Centre for Efficiency and Productivity Analysis

Working Paper Series
No. WP01/2009

Spatial Autocorrelation and Extrapolation of Purchasing Power Parities. Modelling and Sensitivity Analysis

Alicia Rambaldi , D.S. Prasada Rao, and K. Renuka Ganegodage

Original version: 18 March 2009

School of Economics
The University of Queensland
St. Lucia, Qld. 4072
Australia

ISSN No. 1932 – 4398

Spatial Autocorrelation and Extrapolation of Purchasing Power Parities. Modelling and Sensitivity Analysis

Alicia N. Rambaldi, D.S. Prasada Rao and K. Renuka Ganegodage

This version: 18 March 2009

School of Economics, The University of Queensland, St Lucia, 4072 Australia

Abstract

The paper examines the role and significance of modeling spatially correlated disturbances in the extrapolation of purchasing power parities (*PPPs*) within the general econometric framework developed by Rao *et al* for the purpose of constructing a consistent time-space panel of *PPPs.* Alternative measures of economic distance are considered using trade closeness as well as a constructed measure using a common factor approach which combines indicators of trade, cultural and geographical closeness. The measures are used to construct spatial weight matrices. A comparative analysis of the effect of alternative specifications of the spatial weight matrix on the *PPP* extrapolations is conducted with emphasis in the model's prediction ability. Specifically, the out-of-sample prediction of the *PPPs* for GDP recently released by the International Comparisons Program (World Bank) for the 2005 ICP Benchmark year are used to evaluate the alternative specifications. The results clearly indicate the need to model and use a spatially correlated error structure especially when the benchmark data are incomplete. The results are very similar when the spatial weight matrices are based on trade closeness or the more comprehensive economic distance measure.

Keywords: Purchasing Power parities; Spatial autocorrelation; Principal Components, Economic Distance, Kalman Filter

JEL *Classification*: C53, C33

1 Introduction

PPP-converted real per capita incomes are used in influential publications like the World Development Indicators of the World Bank (World Bank, 2006 and other years) and the Human Development Report ([43]) which publishes values of the Human Development Index (HDI) for all countries in the world. The *PPPs* are also used in a variety of areas including: the study of global and regional inequality ([33]); measurement of regional and global poverty using international poverty lines like $1/day and $2/day (regularly published in the World Development Indicators, World Bank); the study of convergence and issues surrounding carbon emissions and climate change ([32];[9]); and in the study of catch-up and convergence in real incomes ([5]; [16]; [39]). The only source for $PPPs$ for the economy as a whole is the International Comparison Program (ICP). The *PPP* data are compiled under the ICP which began as a major research project by Kravis and his associates at the University of Pennsylvania in 1968 and in more recent years has been conducted under the auspices of the UN Statistical Commission. Due to the complex nature of the project and the underlying resource requirements, it has been conducted roughly every five years since 1970. The latest round of the ICP for the 2005 benchmark year was released in early 2008. The final results are available on the World Bank website: `http://siteresources.worldbank.org/ICPINT/Resources/ICP_final-results.pdf`. In more recent years, beginning from early 1990's, the OECD and EUROSTAT have been compiling *PPPs* roughly every three years. The country coverage of the ICP in the past benchmarks has been limited with 64 countries participating in the 1996 benchmark comparisons. However this coverage has increased dramatically to 147 for the 2005 benchmark year. Details of the history of the ICP and its coverage are well documented in the recent report of the Asian Development Bank (`http://adb.org/Documents/Reports/ICP-Purchasing-Power-Expenditures/default.asp`).

For most analytical and policy purposes, there is a need for $PPPs$ covering all the countries and a three to four-decade period[1]. The Penn World Tables (PWT) has been the main source of such data. Summers and Heston are pioneers in this field. [41] provides a clear description of the construction of the earlier versions of the PWT. The most recent version, PWT 6.2, available on `http://pwt.econ.upenn.edu`, covers 188 countries and a period in excess of five decades starting from 1950. In addition to the PWT, there is the real gross domestic product (GDP) series constructed by Angus Maddison ([30, 31]). The Maddison series is available on Groningen Growth and Development Centre website: `www.ggdc.net/dseries/totecon.html`. The series constructed by the World Bank are available in various issues of World Development Indicators publication. The Maddison series make use of a single benchmark and national growth rates to construct panel data of real GDP and no estimates are available for non-benchmark countries. The World Bank series are based on the methodology described in [1] and the series makes use of a single

[1]For example, the Human Development Index is computed and published on an annual basis. Similarly, the World Development Indicators publication provides PPP converted real per capita incomes for all the countries in the world for every year.

benchmark year for which extrapolations to non-benchmark countries are derived using a regression-based approach. The benchmark and non-benchmark *PPPs* are extrapolated using national growth rates[2] in national prices.

Recent work by Rao and colleagues at the University of Queensland has proposed a new method to construct a panel of $PPPs$ similar to the PWT (see [37] for details), which we will refer to as the RRD method. The method proposed has several desirable properties including providing $PPPs$ with standard errors from an econometric method that is invariant to the reference country and makes use of all available ICP benchmark information to date. The new method, which is described briefly in Section 3, like PWT and the World Bank methods, includes as a component a *model of the price level* whose main function is to assist with the prediction of $PPPs$ for non-participating countries. We define price level and present the a summary of the theory behind this model in the next section. One of the differences in the approach of RRD to that of exisiting approaches relates to the modelling of price levels, which is specified with a spatially correlated error. In this paper we evaluate the sensitivity of the final results to the use of a spatial error, as well as the sensitivity of the final predictions to alternative spatial specifications within this component of the method. Given the objectives of the paper, we present and discuss the modelling of national price levels before moving to the description of the RRD method.

2 The National Price Levels Model

The exchange rate deviation index, more commonly referred to as the national price level is a ratio. If ER_{it} denotes the exchange rate of the currency of country i at time t, then the national price level for country i (or exchange rate deviation index) is the ratio of PPP_{it}, the *Purchasing Power Parity* of country i at time t to ER_{it}. The notation R_{it} is used to denote the *Price Level* of country i at time t.

$$R_{it} = \frac{PPP_{it}}{ER_{it}} \tag{1}$$

For example, if the PPP and ER for Japan, with respect to one US dollar, are 130 and 110 yen respectively, then the price level in Japan is 1.18 indicating that prices in Japan are roughly twenty per cent higher than those in the United States. A value of this ratio greater than one implies national price levels in excess of international levels and vice versa. Most of the explanations of price levels are based on productivity differences in traded and non-traded goods across developed and developing countries. Much of the early literature explaining national price levels ([28, 27]) has relied on the structural characteristics of countries such as the level of economic development, resource endowments, foreign trade ratios, education levels. More recent literature has focused on measures like openness of the economy,

[2] We define "national growth rates" in the next section.

size of the service sector reflecting the size of the non-tradable sector and on the nature and extent of any barriers to free trade ([1]; [8, 7]; [11]).

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 unity. In general it is possible to identify a vector of regressor variables and postulate a regression relationship:

$$r_{it} = \beta_{0t} + \boldsymbol{x}'_{it}\boldsymbol{\beta}_s + u_{it} \tag{2}$$

where,

$r_{it} = ln(PPP_{it}/ER_{it})$

$\boldsymbol{x}'_{it}$ is a set of conditioning variables

β_{0t} intercept parameter

$\boldsymbol{\beta}_s$ a vector of slope parameters

u_{it} a random disturbance with specific distributional characteristics.

Provided estimates of β_{0t} and $\boldsymbol{\beta}_s$ are available, model (2) can provide a prediction of the $ln(PPP_{it})$ consistent with price level theory.

$$\hat{p}_{it} = \hat{\beta}_{0t} + \boldsymbol{x}'_{it}\hat{\boldsymbol{\beta}}_s + ln(ER_{it}) \tag{3}$$

We return to the estimation of β_{0t} and $\boldsymbol{\beta}_s$ in Section 3.

2.1 *The Spatial Error Structure*

The modelling of cross-sectional dependence in Economics and Finance is well established in the Real Estate literature. The most popular approach is to use spatial autocorrelated errors (examples are [6],[21] and [34]), although other cross-correlation structures have been used (see [36]). The reader is referred to [2] for a comprehensive collection of works in Spatial Econometrics. In other areas the use of cross-sectional dependence to model panel data is growing rapidly (a summary is presented in [35]). In the RRD method the cross-sectional dependence is assumed to be a function of a spatial weight matrix. However, the term "spatial distance" in the present context refers to *economic distance* rather than the traditional geographical distance (as in [13]), and we discuss shortly the alternative measures considered in this paper.

In RRD the errors u_{it} in the regression relationship (2) are of the form,

$$\mathbf{u}_t = \phi \mathbf{W}_t \mathbf{u}_t + \mathbf{e}_t \tag{4}$$

where $\phi < 1$ and $\mathbf{W}_t$ $(N \times N)$ is a spatial weights matrix. That is, the diagonal elements, w_{ii}, are zero and the off diagonal elements, w_{ij}, measure the "distance" between observations. It is customary for the rows of $\mathbf{W}_t$ to add up to one (this is known as row stochastic in the spatial econometrics literature) and it is a sufficient condition for $|\phi|$ <1. It follows that E($\mathbf{u}_t \mathbf{u}_t'$) is proportional to $\mathbf{\Omega}$, where $\mathbf{\Omega}= (\mathbf{I}-\phi \mathbf{W}_t)^{-1} (\mathbf{I}-\phi \mathbf{W}_t)^{-1\,\prime}$.

It is easily seen that if ϕ is zero in (4), the error term $\mathbf{u}_t = \boldsymbol{e}_t$, and $\boldsymbol{e}_t$ is assumed not to suffer from auto correlation or heteroskedasticity. That is, when $\phi = 0$ the model in (2) is a multiple regression with spherical errors. Through the size of the parameter ϕ and the specification of $\mathbf{W}_t$ it is possible to study the influence asserted by the spatial specification on the final predictions, p^*_{it}. Section 4 specifically discusses the alternatives used in this paper to evaluate the role of the spatial specification.

The remaining of the paper is structured as follows. Section 3 briefly presents the RRD method to show where the spatial error appears in the method. Section 4 describes a series of alternative specifications of the spatial structure that are used in the empirical estimations as well as the data used in the estimations. Section 5 presents and discusses the empirical findings and Section 6 concludes.

3 The RRD Method

RRD is a smoothing method grounded in an econometric model designed to make use of all the information available for the purpose of constructing a panel of $PPPs$. Sources of data available from national and international sources are combined in an econometric model used by the smoothing algorithm. The description is brief and the reader is referred to [37] for a complete version.

3.1 The Econometric formulation of RRD

In this section we describe the econometric model underlying RRD. The description is brief and intended to show where the price level model fits within the smoothing method.

The variable of interest is denoted by $p_{it} = ln(PPP_{it})$ for country $i = 1, ..., N$ and time $t = 1, ..., T$ where PPP_{it} represents the purchasing power parity of the currency of country i with respect to a reference country currency. Although it is directly unobservable, several noisy sources of information can be combined to obtain an optimal prediction, p^*_{it}. The econometric model that encompasses these sources of information is written in state-space form and thus given by two sets of equations, the observation equations and the transition equations.

3.1.1 *Observation equations*

The observation equations map the observations (ICP and predictions) and explanations (conditioning structural variables) to the unknown variable (vector) of interest known as the "state vector". In RRD they take the following form:

$$\mathbf{y}_t = \mathbf{Z}_t \mathbf{p}_t + \mathbf{B}_t \mathbf{X}_t \boldsymbol{\theta} + \boldsymbol{\zeta}_t \tag{5}$$

where,

$\mathbf{y}_t = \begin{bmatrix} 0 \\ \mathbf{S}_{np}\hat{\mathbf{p}}_t \\ \tilde{\mathbf{p}}_t \end{bmatrix}$ is a vector of "observations" of the state vector. The observations are: the reference country with a value of zero, predictions of the state vector from (3), $\hat{\boldsymbol{p}}_t$, and benchmark observations (only observed in benchmark years), $\widetilde{\boldsymbol{p}}_t$.

$\mathbf{Z}_t, \mathbf{B}_t$ are known selection matrices that map the unobservable state vector and conditioning variables to the observations in $\mathbf{y}_t$.

$\mathbf{X}_t$ is a matrix of observable socio-economic variables.

$\mathbf{p}_t$ is the unobserved state vector

$\boldsymbol{\theta}$ is a vector of parameters to be estimated and is a known form of the vector $\hat{\boldsymbol{\beta}}$ in (3)

$\boldsymbol{\zeta}_t$ is an error with $\mathrm{E}(\boldsymbol{\zeta}_t) = 0$ and $E\left(\boldsymbol{\zeta}_t \boldsymbol{\zeta}'_t\right) \equiv \mathbf{H}_t$

$\boldsymbol{S}_{np}$ is a known selection matrix for non-participating countries at time t.

The observation vector $\mathbf{y}_t$ contains two sources of noisy observations of the (unobservable) state vector, $\mathbf{p}_t$. The ICP collected observations of *PPPs* for participating countries in benchmark years, denoted by $\tilde{\mathbf{p}}_t$, and the predictions of the model in (3) where the spatial error structure is located, denoted by $\hat{\mathbf{p}}_t$ (see Section 2.1). We expand on each next.

- *Observations from the ICP*

Data in the form of *PPPs* from the ICP benchmarks are a crucial component of the model. These are *PPPs* compiled by the global office of the ICP or regional offices of the ICP by conducting extensive price surveys in the participating countries, i.e., from the first benchmark comparison in 1970 till to date inclusive of the recently completed 2005 benchmark. The data on $PPPs$ compiled over the past benchmarks may be best viewed as an incomplete panel due to the differing degrees of participation of countries in different benchmarks and due to the fact that the benchmark comparisons are conducted roughly once in five years. Due to the complexity in the design and collection of the ICP benchmark data (see Chapters 4-6 of the ICP Handbook which can be found on the World Bank ICP website:`www.worldbank.org/data/ICP`), the observed $PPPs$ are likely to be contaminated with some measurement error. As the surveys for these benchmark exercises are conducted by national statistical offices, the availability of resources to national statistical offices is likely to be positively related to the level of resources (technical and human) available in individual countries and it is likely to be reflected in the quality of the data collection by individual countries. Thus, ICP benchmark observations are assumed to be measured with error, giving rise to the bottom partition in 5 (and (8) as shown shortly),

$$\tilde{p}_{it} = p_{it} + \xi_{it} \tag{6}$$

where,

$\tilde{p}_{it}$ is the ICP benchmark observation for participating country i at time t; and

ξ_{it} is a random error accounting for measurement error.

$E(\xi_{it}) = 0,\ E(\xi_{it}^2) = \sigma_\xi^2 V_{it}$

The measurement error variance-covariance is of the form

$$\boldsymbol{V}_t = \begin{bmatrix} \sigma_{1t}^2 & \mathbf{0} \\ \mathbf{0} & \sigma_{1t}^2 \boldsymbol{j}\boldsymbol{j}' + diag(\sigma_{2t}^2, ..., \sigma_{Nt}^2) \end{bmatrix} \tag{7}$$

where, σ_{it}^2 is the variance of country i at time t, which is measured as the inverse of the a country's degree of development,[3] and σ_{1t}^2 is the variance of the reference country. This form of the covariance is sufficient for the invariance of the method to the choice of reference country (see [37] for details and proof).

- *Predictions from the Price Level Model*

The conditioning variables, $\boldsymbol{X}_t$, and predictions from the price level model, $\hat{\mathbf{p}}_t$, are mapped through the matrices $\boldsymbol{Z}_t$ and $\boldsymbol{B}_t$ to the state vector, $\boldsymbol{p}_t$. This is achieved by re-writing equation (3) (details are shown in [37])).

[3] In the empirical implementation we model σ_{it}^2 as inversely related to GDP_{it} per capita measured in \$US (exchange rates adjusted). It is well known that exchange rates adjustments accentuate the difference between developed and developing countries and thus provide a suitable measurement of the desired effect.

- *The Reference Country Constraint*

The first row in the observation equations (5) and subsequent definitions correspond to the reference country (this is without loss of generality). The form of the observation and its variance emanate from the basic concept of $PPPs$. The PPP for a particular country's currency is always defined or measured relative to the currency of a selected reference country. For example, the PPP for the currency of a country, say India, with respect to the currency of a reference country, say the United States, is defined as the number of currency units of Indian rupees required to purchase the amount of goods and services purchased with one US dollar. Hence, $PPPs$ are determined only when the currency of a country is chosen as the base or reference currency. Therefore, by definition the PPP of the *reference currency* is always equal to unity in all periods. So, if country 1 is chosen as the base currency, the $p_{1t} = 0$ for all t with variance zero is set as a constraint which insures that the time series $\{P\hat{P}P_1\}$ predicted by RRD is equal to 1 with standard error zero in all periods.

- *The Covariance of the Observation Equations' Error*

Equation (5) takes a different form in benchmark and non-benchmark years as in non-benchmark years only observations $\hat{\mathbf{p}}_t$ are available. Accordingly, so does the covariance of $\boldsymbol{\zeta}_t$ in (5), $\boldsymbol{H}_t$. The covariance of the spatial error, $\boldsymbol{\Omega}_t$, is in the matrix $\boldsymbol{H}_t$, which is partitioned to account for the reference country's constraint[4] and the variance-covariance structure associated with the $\hat{\mathbf{p}}_t$ and $\tilde{\mathbf{p}}_t$. In a benchmark year, its form is:

$$\mathbf{H}_t = \begin{bmatrix} 0 & \mathbf{0} & 0 \\ 0 & \sigma_u^2 \boldsymbol{S}_{np} \boldsymbol{\Omega} \boldsymbol{S}'_{np} & 0 \\ 0 & 0 & \sigma_\xi^2 \boldsymbol{S}_p \boldsymbol{V}_t \boldsymbol{S}'_p \end{bmatrix} \tag{8}$$

$\boldsymbol{S}_{np}$ and $\boldsymbol{S}_p$ are known selection matrices for non-participating and participating countries at time t, respectively.

In non-benchmark years the bottom partition is not present as that is the covariance of the measurement error in the ICP benchmark observations.

3.1.2 *Transition equations*

The transition equations model the movement of the state vector across time. In the RRD case the transition equations model the movement of $PPPs$ over time.

[4] $PPPs$ between currencies of two countries are invariant to the choice of the base country, which in turn requires the predictions of the reference country to be zero with variance zero in all time periods, $p_{US,t}$=0. See [37] for a proof that the method is invariant to the choice of the reference currency.

A major consideration in the construction of a panel of $PPPs$, and real incomes, is that the growth rates in real income obtained using $PPPs$ should be the same or close to the national growth rates in prices observed and reported by the respective national statistical offices. This is considered an important property to be satisfied by the extrapolated $PPPs$. The currently available series from PWT, the World Bank's World Development Indicators and the Maddison series all adhere to this important principle. Thus, the national growth rates and the price movements implicit in such growth rates which are referred to as GDP deflators offer crucial information for updating $PPPs$.

The temporal movements in $PPPs$ are, therefore, governed by a simple relationship presented in equation (9). It is easy to see that equation (9) is a simple identity if *PPPs* were the price of a single commodity. However in the case of *PPPs* at GDP level, GDP is treated as a composite commodity.

$$PPP_{i,t} = PPP_{i,t-1} \times \frac{GDPDef_{i,[t-1,t]}}{GDPDef_{US,[t-1,t]}} \tag{9}$$

where $GDPDef_{i,[t-1,t]}$ denotes the GDP deflator showing price movements from period $t-1$ to t in country i, and the US is the reference country.

Equation (9) simply provides a mechanism for updating $PPPs$ using movements in the GDP deflator of the country concerned and therefore, provides a definition for the growth rate of PPP_{it}.

Thus, implicit GDP deflators provide a measure of movements in prices in different countries over time. These deflators provide critical information on country-specific temporal movements in prices. The main source of data on deflators is the national accounts published by countries, generally on an annual basis. In the econometric specification, equation (9) is modified to include a random disturbance term that makes it possible for the extrapolated $PPPs$ to deviate from the $PPPs$ implied by the growth rates in GDP deflators.

Therefore, the 'transition equations' of the state-space representation follow from equation (9) and are given by:

$$\mathbf{p}_t = \mathbf{p}_{t-1} + \mathbf{c}_t + \boldsymbol{\eta}_t \tag{10}$$

where,

$\boldsymbol{c}_t$ is the observed growth rate of $\boldsymbol{p}_t$ with elements $\mathrm{c}_{it} = ln\left(\frac{GDPDef_{i,[t,t-1]}}{GDPDef_{US,[t,t-1]}}\right)$,

$\boldsymbol{\eta}_t$ is a measurement error with $E(\boldsymbol{\eta}_t) = 0$ and $E\left(\boldsymbol{\eta}_t\boldsymbol{\eta}_t'\right) \equiv \mathbf{Q}_t = \sigma_\eta^2\mathbf{V}_t$

As GDP data are collected by national statistical offices, the argument made previously to justify the structure of the measurement error holds in this case also.

Equation (10) simply updates $PPPs$ from period $t-1$ using the observed price changes over the period represented by $\boldsymbol{c}_t$. We note that equation (10) offers flexibility in imposing the national growth rates. If η_{it} is set to zero or its variance set close to zero then the temporal movements in $PPPs$ track the relative movements in national GDP deflators, and hence the implied growth rates in income are also maintained. If there is no restriction that national movements are to be tracked by the extrapolated $PPPs$ then η_{it} can be determined by the data rather than any a priori restriction imposed on its variance.

3.2 Estimation and Prediction of *PPPs*

The unknown parameters in equations (5) and (10) are estimated by maximum likelihood (the estimation method is described in detail in [37]). The likelihood function is computed by running the Kalman filter through the state-space equations. Upon convergence, and given these estimates and the initial distribution of the state vector, $\mathbf{p}_0$, the Kalman filter computes the conditional mean (based on the information available at time t), $\check{\boldsymbol{p}}_t$, and corresponding covariance matrix, $\boldsymbol{\Psi}_t$, of the distribution of $\mathbf{p}_t$. Further, $\check{\boldsymbol{p}}_t$ is a minimum mean square estimator (MMSE) of the state vector, $\mathbf{p}_t$, under Gaussian assumptions. When Gaussian assumptions are dropped, the Kalman filter is still the optimal estimator in the sense that it minimizes the mean square error within the class of all linear estimators (see [22] pp. 100-12), [14] Sections 4.2 and 4.3). A fixed interval Kalman smoother is used to smooth the Kalman filter predictions and generate $PPPs$ for all the countries and years in the data set. The interested reader is referred to [37] for full description of the maximum likelihood estimation, the Kalman filter and smoother used in RRD.

Since the state vector $\boldsymbol{p}_t$ is in fact $ln(PPP_{it})$ and our interest is in $PPPs$, the following transformation is used to derive the predicted $PPPs$.

$$P\hat{P}P_{it} = e^{p^*_{it}} \tag{11}$$

where, p^*_{it} is the corresponding Kalman smoothed element.

The standard errors for the predicted $PPPs$ are computed as follows[5]:

$$se(P\hat{P}P_{it}) = \sqrt{e^{2p^*_{it}} e^{\psi^*_{ii,t}} (e^{\psi^*_{ii,t}} - 1)} \tag{12}$$

where,

$\psi^*_{ii,t}$ is the ith diagonal element of the estimated smoothed covariance of the state vector, $\boldsymbol{\Psi}^*_t$.

[5]The standard errors are computed under the assumption of the lognormality of the predictions.

4 Spatial Specifications Considered in the Analysis

We wish to assess whether the definition of the weight matrix, $\boldsymbol{W}_t$ (see equation (4)) has a significant influence on the final results. It is important to reiterate that the objective of the spatial structure in RRD is to capture the "economic distance" between pairs of countries so that the predictions of *PPPs* from the national price level's regression included in the smoothing are improved. The regression predictions are the only source of observations on the state vector for those countries that did not participate in the ICP benchmark exercises.

4.1 Definitions

We explore three alternative specifications,

EW *Equal Weights*: The spatial weights matrix is constructed by identifying the five nearest trade "neighbours" for each country in the study. We define trade neighbours through bilateral trade flows. For each country, i (the i^{th} row of $\boldsymbol{W}_t$), five columns have a value of 0.25 corresponding to its five major trading partners.

TW *Trade Weights*: Each row of $\boldsymbol{W}_t$, i, has columns with values that are directly proportional to the volume of bilateral trade between country i and j ($j \neq i$). Thus, any pair of countries in the sample that trades will have a non-zero weight and the sum of the weights for each row is one.

PCW *Economic Distance Factor Weights*: The spatial weights matrix, $\boldsymbol{W}_t$, is derived from a measure of economic distance constructed by the authors. The measure is constructed by extracting a common factor (through principal components analysis) for each country that combines trade closeness, geographical proximity, and cultural closeness. We present a brief description of its construction next and a more detailed description in Appendix 1.

Variables included in the construction of the common factor

- *Trade closeness* is measured as the percentage of bilateral trade between each country and all others in the sample (compiled using data from [38] and IMF Trade Directions).
- *Geographical proximity* is measured by a series of dummies for *border* (both land and sea proximity), and *regional membership* (such us Asia pacific region, Europe, south America, north and central America, sub Saharan Africa, middle east). The data were constructed using Atlas, CIA factbook and individual country references.
- *Cultural and colonial closeness* dummies are used for *common language* and *common colonial history.* The data were constructed from the CIA factbook and individual country references.

Construction of the distance score

The objective is to measure "an economic distance" between pairs of countries. The steps involved in the construction of the measure can be summarised as follows:

1) A separate principal components (PC) model is estimated for each country to measure the distance between the respective country and each of the other countries in the sample. Therefore, for each time period 141 models are estimated. The analysis was conducted for the years 1970, 1975, 1980, 1985, 1990, 1995, 2000 and 2005 to account for the changing patterns in bilateral trade over time.

2) After the PC are extracted for a particular country and time period only one PC is retained since the number of variables is small. This is the *common factor* for each country and time period. That is, it is a linear combination of the variables.

3) A factor score is computed using the estimated factor loadings and the data (see Appendix 1 for details). These scores are not bounded; therefore, they are rescaled to prepare a *proximity matrix* using the formula:

$$S_{ij} = \left[\frac{f_{ij} - f_{\min}}{f_{\max} - f_{\min}} \right] \tag{13}$$

where, S_{ij} is the proximity score, $f_{\min}$, $f_{\max}$ and f_{ij} are respectively the minimum value, maximum value and factor score of country i in relation to j. These rescaled factor scores are in the range of 0 to 1, and if country g and j are the same (e.g. $i = j = 1$), the rescaled value is zero.

The distance or proximity score is assumed to be constant within the five yearly intervals (e.g. from 1970 to 1974, 1975 to 1979, and so on).

Construction of the Weight Matrix

The proximity matrix is transformed into a row stochastic matrix $\boldsymbol{W}_t$ (i.e. rows add up to one) by simply dividing each proximity score within a row (which represents a country) by the sum of that row, and thus creating weights.

4.2 Evaluation

As briefly mentioned in the introduction, the latest round of the ICP was conducted in 2005 and the $PPPs$ for the 147 participating countries released in early 2008. This round was the first global round of the ICP since 1996 when only 64 countries participated and there was no systematic linking of the results across countries. Thus, the 2005 round is a milestone both because of the number of countries that participated as well as the careful methodology applied to the data collected in order to produce the benchmark $PPPs$

(see `http://adb.org/Documents/Reports/ICP-Purchasing-Power-Expenditures/default.asp` for a detailed report). It is then of interest to assess whether a spatial specification became less relevant once the comprehensive 2005 benchmark data were available. Specifically, we explore two hypotheses:

a) A spatially correlated error made a significant difference to the predictions of $PPPs$ for non-participating countries when the ICP 2005 round was unknown

b) The use of a spatially correlated error does not significantly add to the predictions of $PPPs$ when the 2005 ICP benchmarks are used.

To assess these hypothesis, we use RRD to construct tables of $PPPs$ for the period 1970 to 2005 under the following alternatives:

No05 Assuming the year 2005 was not a benchmark year (this table is comparable to PWT 6.2) to produce tables from the model with and without a spatial error specification. Estimates based on assuming spherical errors in (4), $\mathbf{u}_t = \boldsymbol{e}_t$, are obtained by setting the spatial parameter ϕ to zero and will be denoted by the post-fix "No05_NoSpt" indicating the 2005 ICP data have been ignored and the errors are not spatial. Estimates obtained allowing for spatial errors (without constraining ϕ to zero) will be denoted with the post-fix "No05."

Y05 Including the benchmark ICP information for the year 2005 to produce tables from the model with and without a spatial error specification. Similar to above this is achieved by restricting the spatial parameter to zero to obtain a table without spatial errors. The estimates will be denoted by the post-fix "NoSpt" if they are obtained without the spatial error.

In order to obtain an average measure of prediction performace we compare the PPP predictions obtained from the RRD approach under the the three spatial specifications and both the No05 and Y05 cases. We use the benchmark year 2005 to compute the measure. Since PPP_i is measured in the domestic current of the ith country, we construct a *mean percent absolute deviation (MPAD)* measure, defined as follows:

$$MPAD = \frac{1}{110}\left(\sum_{i=1}^{110}\left|\frac{P\tilde{P}P_i - P\hat{P}P_i}{P\tilde{P}P_i}\right| \times 100\right) \tag{14}$$

where,

$P\tilde{P}P_i$ is the ICP benchmark observation for country i in the 2005 round.

$P\hat{P}P_i$ is the RRD predicted PPP value for country i in 2005.

All three spatial specifications are estimated for both the No05 and Y05 cases. The next section presents the data used in the estimations.

5 Data and Empirical Results

In this section we present the empirical comparisons of the alternative scenarios described above. Section 4.1 describes the dataset used and Section 4.2 presents and discusses the empirical results

5.1 Data compilation and data construction

The data set covers 141 countries over the years 1970 to 2005. It is worth noting that only 110 of the 141 countries in the sample participated in the 2005 round of the ICP. The dimensions of the data set were largely determined by data availability. That is, a number of countries were excluded because of missing data. The reader is referred to the data appendices in [37] for a detailed description. Appendix Table DA.1 lists the 141 countries included in the study. This table also lists the currency of each country and the years each country has participated in the ICP Benchmark comparisons. Appendix Table DA.2 gives definitions and sources of the variables used in the study, while Table DA.3 provides some basic descriptive statistics of the variables.

5.1.1 PPP Data

The state variable in the state space model is $ln(PPP_{it})$, and observed values (which define the dependent variable in the measurement equation) are obtained from all the benchmarks conducted since 1975. Thus *PPP* data are drawn from the early benchmarks of 1975, 1980 and 1985 as well as from more recent benchmark information for the years 1990, 1993, 1996, 1999, 2002 and 2005. Several features of the *PPP* data are noteworthy. The first benchmark covered 13 countries. The 1980, 1985 and the recent 2005, benchmarks represent truly global comparisons with *PPPs* computed using data for all the participating countries. For the years beginning from 1990 to 2002, data are essentially from the OECD and EU comparisons with the exception of 1996[6]. The 1996 benchmark year again is a global comparison with *PPPs* for countries from all the regions of the world. However, the 1996 benchmark may be considered weaker than the 1980, 1985 and 2005 benchmark comparisons as no systematic linking of regional *PPPs* was undertaken. In terms of reliability, one would consider the 1996 benchmark *PPPs* to be less reliable. Another related point of interest is the fact that *PPPs* for all the benchmarks prior to 1990 were based on the Geary-Khamis method and *PPPs* for the more recent years are all based on the EKS method of aggregation.[7] In the current empirical analysis, we have not made any adjustments to the *PPP* data

[6] We are indebted to Ms Francette Koechlin (OECD) for providing ICP benchmark data for these years. PPPs for those countries which joined in the Euro zone, the pre-Euro domestic currencies were converted using the 1999 Irrevocable Conversion Rates (Source:`http://www.ecb.int/press/date/1998/html/pr981231_2.en.html`). The irrevocable conversion rate of the drachma vis a vis the euro was set at GRD 340.750 Source: `http://www.bankofgreece.gr/en/euro`.

[7] This was brought to our attention by Steve Dowrick who attended a seminar on the topic presented at the Australian National University in October 2007.

but making the series comparable through the use of the same aggregation methodology is part of our ongoing research program.

5.1.2 Socio-Economic Variables included in the Price Level Regression

The variables used come under two categories. We use a set of variables that are essentially dummy variables designed to capture country-specific episodes that may influence the exchange rates or *PPPs* or both as well as benchmark dummies (these are sufficient to insure invariance of the method to the choice of reference country). The second set of variables are more of a structural nature commonly discussed in the works of [27, 28], [11], [8, 7] and [1].[8] It is important to recall at this point that the role of the regression component of the model is to provide a prediction of the $ln(PPP)$ and thus the emphasis is not on the marginal effect of individual variables but on its overall prediction ability.

5.1.3 Covariance Variables

Measuring spatial correlation:

The alternative spatial weight matrices, W_t, used in modeling spatial autocorrelation were discussed in Section 4 above, and Appendix 1 presents a detailed description of the method and summary statistics of the data used to generate each alternative for a subset of countries. Due to space constrains not all countries are shown. However, the data are available upon request from the authors.

Accuracy of benchmarks and national accounts' growth rates:

The specification includes the modeling of the accuracy of benchmark $PPPs$ and national growth rates. We assume that the measurement errors in both cases have variances that are inversely proportional to the per capita GDP expressed in US dollars. This means that countries with higher per capita incomes are expected to have more reliable data, as reflected by lower variances associated with them.[9]

5.2 Empirical Evidence

5.2.1 Parameter Estimates and Tests for Spatial Correlation

Tables 1, 2 and 3 summarise the results obtained from the estimation of the models and testing for spatial autocorrelation. Table 1 presents the estimates of the Y05 model, that is when the 2005 ICP data

[8] We are conscious of the fact that serious multicollinearity issues may be present here as the variables are potentially correlated. As the main purpose of inclusion of these variables is to improve the quality of the predictions, we decided to leave the variables in the model with the view that the model results in better predictions.

[9] We make use of exchange rate converted per capita incomes to overcome the problem of possible endogeneity arising out of the use of *PPP* converted exchange rates. These data are drawn from the UN sources. Given the systematic nature of the exchange rate deviation index (ratio of *PPP* to *ER*), use of exchange rate converted per capita GDP is likely to magnify differences in per capita incomes.

are included (2005 is a benchmark year) under the three spatial weights matrices as well as when the model assumes no spatially correlated errors. Panel 1 presents the least squares estimates of the price level model while the other panels present the maximum likelihood estimates of all the parameters in the state-space model. Table 2 shows the same information as Table 1 for the No05 model, that is, the 2005 ICP data are not included (that is 2005 is treated as a non-benchmark year). Table 3 presents the computed LM Statistics for the null hypothesis of no spatial errors (with p-values) computed for two global ICP benchmark years, 1985 and 2005.

[Insert Tables 1,2, and 3 here]

The results can be summarised as follows,

- The goodness of fit of the price level regression is high. The R^2 of the pooled regression including the 2005 data is 0.737 (see Panel 1, Table 1). The sample contains 449 benchmark points from 1975 to 2005. The R^2 of the pooled regression for the model not including the 2005 data is 0.753 (see Panel 1, Table 2), and the sample size is 339. The same set of conditioning variables are used in both cases. These results indicate that this important component of the state-space model is strong and able to provide reasonable predictions for non-participating countries and non-benchmark years.
- The estimates of the some of the regression slopes change when these parameters are estimated jointly with the covariance parameters by the maximum likelihood procedure in the state-space model, although some do not change substantially. For example the coefficient for PHONES, RURPOP and LIFE remain almost unchanged.
- The log-likelihood values are identical and highest for both the model without spatial correlation (Panel 5, when $\phi = 0$) and that with PC weights (Panel 2). This is the case for both models (Y05 and No05).
- The estimate of the spatial parameter is around 0.7 for the Y05 model and 0.55 for the No05 model.
- The computed LM statistic for the null hypothesis of no spatial correlation (the reader is referred to [20] for a description of this test) provides evidence of spatial autocorrelation. The residuals of the multiple regression in Panel 1 of Table 1 are used for the testing. Table 3 presents the computed values. The LM statistics is computed for the least squares residuals corresponding to the year 1985 (56 observations) and those corresponding to the year 2005 (110 observations) and for each of the alternative specification of the $\boldsymbol{W}_t$ matrix. The null is rejected in all cases when the 2005 residuals are used, but only rejected in one case (EW) when the 1985 residuals are used.

In summary, the variables included in the price level regression seem to explain over 70 per cent of the variance of the deviation of *PPPs* from *ERs;* there is evidence that the errors of the price level regression are spatially correlated although the likelihood value of the models with and without spatial errors do not differ substantially. Since the main objective of the RRD method is to produce a panel of *PPPs,* the next section evaluates the prediction accuracy of the constructed panels.

5.2.2 PPP Predictions and Prediction Performance

As an illustration of the *PPPs* series that are produced by the method, Tables 4, 5 and 6 present the constructed series for three countries (Spain, China and India) for the combinations, Y05_PCW, Y05_TW, Y05_EW, No05_PCW, No05_TW and No05_EW. Table 7 presents the computed MAPD for each combination.

[Insert Tables 4,5,6 and 7 here]

Thus, for each case the *MPAD* value in the body of the table can be read as a per cent. For example, the average deviation in the *PPP* predictions for the 110 countries for the year 2005 obtained from the No05_PCW model is 34.04 per cent, which decreases to 0.45 per cent when the 2005 ICP data are incorporated (Y05_PCW). The predictions from the "Y05_" models are *in-sample* predictions given that the 2005 data are used to estimate the model and therefore expected to be much closer to the ICP observed values although not necessarily identical given the model accounts for some measurement error. Using the *MPAD* we can also evaluate the performance of the models with and without a spatial error. By treating 2005 as a non-benchmark year, it is clear that the predictions made by the model without spatial errors are worse than those made using any of the alternative spatial specifications. The spatial specifications PCW and TW have an *MPAD* of 34 per cent, the EW of 35 per cent and the NoSpt of 38 per cent. What is interesting is that this pattern still exists when the *MPAD* of the Y05 model are considered. The *MPAD* of the PCW is 0.45 per cent, TW is 0.44 per cent, EW is 0.47 per cent and NoSpt is 0.76 per cent.

The use of averages allows an overall comparison, however, it can conceal the extent of the deviations for some countries. For instance, China's predictions from the No05 models (Table 5) show that the *PPP* predictions from the model with spatial errors (either of them) were significantly closer to the ICP measurement than that of the model without spatial errors. The ICP value was Yuan 3.45, the predictions of the spatial models were Yuan 3.59 from the No05_PWC, Yuan 3.18 from the No05_TW, Yuan 3.24 from the No05_EW and Yuan 0.86 from the No05_NoSpt. China had never participated in an ICP exercise before 2005, and thus, the predictions of the spatial models came remarkably close to the ICP benchmark of 2005. Further, the PWT6.2 includes predictions up to the year 2004 and so we can compare the predicted value from the No05 models for the year 2004. The spatial versions of RRD predict: Yuan 3.51, Yuan 3.10, and Yuan 3.16 (PWC, TW, EW, respectively), while PWT6.2 is Yuan 2.15. A set of similar arguments can be made for India (see Table 6).

From the discussion so far we conclude that the use of a spatial error structure produces a substantial improvement in the prediction of *PPPs* both on average and for the less developed countries in the sample even when the 2005 data are incorporated in the estimation. However, this might not be the case for OECD countries that have been involved in frequent comparisons since the early 1990s. Table 4 presents the predicted series for Spain. Spain has been involved in the EUROSTAT/OECD comparisons of 1990, 1993, 1996, 1999, 2002 and 2005. It is however interesting to note that while the spatial versions of the No05 model predicted Euro 0.77 for 2005 (ICP value for 2005 is 0.77), the non-spatial version predicted 0.75, a small deviation. For the Y05 model, all predictions are Euro 0.77. This pattern repeats across all the EUROSTAT/OECD countries (available from the authors). Thus, the use of a spatial error does not change the predictions in any significant way. This is reassuring, as the comparisons of EUROSTAT/OECD are of high quality and thus the model should not adjust observed international comparison's values. Finally, we note that the PWT6.2 for 2004 comes higher than any of the predictions made from any of the versions of the RRD method (Euro 0.84).

6 Conclusions

The paper builds on the earlier work of Rao, Rambaldi and Doran (2008) where a comprehensive econometric approach to the construction of consistent time-space extrapolations of *PPPs* was proposed. The Rao *et al* approach makes use of a particular specification for the spatially correlated errors and in this paper we focus on alternative specifications of the spatial weight matrix. An approach based on principal components analysis is used to estimate a common factor for each country as a measure of the pairwise distance to all other countries in the sample. This measure is converted into spatial weights and compared to alternative weight matrices based only on bilateral trade information. The empirical analysis reported in the paper makes use of the data set compiled by Rao *et al* spanning the period 1970 to 2005 and 141 countries. The results clearly indicate the need to adequately model spatial autocorrelation in predicting *PPPs* for non-benchmark countries and years. The trade weights matrix and the matrix based on principal components appear to perform equally well. Though the empirical results presented here focus on selected countries, detailed results for all the countries included in the analysis are available from the authors.

References

[1] Ahmad, S 1996, "Regression Estimates of per Capita GDP Based on Purchasing Power Parities", in J Salazar-Carrillo & PDS Rao (eds), International Comparisons of Prices, Output and Productivity:Contributions to Economic Analysis Series, Elsevier, North Holland.

[2] Anselin, L., R.J.G. Florax and S.J. Rey (eds.), 2004, Advances in Spatial Econometrics. Methodolgy, Tools and Applications. Series Advances in Spatial Science. Springer-Verlag, Berlin, Germany.

[3] Asian Development Bank 2005, Purchasing Power Parities and Real Expenditures, `www.adb.org/Documents/Reports/ICP-Purchasing-Power-Expenditures/default.asp`.

[4] AS 2006, Cross-National Time-Series Data Archive, Databanks International, Bronx, NY.

[5] Barro, RJ and Sala-i-Martin, XX 2004, Economic Growth, Second edn, MA: MIT Press, Cambridge.

[6] Basu, S. and T Thibodeau, 1998, Analysis of Spatial Autocorrelation in House Prices, Journal of Real Estate Finance and Economics, vol 17, 1, 61-85.

[7] Bergstrand, JH 1991, Structural Determinants of Real Exchange Rates and National Price Levels: Some Empirical Evidence, American Economic Review, vol. 81, no. 1, pp. 325-34.

[8] Bergstrand, JH 1996, Productivity, Factor Endowments, Military Expenditures, and National Price Levels, in PDS Rao & J Salazar-Carrillo (eds), International Comparisons of Prices, Ouput and Productivity, Elsevier Science Publishers B.V., North Holland.

[9] Castles, I & Hendersen, D 2003, IPPC Issues: A Swag of Documents, viewed 14 December, 2007, `http://www.lavoisier.com.au/papers/articles/IPPCissues.html`.

[10] CIA 2008, The CIA World Factbook The Central Intelligence Agency, Langley, Virginia, U.S.A., `https://www.cia.gov/library/publications/the-world-factbook/`.

[11] Clague, C 1988, Explanations of National Price Levels?, in PDS Rao & J Salazar-Carrillo (eds), World Comparisons of Incomes, Prices and Product: Contributions to Economic Analysis series: no 173 Elsevier, North Holland.

[12] Doran, HE 1992, Constraining Kalman Filter and Smoothing Estimates to Satisfy Time-Varying Restrictions, Review of Economics and Statistics, vol. 74, no. 3, pp. 568-72

[13] Dubin, R.A. 1988, Estimation of Regression Coefficients in the Presence of Spatially Autocorrelated Error Terms, The Review of Economics and Statistics, vol. 70, No 3, 466-474.

[14] Durbin, J and Koopman, SJ 2001, Time Series Analysis by State Space Methods, Oxford University Press, Oxford.

[15] Durbin, J and Koopman, SJ 2002, A Simple and Efficient Simulation Smoother for State Space Time Series Analysis, Biometrika, vol. 89, pp. 603-16.

[16] Durlauf, SN, Johnson, P and Temple, J 2005, Growth Econometrics, in P Aghion & SN Durlauf (eds), Handbook of Economic Growth, Elselvier, Amsterdam vol. 1, pp. 555-677.

[17] Easterly, WR 2006, Global Development Network Growth Database, NYU DRI, http://www.nyu.edu/fas/institute/dri/globaldevelopmentnetworkgrowthdatabase.htm.

[18] European Central Bank 1998, 31 December 1998 - Determination of the euro conversion rates, Press Release, http://www.ecb.eu/press/pr/date/1998/html/pr981231_2.en.html.

[19] FAO 2006, AGROSTAT, Food and Agriculture Organization, http://faostat.fao.org/default.aspx.

[20] Florax, RJGM, Graaff, Tde 2004, The Performance of Diagnostic Tests for Spatial Dependence in Linear Regression Models: A Meta-Analysis of Simulation Studies, in Anselin, L, Florax, RJGM, and Rey, SJ, Advances in Spatial Econometrics. Methodology, Tools and Applications, Springer.

[21] Lessage, J.P., and R.K. Pace, 1998, Models for Spatially Dependent Missing Data, Journal of Real Estate Finance and Economics, 29:2, 233-254.

[22] Harvey, AC 1990, Forecasting, Structural Time Series Models and the Kalman Filter, Cambridge University Press Cambridge.

[23] Harvey, AC, Trimbur, TM & van Dijk, HK 2005, Trends and Cycles in Economic Time Series: A Bayesian Approach, manuscript.

[24] Heston, A, Summers, R & Aten, B 2006, Penn World Table Version 6.2, Center for International Comparisons of Production, Income and Prices at the University of Pennsylvania, http://pwt.econ.upenn.edu/php_site/pwt_index.php.

[25] IMF 2007, International Financial Statistics (IFS), no. The International Monetary Fund.

[26] Koop, G & van Dijk, HK 2000, Testing For Integration Using Evolving Trend and Seasonal Models: A Bayesian Approach, Journal of Econometrics, vol. 97, pp. 261-91.

[27] Kravis, IB & Lipsey, RE 1983, Toward an Explanation of National Price Levels, Princeton Studies in International Finance, No. 52 Princeton University Press, Princeton.

[28] Kravis, IB & Lipsey, RE 1986, The Assessment of National Price Levels, paper presented to Eastern Economic Association Meetings, Philadelphia, April.

[29] Kravis, IB, Summers, R & Heston, A 1982, World Product and Income, Johns Hopkins University Press Baltimore.

[30] Maddison, A 1995, Monitoring the World Economy, 1820-1992, , OECD, Paris.

[31] Maddison, A 2007, Contours of the World Economy 1?2030 AD: Essays in Macro-Economic History, , Oxford University Press, Oxford.

[32] McKibbin, WJ & Stegman, A 2005, Convergence and Per Capita Carbon Emissions, Working Paper 04.05, Lowey Institute for International Policy, Sydney.

[33] Milanovic, B 2002, True World Income Distribution, 1988 and 1993: First Calculation Based on Household Surveys Alone', The Economic Journal, vol. 112, pp. 51-92.

[34] Pace, R.K., R. Barry and C.F. Sirmans, 1998, Spatial Statistics and Real Estate, Journal of Real Estate Finance and Economics, vol 17, 1, 5-13.

[35] Pesaran, M.H. and L Tosseti 2009, "Large Panels with Spatial Correlations and Common Factors," Working Paper 09, http://www.econ.cam.ac.uk/faculty/pesaran/wp09/PesaranTosetti04Mar09.pdf

[36] Rambaldi, A.N., R.C.Hill, and H.E. Doran 2004, Perdicting Incomplete Observations in Unbalanced Panels: A Kalman Filtering-Smoothing Approach, Chapter 11, pp. 226-240, in Becker, R and S. Hurn (eds) Contemporary Issues in Economics and Econometrics. Theory and Application. Edward Elgar Publishing Ltd., Cheltenham, UK.

[37] Rao, DSP, Rambaldi, AN & Doran, HE 2008. A Method to Construct World Tables of Purchasing Power Parities and Real Incomes Based on Multiple Benchmarks and Auxiliary Information: Analytical and Empirical Results. WP05/08 CEPA Working Paper Series. School of Economics, University of Queensland. ISSN No. 1932 – 4398, 52 pp.

[38] Rose, A 2004, Bilateral trade data set, viewed January 2007, http://faculty.haas.berkeley.edu/arose/RecRes.htm.

[39] Sala-i-Martin, XX 2002, 15 Years of New Growth Economics: What have we learnt?, Unpublished manuscript.

[40] Summers, R & Heston, A 1988, Comparing International Comparisons, in J Salazar-Carrillo & PDS Rao (eds), World Comparisons of Incomes, Prices and Product, Contributions to Economic Analysis Series, no 173, North-Holland, Amsterdam.

[41] Summers, R & Heston, A 1991, The Penn World Tables (Mark 5): An expanded set of international comparisons, 1950-88, Quarterly Journal of Economics, vol. 2, no. 1, pp. 1-45.

[42] UN 2007, National Accounts Main Aggregates Database, United Nations, viewed June 2007, http://unstats.un.org/unsd/snaama/.

[43] UNDP 2006 Human Development Report, United Nations Development Program, New York. World Bank 2006 and various years, World Development Indicators, viewed May 2007 http://devdata.worldbank.org/wdi2006/contents/cover.htm.

Table 1: Parameter Estimates Under Alternative Specifications -Y05 Model

	Regression		State Space Model Y05							
	Without Spatial Errors (Panel1)		Spatial PC Weights (Panel 2)		Spatial TW Weights (Panel 3)		Spatial EW Weights (Panel 4)		Spatial No Spatial (Panel 5)	
Variable	Estimate	S.E.	Estimate	S.E.	Estimate	S.E.	Estimate	S.E.	Estimate	S.E.
Intercept			2.078	1.338	3.780	1.325	2.462	1.329	3.200	1.172
dum75_79	-0.199	0.063	0.868	0.341	1.191	0.350	1.675	0.354	0.030	0.153
dum80_84	-0.128	0.238	0.668	0.331	0.977	0.337	1.011	0.338	-0.130	0.155
dum85_89	-0.621	0.239	-0.040	0.324	0.105	0.327	0.257	0.327	-0.865	0.154
dum90_92	-0.282	0.244	-0.504	0.376	-0.742	0.378	-0.671	0.379	-0.937	0.168
dum93_95	-0.451	0.244	-1.059	0.375	-1.212	0.377	-1.012	0.378	-1.275	0.170
dum96_98	-0.445	0.241	-1.571	0.376	-1.808	0.378	-1.716	0.381	-1.538	0.174
dum99_01	-0.692	0.246	-1.484	0.382	-1.602	0.387	-1.280	0.391	-1.624	0.180
dum02_04	-0.786	0.238	-1.650	0.389	-1.828	0.399	-1.480	0.405	-1.770	0.185
dum05	-0.540	0.237	-3.306	0.582	-4.752	0.591	-4.761	0.594	-2.693	0.233
D_anz	-0.770	0.221	-0.443	0.394	-0.519	0.362	-0.328	0.380	-0.395	0.400
D_asean	0.016	0.080	0.075	0.281	0.137	0.267	0.010	0.269	0.010	0.250
D_cac	-0.029	0.155	0.221	0.278	0.203	0.277	0.311	0.292	0.372	0.255
D_cafrica	0.101	0.116	0.033	0.321	0.077	0.314	-0.025	0.311	0.329	0.306
D_eafrica	0.118	0.094	0.090	0.283	0.105	0.280	-0.007	0.277	0.321	0.264
D_euro	0.092	0.045	0.104	0.170	0.169	0.174	0.065	0.170	0.164	0.170
D_mena	0.045	0.073	-0.041	0.194	-0.103	0.190	-0.193	0.187	-0.032	0.184
D_mercsr	-0.081	0.082	0.720	0.274	0.846	0.267	0.817	0.272	1.182	0.244
D_nafta	-0.243	0.086	-0.023	0.305	0.034	0.311	-0.025	0.285	0.032	0.284
D_safrica	0.066	0.122	-0.052	0.302	-0.085	0.290	-0.190	0.289	0.171	0.284
D_scucar	0.228	0.148	0.293	0.261	0.159	0.266	0.281	0.264	0.432	0.254
D_spr	0.632	0.206	0.925	0.302	0.810	0.290	0.696	0.287	0.833	0.269
D_usd	0.073	0.069	0.569	0.138	0.576	0.138	0.589	0.133	0.571	0.137
D_wafrica	0.256	0.089	-0.551	0.269	-0.526	0.263	-0.666	0.259	-0.326	0.253
Agedep	0.365	0.174	-0.258	0.571	-0.344	0.560	-0.226	0.560	-0.458	0.556
Agvagun	-0.009	0.002	-0.019	0.007	-0.021	0.007	-0.020	0.007	-0.019	0.007
Tractorpw	0.094	0.061	0.159	0.245	0.216	0.245	0.253	0.239	0.308	0.242
Labpop	-0.003	0.003	-0.013	0.011	-0.015	0.011	-0.012	0.011	-0.025	0.011
Life	-0.006	0.004	-0.007	0.012	-0.012	0.012	-0.008	0.012	-0.013	0.011
Literate	2.1E-04	1.4E-04	-4.0E-04	4.2E-04	-4.0E-04	4.1E-04	-4.8E-04	4.2E-04	-2.4E-04	4.1E-04
Ntrvag2	-0.004	0.003	-0.012	0.008	-0.013	0.008	-0.016	0.008	-0.010	0.008
Expg	-0.002	0.003	-0.006	0.006	-0.008	0.006	-0.006	0.006	-0.005	0.006
Phones	0.001	1.8E-04	0.003	0.001	0.003	0.001	0.003	0.001	0.003	0.001
Radpccn	5.0E-06	7.0E-06	-5.5E-05	2.3E-05	-4.8E-05	2.3E-05	-6.7E-05	2.3E-05	-6.6E-05	2.3E-05
Rurpop	-0.004	0.001	-0.004	0.005	-0.004	0.005	-0.005	0.005	-0.004	0.005
Secenr	3.3E-05	5.4E-05	-9.5E-05	1.7E-04	-1.1E-04	1.6E-04	-9.5E-05	1.6E-04	-1.9E-04	1.7E-04
Tradegun	-2.1E-04	0.002	2.4E-05	3.2E-03	1.4E-04	0.003	-8.0E-05	3.2E-03	-0.002	0.003
Manufexp	-2.4E-04	0.001	0.002	0.002	0.002	0.002	0.001	0.002	0.003	0.002
Manufimp	0.003	0.001	0.004	0.004	0.003	0.004	0.006	0.004	0.004	0.004
R^2	0.737									
lnL			-1.30e+07		-1.37e+07		-1.33e+07		-1.30e+07	
σ_η^2			7.00		7.01		7.00		7.00	
σ_u^2			4.50		4.50		4.50		4.50	
σ_ξ^2			0.79		0.80		0.80		1.00	
ϕ			0.70		0.70		0.69		0.00	

Table 2: Parameter Estimates Under Alternative Specifications -No05 Model

	Regression		State Space Model No05							
	Without Spatial Errors (Panel1)		Spatial PC Weights (Panel 2)		Spatial TW Weights (Panel 3)		Spatial EW Weights (Panel 4)		Spatial No Spatial (Panel 5)	
Variable	Estimate	S.E.	Estimate	S.E.	Estimate	S.E.	Estimate	S.E.	Estimate	S.E.
Intercept			2.864	1.474	4.294	1.460	3.339	1.460	3.553	1.334
dum75_79	-0.197	0.064	0.137	0.311	0.188	0.311	0.429	0.311	-0.435	0.188
dum80_84	-2.296	0.540	-2.005	0.306	-1.965	0.305	-1.966	0.305	-2.538	0.191
dum85_89	-2.810	0.544	-2.839	0.300	-2.914	0.299	-2.809	0.299	-3.330	0.189
dum90_92	-2.507	0.548	-3.192	0.337	-3.480	0.337	-3.392	0.339	-3.419	0.206
dum93_95	-2.697	0.551	-3.697	0.338	-3.951	0.338	-3.796	0.340	-3.782	0.209
dum96_98	-2.686	0.549	-4.157	0.340	-4.501	0.341	-4.347	0.345	-4.069	0.214
dum99_01	-2.957	0.554	-4.166	0.347	-4.415	0.350	-4.184	0.354	-4.159	0.222
dum02_04	-3.078	0.556	-4.485	0.335	-4.742	0.342	-4.559	0.347	-4.418	0.221
D_anz	-0.792	0.302	-0.491	0.457	-0.538	0.426	-0.358	0.445	-0.451	0.468
D_asean	0.034	0.097	0.092	0.307	0.153	0.295	0.062	0.298	0.063	0.285
D_cac	-0.054	0.158	0.274	0.307	0.295	0.308	0.351	0.321	0.361	0.293
D_cafrica	0.324	0.151	0.348	0.353	0.392	0.347	0.319	0.345	0.543	0.347
D_eafrica	0.274	0.113	0.322	0.311	0.329	0.308	0.254	0.305	0.473	0.300
D_euro	0.119	0.052	0.173	0.201	0.212	0.206	0.135	0.203	0.193	0.201
D_mena	0.123	0.096	0.063	0.219	0.025	0.215	-0.024	0.213	0.048	0.212
D_mercsr	0.095	0.103	0.881	0.304	0.991	0.300	0.955	0.304	1.262	0.282
D_nafta	-0.243	0.094	-0.011	0.352	0.020	0.363	0.024	0.337	0.025	0.336
D_safrica	-0.017	0.155	-0.002	0.338	-0.017	0.327	-0.095	0.326	0.130	0.326
D_scucar	0.184	0.158	0.279	0.295	0.194	0.301	0.260	0.299	0.387	0.293
D_spr	0.584	0.288	0.896	0.326	0.848	0.317	0.761	0.314	0.844	0.305
D_usd	0.112	0.078	0.550	0.159	0.559	0.159	0.556	0.154	0.560	0.160
D_wafrica	0.542	0.118	-0.139	0.297	-0.118	0.291	-0.211	0.288	-0.010	0.289
Agedep	0.962	0.251	0.272	0.641	0.104	0.631	0.217	0.632	0.136	0.632
Agvagun	-0.006	0.003	-0.014	0.007	-0.016	0.007	-0.016	0.007	-0.014	0.007
Tractorpw	0.026	0.072	0.071	0.281	0.108	0.280	0.141	0.276	0.158	0.278
Labpop	0.001	0.004	-0.013	0.013	-0.016	0.013	-0.016	0.013	-0.023	0.012
Life	0.013	0.006	0.009	0.013	0.004	0.013	0.007	0.013	0.005	0.013
Literate	1.4E-04	1.9E-04	-3.9E-04	4.6E-04	-3.6E-04	4.6E-04	-3.9E-04	4.6E-04	-2.3E-04	4.6E-04
Ntrvag2	-0.003	0.003	-0.012	0.009	-0.013	0.009	-0.015	0.009	-0.010	0.009
Expg	0.008	0.005	0.003	0.007	0.002	0.007	0.003	0.007	0.004	0.007
Phones	0.001	2.2E-04	0.002	0.001	0.003	0.001	0.003	0.001	0.003	0.001
Radpccn	5.0E-06	8.0E-06	-4.4E-05	2.6E-05	-4.3E-05	2.6E-05	-5.4E-05	2.6E-05	-5.4E-05	2.6E-05
Rurpop	-0.003	0.002	-0.005	0.005	-0.005	0.005	-0.004	0.005	-0.005	0.005
Secenr	1.3E-04	7.4E-05	6.0E-06	1.9E-04	1.2E-05	1.9E-04	-1.2E-05	1.9E-04	-6.5E-05	1.9E-04
Tradegun	-0.005	0.003	-0.004	0.004	-0.004	0.004	-0.005	0.004	-0.005	0.004
Manufexp	0.001	0.001	0.003	0.003	0.003	0.003	0.003	0.003	0.004	0.003
Manufimp	0.005	0.001	0.005	0.004	0.004	0.004	0.006	0.004	0.005	0.004
R^2	0.753									
lnL			-1.39e+04		-1.41e+04		-1.42e+04		-1.39e+04	
σ^2_η			7.00		6.98		7.01		8.00	
σ^2_u			6.50		6.50		6.50		6.50	
σ^2_ξ			0.80		0.80		0.81		0.80	
ϕ			0.55		0.56		0.55		0.00	

Table 3: LM Tests for Spatial Correlation

W_t	**PCW**		**TW**		**EW**	
	LM	P-VALUE	LM	P-VALUE	LM	P-VALUE
LS Resid for 1985	**0.122**	0.726	**0.069**	0.793	**2.791**	0.095
LS Resid for 2005	**4.48**	0.034	**4.208**	0.040	**14.54**	0.0001

Table 4: *PPP* Series for Spain (Implied Price Movements Preserved)

year	ER	ICP	2005 is a Benchmark Year				2005 is not a Benchmark Year				PWT6.2[a]
			PC Weights	Trade Weights	Equal Weights	No Spatial	PC Weights	Trade Weights	Equal Weights	No Spatial	
1971	0.4175		0.1763	0.1763	0.1763	0.1760	0.1763	0.1768	0.1765	0.1724	32.9789
1972	0.3863		0.1835	0.1836	0.1836	0.1833	0.1836	0.1840	0.1838	0.1795	34.1987
1973	0.3502		0.1945	0.1945	0.1945	0.1942	0.1945	0.1950	0.1947	0.1902	36.2469
1974	0.3467		0.2068	0.2068	0.2068	0.2065	0.2068	0.2073	0.2070	0.2023	39.0841
1975	0.3450	**0.2540**	0.2206	0.2207	0.2207	0.2203	0.2207	0.2212	0.2209	0.2158	41.4173
1976	0.4021		0.2430	0.2431	0.2431	0.2427	0.2431	0.2437	0.2433	0.2377	45.7205
1977	0.4565		0.2820	0.2820	0.2820	0.2816	0.2820	0.2827	0.2823	0.2758	52.9058
1978	0.4608		0.3178	0.3179	0.3179	0.3174	0.3179	0.3187	0.3182	0.3109	58.9438
1979	0.4034		0.3431	0.3432	0.3432	0.3427	0.3432	0.3440	0.3435	0.3357	63.1692
1980	0.4309	**0.3825**	0.3566	0.3566	0.3566	0.3561	0.3567	0.3575	0.3570	0.3488	66.3191
1981	0.5549		0.3662	0.3663	0.3663	0.3657	0.3663	0.3672	0.3667	0.3582	69.6305
1982	0.6603		0.3921	0.3921	0.3921	0.3915	0.3922	0.3931	0.3925	0.3835	74.7093
1983	0.8620		0.4220	0.4220	0.4220	0.4214	0.4221	0.4231	0.4225	0.4128	81.3117
1984	0.9662		0.4509	0.4510	0.4510	0.4503	0.4510	0.4521	0.4514	0.4411	86.6931
1985	1.0220	**0.5728**	0.4751	0.4751	0.4751	0.4744	0.4752	0.4763	0.4756	0.4647	90.8481
1986	0.8417		0.5153	0.5153	0.5153	0.5146	0.5154	0.5166	0.5159	0.5040	96.2679
1987	0.7421		0.5312	0.5313	0.5313	0.5305	0.5314	0.5326	0.5319	0.5197	98.5311
1988	0.7001		0.5441	0.5442	0.5442	0.5433	0.5442	0.5455	0.5448	0.5322	100.2722
1989	0.7115		0.5604	0.5604	0.5604	0.5596	0.5605	0.5618	0.5610	0.5481	102.9329
1990	0.6126	**0.6581**	0.5790	0.5791	0.5791	0.5782	0.5792	0.5805	0.5797	0.5664	105.1833
1991	0.6245		0.5983	0.5983	0.5983	0.5974	0.5984	0.5998	0.5990	0.5852	108.4699
1992	0.6153		0.6241	0.6241	0.6241	0.6232	0.6242	0.6257	0.6248	0.6104	112.8342
1993	0.7649	**0.7032**	0.6377	0.6378	0.6378	0.6368	0.6379	0.6394	0.6385	0.6238	116.3522
1994	0.8051		0.6488	0.6488	0.6488	0.6479	0.6489	0.6505	0.6495	0.6346	119.0284
1995	0.7494		0.6672	0.6672	0.6672	0.6662	0.6673	0.6689	0.6680	0.6526	121.9997
1996	0.7613	**0.7433**	0.6774	0.6774	0.6774	0.6764	0.6775	0.6791	0.6781	0.6626	124.1070
1997	0.8800		0.6821	0.6822	0.6822	0.6811	0.6823	0.6839	0.6829	0.6672	125.8340
1998	0.8979		0.6913	0.6914	0.6914	0.6904	0.6915	0.6932	0.6922	0.6763	127.7315
1999	0.9386	**0.7493**	0.6994	0.6995	0.6995	0.6984	0.6996	0.7012	0.7002	0.6841	0.7773
2000	1.0854		0.7081	0.7082	0.7082	0.7071	0.7083	0.7100	0.7089	0.6927	0.7923
2001	1.1175		0.7203	0.7204	0.7204	0.7193	0.7205	0.7222	0.7212	0.7046	0.8002
2002	1.0626	**0.7428**	0.7393	0.7394	0.7394	0.7383	0.7395	0.7413	0.7402	0.7232	0.8121
2003	0.8860		0.7532	0.7533	0.7533	0.7522	0.7534	0.7552	0.7541	0.7368	0.8220
2004	0.8054		0.7637	0.7638	0.7638	0.7626	0.7639	0.7657	0.7646	0.7470	0.8361
2005	0.8041	**0.7700**	0.7700	0.7700	0.7700	0.7689	0.7701	0.7720	0.7709	0.7532	
SE			**0.0063**	**0.0063**	**0.0063**	**0.0070**	**0.0339**	**0.0340**	**0.0339**	**0.0352**	

[a] 1971-1998 in Pesetas, 1999 onwards in Euros

Table 5: *PPP* Series for China (Implied Price Movements Preserved)

year	ER	ICP	2005 is a Benchmark Year				2005 is not a Benchmark Year				PWT6.2
			PC Weights	Trade Weights	Equal Weights	No Spatial	PC Weights	Trade Weights	Equal Weights	No Spatial	
1971	2.4600		3.0921	3.0908	3.0910	3.0687	3.2156	2.8455	2.8976	0.7692	1.8079
1972	2.2500		2.9659	2.9647	2.9650	2.9435	3.0844	2.7294	2.7794	0.7379	1.7330
1973	1.9900		2.8133	2.8121	2.8123	2.7920	2.9257	2.5889	2.6363	0.6999	1.6537
1974	1.9600		2.5862	2.5852	2.5854	2.5667	2.6896	2.3800	2.4235	0.6434	1.4735
1975	1.8600		2.3354	2.3345	2.3347	2.3178	2.4288	2.1492	2.1885	0.5810	1.3468
1976	1.9400		2.2042	2.2033	2.2035	2.1875	2.2923	2.0284	2.0655	0.5484	1.2158
1977	1.8600		2.0953	2.0944	2.0946	2.0794	2.1790	1.9282	1.9635	0.5212	1.1718
1978	1.6800		1.9837	1.9829	1.9831	1.9687	2.0630	1.8255	1.8590	0.4935	1.1341
1979	1.5500		1.8967	1.8960	1.8961	1.8824	1.9725	1.7455	1.7774	0.4719	1.0551
1980	1.5000		1.8046	1.8038	1.8040	1.7909	1.8767	1.6606	1.6910	0.4489	0.9971
1981	1.7000		1.6877	1.6870	1.6871	1.6749	1.7551	1.5531	1.5815	0.4199	0.9372
1982	1.8900		1.5877	1.5871	1.5872	1.5757	1.6512	1.4611	1.4879	0.3950	0.9002
1983	1.9800		1.5436	1.5430	1.5431	1.5320	1.6053	1.4205	1.4465	0.3840	0.8881
1984	2.3200		1.5606	1.5599	1.5600	1.5488	1.6229	1.4361	1.4624	0.3882	0.8779
1985	2.9400		1.6676	1.6669	1.6671	1.6550	1.7342	1.5346	1.5627	0.4149	0.9262
1986	3.4500		1.7063	1.7056	1.7058	1.6934	1.7745	1.5703	1.5990	0.4245	0.9518
1987	3.7200		1.7446	1.7439	1.7440	1.7314	1.8143	1.6055	1.6349	0.4340	0.9810
1988	3.7200		1.8912	1.8905	1.8906	1.8769	1.9668	1.7404	1.7723	0.4705	1.1012
1989	3.7700		1.9826	1.9818	1.9819	1.9676	2.0618	1.8245	1.8579	0.4932	1.1724
1990	4.7800		2.0171	2.0163	2.0164	2.0018	2.0977	1.8562	1.8902	0.5018	1.1418
1991	5.3200		2.0802	2.0793	2.0795	2.0644	2.1633	1.9143	1.9493	0.5175	1.1610
1992	5.5100		2.1940	2.1931	2.1933	2.1774	2.2817	2.0190	2.0560	0.5458	1.2352
1993	5.7600		2.4955	2.4945	2.4947	2.4766	2.5952	2.2965	2.3385	0.6208	1.4751
1994	8.6200		2.9476	2.9464	2.9466	2.9253	3.0654	2.7125	2.7622	0.7333	1.7552
1995	8.3500		3.2855	3.2841	3.2844	3.2606	3.4167	3.0235	3.0788	0.8173	1.9755
1996	8.3100		3.4316	3.4302	3.4305	3.4056	3.5687	3.1579	3.2157	0.8537	2.0745
1997	8.2900		3.4262	3.4249	3.4251	3.4003	3.5631	3.1530	3.2107	0.8524	2.0825
1998	8.2800		3.3595	3.3581	3.3584	3.3341	3.4937	3.0916	3.1482	0.8358	2.0595
1999	8.2800		3.2701	3.2688	3.2690	3.2454	3.4008	3.0093	3.0644	0.8135	1.9973
2000	8.2800		3.2664	3.2650	3.2653	3.2417	3.3969	3.0059	3.0609	0.8126	1.9630
2001	8.2800		3.2550	3.2537	3.2539	3.2304	3.3850	2.9954	3.0502	0.8098	1.9597
2002	8.2800		3.2177	3.2164	3.2166	3.1934	3.3463	2.9611	3.0153	0.8005	1.9411
2003	8.2800		3.2359	3.2345	3.2348	3.2114	3.3652	2.9778	3.0323	0.8050	1.9769
2004	8.2800		3.3711	3.3697	3.3700	3.3456	3.5058	3.1022	3.1590	0.8386	2.1447
2005	8.1943	**3.45**	3.4546	3.4532	3.4535	3.4285	3.5926	3.1791	3.2373	0.8594	
SE			**0.0925**	**0.0924**	**0.0924**	**0.1026**	**2.3203**	**2.0502**	**2.0880**	**0.6014**	

Table 6: *PPP* Series for India (Implied Price Movements Preserved)

year	**ER**	**ICP**	**2005 is a Benchmark Year**				**2005 is not a Benchmark Year**				
			PC Weights	**Trade Weights**	**Equal Weights**	**No Spatial**	**PC Weights**	**Trade Weights**	**Equal Weights**	**No Spatial**	**PWT6.2**
1971	7.4900		4.3430	4.3441	4.3399	4.3146	3.6719	3.8755	3.7932	2.2284	2.8198
1972	7.5900		4.6204	4.6216	4.6172	4.5903	3.9065	4.1231	4.0355	2.3708	2.9330
1973	7.7400		5.1595	5.1608	5.1559	5.1259	4.3623	4.6041	4.5063	2.6474	3.2572
1974	8.1000		5.5225	5.5239	5.5186	5.4865	4.6692	4.9280	4.8234	2.8337	3.6413
1975	8.3800	**2.5940**	4.9675	4.9687	4.9640	4.9351	4.1999	4.4328	4.3386	2.5489	3.2869
1976	8.9600		4.9774	4.9786	4.9739	4.9449	4.2083	4.4416	4.3473	2.5540	3.1441
1977	8.7400		4.9415	4.9427	4.9380	4.9093	4.1779	4.4096	4.3159	2.5356	3.1191
1978	8.1900		4.7335	4.7347	4.7302	4.7027	4.0021	4.2240	4.1343	2.4289	3.0267
1979	8.1300		5.0607	5.0620	5.0572	5.0277	4.2787	4.5160	4.4201	2.5967	3.0674
1980	7.8600	**3.1045**	5.1732	5.1746	5.1696	5.1395	4.3739	4.6164	4.5183	2.6545	3.0990
1981	8.6600		5.2145	5.2158	5.2108	5.1805	4.4087	4.6532	4.5543	2.6756	3.1755
1982	9.4600		5.2947	5.2960	5.2910	5.2602	4.4765	4.7247	4.6244	2.7168	3.1664
1983	10.1000		5.5457	5.5472	5.5419	5.5096	4.6888	4.9488	4.8437	2.8456	3.3516
1984	11.4000		5.7418	5.7433	5.7378	5.7044	4.8546	5.1238	5.0150	2.9462	3.4445
1985	12.4000	**4.6670**	5.9716	5.9731	5.9674	5.9326	5.0488	5.3288	5.2156	3.0641	3.5533
1986	12.6000		6.2370	6.2386	6.2326	6.1963	5.2733	5.5656	5.4474	3.2003	3.6601
1987	13.0000		6.6284	6.6301	6.6237	6.5852	5.6042	5.9149	5.7893	3.4011	3.7893
1988	13.9000		6.9401	6.9419	6.9352	6.8949	5.8677	6.1931	6.0615	3.5611	4.0469
1989	16.2000		7.2445	7.2463	7.2394	7.1972	6.1250	6.4647	6.3274	3.7173	4.2150
1990	17.5000		7.7103	7.7123	7.7049	7.6600	6.5189	6.8803	6.7342	3.9563	4.4348
1991	22.7000		8.4792	8.4814	8.4733	8.4239	7.1690	7.5665	7.4058	4.3508	4.8928
1992	25.9000		9.0215	9.0238	9.0152	8.9627	7.6275	8.0504	7.8795	4.6291	5.2393
1993	30.5000		9.6550	9.6575	9.6482	9.5921	8.1631	8.6157	8.4327	4.9542	5.4891
1994	31.4000		10.3713	10.3740	10.3640	10.3037	8.7687	9.2549	9.0584	5.3217	6.0479
1995	32.4000		11.0759	11.0787	11.0681	11.0037	9.3645	9.8837	9.6738	5.6832	6.5390
1996	35.4000		11.6557	11.6587	11.6475	11.5797	9.8546	10.4010	10.1802	5.9807	6.8681
1997	36.3000		12.2106	12.2137	12.2020	12.1310	10.3238	10.8962	10.6648	6.2655	7.0947
1998	41.3000		13.0289	13.0322	13.0198	12.9440	11.0157	11.6264	11.3795	6.6854	7.5103
1999	43.1000		13.4420	13.4454	13.4326	13.3544	11.3649	11.9951	11.7403	6.8973	7.7342
2000	44.9000		13.6184	13.6219	13.6089	13.5297	11.5141	12.1525	11.8944	6.9879	7.8449
2001	47.2000		13.7141	13.7176	13.7045	13.6247	11.5950	12.2379	11.9780	7.0370	8.0032
2002	48.6000		14.0024	14.0060	13.9926	13.9111	11.8388	12.4952	12.2298	7.1849	8.1162
2003	46.6000		14.2440	14.2476	14.2340	14.1511	12.0430	12.7107	12.4408	7.3088	8.1461
2004	45.3000		14.4862	14.4899	14.4760	14.3917	12.2478	12.9268	12.6523	7.4331	
2005	44.2725	**14.6700**	14.6851	14.6889	14.6748	14.5894	12.4160	13.1044	12.8261	7.5352	
SE			**0.5038**	**0.5039**	**0.5034**	**0.5593**	**7.0325**	**7.4189**	**7.2084**	**4.5895**	

Table 7: Performance in the Prediction of the 2005 ICP Benchmark by Alternative Spatial Specifications

Mean Percent Absolute Deviation	**PPP PCW**	**PPP TW**	**PPP EW**	**PPP NoSpt**
Model Estimated Without 2005 ICP Data	34.04	33.58	34.72	38.40
Model Estimated With 2005 ICP Data	0.45	0.44	0.47	0.76

Appendix 1. The Construction of the Economic Distance Measure used in the PCW

A principal components approach is used to construct the measure. This technique allows the representation of the variance–covariance (or correlation) structure of a set of variables through a small number of linear combinations called components. Variables are grouped into components by their cross-correlations (Johnson & Wichern 2002).

Variables included in the Construction

The distance between countries is measured using a range of variables. The variables are chosen considering trade closeness, geological proximity, cultural closeness. To provide the reader with an example of the data used, summary statistics for a small group of countries are presented in Appendix DA.4.

a) Trade closeness:

We use the trade share between countries which is expressed as the volume of trade (export plus import) with each trading partner in the sample as a percentage of total trade of a particular country. This is constructed for every five year intervals ; 1970, 1975, 1980, 1985, 1990, 1995, 2000 and 2005

b) Geographical proximity:

Two dummies are used to consider geographical proximity, regional membership and close neighbours.

1. Regional membership: Asia pacific region, Europe, South America, North America, Central America and the Caribbean, Saharan Africa (except North Africa), North Africa and Middle East.
2. Close neighbours: We consider both land and sea proximities: e.g. Canada and the US are bordering countries. Sri Lanka and India as well as Singapore and Malaysia are also close neighbours. This dummy captures some aspects of proximity not caputred by the regional dummies. For instance, Venezuela and Trinidad and Tobago are close neighbours, but they are classified in different regions. Further, Japan and Australia are not close in terms of distance, but they are in the same region.

c) Cultural and colonial closeness:

1. Common language: A dummy is used for each language. In addition, the closeness of the dialect is also considered. For instance, Danish is very close to Swedish and Norwegian.

2. Common colonies: This dummy indicates the colonial relationship of countries. We do not totally fix to the standard definition for a colony but include protectorates and other types of foreign rules and consider countries under different types of foreign rules and their colonial occupants (such as UK, Spain etc.)to construct the dummy. Some countries had several colonial relationships over their history. For instance, Sri Lanka was partly or fully under the rules of England, Portugal and Holland. To avoid this complexity, we construct the dummy considering the last colonial power of the country or the colonial rule that made a significant impact on the particular country.

Estimation

The steps involved in the PC estimation procedure are summarized in the main text and some more details are presented here.

Step 1

A separate principal components model is estimated for each country using the variables for each time period. Therefore, 141 models are estimated. For each country there could be up to nine variables define: Trade period, region, border, language1, language2,..., language5, colonial. We will refer to the number of variables by m.

Step 2

The m principal components are orthogonal linear combinations of the m variables. The estimate of the weight of a given variable on a principal component is known as the "loading." We select the first component (corresponding to the largest eigenvalue) as the common factor. During the procedure we drop variables and re-estimate the model if, a) it has a negative loading on the first component, b) its loading is below 0.4. Although this choice of "significance" of the cvariables is rather ad hoc, it is a common rule of thumb in the principal components literature. For each country we use the same model (that is, the same subset of variables) to estimate the principal components model for all eight time periods.

We present the example of France to illustrate. The factor loadings for common colony and common language are not significant in the first component as the magnitude of the loading is less than 0.4 (see Table). These variables, common colony and Lang 1, are significantly loaded on the second component.

France (All Available Variables)		
	Components	
	1	2
Trade75	.865	.036
Border	.906	-.006
Comcol	.005	.934
Lang 1	.176	.924
Region	.743	-.258

Thus, in this case the principal component model is re-estimated without Comcol and Lang1 and shown on the next table.

France (Reduced Set of Variables)	
	1
Trade75	.860
Border	.902
Region	.763

Thus, the common factor for France for the period 1975-1979 is given by

$$cfFr7579 = 0.86 \times Trade + 0.902 \times Border + 0.763 \times Region$$

Interested readers can consult the authors for the complete set of results.

Step 3

A factor score is computed for each pair of countries using the common factors, for example *cfFr7579* is used to compute the scores for France for the years 1975-1979. These factor scores are rescaled to prepare the proximity matrix using the formula presented in (13).

Descriptive Statistics for the Variables used to Construct the PCW. Selected Countries Shown.

		Bilateral Trade share								Border	Common	Common Language					Region
Country		70	75	80	85	90	95	00	05		Colony	Lang-1	Lang-2	Lang-3	Lang -4	Lang -5	
US	No.	110	127	127	127	138	139	140	140	5	57	67	18				21
	Mean	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.04	0.40	0.48	0.13				0.15
	SD	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.19	0.49	0.50	0.33				0.36
	min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00				0.00
	max	0.24	0.22	0.17	0.21	0.20	0.21	0.21	0.20	1.00	1.00	1.00	1.00				1.00
UK	No.	129	132	140	140	138	137	138	138	7	57	67					24
	Mean	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.05	0.40	0.48					0.17
	SD	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.22	0.49	0.50					0.38
	min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00					0.00
	max	0.13	0.09	0.11	0.13	0.14	0.14	0.15	0.13	1.00	1.00	1.00					1.00
Belgium	No.	118	125	132	126	133	135	134	135	5	3	34	2	9			24
	Mean	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.04	0.02	0.24	0.01	0.06			0.17
	SD	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.19	0.14	0.43	0.12	0.25			0.38
	min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			0.00
	max	0.24	0.23	0.21	0.21	0.23	0.22	0.17	0.19	1.00	1.00	1.00	1.00	1.00			1.00
Denmark	No.	128	132	138	134	133	133	134	134	6	3	67	2	9			24
	Mean	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.04	0.02	0.48	0.01	0.06			0.17
	SD	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.20	0.14	0.50	0.12	0.25			0.38
	min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			0.00
	max	0.17	0.17	0.19	0.19	0.22	0.23	0.21	0.20	1.00	1.00	1.00	1.00	1.00			1.00
France	No.	118	129	130	131	136	137	137	135	8	23	34					24
	Mean	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.06	0.16	0.24					0.17
	SD	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.23	0.37	0.43					0.38
	min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00					0.00
	max	0.20	0.17	0.16	0.16	0.18	0.17	0.16	0.18	1.00	1.00	1.00					1.00
Domincan	No.	27	32	72	68	68	29	106	93	13	17	18					21
Rep	Mean	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.09	0.12	0.13					0.15
	SD	0.07	0.06	0.04	0.05	0.04	0.05	0.06	0.05	0.29	0.33	0.33					0.36
	min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00					0.00
	max	0.80	0.69	0.47	0.51	0.49	0.51	0.71	0.61	1.00	1.00	1.00					1.00
Ecuador	No.	58	71	46	47	47	54	96	104	2	2	18					11
	Mean	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.13					0.08
	SD	0.04	0.04	0.04	0.05	0.04	0.03	0.03	0.03	0.12	0.12	0.33					0.27
	min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00					0.00
	max	0.43	0.45	0.41	0.57	0.48	0.38	0.36	0.39	1.00	1.00	1.00					1.00
El Salvador	No.	44	46	45	44	64	73	78	81	4	17	18					21
	Mean	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.03	0.12	0.13					0.15
	SD	0.03	0.03	0.03	0.04	0.04	0.03	0.05	0.04	0.17	0.33	0.33					0.36
	min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00					0.00
	max	0.25	0.29	0.32	0.40	0.40	0.38	0.58	0.51	1.00	1.00	1.00					1.00
Guatemala	No.	57	59	59	80	62	68	95	99	6	17	18					21
	Mean	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.04	0.12	0.13					0.15
	SD	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.20	0.33	0.33					0.36
	min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00					0.00
	max	0.31	0.30	0.33	0.39	0.41	0.41	0.40	0.44	1.00	1.00	1.00					1.00
China	No.	91	109	53	121	130	134	135	137	9	1	4					25
	Mean	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.06	0.01	0.03					0.18
	SD	0.02	0.03	0.03	0.03	0.04	0.03	0.03	0.02	0.25	0.08	0.17					0.38
	min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00					0.00
	max	0.23	0.31	0.27	0.33	0.39	0.23	0.20	0.18	1.00	1.00	1.00					1.00
India	No.	115	115	128	100	132	133	132	134	6	57	67	2	3	2		25
	Mean	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.04	0.40	0.48	0.01	0.02	0.01		0.18
	SD	0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.20	0.49	0.50	0.12	0.14	0.12		0.38
	min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00
	max	0.25	0.21	0.15	0.16	0.14	0.14	0.16	0.13	1.00	1.00	1.00	1.00	1.00	1.00		1.00