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## Assessing the accuracy of the Penn World Tables

Timothy Scott Fitzgerald  
*University of Nevada, Las Vegas*

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ASSESSING THE ACCURACY OF THE  
PENN WORLD TABLES

by

Timothy Scott Fitzgerald

Bachelor of Science  
University of Nevada, Las Vegas  
1996

A thesis submitted in partial fulfillment  
of the requirement for the

**Master of Arts Degree  
Department of Economics  
College of Business**

**Graduate College  
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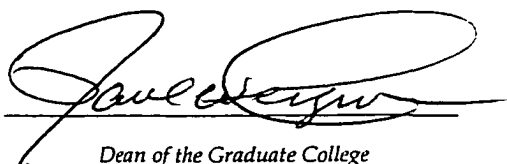
Assessing the Accuracy of the Penn World Tables

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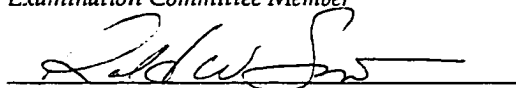
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Examination Committee Chair

  
Dean of the Graduate College

  
Examination Committee Member

  
Examination Committee Member

  
Graduate College Faculty Representative

## ABSTRACT

### **Assessing the Accuracy of the Penn World Tables**

by

Timothy S. Fitzgerald

Dr. Lein-Lein Chen, Examination Committee Chair  
Professor of Economics  
University of Nevada, Las Vegas

The Penn World Tables are a data set used by many important, widely cited empirical studies on growth and international finance. It displays a set of national accounts time series covering developed and developing countries. Its expenditure entries are denominated in a common set of prices in a common currency so that real international quantity comparisons can be made over time and space using an interspatial extrapolation procedure. The Penn World Tables cover substantially more countries than those included in the individual benchmark year studies.

The purpose of this study is to assess the accuracy of the price estimates given in the Penn World Tables. I have two important findings. First, I find that the procedure that the Penn World Tables use to estimate the price of non-benchmark countries is flawed. Second, I find that the price estimates of the Penn World Tables for benchmark countries, of a non-benchmark year, as well as non-benchmark countries may have errors. My findings have serious implications for empirical research in growth and development.

Future research should address the accuracy issue to ensure reliable estimates of economic variables can be made.



## TABLE OF CONTENTS

ABSTRACT.....	iii
LIST OF FIGURES.....	vi
ACKNOWLEDGEMENTS.....	vii
CHAPTER I INTRODUCTION.....	1
CHAPTER II REVIEW OF LITERATURE.....	5
CHAPTER III THE PENN WORLD TABLES.....	10
CHAPTER IV THE EMPIRICAL MODEL USED BY THE PWT TO CONSTRUCT PRICE ESTIMATES FOR NON-BENCHMARK COUNTRIES.....	14
CHAPTER V ASSESSING THE PWT'S PROCEDURE FOR ESTIMATING PRICES AND CONSTRUCTING ALTERNATIVE ESTIMATES.....	17
CHAPTER VI CONCLUDING REMARKS.....	32
APPENDICES.....	34
The Penn World Tables – Country List.....	34
Comparison of the PWT's Published Estimates and Projected Estimates Using Equation 1.....	39
BIBLIOGRAPHY.....	46
VITA.....	48

## LIST OF ILLUSTRATIONS

Table 1	Benchmark Price Estimates of Braithwaite and the PWT for 1960 .....	7
Table 2	Benchmark Price Estimates of Salazar-Carillo and the PWT for 1970.....	8
Equation 1	The PWT's Empirical Model Used to Estimate Price Indices for Non-Benchmark Countries (the Standard Errors are Given in the Parentheses) .....	15
Table 3	Forty Countries Used by the PWT to Estimate Equation 1.....	16
Equation 2	Author's Replication of the PWT's Equation 1 (the Standard Errors are Given in the Parentheses) .....	18
Table 4	Parameter Estimates Using the Variables Specified in Equation 1 for Five Benchmark Years (the Standard Errors are Given in the Parentheses).....	19
Table 5	Restricted and Unrestricted Equation Used to Form a F-Test (the Standard Errors are Given in the Parentheses).....	20
Table 6	Mean ICP/UN Ratios for Eighty Countries Covered by the ICP Benchmark Studies .....	21
Table 7	Comparing Price Estimates Using Ratio Method and the PWT Method for Benchmark Countries for Benchmark Years.....	23
Table 8	Determining the Accuracy of the PWT Using Benchmark Countries for Non-Benchmark Years.....	29

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Without their help, I could not have completed this paper.

## CHAPTER 1

### INTRODUCTION

The purpose of this study is to assess the accuracy of the price estimates given in the Penn World Tables, PWT.

Data on absolute prices is essential in determining and assessing economic performance across countries. Macroeconomic variables such as real GDP, real wages and real exchange rates cannot be correctly compared internationally unless we have accurate and comparable price data.

In 1968, the United Nations' International Comparison Program, ICP, launched the first major and concentrated effort to make such comparisons possible on a consistent basis. With participants ranging from international organizations to unofficial research entities and individuals world wide, the ICP developed a system that makes real quantity and price comparisons across countries possible. This system is based on a series of benchmark price studies.

The ICP's benchmark price study starts with a survey of absolute price levels for an identical set of goods and services for a group of developed and developing countries. Using the survey results, price parities are compiled for about 150 detailed categories in GDP.<sup>1</sup> Next, ICP uses the individual country's budget shares (consumption patterns) as weights to construct the overall price level as well as prices for various components and

sub-components of GDP. Between 1970 and 1990, over 90 countries in total participated in the ICP's benchmark studies. The studies take place at five-year intervals. At present, the ICP covers 1970, 1975, 1980, 1985 and 1990. However, the number of participants in each period varies in each study. These benchmark data are the main basis for the construction of prices in the Penn World Tables - the data source that most empirical researchers rely on for cross-countries studies.

The current version of the PWT, Mark 5.6, covers the period from 1950 to 1992. The unique feature of the PWT is that its data are adjusted to allow for inter-country comparisons at different points in time as well as inter-temporal comparisons within each country.

Notice, the PWT does not conduct its own price survey. Instead, it takes the absolute price benchmarks from the ICP. The PWT, however, covers more countries than those originally included in the ICP studies. The PWT has data on 152 countries, while the ICP benchmark studies surveyed 92 countries.

How the PWT constructs its price estimates using the limited benchmark data from the ICP is an important question. The method that the PWT uses is the following. It divides countries into two groups - benchmark countries and non-benchmark countries. Benchmark countries are those countries included in the ICP's five independent benchmark studies at least two times, while non-benchmark countries are those that appeared only once in one of the ICP studies or have never been included in any of the ICP benchmark studies.

For benchmark countries, the PWT uses individual country's Consumer Price Indices (CPI's) to extrapolate the absolute price level for a particular year from a given

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<sup>1</sup> GDP is divided into 110 consumption, 35 investment and 5 government categories.

benchmark price estimate obtained from the ICP. Then, the procedure is repeated for the rest of the periods for that country. The extrapolation can be either forward or backward. For non-benchmark countries, the PWT uses a different approach. It uses a set of parameters, derived from regression analyses, and the city price data collected by the United Nations (UN), to estimate the price level for a given year. Then, they project this estimate backwards and forwards using its CPI data. A detailed account of this process will be given later in this study.

Summers and Heston (1996) note that the use of PWT data for testing theories has its potential problems. The single most important difficulty, they claim, is that researchers do not make a distinction between benchmark and non-benchmark country estimates. Or, put differently, the researchers consider all PWT estimates to be equal in quality. In fact, non-benchmark countries' price estimates are distinctly inferior to those of benchmark countries. They claim that the PWT's price estimates for non-benchmark countries are probably subject to twice as much error as those for the benchmark countries.

Despite the warning of Summers and Heston, most empirical researchers seem to pay little attention to the issue of data quality. The extensive use of the PWT (20,000 plus published regressions that have been performed on the PWT data, as Summers and Heston (1996) mentioned) illustrates the high demand for this data set. An important example is Barro (1997). He uses real GDP data from the PWT to estimate the determinants of economic growth, and finds that the evidence strongly supports real income convergence. These findings assume that prices are correctly measured. Other important examples using PWT data, includes the work of Romer (1987, 1990), Aghion and Howitt (1992), Grossman and Helpman (1991) and Barro and Sala-i-Martin (1995).

Considering the extensive use of the PWT data and its central role in growth studies, it is important that we have some idea as to the accuracy of the price estimates in the PWT.

As an example of the problems that can arise, let's turn to the PWT's estimates of consumption for 1960. The PWT claims that Venezuela had a private consumption expenditure level of \$568 per person, the Netherlands had a level of \$558, and Italy \$397. These data suggest that the average Venezuelan citizen was as equally well-off as a citizen of the Netherlands and substantially better off than one in Italy in 1960. Many social indicators, however, seem to suggest otherwise. Venezuela was known for a lower life expectancy and lower consumption on durable goods than Italy and the Netherlands during the same period.<sup>2</sup> In addition, other independent benchmark studies such as Braithwaite (1968), finds that the real GDP per capita for Venezuela for 1960 in 1985 U.S. dollars is substantially lower than that shown by the PWT, \$2,939 vs. \$6,313. All this suggests a need for a closer look of the PWT.

The rest of the paper is organized as follows. Chapter two provides a literature survey including a discussion on alternative benchmark price studies of Braithwaite (1968) and Salazar-Carillo (1978). Chapter three discusses the ICP and the PWT study. Chapter four takes a closer look at the procedure used by the PWT for its price estimates. Chapter five constructs alternative price estimates and provides measures for differences in the PWT. The last chapter gives the concluding remarks.

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<sup>2</sup> World Tables. Various issues.

## CHAPTER 2

### REVIEW OF LITERATURE

The accuracy of the Penn World Tables has received little attention. Summers and Heston (1996) discuss some potential problems of the PWT, but they provide no empirical evidence on the accuracy of the PWT.

There are two related bodies of work in the literature. First, there is literature on errors in consumer price indices, CPI's, which includes Boskin et al. (1998), Baker (1998) and Chen and Devereux (1999). Second, there are alternative benchmark price estimates, which includes the work of Braithwaite (1968) and Salazar-Carillo (1978).

#### (1) Errors in Consumer Price Indices

Boskin et al. (1998) investigated the accuracy of the U.S. consumer price index. They concluded that at present there is a 1.1 percentage upward bias per year in the CPI. That is, if inflation, as measured by the percentage change in the CPI is running 3 percent, the true change in the cost of living is about 2 percent.

Boskin et al. identify four sources of bias in the U.S. CPI: substitution bias, retail outlet substitution bias, quality bias and new goods bias. They argue that the CPI has substantially overstated the actual rate of inflation, and is likely to continue to overstate the change in the cost of living for the future. Compounded over a 10 year period, this is a 11.56 percent rate of upward bias. Furthermore, this overstatement will have other



consequences, such as overindexing of social security. Note that errors in consumer price indices will lead to errors in the PWT's estimates. Thus, this literature is relevant to my work, as the PWT's estimates depend on the accuracy of the price indices.

Baker (1998) comments on the findings of the Boskin Commission's report. He argues that if correct, the Boskin findings would require a substantial reexamination of current economic beliefs in the field of international finance. Since the real exchange rate is constructed using the CPI as a deflator, an upward bias in changes in the CPI would cause a downward bias in measured changes in the real exchange rate. He argues that it is possible that the price indices of foreign countries overstate inflation by approximately the same amount as the U.S. CPI. Although this might remove the problem of the decline in the real exchange rate, it still leaves other problems for economic analysis, as it is unlikely that all price indices overstate inflation to the same extent. Again, the overstatement of foreign price indices will distort international comparisons, introducing erroneous estimates into the PWT.

Chen and Devereux (1999) analyzed the behavior of absolute price levels for developed economies during this century. Using data from various sources, they also find large CPI errors. In addition, they find that the evidence does not support the proposition that absolute price levels have converged over the last century. They argue that absolute price levels in the United States, Australia, Canada and New Zealand have declined relative to price levels in Europe. The importance of this study for my purposes is that they show that consumer price indices have large errors. This, in turn, implies that errors in the PWT's estimates could be substantial.

## (2) Alternative Benchmark Studies

Braithwaite (1968) and Salazar-Carillo (1978) are the only two studies that I am aware of that provide independent price estimates for the period covered by the PWT. First, I turn to Braithwaite (1968).

Braithwaite (1968) measured and examined Latin American real income levels for the period 1955 to 1964. Using a purchasing power parity approach, he estimates the prices and incomes for Latin American countries. Then, he compares them with the United States and certain countries in Western Europe. The main objective of Braithwaite's study was to determine the size of the income gaps between Latin American countries and non-Latin American countries, and to ascertain whether the income levels were increasing, decreasing or remaining unchanged in size. He concluded that the spread of real GDP per capita between Latin America and non-Latin American countries increased considerably between 1955 and 1964.

His benchmark price estimates and the PWT's price estimates are given in Table 1 below. All price estimates are in U.S. dollars. The second column gives the PWT estimates. The U.S. is the base country. Notice there are large differences between Braithwaite's estimates and the PWT's estimates. On average, Braithwaite's estimates are 60 percent higher.

Table 1. Benchmark Price Estimates of Braithwaite and the PWT for 1960

<u>Countries</u>	<u>Braithwaite</u>	<u>PWT</u>	<u>Braithwaite/PWT</u>
Argentina	63	56	1.13
Bolivia	70	36	1.94
Brazil	89	42	2.12
Chile	98	68	1.44
Colombia	84	55	1.53

Table 1. Continuation

<u>Countries</u>	<u>Braithwaite</u>	<u>PWT</u>	<u>Braithwaite/PWT</u>
Ecuador	81	62	1.31
Mexico	66	41	1.61
Paraguay	65	51	1.27
Peru	64	35	1.83
Uruguay	60	34	1.76
Venezuela	146	90	1.62
		Mean Ratio	1.60

Subsequently, Salazar-Carillo (1978) constructs a benchmark price study for 1970 to study the economic integration of Latin America from 1960 to 1972. He concluded that price dispersion among Latin American countries is significantly lower at the GDP level than at the private consumption level.

His benchmark estimates and the PWT's estimates are given in Table 2. Again, all price estimates are in U.S. dollars, using the U.S. as the base country. There are also differences between Salazar-Carillo's estimates and the PWT's estimates, though the differences are smaller than Braithwaite's. On average, Salazar-Carillo's estimates are 14 percent higher than the PWT's estimates.

I find that both studies give higher estimates than the PWT. It seems that the further away from an ICP benchmark estimate, the larger the discrepancy.

Table 2. Benchmark Price Estimates of Salazar-Carillo and the PWT for 1970

<u>Countries</u>	<u>Salazar</u>	<u>PWT</u>	<u>Salazar/PWT</u>
Argentina	63	48	1.31

Table 2. Continued

<u>Countries</u>	<u>Salazar</u>	<u>PWT</u>	<u>Salazar/PWT</u>
Bolivia	61	41	1.49
Brazil	53	48	1.10
Chile	67	69	0.97
Colombia	45	42	1.07
Ecuador	45	47	0.96
Mexico	58	48	1.21
Paraguay	48	50	0.96
Peru	60	51	1.18
Uruguay	56	50	1.12
Venezuela	76	67	1.13
		Mean Ratio	1.14

## CHAPTER 3

### THE PENN WORLD TABLES

The Penn World Tables currently cover 152 countries and 29 series over the period of 1950 to 1992. An earlier version was published in the *Quarterly Journal of Economics* (1991) by Alan Heston and Robert Summers of the University of Pennsylvania. There are five versions of the PWT. The latest version includes more countries, years and variables than earlier versions.

The PWT consists of estimates of GDP plus its components and sub-components. At its highest aggregation level, it has population, GDP, overall price level, and exchange rates, etc. At lower aggregation levels, it has the components of GDP, including Consumption (C), Investment (I), and Government Spending (G). It also gives the price level of these GDP components. This includes the price level of C, I and G. The distinct feature of the PWT is that its data set is denominated in U.S. prices, so that real international quantity comparisons can be made both between countries and over time. In this study, I focus on the price estimates of the PWT.

Since the PWT is derived from the benchmark price studies of the ICP, it is best to begin with the work of the ICP. The ICP is an organization of the United Nations (UN) that conducts benchmark price studies. At present, they have conducted five independent benchmark studies (1970, 1975, 1980, 1985 and 1990). There are a total of 92 countries

that have been covered in these benchmark studies. In each benchmark year, a group of countries are selected by the ICP for its price survey. The number of participants selected varies from 11 to 56. Some countries participated in the survey once, while others did more than once, with a maximum number of five times.

The procedure used by the ICP to estimate its benchmark price is as follows. First, the ICP divides GDP of each participating country into 150 detailed categories (approximately 100 consumption, 35 investment and 5 government). Then, prices of hundreds of identically specified goods and services prevailing in each country are collected. Price parities are constructed for each participating country at a number of aggregation levels, including an overall price level, price level of C, price level of I and price level of G.

During the aggregation process, if the price of a good or service is not directly observable, there are two ways that the ICP can obtain the price. First, the cost of producing a standardized unit of that good or a service is used as a proxy. For example, there are many varieties of apartments in the market. The ICP determines rents by using only well-defined housing units. The second way the ICP obtains its price is by using the existing data on national quantity and national expenditure. For example, if expenditure on goods  $i$  ( $E_i$ ) and  $j$  ( $E_j$ ) are known, and the relative quantity of goods  $i$  ( $Q_i$ ) and  $j$  ( $Q_j$ ) are also known, then the relative price of good  $i$  ( $P_i$ ) with respect to  $j$  ( $P_j$ ) can be determined. The relationship between relative price, expenditure and quantity is shown in the equation below.

$$P_i/P_j = (E_i/E_j)*(Q_j/Q_i)$$

This approach is, however, feasible only if measures of direct quantity are available, and appropriate quality adjustments can be made. On the other hand, if quantities of output are not directly observable, the ICP uses information from input quantities. For example, the total quantity of elementary education of a country is taken to be proportional to the number of its elementary school teachers, that are appropriately standardized for training.

Altogether, the ICP constructed price estimates for 92 countries with a maximum of five discrete years for some countries.<sup>3</sup> Building on the ICP's work, the PWT extended its price estimates to 152 countries over the period 1950 to 1990.

The procedure used by the PWT is as follows. It divides countries into two groups – benchmark countries and non-benchmark countries. For the benchmark countries, the PWT projects prices for non-benchmark years from a benchmark price using the individual country's CPI's. Suppose that the benchmark price of France at time  $t$  is  $P_t$ , and that the rate of inflation of the CPI in France between time  $t$  and  $T$  is  $\Pi_T$ . Then the  $P_T$  projected from time  $t$  is simply the product of  $P_t$  and  $1 + \Pi_T$ . That is  $P_t * (1 + \Pi_T)$ . For all benchmark countries, there are at least two benchmark prices available. The PWT uses the latest estimate.

There are potential problems with this procedure, as noted by Summers and Heston (1996). The problem is due to different market baskets of goods and weights used by individual countries and by the ICP. Indeed, as they argue, the inconsistencies arise partly as a consequence of mismatches between the specifications and pricing of goods by the national accountants who construct the CPI's and by the ICP who constructs the

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<sup>3</sup> The five benchmark years are 1970, 1975, 1980, 1985 and 1990.

benchmark prices. In addition, there are problems associated with the change of quality of goods over time as mentioned earlier by Boskin (1996) and Baker (1998). Finally, the non-benchmark price estimates can be devastated by the compounded errors if the projected prices are used for subsequent years' projections.

As for the non-benchmark countries, their price construction is more complicated. The detailed procedure is discussed in the next section.



## CHAPTER 4

### THE EMPIRICAL MODEL USED BY THE PWT TO CONSTRUCT PRICE ESTIMATES FOR NON-BENCHMARK COUNTRIES

The method used by the PWT for constructing price estimates for non-benchmark countries is very different from that for the benchmark countries. In this section, I outline such procedure.

To begin, it is important to know that the PWT assumes that there exists a relationship between the ICP's benchmark price estimate of a country and the city price data constructed by the UN for that country. To understand this relationship, a knowledge of UN city price data is necessary.

The UN conducts capital city price surveys as part of its program designed to supplement salaries in such a way as to equalize real incomes of high-ranking civil servants and business executives assigned to different countries. Note that the price indexes for this group – high-income professionals, living usually in capital cities – do not necessarily reflect the overall price in the country, nor do the individual price weights reflect the relative importance of the individual goods in the countries for the nationals. Nevertheless, the PWT claims to have found a relationship between a country's overall price index and its capital cities' price index. It is from this relationship that the PWT constructs its empirical model for estimating the price for non-benchmark countries.

The procedure used by the PWT is described as follows. First, the PWT makes a list of countries included in the ICP's 1985 benchmark study. There are 56 countries in total. But, the PWT uses only those 42 countries that have appeared in the ICP's benchmark studies at least twice. The rationale for this selection process is that countries with multiple benchmarks might have more reliable information. These countries are listed in Table 3. Next, the corresponding city price data of the UN are obtained for these countries. Using these price data, an empirical equation is estimated, where the dependent variable, *PWT*, is the benchmark price obtained from the ICP, and the explanatory variables, *UN* and *AD*, are the UN city price data and a dummy variable for African countries. The African dummy variable is used to capture any systematic factors affecting the *UN* variable for African countries (according to the authors of the PWT). The variables are in natural logarithm. The estimated equation is listed below, with standard errors in parentheses (Equation 1).

$$\ln PWT = 0.739 \ln UN - 0.234 AD + 0.008 \quad \text{Root MSE} = 0.175$$

$$(0.027) \quad (0.089) \quad (0.067) \quad n = 42 \quad R^2 = 0.978$$

Equation 1. The PWT's Empirical Model Used to Estimate Price Indices for Non-Benchmark Countries (standard errors are given in parentheses)

The coefficient on *UN* indicates that a 1 percent average increase in prices in the capital cities relative to New York would mean a .74 percent average increase in the overall price level of that country. The coefficients in the above equation are used to estimate the price level for a non-benchmark country for a given year. If *UN* data are not

available, then the PWT uses alternative city price data from the United States State Department (USS) and the Employment Conditions Abroad (ECA) to construct price estimates with equations different from Equation 1. The UN city price data, however, is the primary source.

Table 3. Forty Countries Used by the PWT to Estimate Equation 1

<u>Africa</u>	<u>Europe</u>	<u>Asia</u>
Botswana	Austria	Hong Kong
Cameroon	Belgium	India
Ethiopia	Denmark	Iran
Ivory Coast	Finland	Japan
Kenya	France	Korea, Rep. Of
Madagascar	Germany, Fed. Rep.	Pakistan
Malawi	Greece	Philippines
Mali	Hungary	Sri Lanka
Morocco	Ireland	Thailand
Nigeria	Italy	
Senegal	Luxembourg	
Tanzania	Netherlands	
Tunisia	Norway	
Zambia	Poland	
Zimbabwe	Portugal	
	Spain	
	United Kingdom	
	Yugoslavia	

## CHAPTER 5

### ASSESSING THE PWT'S PROCEDURE FOR ESTIMATING PRICES AND CONSTRUCTING ALTERNATIVE PRICE ESTIMATES

The procedure used by the PWT for estimating the prices for non-benchmarks implicitly assumes that the relationship between PWT and UN observed in 1985 is constant over time, and across countries. In this section, I attempt to assess the validity of their assumptions. I do so first, by replicating Equation 1, and then testing the ability of Equation 1 to reproduce the PWT's price estimates. In addition, I test the stability of the relationship specified in Equation 1 over different periods. Finally, I develop an alternative method for constructing price estimates.

#### (1) Replicating the PWT's empirical model

The PWT constructs its price estimates for non-benchmark countries using data from 42 countries given in ICP's 1985 benchmark study. Here, I use 39 of the 42 countries, due to the fact that only 39 UN price estimates were published. I believe that this data set should be close enough to allow me to replicate Equation 1.<sup>4</sup>

The estimated equation is presented in Equation 2. The standard errors are given in parentheses. The results are very different from those found in Equation 1. First, Equation 2 has an adjusted R-squared value that is much lower than the PWT's estimates, and second, the coefficient for UN benchmarks is almost double that of the PWT's

estimates. In addition, the intercepts have the opposite sign. The only similar coefficients found in these two equations is the variable AD.

$$\ln PWT = 1.591 \ln UN - 0.298 AD - 2.699 \quad \text{Root MSE} = 0.305$$

$$(0.257) \quad (0.104) \quad (1.084) \quad n = 39 \quad R^2 = 0.572$$

Equation 2. Author's Replication of the PWT's Equation 1 (the standard errors are given in the parentheses)

Obviously, I was not able to reproduce the results in Equation 1. Next, I test the ability of Equation 1 to reproduce the price estimates given by the PWT. The best data that I can obtain for this test are those from the benchmark years. This is because on average, the benchmark price data are more reliable. I do so by estimating the fitted values of the dependent variable, using parameters given in Equation 1. Then, I compare them with the PWT's published price estimates. If the parameters given by Equation 1 reflect the true relationship between the variables *PWT* and *UN*, I shall expect small differences between these two estimates. To my surprise, the differences are large. The differences range in value from 18.80 to 44.72, as compared to the mean of the PWT's published estimates, 30.50 (see Appendix 2). From this, I conclude that the errors of prices for non-benchmark countries will be even greater. To further illustrate the problem of the PWT's procedure, I test the stability of the relation, given in Equation 1. I do this by re-estimating Equation 1 using data from the five benchmark studies. The estimated parameter values are given in Table 4.

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<sup>4</sup> UN city price data is not published for Finland, Ireland and Luxembourg.

Table 4. Parameter Estimates Using the Variables Specified in Equation 1 for Five Benchmark Years (the standard errors are given in the parentheses)

Years		
1970	$\ln \text{PWT} = 4.34 \ln \text{UN} + 0.04 \text{AD} - 14.98$ (1.49) (0.27) (6.54)	Root MSE = 0.248 n = 11 $R^2 = 0.52$
1975	$\ln \text{PWT} = 1.97 \ln \text{UN} - 0.04 \text{AD} - 4.81$ (0.27) (0.27) (1.22)	Root MSE = 0.263 n = 26 $R^2 = 0.70$
1980	$\ln \text{PWT} = 1.34 \ln \text{UN} - 0.06 \text{AD} - 1.98$ (0.21) (0.10) (0.99)	Root MSE = 0.319 n = 51 $R^2 = 0.46$
1985	$\ln \text{PWT} = 1.03 \ln \text{UN} - 0.28 \text{AD} - 0.40$ (0.21) (0.09) (0.88)	Root MSE = 0.336 n = 56 $R^2 = 0.44$
1990	$\ln \text{PWT} = 1.79 \ln \text{UN} - 3.59^*$ (0.24) (1.10)	Root MSE = 0.295 n = 15 $R^2 = 0.81$

\* For the 1990 data set, there are no African countries.

For the PWT procedure to work, the parameter values (the slope and intercept coefficients) across the estimated equations in Table 4 should be stable. The stability test is performed as follows. First, I pool the data from 1970, 1975, 1980, 1985 and 1990. Then, a restricted equation is estimated. The restricted equation forces all intercept coefficients ( $I$ ) and slope coefficients ( $S$ ) to be identical across periods. It produces sum of square error, SSE restricted. On the other hand, the unrestricted equation allows the intercept and slope coefficients to differ from period to period. This produces sum of square error, SSE unrestricted. The difference between the restricted and the unrestricted form is that there are eight additional dummy variables in the un-restricted form. The variable  $I$  represents the intercept dummy and the variable  $S$  represents the product dummy for the slope. I use four dummies for each variable, as I have data on five benchmark years. Next, an F-statistic is calculated, using the sum squared errors (SSE)

from the restricted and unrestricted equations. The equation is given below. K is the number of restrictions, T is the total number of observations, and N is the number of parameters to be estimated.

$$F = \frac{[SSE(\text{restricted}) - SSE(\text{unrestricted})]/K}{SSE(\text{unrestricted})/(T - N)}$$

The results of the F-test indicates a change in parameter value between the estimated equations (the F-statistic is 5.44; significant at the 1 percent level). This raises the question of the validity of using the PWT's procedure to estimate prices for non-benchmark countries.

Table 5. Restricted and Unrestricted Equations Used to Form a F-Test  
(the standard errors are given in the parentheses)

Restricted Equation	In PWT = 1.24 In UN - 0.19 AD - 1.36 (0.00) (0.06) (0.11)	SSE = 17.74 n = 162 R <sup>2</sup> = 0.55
Unrestricted Equation	In PWT = 4.10 In UN - 0.17 AD + 9.14 I <sub>75</sub> + 11.91 I <sub>80</sub> + (1.78) (0.06) (7.92) (7.85)  13.26 I <sub>85</sub> + 11.69 I <sub>90</sub> - 2.14 S <sub>75</sub> *UN <sub>75</sub> - 2.75 S <sub>80</sub> *UN <sub>80</sub> (7.83) (8.04) (1.80) (1.79)  - 3.02 S <sub>85</sub> *UN <sub>85</sub> - 2.60 S <sub>90</sub> *UN <sub>90</sub> - 13.91 (1.78) (1.83) (7.79)	SSE = 13.77 n = 162 R <sup>2</sup> = 0.65
F-Statistic = 5.44 Significant at the 1 percent level N = 11, K = 8, T = 162		

There is clearly a need for greater transparency with regard to the procedures that have been employed by the PWT to estimate prices for non-benchmark countries. I now develop an alternative method to construct price estimates for countries that have been selected by the ICP benchmark studies.

(2) Constructing price estimates using a ratio method.

The large differences between the PWT's published estimates and its projected values using Equation 1 suggest that the PWT's procedure is flawed. My explanation is that the relationship given in Equation 1 may work for some countries, while it is inadequate to extend this relation to a large sample of countries with various economic structures. To remedy this problem, I develop a ratio method. I assume that there exists a relationship between ICP benchmark price and UN city price. But unlike the PWT's procedure, the ratio method does not force a linear relationship between ICP benchmark price and UN city price of all countries. Rather, it is constructed using the ratio of ICP's price to UN's price from an individual country. Then, the procedure is repeated for all years and for all countries. Next, I sum up the ICP/UN ratios for each country across time and compute its arithmetic mean (see Table 6). As I expected, there is little variance between the ICP/UN ratios from one benchmark year to another, indicating the ratio method is stable across time. I understand that the ratio method may remain subject to the criticism of being ad hoc. But, it is superior to previous results.

Table 6. Mean ICP/UN Ratios for 80 Countries Covered by the ICP Benchmark Studies

<u>Country</u>	<u>ICP/UN Ratios</u>	<u>Country</u>	<u>ICP/UN Ratios</u>
Argentina	0.82	Kenya	0.61
Australia	1.17	Korea	0.58



Table 6. Continued

<u>Country</u>	<u>ICP/UN Ratios</u>	<u>Country</u>	<u>ICP/UN Ratios</u>
Austria	0.98	Sri Lanka	0.43
Belgium	0.99	Morocco	0.53
Benin	0.38	Madagascar	0.53
Bangladesh	0.36	Mexico	0.61
Bahamas	0.65	Mali	0.35
Bolivia	0.66	Mauritius	0.34
Brazil	0.75	Malawi	0.55
Barbados	0.68	Malaysia	0.59
Botswana	0.78	Nigeria	1.04
Canada	1.26	Netherlands	0.96
Switzerland	1.18	Nepal	0.40
Chile	0.68	Pakistan	0.44
Ivory Coast	0.72	Panama	0.72
Cameroon	0.45	Peru	0.52
Congo	0.70	Philippines	0.45
Colombia	0.56	Poland	0.86
Costa Rica	0.67	Portugal	0.76
Germany	1.05	Paraguay	0.69
Denmark	1.10	Romania	0.70
Dominican Republic	0.74	Rwanda	0.48
Ecuador	0.65	Senegal	0.53
Egypt	0.37	Sierra Leone	0.67
Spain	0.85	El Salvador	0.48
Ethiopia	0.50	Suriname	0.62
Finland	1.36	Sweden	1.20
France	0.97	Swaziland	0.80
Greece	0.90	Syria	0.34
Grenada	0.68	Thailand	0.49
Guatemala	0.51	Trinidad and Tobago	0.67
Hong Kong	0.74	Tunisia	0.46
Honduras	0.57	Turkey	0.63
Hungary	0.71	Tanzania	1.04
Indonesia	0.43	United Kingdom	0.92
India	0.49	Uruguay	0.69
Iran	0.52	Venezuela	0.52
Italy	0.97	Yugoslavia	0.68
Jamaica	0.77	Zambia	0.99
Japan	0.91	Zimbabwe	0.74

Next, I compute my price estimates by multiplying the UN's city price with the individual country's mean ICP/UN ratio obtained earlier. The results are provided in Table 7. The differences between the projections using the ratio method and the PWT's published estimates are given as absolute differences 1, while the differences between the PWT fitted values (using the equations given in Table 4) and the published estimates are given as absolute differences 2. It shows that price estimates using the ratio method have much smaller differences.

Table 7. Comparing Price Estimates Using Ratio Method and the PWT Method for Benchmark Countries for Benchmark Years

Benchmarks 1970	A	B	C	(A-C)	(A-B)
	PWT	PWT	Projections	Absolute	Absolute
<u>Country</u>	<u>Benchmarks</u>	<u>Fitted</u>	<u>Using</u>	<u>Diff. 1</u>	<u>Diff. 2</u>
		<u>Values</u>	<u>Ratio Method</u>		
United Kingdom	77.15	56.71	73.60	3.55	20.44
France	83.71	94.55	83.70	0.01	10.84
Germany	88.34	77.62	90.30	1.96	10.72
Italy	76.10	63.13	79.54	3.44	12.97
Colombia	46.43	42.86	42.00	4.43	3.57
Kenya	52.49	51.32	47.58	4.91	1.17
India	35.41	48.04	37.73	2.32	12.63
Netherlands	75.03	56.71	76.80	1.77	18.32
Iran	40.64	50.81	40.56	0.08	10.17
Malaysia	46.08	50.81	46.02	0.06	4.73
Korea	51.47	70.09	48.72	2.75	18.62
			Mean Absolute Differences	2.30	11.29

Table 7. Continuation

Benchmarks 1975					
Country	<u>PWT Benchmarks</u>	<u>PWT Fitted Values</u>	<u>Projections Using Ratio Method</u>	<u>Absolute Diffs. 1</u>	<u>Absolute Diffs. 2</u>
Brazil	68.47	58.93	66.43	2.04	9.54
Colombia	34.86	30.37	36.40	1.54	4.49
Jamaica	78.35	62.82	72.38	5.97	15.52
Mexico	59.40	60.22	56.12	3.28	0.82
Uruguay	40.52	37.15	49.68	9.16	3.37
Kenya	51.85	53.00	53.68	1.83	1.15
Malawi	40.56	40.26	N/A	N/A	0.30
Zambia	71.37	N/A	N/A	N/A	N/A
India	32.59	40.26	36.75	4.16	7.67
Japan	91.11	N/A	N/A	N/A	N/A
Korea	41.30	73.79	59.16	17.86	32.49
Malaysia	56.12	64.14	56.05	0.07	8.02
Pakistan	34.10	41.33	33.44	0.66	7.22
Philippines	38.63	58.93	40.95	2.32	20.30
Sri Lanka	40.53	40.26	32.25	8.28	0.27
Syria	30.58	57.66	30.60	0.02	27.08
Thailand	37.00	49.16	40.67	3.67	12.16
Austria	94.52	98.32	115.64	21.12	3.80
Belgium	114.00	113.64	125.73	11.73	0.36
Denmark	131.02	124.46	146.30	15.28	6.56
France	117.08	126.31	129.98	12.90	9.23
Germany	120.73	118.99	136.50	15.77	1.74
Italy	92.24	70.96	97.00	4.76	21.28
Netherlands	114.60	101.63	115.20	0.60	12.97
Poland	68.30	44.60	67.94	0.36	23.70
Romania	65.78	62.82	65.80	0.02	2.96
Spain	72.35	62.82	79.90	7.55	9.53
United Kingdom	87.70	62.82	86.48	1.22	24.88
Yugoslavia	59.79	56.41	60.52	0.73	3.38
			Mean Absolute Differences	5.27	10.40

Table 7. Continuation

Benchmarks 1980					
<u>Country</u>	<u>PWT Benchmarks</u>	<u>PWT Fitted Values</u>	<u>Projections Using Ratio Method</u>	<u>Absolute Diffs. 1</u>	<u>Absolute Diffs. 2</u>
Belgium	130.62	110.74	145.53	14.91	19.88
Denmark	142.25	103.73	154.00	11.75	38.52
France	130.85	106.72	138.71	7.86	24.13
Germany	141.00	110.74	154.35	13.35	30.26
Greece	94.82	71.45	95.40	0.58	23.37
Italy	92.57	67.86	98.94	6.37	24.71
Netherlands	128.43	105.72	136.32	7.89	22.71
United Kingdom	114.73	99.78	125.12	10.39	14.95
Austria	122.36	101.75	135.24	12.88	20.61
Hungary	68.94	59.10	65.32	3.62	9.84
Poland	55.08	39.41	58.48	3.40	15.67
Spain	97.17	82.49	100.30	3.13	14.68
Yugoslavia	68.42	53.99	58.48	9.94	14.42
Botswana	74.60	47.70	63.96	10.64	26.90
Ethiopia	41.48	54.04	45.00	3.52	12.56
Ivory Coast	110.44	103.34	105.12	5.32	7.10
Kenya	63.77	63.91	62.22	1.55	0.14
Madagascar	58.80	70.71	59.40	0.60	11.91
Malawi	50.00	50.85	47.30	2.70	0.85
Mali	32.63	84.83	44.10	11.47	52.20
Morocco	73.63	81.24	64.66	8.97	7.61
Nigeria	118.01	78.57	123.76	5.75	39.44
Senegal	73.56	83.93	66.25	7.31	10.37
Tanzania	82.35	52.44	91.52	9.17	29.91
Tunisia	65.22	78.57	54.74	10.48	13.35
Zambia	119.51	63.91	100.98	18.53	55.60
India	44.38	51.48	40.67	3.71	7.10
Indonesia	44.16	68.75	44.29	0.13	24.59
Japan	113.34	124.06	145.60	32.26	10.72
Korea	70.53	77.84	65.54	4.99	7.31
Pakistan	31.80	52.32	36.96	5.16	20.52
Philippines	40.54	63.44	43.65	3.11	22.90
Sri Lanka	23.37	46.56	33.11	9.74	23.19
Argentina	129.92	123.02	130.38	0.46	6.90
Bolivia	62.94	62.57	63.36	0.42	0.37
Brazil	56.98	49.83	59.13	2.15	7.15
Chile	74.03	74.17	74.12	0.09	0.14
Colombia	48.47	60.83	52.64	4.17	12.36

Table 7. Continuation

Benchmarks 1980					
<u>Country</u>	<u>PWT Benchmarks</u>	<u>PWT Fitted Values</u>	<u>Projections Using Ratio Method</u>	<u>Absolute Diffs. 1</u>	<u>Absolute Diffs. 2</u>
Costa Rica	65.85	65.20	66.33	0.48	0.65
Dominican Republic	63.48	53.99	63.64	0.16	9.49
Ecuador	54.48	52.32	54.60	0.12	2.16
El Salvador	48.70	66.97	48.48	0.22	18.27
Guatemala	50.43	65.20	50.49	0.06	14.77
Honduras	57.39	66.97	57.57	0.18	9.58
Mexico	50.87	57.38	54.90	4.03	6.51
Panama	67.83	60.83	67.68	0.15	7.00
Paraguay	69.87	67.86	70.38	0.51	2.01
Peru	46.58	56.53	46.28	0.30	9.95
Uruguay	88.35	72.36	73.83	14.52	15.99
Venezuela	74.16	105.72	73.84	0.32	31.56
Canada	93.70	48.19	99.54	5.84	45.51
Mean Absolute Differences				5.79	16.83

Table 7. Continuation

Benchmarks 1985					
<u>Country</u>	<u>PWT Benchmarks</u>	<u>PWT Fitted Values</u>	<u>Projections Using Ratio Method</u>	<u>Absolute Diffs. 1</u>	<u>Absolute Diffs. 2</u>
Germany	81.26	60.37	82.95	1.69	20.89
France	78.40	55.66	70.81	7.59	22.74
Italy	63.54	46.26	59.17	4.37	17.28
Netherlands	73.98	61.16	76.80	2.82	12.82
Belgium	76.14	58.80	76.23	0.09	17.34
United Kingdom	72.76	61.95	74.52	1.76	10.81
Denmark	93.22	65.10	93.50	0.28	28.12
Greece	58.31	49.39	58.50	0.19	8.93
Spain	63.32	55.66	62.05	1.27	7.66
Portugal	46.49	47.04	47.12	0.63	0.55
Austria	80.58	53.30	69.30	11.28	27.28
Sweden	94.75	60.37	94.80	0.05	34.37

Table 7. Continuation

Benchmarks 1985		PWT	Projections	Absolute	Absolute
<u>Country</u>	<u>PWT</u> <u>Benchmarks</u>	<u>Fitted</u> <u>Values</u>	<u>Using</u> <u>Ratio Method</u>	<u>Diff. 1</u>	<u>Diff. 2</u>
Australia	71.68	50.17	77.22	5.54	21.51
Japan	100.50	76.96	91.00	9.50	23.54
Canada	91.51	53.30	88.20	3.31	38.21
Turkey	33.33	42.36	35.28	1.95	9.03
Hong Kong	55.28	57.23	55.50	0.22	1.95
Korea	54.05	61.95	46.98	7.07	7.90
Thailand	30.98	44.70	28.91	2.07	13.72
Indonesia	38.64	55.66	35.77	2.87	17.02
Sri Lanka	24.29	40.02	22.79	1.50	15.73
Pakistan	26.14	39.24	22.88	3.26	13.10
Philippines	35.45	51.73	30.60	4.85	16.28
Botswana	33.41	29.07	39.78	6.37	4.38
Egypt	33.60	53.38	34.04	0.44	19.78
Ethiopia	41.82	45.63	39.50	2.32	3.81
Kenya	33.47	34.96	37.21	3.74	1.49
Malawi	26.27	29.07	28.05	1.78	2.80
Mauritius	22.17	37.32	22.10	0.07	15.15
Nigeria	98.37	52.19	93.60	4.77	46.48
Sierra Leone	43.00	36.73	42.88	0.12	6.27
Swaziland	33.58	23.80	33.60	0.02	9.78
Tanzania	80.44	40.28	72.80	7.64	40.16
Zambia	46.76	33.19	57.42	10.66	13.57
Zimbabwe	36.86	28.49	37.00	0.14	8.38
Benin	23.70	35.55	23.56	0.14	11.85
Cameroon	32.56	41.47	32.40	0.16	8.91
Congo	42.77	34.96	42.70	0.07	7.81
Ivory Coast	37.10	35.55	44.64	7.54	1.55
Madagascar	38.37	40.28	37.80	0.57	1.91
Mali	32.61	42.66	25.90	6.71	10.05
Morocco	23.30	29.07	30.60	7.30	5.77
Rwanda	41.24	49.80	41.28	0.04	8.56
Senegal	31.02	37.91	34.98	3.96	6.89
Tunisia	33.27	51.59	40.94	7.67	18.32
Poland	42.17	34.59	39.56	2.61	7.58
Hungary	30.03	33.81	31.95	1.92	3.78
Yugoslavia	33.92	43.92	39.44	5.52	10.00
Bahamas	67.91	80.14	67.60	0.31	12.23
Barbados	67.16	76.17	67.32	0.16	9.01

Table 7. Continuation

Benchmarks 1985					
<u>Country</u>	<u>PWT Benchmarks</u>	<u>PWT Fitted Values</u>	<u>Projections Using Ratio Method</u>	<u>Absolute Diffs. 1</u>	<u>Absolute Diffs. 2</u>
Grenada	61.36	69.05	61.20	0.16	7.69
Jamaica	42.11	45.48	46.20	4.09	3.37
Suriname	60.71	75.38	60.76	0.05	14.67
Trinidad and Tobago	79.91	92.07	79.73	0.18	12.16
Bangladesh	24.70	52.52	24.84	0.14	27.82
Nepal	28.84	54.87	28.80	0.04	26.03
Mean Absolute Differences				2.89	15.25

Table 7. Continuation

Benchmarks 1990					
<u>Country</u>	<u>PWT Benchmarks</u>	<u>PWT Fitted Values</u>	<u>Projections Using Ratio Method</u>	<u>Absolute Diffs. 1</u>	<u>Absolute Diffs. 2</u>
Germany	120.96	88.63	95.55	25.41	32.33
France	116.25	120.42	104.76	11.49	4.17
Italy	108.79	116.46	102.82	5.97	7.67
Netherlands	107.98	104.93	96.00	11.98	3.05
Belgium	114.07	97.53	95.04	19.03	16.54
United Kingdom	100.34	114.50	96.60	3.74	14.16
Denmark	142.54	122.43	119.90	22.64	20.11
Greece	80.35	73.55	80.36	0.01	6.80
Spain	105.42	128.52	95.20	10.22	23.10
Portugal	63.95	73.55	62.32	1.63	9.60
Austria	119.07	122.43	106.82	12.25	3.36
Switzerland	156.03	172.47	155.76	0.27	16.44
Finland	169.47	156.44	170.00	0.53	13.03
Sweden	149.34	156.44	150.00	0.66	7.10
Turkey	47.50	58.28	45.36	2.14	10.78
Australia	105.26	76.80	98.28	6.98	28.46
Japan	124.29	151.99	111.93	12.36	27.70
Canada	111.86	81.76	109.62	2.24	30.09
Mean Absolute Differences				8.31	15.25

So far, I have shown that the ratio method produces much smaller errors (almost one half) than that produced by the PWT's procedure using data from benchmark years. I suspect that the differences would be larger even with the ratio method if data from non-benchmark years are applied. Indeed, as confirmed by the results in Table 8, the differences obtained from the non-benchmark years, 1955 and 1960, are twice larger than those from the benchmark years. This happens because the price estimates of the PWT for non-benchmark years are also subjected to CPI errors, as noted earlier.

Table 8. Determining the Accuracy of the PWT Using Benchmark Countries for Non-Benchmark Years

Non-Benchmark Year 1955			
<u>Country</u>	<u>PWT</u>	<u>Projections Using Ratio Method</u>	<u>Absolute Differences</u>
Greece	76.84	78.30	1.46
Thailand	34.15	59.78	25.63
Belgium	78.51	85.14	6.63
Argentina	131.17	87.74	43.43
Denmark	67.22	77.00	9.78
Switzerland	62.15	72.80	10.65
Guatemala	58.26	49.47	8.79
Netherlands	57.19	76.80	19.61
Peru	43.13	40.56	2.57
United Kingdom	69.80	73.60	3.80
Philippines	67.47	56.70	10.77
Mexico	34.24	48.19	13.95
India	45.59	41.16	4.43
France	93.71	96.03	2.32
Brazil	83.89	41.61	42.28
Italy	68.69	88.27	19.58
Costa Rica	74.14	50.25	23.89
Chile	129.65	53.04	76.61
Australia	70.02	99.45	29.43
Austria	60.16	76.44	16.28
Mean Absolute Differences			18.59



Table 8. Continuation

Non-Benchmark Year 1960		Projections	
<u>Country</u>	<u>PWT</u>	<u>Using</u> <u>Ratio Method</u>	<u>Absolute</u> <u>Differences</u>
Ethiopia	62.05	54.50	7.55
Thailand	33.80	56.84	23.04
Colombia	55.59	49.84	5.75
Congo	47.27	77.00	29.73
Argentina	56.33	55.76	0.57
Egypt	71.46	22.94	48.52
Venezuela	89.54	81.12	8.42
Sri Lanka	41.75	33.97	7.78
Denmark	67.68	78.10	10.42
Switzerland	59.85	96.76	36.91
Guatemala	53.43	52.02	1.41
Netherlands	58.21	70.08	11.87
Turkey	74.29	49.14	25.15
Pakistan	41.20	35.64	5.56
Peru	35.37	41.08	5.71
United Kingdom	71.69	74.52	2.83
Philippines	67.38	40.05	27.33
Mexico	41.33	53.68	12.35
Uruguay	34.23	42.09	7.86
Canada	107.32	118.44	11.12
India	45.48	44.59	0.89
France	80.83	84.39	3.56
Morocco	72.65	38.69	33.96
Brazil	41.56	56.94	15.38
Italy	69.19	82.45	13.26
Costa Rica	72.21	55.61	16.60
Chile	68.02	63.92	4.10
Iran	27.86	48.36	20.50
Austria	57.69	99.45	41.76
Mean Absolute Differences			15.17

In summary, I show that the procedure used by the PWT to construct its price estimates is flawed. In particular, Equation 1, which the PWT relies on for obtaining

price estimates for non-benchmark countries. I find that there is no stable relationship between *PWT* and *UN* over time. Neither do I find any systematic errors between projected *PWT* and the published PWT's price estimates. As a result, the absolute price level of a non-benchmark country can either be under- or over-estimated from its true value. If so, it makes the real quantity comparisons between countries or within countries very difficult.

## CHAPTER 6

### CONCLUDING REMARKS

The PWT has had an important influence on economic research. And its presence has made economists understand better the economic performance of the international economy. It is no exaggeration to say that the PWT is one of the most widely used data sets in economics.

Economists have not devoted much effort to determining the quality of this data. In particular, little attention was given to the differences in data quality between benchmark and non-benchmark countries.

To fill this gap, this paper examines the accuracy of the price estimates in the PWT. The main goal is to assess the price-estimation procedure used by the PWT. I have two important findings. First, I show that the procedure that the PWT uses to estimate prices for non-benchmark countries is flawed. I show that it leads to large errors in the PWT. This issue has gone unnoticed. Second, I develop a ratio method to project the prices in the PWT for the benchmark years. I find that the alternative method produces much smaller mean absolute difference than using the PWT's procedure. Also, my results show that the projection error is substantially greater for non-benchmark years and for non-benchmark countries.

These findings have implications for studies that use the PWT's data. These include Baumol (1986), DeLong (1988) and Barro (1991, 1992). In addition, my results have implications for studies, such as those relating to world growth, require real GDP per capita and comparable price and quantity data. In the business world, for example, large multinational firms draw on income and price comparisons as an aid to their location decisions. These studies require the use of accurate and reliable price estimates. Future research should focus on addressing the accuracy issue and the underlying problems of constructing reliable price estimates.

## APPENDIX 1

### Appendix 1. The Penn World Tables - Country List

<u>Country</u>	<u>Benchmark Years</u>			
<u>Africa</u>				
Algeria				
Angola				
Benin				1985
Botswana		1980		1985
Burkina Faso				
Burundi				
Cameroon		1980		1985
Cape Verde Is.				
Central African Republic				
Chad				
Comoros				
Congo, Peop. Rep.				1985
Egypt				1985
Ethiopia		1980		1985
Gabon				
Gambia, the				
Ghana				
Guinea				
Guinea Bissau				
Ivory Coast			1980	1985
Kenya	1970	1975	1980	1985
Lesotho				
Liberia				
Madagascar			1980	1985
Malawi		1975	1980	1985
Mali			1980	1985
Mauritania				

## Appendix 1. Continuation

Mauritius				1985	
Morocco		1980		1985	
Mozambique					
Niger					
Nigeria		1980		1985	
Rwanda				1985	
Senegal		1980		1985	
Seychelles					
Sierra Leone				1985	
Somalia					
South Africa					
Sudan					
Swaziland				1985	
Tanzania		1980		1985	
Togo					
Tunisia		1980		1985	
Uganda					
Zaire					
Zambia	1975	1980		1985	
Zimbabwe		1980		1985	
<u>Asia</u>					
Afghanistan					
Bahrain					
Bangladesh				1985	
Burma (Myanmar)					
China, P.R.					
Hong Kong			1980	1985	
India	1970	1975	1980	1985	
Iran	1970	1975	1985		
Iraq					
Israel			1980		
Japan	1970	1975	1980	1985	1990
Jordan					
Korea, Rep. Of	1970	1975	1980	1985	

## Appendix I. Continuation

Kuwait					
Malaysia	1970	1975			
Nepal				1985	
Oman					
Pakistan		1975	1980	1985	
Philippines	1970	1975	1980	1985	
Saudia Arabia					
Singapore					
Sri Lanka		1975	1980	1985	
Syrian Arab Rep.		1975			
Taiwan					
Thailand		1975		1985	
United Arab Emirates					
Yemen					
<u>Europe</u>					
Austria		1975	1980	1985	1990
Belgium	1970	1975	1980	1985	1990
Cyprus					
Denmark		1975	1980	1985	1990
Finland			1980	1985	1990
France	1970	1975	1980	1985	1990
Germany, Fed. Rep.	1970	1975	1980	1985	1990
Greece			1980	1985	1990
Hungary	1970	1975	1980	1985	
Iceland					
Ireland		1975	1980	1985	
Italy	1970	1975	1980	1985	1990
Luxembourg		1975	1980	1985	
Malta					
Netherlands	1970	1975	1980	1985	1990
Norway			1980	1985	
Poland		1975	1980	1985	

## Appendix I. Continuation

Portugal			1980	1985	1990
Romania		1975			
Spain		1975	1980	1985	1990
Sweden				1985	1990
Switzerland					1990
Turkey				1985	1990
United Kingdom	1970	1975	1980	1985	1990
Yugoslavia		1975	1980	1985	
<u>Central and North America</u>					
Bahamas					
Barbados				1985	
Canada			1980		1990
Costa Rica			1980		
Dominica					
Dominican Republic			1980		
El Salvador			1980		
Grenada					
Guatemala			1980		
Haiti					
Honduras			1980		
Jamaica			1980		
Mexico			1980		
Nicaragua					
Panama			1980		
St. Lucia					
Trinidad and Tobago					
United States	1970	1975	1980	1985	1990
St. Vincent					
<u>South America</u>					
Argentina			1980		
Bolivia			1980		



## Appendix 1. Continuation

Brazil	1975	1980		
Chile			1980	
Colombia	1970	1975	1980	
Ecuador			1980	
Guyana				
Paraguay			1980	
Peru			1980	
Suriname				
Uruguay	1975	1980		
Venezuela			1980	
<u>Oceania</u>				
Australia			1985	1990
Fiji				
Indonesia		1980		
New Zealand			1985	
Papua New Guinea				
Solomon Is.				
Tonga				
Vanuatu				
Western Samoa				

## APPENDIX 2

### Appendix 2. Comparison of the PWT's Published Estimates and Projected Estimates Using Equation 1

Benchmarks 1970			
	<u>PWT</u>	<u>Projection</u>	<u>Absolute Differences</u>
United Kingdom	77.15	85.47	8.33
France	83.71	93.25	9.54
Germany	88.34	90.17	1.83
Italy	76.10	87.05	10.95
Colombia	46.43	81.50	35.07
Kenya	52.49	66.39	13.90
India	35.41	83.10	47.69
Netherlands	75.03	85.48	10.45
Iran	40.64	83.89	43.25
Malaysia	46.08	83.89	37.81
Korea	51.47	88.62	37.15
		Mean Absolute Differences	23.27
		Mean of PWT's Published Estimates	61.17

## Appendix 2. Continuation

Benchmarks 1975			
	<u>PWT</u>	<u>Projection</u>	<u>Absolute Differences</u>
Brazil	68.47	94.02	25.55
Colombia	34.86	73.32	38.46
Jamaica	78.35	96.30	17.95
Mexico	59.40	94.78	35.38
Uruguay	40.52	79.08	38.56
Kenya	51.85	72.58	20.73
India	32.59	81.50	48.91
Korea	41.30	102.29	60.99
Malaysia	56.12	97.05	40.93
Pakistan	34.10	82.30	48.20
Philippines	38.63	94.02	55.39
Sri Lanka	40.53	81.50	40.97
Syria	30.58	93.25	62.67
Thailand	37.00	87.84	50.84
Austria	94.52	113.92	19.40
Belgium	114.00	120.28	6.28
Denmark	131.02	124.45	6.57
France	117.08	125.14	8.06
Germany	120.73	122.37	1.64
Italy	92.24	100.80	8.56
Netherlands	114.60	115.34	0.74
Poland	68.30	84.69	16.39
Romania	65.78	96.29	30.52
Spain	72.35	96.30	23.95
United Kingdom	87.70	96.30	8.60
Yugoslavia	59.79	92.49	32.70
		Mean Absolute Differences	28.80
		Mean of PWT's Published Estimates	68.46

## Appendix 2. Continuation

Benchmarks 1980			
	<u>PWT</u>	<u>Projection</u>	<u>Absolute Differences</u>
Belgium	130.62	134.00	3.39
Denmark	142.25	129.26	12.99
France	130.85	131.30	0.45
Germany	141.00	134.00	6.99
Greece	94.82	105.24	10.42
Italy	92.57	102.29	9.72
Netherlands	128.43	130.62	2.19
United Kingdom	114.73	126.52	11.79
Austria	122.36	127.89	5.53
Hungary	68.94	94.78	25.84
Poland	55.08	75.81	20.73
Spain	97.17	113.92	16.75
Yugoslavia	68.42	90.17	21.75
Botswana	74.60	68.89	5.71
Ethiopia	41.48	73.80	32.32
Ivory Coast	110.44	105.51	4.93
Kenya	63.77	80.95	17.18
Madagascar	58.80	85.59	26.79
Malawi	50.00	71.36	21.36
Mali	32.63	94.63	62.00
Morocco	73.63	92.40	18.77
Nigeria	118.01	90.71	27.30
Senegal	73.56	94.07	20.51
Tanzania	82.35	72.58	9.77
Tunisia	65.22	90.71	25.49
Zambia	119.51	80.95	38.56
India	44.38	87.84	43.46
Indonesia	44.16	103.03	58.87
Japan	113.34	142.67	29.33
Korea	70.53	110.33	39.80
Pakistan	31.80	88.62	56.82

## Appendix 2. Continuation

Philippines	40.54	98.56	58.02
Sri Lanka	23.37	83.10	59.73
Argentina	129.92	142.01	12.09
Bolivia	62.94	97.81	34.87
Brazil	56.98	86.27	29.29
Chile	74.03	107.43	33.40
Colombia	48.47	96.30	47.83
Costa Rica	65.85	100.06	34.21
Dominican Republic	63.48	90.17	26.69
Ecuador	54.48	88.62	34.14
El Salvador	48.70	101.55	52.85
Guatemala	50.43	100.06	49.63
Honduras	57.39	101.55	44.16
Mexico	50.87	93.25	42.38
Panama	67.83	96.30	28.47
Paraguay	69.87	102.29	32.42
Peru	46.58	92.49	45.91
Uruguay	88.35	105.97	17.62
Venezuela	74.16	130.62	56.46
Canada	93.70	84.69	9.01
	Mean Absolute Differences		44.72
	Mean of PWT's Published Estimates		76.93

## Appendix 2. Continuation

Benchmarks 1985			
	<u>PWT</u>	<u>Projection</u>	<u>Absolute Differences</u>
Germany	81.26	84.79	3.53
France	78.40	80.01	1.61
Italy	63.54	70.13	6.59
Netherlands	73.98	85.57	11.59
Belgium	76.14	83.21	7.07

## Appendix 2. Continuation

United Kingdom	72.76	86.36	13.60
Denmark	93.22	89.47	3.75
Greece	58.31	73.48	15.17
Spain	63.32	80.01	16.69
Portugal	46.49	70.97	24.48
Austria	80.58	77.58	3.00
Sweden	94.75	84.79	9.96
Australia	71.68	74.31	2.63
Japan	100.50	100.80	0.30
Canada	91.51	77.58	13.93
Turkey	33.33	65.86	32.53
Hong Kong	55.28	81.61	26.33
Korea	54.05	86.36	32.31
Thailand	30.98	68.44	37.46
Indonesia	38.64	80.01	41.37
Sri Lanka	24.29	63.25	38.96
Pakistan	26.14	62.38	36.24
Philippines	35.45	75.95	40.50
Botswana	33.41	48.66	15.25
Egypt	33.60	75.04	41.44
Ethiopia	41.82	67.10	25.28
Kenya	33.47	55.50	22.03
Malawi	26.27	48.66	22.39
Mauritius	22.17	58.15	35.98
Nigeria	98.37	73.84	24.53
Sierra Leone	43.00	57.49	14.49
Swaziland	33.58	42.20	8.62
Tanzania	80.44	61.40	19.04
Zambia	46.76	53.48	6.72
Zimbabwe	36.86	47.96	11.10
Benin	23.70	56.16	32.46
Cameroon	32.56	62.68	30.12
Congo	42.77	55.50	12.73
Ivory Coast	37.10	56.16	19.06
Madagascar	38.37	61.40	23.03
Mali	32.61	63.95	31.34
Morocco	23.30	48.66	25.36
Rwanda	41.24	71.41	30.17
Senegal	31.02	58.80	27.78

## Appendix 2. Continuation

Tunisia	33.27	73.23	39.96
Poland	42.17	57.01	14.84
Hungary	30.03	56.10	26.07
Yugoslavia	33.92	67.58	33.66
Bahamas	67.91	103.75	35.84
Barbados	67.16	100.06	32.90
Grenada	61.36	93.30	31.94
Jamaica	42.11	69.28	27.17
Suriname	60.71	99.32	38.61
Trinidad and Tobago	79.91	114.53	34.62
Bangladesh	24.70	76.77	52.07
Nepal	28.84	79.21	50.37
	Mean Absolute Differences		23.51
	Mean of PWT's Published Estimates		76.93

## Appendix 2. Continuation

Benchmarks 1990			
	<u>PWT</u>	<u>Projection</u>	<u>Absolute Differences</u>
Germany	120.96	94.06	26.90
France	116.25	106.66	9.59
Italy	108.79	105.21	3.58
Netherlands	107.98	100.80	7.18
Belgium	114.07	97.83	16.24
United Kingdom	100.34	104.48	4.14
Denmark	142.54	107.39	35.15
Greece	80.35	87.14	6.79
Spain	105.42	109.55	4.13
Portugal	63.95	87.14	23.19
Austria	119.07	107.39	11.68
Switzerland	156.03	123.59	32.44
Finland	169.47	118.74	50.73
Sweden	149.34	118.74	30.60

## Appendix 2. Continuation

Turkey	47.50	79.21	31.71
Australia	105.26	88.69	16.57
Japan	124.29	117.35	6.94
Canada	111.86	91.01	20.85
	Mean Absolute Differences		18.80
	Mean of PWT's Published Estimates		50.88



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## VITA

Graduate College  
University of Nevada, Las Vegas

Timothy Scott Fitzgerald

**Home Address:**

9412 Mountainair Ave.  
Las Vegas, NV 89134

**Degrees:**

Bachelor of Science, Biology, 1996  
University of Nevada, Las Vegas

**Special Honors and Awards:**

Regents Award Program, 1997  
University of Nevada, Las Vegas

**Publications:**

Chapter 3: Air Quality, The Las Vegas Metropolitan Area Project, 1998  
University of Nevada, Las Vegas

**Thesis Title:** Assessing the Accuracy of the Penn World Tables

**Thesis Examination Committee:**

Chairperson, Dr. Lein-Lein Chen, Ph.D.  
Committee Member, Dr. Ronald Cronovich, Ph.D.  
Committee Member, Dr. Bradley Wimmer, Ph.D.  
Graduate Faculty Representative, Dr. Ronald Smith, Ph.D.