1.8618		-0.0003	1.8613	0.2686
1993		0.8428	0.9685	0.1742	1.0032	0.2770		1.8505	1.5117	0.0087	1.8666	0.2403
1994		0.8259		0.1674	0.9764	0.2794		1.6865		0.0429	1.7604	0.1903
1995		0.7286		0.1376	0.8360	0.2470		1.5239		0.0393	1.5850	0.1245
1996		0.7650	0.9278	-0.0169	0.7522	0.2287		1.4549	1.4779[K]	0.0157	1.4779	0.0012
1997		0.8854		-0.1380	0.7713	0.2406		1.5124		-0.0486	1.4406	0.1144
1998		0.9002		-0.1370	0.7849	0.2505		1.8683		-0.1766	1.5659	0.1733
1999		0.9386	0.8923	-0.1826	0.7819	0.2546		1.8896	1.4347	-0.1366	1.6484	0.2202
2000		1.0854		-0.3244	0.7847	0.2608		2.2012		-0.2854	1.6546	0.2539

	NORWAY	ER	B PPP	**PLPL**	**Predicted PPP**	**SE**	**PORTUGAL**	ER	B PPP	**PLPL**	**Predicted PPP**	**SE**
1971		7.0418		0.7532	14.9557	4.2965		0.1412		-1.2273	0.0414	0.0144
1972		6.5883		0.7699	14.2274	3.7770		0.1349		-1.2245	0.0396	0.0132
1973		5.7658		0.7605	12.3351	2.9944		0.1223		-1.2085	0.0365	0.0115
1974		5.5397		0.6159	10.2556	2.2403		0.1267		-1.2921	0.0348	0.0104
1975		5.2269	8.3615	0.5740	9.2792	1.7836		0.1275	0.0919	-1.2263	0.0374	0.0106
1976		5.4565		0.5331	9.2987	1.6360		0.1508		-1.1781	0.0464	0.0123
1977		5.3235		0.5625	9.3427	1.4536		0.1909		-1.1298	0.0617	0.0153
1978		5.2423		0.5856	9.4158	1.2221		0.2192		-1.0484	0.0768	0.0176
1979		5.0641		0.5791	9.0364	0.8478		0.2440		-1.0633	0.0843	0.0177
1980		4.9392	8.4734[K]	0.5397	8.4734	0.0059		0.2497	0.1634	-1.0595	0.0866	0.0164
1981		5.7395		0.4245	8.7743	0.8304		0.3070		-1.1551	0.0967	0.0163
1982		6.4540		0.4396	10.0169	1.3280		0.3964		-1.1358	0.1273	0.0184
1983		7.2964		0.4367	11.2923	1.8166		0.5526		-1.1127	0.1816	0.0212
1984		8.1615		0.4273	12.5129	2.3029		0.7302		-1.0618	0.2525	0.0206
1985		8.5972	9.5428	0.4237	13.1332	2.6776		0.8499	0.3313[K]	-0.9421	0.3313	0.0004
1986		7.3947		0.5054	12.2577	2.7126		0.7461		-0.6474	0.3905	0.0304
1987		6.7375		0.5271	11.4136	2.7034		0.7027		-0.6264	0.3756	0.0397
1988		6.5170		0.5086	10.8374	2.7194		0.7180		-0.6720	0.3667	0.0454
1989		6.9045		0.4164	10.4707	2.7616		0.7854		-0.6950	0.3920	0.0534
1990		6.2597	9.7310	0.4316	9.6379	2.6555		0.7111	0.5173	-0.5566	0.4076	0.0589
1991		6.4829		0.3361	9.0726	2.5986		0.7207		-0.5463	0.4173	0.0623
1992		6.2145		0.3629	8.9331	2.6490		0.6734		-0.4028	0.4501	0.0678
1993		7.0941	8.9309	0.2621	9.2203	2.8210		0.8021	0.5834	-0.4536	0.5096	0.0759
1994		7.0576		0.2884	9.4172	2.9643		0.8280		-0.3592	0.5781	0.0835
1995		6.3352		0.3185	8.7109	2.8139		0.7537		-0.3200	0.5473	0.0746
1996		6.4498	9.1140	0.2331	8.1430	2.6937		0.7694	0.6105	-0.3821	0.5251	0.0650
1997		7.0734		0.1467	8.1911	2.7670		0.8745		-0.4329	0.5672	0.0600
1998		7.5451		0.1172	8.4837	2.9170		0.8984		-0.3895	0.6086	0.0474
1999		7.7992	9.2462	0.1352	8.9287	3.1157		0.9386	0.6348[K]	-0.3911	0.6348	0.0006
2000		8.8018		0.1113	9.8382	3.4949		1.0854		-0.4782	0.6728	0.0540

	SPAIN	ER	B PPP	**PLPL**	**Predicted PPP**	SE	**SWEDEN**	ER	B PPP	**PLPL**	**Predicted PPP**	SE
1971		0.418		-0.4315	0.2712	0.1430		5.117		0.6008	9.3307	1.8644
1972		0.386		-0.3995	0.2591	0.1322		4.762		0.6270	8.9153	1.5285
1973		0.350		-0.3864	0.2379	0.1173		4.367		0.5802	7.8016	1.0805
1974		0.347		-0.4403	0.2232	0.1063		4.439		0.4095	6.6861	0.6465
1975		0.345	0.270	-0.4303	0.2244	0.1031		4.152	6.303[K]	0.4174	6.3033	0.0046
1976		0.402		-0.4660	0.2523	0.1117		4.356		0.4437	6.7885	0.5826
1977		0.457		-0.3938	0.3079	0.1311		4.482		0.4827	7.2622	0.7632
1978		0.461		-0.2785	0.3488	0.1426		4.519		0.5245	7.6346	0.8023
1979		0.403		-0.1757	0.3384	0.1326		4.287		0.5373	7.3367	0.6296
1980		0.431	0.424	-0.2901	0.3224	0.1208		4.230	7.052[K]	0.5112	7.0518	0.0050
1981		0.555		-0.4244	0.3630	0.1298		5.063		0.3873	7.4586	0.7091
1982		0.660		-0.3931	0.4457	0.1515		6.283		0.3193	8.6462	1.1516
1983		0.862		-0.4390	0.5557	0.1791		7.667		0.2791	10.1355	1.6380
1984		0.966		-0.3705	0.6670	0.2030		8.272		0.3091	11.2673	2.0831
1985		1.022	0.552	-0.3321	0.7332	0.2097		8.604	7.973	0.3167	11.8095	2.4187
1986		0.842		-0.1069	0.7564	0.2069		7.124		0.4672	11.3654	2.5265
1987		0.742		-0.0719	0.6906	0.1798		6.340		0.4501	9.9449	2.3659
1988		0.700		-0.0737	0.6503	0.1601		6.127		0.4043	9.1801	2.3132
1989		0.712		-0.0729	0.6615	0.1527		6.447		0.3569	9.2118	2.4393
1990		0.613	0.658	0.0608	0.6510	0.1394		5.919	9.336	0.4485	9.2683	2.5632
1991		0.625		0.0193	0.6367	0.1249		6.048		0.4323	9.3175	2.6788
1992		0.615		0.0705	0.6603	0.1161		5.824		0.4580	9.2069	2.7403
1993		0.765	0.703	-0.0283	0.7435	0.1129		7.783	9.833	0.2313	9.8089	3.0120
1994		0.805		0.0223	0.8233	0.1018		7.716		0.2851	10.2610	3.2419
1995		0.749		0.0455	0.7843	0.0683		7.133		0.2354	9.0269	2.9271
1996		0.761	0.743[K]	-0.0239	0.7433	0.0006		6.706	9.678	0.1865	8.0806	2.6833
1997		0.880		-0.1363	0.7678	0.0656		7.635		0.0286	7.8565	2.6603
1998		0.898		-0.1191	0.7971	0.0948		7.950		-0.0152	7.8297	2.6870
1999		0.939	0.749	-0.1544	0.8044	0.1152		8.262	9.640	-0.0668	7.7286	2.6729
2000		1.085		-0.2547	0.8414	0.1386		9.162		-0.1703	7.7274	2.7233

	TURKEY	ER	B PPP	**PLPL**	**Predicted PPP**	**SE**	**UK**	ER	B PPP	**PLPL**	**Predicted PPP**	**SE**
1971		14.92		-3.3507	0.5230	0.2224		0.411		0.1807	0.4923	0.1299
1972		14.15		-3.1638	0.5980	0.2449		0.400		0.1868	0.4826	0.1188
1973		14.15		-3.1160	0.6273	0.2470		0.408		0.1178	0.4592	0.1047
1974		13.93		-3.0278	0.6744	0.2550		0.428		0.0123	0.4331	0.0906
1975		14.44	11.06	-2.9800	0.7336	0.2658		0.452	0.380	0.0379	0.4695	0.0888
1976		16.05		-2.9527	0.8379	0.2904		0.557		-0.0082	0.5520	0.0925
1977		18.00		-2.8580	1.0331	0.3414		0.573		0.0588	0.6080	0.0874
1978		24.28		-2.7629	1.5325	0.4816		0.522		0.1282	0.5928	0.0689
1979		31.08		-2.4510	2.6790	0.7980		0.472		0.1535	0.5506	0.0448
1980		76.04	52.27	-2.5202	6.1169	1.7197		0.430	0.521[K]	0.1918	0.5213	0.0005
1981		111.22		-2.1779	12.5991	3.3275		0.498		0.0902	0.5446	0.0425
1982		162.55		-2.1268	19.3784	4.7784		0.572		0.0894	0.6260	0.0666
1983		225.46		-2.0312	29.5749	6.7539		0.660		0.0734	0.7100	0.0891
1984		366.68		-1.9633	51.4799	10.7763		0.752		0.0327	0.7768	0.1081
1985		521.98	208.84	-1.7180	93.6551	17.7240		0.779	0.551	0.0541	0.8225	0.1225
1986		674.51		-1.4804	153.4899	25.7224		0.682		0.1547	0.7963	0.1238
1987		857.22		-1.3213	228.6965	32.8760		0.612		0.1644	0.7212	0.1149
1988		1422.35		-1.2331	414.4509	48.2405		0.562		0.1645	0.6627	0.1064
1989		2121.68		-0.9079	855.8468	69.7851		0.611		0.0881	0.6675	0.1063
1990		2608.64	1491.00[K]	-0.5596	1490.7421	3.1351		0.563	0.602	0.1692	0.6670	0.1037
1991		4171.82		-0.7040	2063.310	151.779		0.567		0.1480	0.6574	0.0979
1992		6872.42		-0.7321	3304.989	307.419		0.570		0.1551	0.6654	0.0926
1993		10984.60	5989.79	-0.7288	5300.125	522.859		0.667	0.637	0.0437	0.6966	0.0874
1994		29608.70		-0.9304	11677.471	1086.192		0.653		0.0898	0.7148	0.0761
1995		45845.10		-0.6546	23824.503	1752.502		0.634		0.0595	0.6726	0.0524
1996		81404.90	39274.65[K]	-0.7287	39281.468	78.188		0.641	0.644[K]	0.0047	0.6440	0.0005
1997		151865.0		-0.4881	93213.437	7442.962		0.611		0.0208	0.6236	0.0498
1998		260724.0		-0.1527	223802.211	25032.468		0.604		0.0176	0.6145	0.0687
1999		418783.0	197156.6	0.1505	486800.812	66063.773		0.618	0.651	0.0038	0.6204	0.0842
2000		625218.0		0.3952	928207.950	144108.93		0.661		-0.0572	0.6242	0.0969