

Escuela de Economía y Finanzas

# Documentos de trabajo

## Economía y Finanzas

Centro de Investigación  
Económicas y Financieras

No. 12-17  
2013

**ICP 2005 Construction Prices: Are They Underestimated in Developing Countries?**

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# ICP 2005 Construction Prices: Are They Underestimated in Developing Countries?

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April 10, 2013

## Abstract

*Construction prices in developing countries in ICP 2005 are lower relative to prices in developed countries than in earlier versions of the ICP. Our estimates of the Colombia/U.S. ratio of prices for office buildings demonstrate that the ICP 2005 price ratio for these countries is substantially underestimated. We confirm the validity of our results by comparing construction component prices in these countries. Since the ICP 2005 estimate of the Colombia/U.S. price ratio is representative of its ratio of construction prices between all developing and developed countries, we suspect there is a problem with the ICP 2005 estimation methodology.*

Key Words: ICP 2005, Price Indices, Penn World Table, Construction Prices, Colombia

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## I. Introduction

The testing of macroeconomic growth models relies heavily on cross-country economic data, but national economic data cannot be used directly because these data are based on different prices for the same goods and services. The Penn World Table [PWT] was created to provide continually-updated multi-country economic data based on a uniform set of prices. These prices are collected from a large number of countries through periodic surveys managed by the International Comparison Program [ICP].

Johnson, Larson, Papageorgiou, and Subramanian [2013] show that the PWT has not used historic ICP prices to adjust National Accounts data in a consistent, conceptually-appropriate manner. As a result, national economic data for the same year are not consistent across different versions of the PWT. The differences are particularly large between PWT 7.0 and earlier versions of the PWT because the price relationships between developed and less developed countries changed dramatically in ICP 2005 [Breton, 2012].

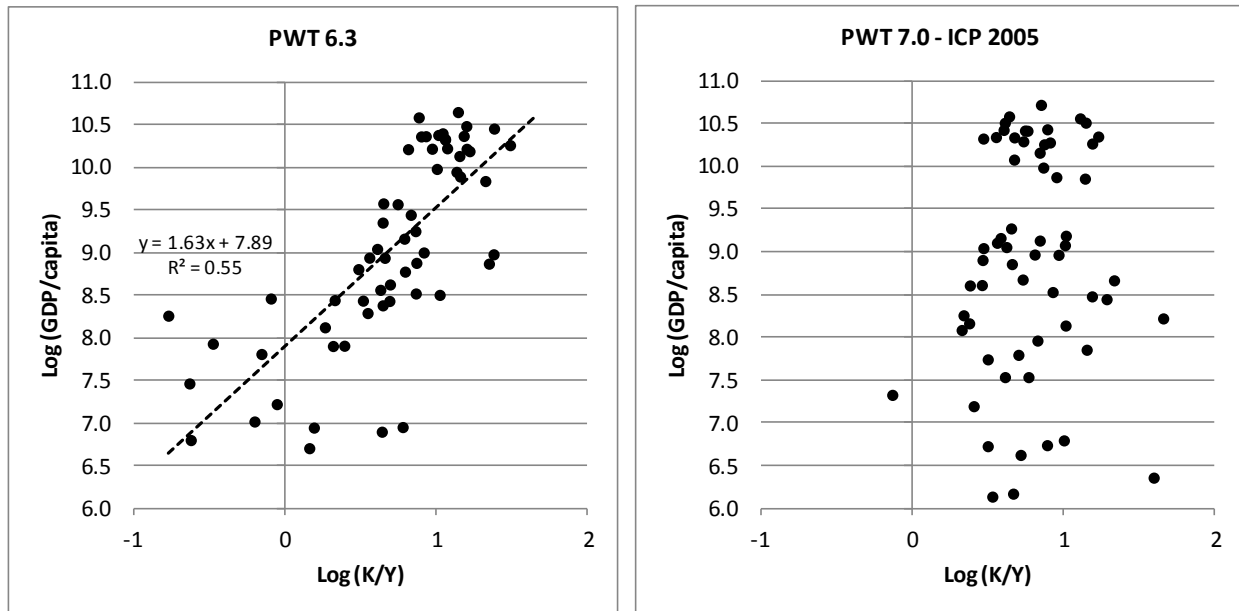
Figure 1 shows the relationship between GDP/capita and the capital/output ratio in 2000 in PWT 6.3 and PWT 7.0 [Heston, Summers, and Aten, 2009 and 2011].<sup>1</sup> In the Solow model the slope of this line is  $\alpha/1-\alpha$ . In the PWT 6.3 data, the implied value of  $\alpha \approx 0.6$ . Since stocks of physical capital and human capital per worker are highly correlated across countries, this slope measures the total effect of these two types of capital [Mankiw, Romer, and Weil, 1992].

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<sup>1</sup> We calculate the capital stock (K) using the perpetual inventory method, investment from 1960 to 1999, and a geometric depreciation rate of 6 percent.

Figure 1

Log(GDP/capita) vs. Log(K/Y) in PWT 6.3 and PWT 7.0 in 2000



In cross-country studies performed between 1992 and 2010 using data from PWT versions prior to PWT 7.0, the estimated elasticity of GDP/capita to the total stock of capital ( $\alpha + \beta$  in the augmented Solow model) was consistently between 0.6 and 0.7 [Breton, 2011]. But as shown in Figure 1, in PWT 7.0 there is no statistical relationship between GDP/capita and the capital/output ratio, so the implied value of  $\alpha = 0$ . This change occurred because the prices for capital investment ( $\pi$ ) in developing countries in ICP 2005 are much lower than in previous versions of the ICP and these prices were used incorrectly to adjust the national accounts in PWT 7.0 all the way back to 1950 [Breton, 2012].

If the ICP 2005 prices were used correctly to adjust only the more recent National Accounts data, their effect on the estimated capital stock in 2000 would be smaller, and the relationship between GDP/capita and the capital/output ratio in PWT 7.0 would be more

similar to the relationship in PWT 6.3. But the issue still remains as to whether the large changes in investment prices between ICP 2005 and the earlier versions of the ICP are valid.

Since the largest component of investment is construction and construction prices are difficult to estimate, we decided to check whether the Colombia/U.S. ratio of construction prices in ICP 2005 are similar to the ratio of actual prices for office buildings in 2005. We selected these two countries for the comparison because they are representative of developing and developed countries and we were able to obtain proprietary data for construction costs in these two countries. We selected office buildings for the price comparison because this type of building has similar characteristics and construction quality in both countries, which is not the case for most other building types.

Based on estimates of costs/square meter in both countries, we estimate that in 2005 the construction price for multi-story office buildings in Colombia was about 70 percent of the price in the U.S. We confirm this relationship using proprietary price data for construction components. Our estimate of the Colombia/U.S. price relationship is over double the ICP 2005 estimate, which is that the construction price in Colombia is only 33 percent of the price in the U.S.

ICP 2005 estimated construction prices in each country using models of different types of construction projects, regional productivity assumptions, and proprietary country-specific prices for construction materials [McCarthy, 2013]. As a consequence, the documentation for the ICP 2005 price estimates in Colombia and the U.S. is not public, and there is no way that we can determine why the ICP 2005 prices are so different from our prices in these countries.

We are concerned that the ICP 2005 ratio of construction prices between developing and developed countries is substantially underestimated and that this underestimate is causing an overestimate of national investment in developing countries in PWT 7.0. We hope that the documented results we present here will encourage the ICP staff to investigate whether there is a problem with the methodology used to estimate construction prices in ICP 2005, and if there is, that they will provide revisions to these prices as soon as possible.

This paper is organized as follows. In section II we describe the methodology used in the ICP estimates of construction prices and the methodology that we used to create our estimates. In section III we present our estimates of construction prices for office buildings in Colombia and the U.S. in 2005. In section IV we present prices for some construction materials and labor categories for Colombia and the U.S., and we use these prices and estimates of the shares of material and labor costs in total construction costs to confirm our estimates of the relative prices for completed buildings. In section V we present estimates of the prices of office buildings in 1996 to confirm that the ratio of Colombian/U.S. prices in 2005 was not unusually high. In section VI we conclude.

## **II. Methodologies for Construction Price Estimation**

The ICP price of capital investment in each country is derived from two components of GDP; construction and machinery/equipment, of which construction is usually the larger component. Since prices of machinery and equipment in ICP 1996 and ICP 2005 were obtained directly from surveys undertaken in each country, these prices are likely to be reasonably accurate.

The situation with respect to construction prices is much more complex. Building characteristics vary considerably across countries, and sales prices include the land value, which varies considerably even within the same country. As a consequence, there is no standard construction product whose price can be surveyed, and the ICP considers construction to be a “comparison-resistant” component of GDP.

The methodology used to estimate construction prices has varied in different ICP exercises. In ICP 1996 the methodology adopted for estimating construction prices was a model-based technique known as the bills of quantities (BOQ) approach [McCarthy, 2011]. This is a very elaborate methodology that includes estimates of the cost of residential buildings, non-residential buildings and civil engineering projects. The cost of a standardized project in each category is estimated in each country based on price estimates for a large number of components, which are then combined and weighted to provide a total project cost.

The data obtained from the non-OECD countries in ICP 1996 was insufficient to implement the BOQ methodology, so ICP 1996 did not release construction price estimates for developing countries. As a consequence, the construction prices in 1996 for these countries in PWT 6 were estimated from prices in ICP 1985 and ICP 1990, which were based on the BOQ technique [McCarthy, 2013].

In an effort to simplify the estimation process for construction prices for ICP 2005, the World Bank created a methodology called the Basket of Construction Components Approach (BCCA). The BCCA uses prices for 12 basic components and for 22 composite components, along with weights appropriate for each country, to create an aggregate construction price for each category of construction. The components include several types of labor, and the weights

account for differences in labor productivity and construction techniques in each country [McCarthy, 2011].

Unfortunately, the data obtained for many of the non-OECD countries did not include the information required to weight the component prices in different types of structures, so the prices in each country in ICP 2005 were estimated using country-specific dummy variables and the ring method, where a uniform set of weights is used for each country within a geographic region [McCarthy, 2013]. The price estimates for Colombia were created using regional assumptions for South America, which are based on data for Chile and Brazil. The price estimates for the U.S. were created using regional assumptions used for the Eurostat-OECD region, which are based on data for the UK, Japan, Estonia, and Slovenia [McCarthy, 2013]. Given the substantial differences in the structure of labor markets in countries within these regions, there may be considerable error in the estimation of construction prices for some countries. If the Colombia/U.S. ratio of construction prices in ICP 2005 is too low, it could be because Colombian prices are too low, or because U.S. prices are too high, or both.

The ICP 2005 methodology creates relative construction prices by estimating prices for each category of construction in a country and then developing an overall price that is consistent with the share of each category in overall construction. If the estimate for each category is valid, then this approach provides an accurate overall price.

Our concern is that construction characteristics and construction quality vary considerably across countries and are more varied in some types of construction than in others. Modern office buildings are very similar across countries, while residential structures are not. If the price of a poor-quality, primitive dwelling in a developing country is compared to the price

of a high-quality dwelling in a developed country, the relative construction price in the developing country will be biased downward. If this estimate is included in a ratio of weighted construction prices, the overall average price ratio will be too low.

Figure 2 presents a photograph of a typical four-story apartment building under construction in Colombia. Unlike the process used in larger apartment buildings, the construction process used in smaller buildings is often quite primitive. The workers participating in this process are illiterate, their productivity is low, and the quality of both the design and the construction of these buildings is often poor.

**Figure 2**

**Construction of a Four-Story Apartment Building in Medellin, Colombia**



In our view a simpler and potentially more reliable methodology for cross-country price comparisons is to compare prices only for buildings that are similar in construction characteristics and in quality. We follow this approach to estimate the Colombia/U.S. price relationship by comparing the cost of 11-20 story office buildings. These structures have similar features in both countries, including air-conditioning, elevators, and modern communication facilities.

Since new office buildings typically are not sold, we estimate their construction cost per square meter in Colombia from proprietary data on the sales prices for individual offices in new buildings in Medellin, Colombia. We then compare these costs to proprietary data on the estimated cost to construct identical buildings in the U.S. We create our overall Colombia/U.S. price relationship using the average price relationship for three buildings constructed in Colombia in 2005. The price of buildings in Medellin is representative of the prices of buildings in other Colombian cities. Construction costs in Bogota, Medellin, Cali, and Barranquilla for a comparable structure in 2005 varied by only 2% [Construdata, 2005].

Our data for building prices and component prices in Colombia are primarily from the Cámara Colombiana de Construcción [Camacol, 2005a and 2005b]. Our data for U.S. building costs are primarily from R. S. Means [2005]. We also use data for labor costs from the U.S. Bureau of Labor Statistics and data for construction component prices from the *Engineering News Record*.

### **III. Office Building Construction Prices in 2005**

Table 1 presents our estimates of the price per square meter for three office buildings in Colombia and the U.S. in 2005. The construction cost in Colombia is calculated by subtracting estimates of the land costs and the sales commissions from the total sale price for individual offices and dividing this cost by the area in these offices, as reported in Camacol [2005b]. The area used in the calculation of prices/square meter includes the allocated share of the common space in the building. We obtained the shares of land costs and sales commissions in the office prices from Gonzalez [2012]. The price comparison in U.S. dollars is based on the average Colombian peso/U.S. dollar exchange rate in 2005.

<b>Buildings in Colombia</b>	<b>San Fernando Plaza</b>	<b>Tesoro</b>	<b>Aguacatala</b>
Area/office - sq. m.	600	40	78
Number of offices	55	115	150
Total Area - sq. m.	33000	4600	11700
Price/office in Col. pesos	1470000000	132000000	189317154
Price/sq. m. in Col. pesos	2450000	3300000	2427143
Pesos/US dollar in 2005	2321	2321	2321
Price/sq. m. in US\$	1056	1422	1046
Sales Commission (% of total)	7	7	7
Land Cost (% of sale price)	18	18	18
Total Adjustment (%)	-25	-25	-0.25
Adjusted Price/sq. m. in US\$	792	1066	784
<b>U.S. Cost Estimate</b>			
Total area - sq. meters	24164	24164	24164
Cost/sq. meter	1128	1128	1128
Adjustment for scale	0.978	1.196	1.060
Site preparation costs (%)	1	2	1
Adjusted cost/sq. m.	1114	1375	1207
Price ratio - Colombia/US	0.71	0.78	0.65

The construction cost in the U.S. for each building is based on RS Means' [2005] data on average U.S. costs for a standardized office building in 2005. The adjustments to these costs

are based on their economy-of-scale and site-preparation-cost relationships for office buildings of different sizes. The ratio of Colombia/U.S. prices for these three buildings ranged from 0.65 to 0.78, with an average ratio of 0.71.

Table 2 compares this price ratio to the price ratio in ICP 2005 and to the price ratio related to the PWT estimate of construction prices in 1996. The ICP 2005 price ratio is 0.33, which is less than half the ratio we calculate from actual office building costs. Since the Colombian and U.S. prices may not be representative of the prices in the ICP 2005 for other developing and developed countries, we also calculate the Colombian/U.S. price ratio using the expected prices in the ICP 2005 data for countries with similar levels of GDP/capita.

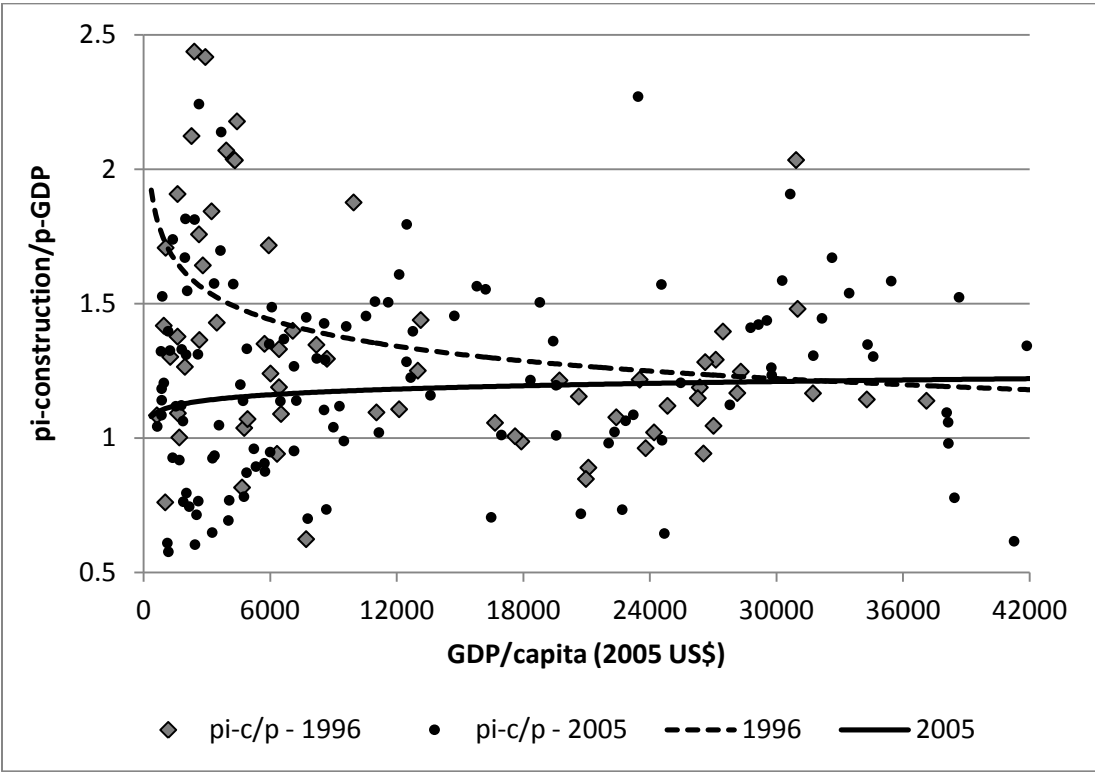
<b>Table 2</b>			
<b>Ratio of Construction Prices in Colombia and the U.S. in 2005</b>			
	<b>Colombia Price</b>	<b>U.S. Price</b>	<b>Colombia/U.S. Ratio</b>
Our Analysis			0.71
ICP 2005 Actual	0.44	1.34	0.33
ICP 2005 Typical	0.55	1.24	0.44
PWT for 1996 Typical			0.58

Figure 3 shows the relationship between the price of construction and the price of GDP across countries in ICP 2005. These data were obtained from World Bank [2012]. The trend line for these data provides expected prices for construction in countries with GDP/capita similar to Colombia and the U.S. The price ratio using these expected prices is 0.44, which is still quite low, so the ICP 2005's low estimate of the Colombia/U.S. price ratio seems to be representative of their price ratios for other countries at similar levels of development.

Colombia did not participate in ICP 1996, so the PWT did not provide an estimate of Colombia's prices in 1996, but the expected price for Colombia can be estimated from the trend in the PWT data for construction prices in 1996. These data were obtained from the PWT web site [Heston, Summers, and Aten, undated]. The trend is shown in Figure 3. The PWT's estimate of the ratio of the construction price in 1996 for a country like Colombia to the price in the U.S. is 0.58. This ratio is lower than our ratio of 0.71 for office buildings in 2005, but it suggests that the estimates of relative construction prices between developing and developed countries in earlier ICP exercises were more accurate than the prices in ICP 2005.

Figure 3

Ratio of pi-construction/p-GDP in PWT prices for 1996 and in ICP 2005



#### IV. Construction Component Prices in 2005

Since our construction price estimates for Colombia are calculated from office sales prices, these estimates could be too high if the land costs were higher than we assumed or if construction companies made abnormal profits on these sales. As a check on the validity of our Colombia/U.S. construction price ratio, we compared the price ratios for identical construction components in Colombia and the U.S. to see if these ratios are consistent with the building price ratios. In theory the component prices were the basis for the estimates of construction prices in ICP 2005, so our component prices are also a check on the reasonableness of the ICP 2005 construction price estimates. Table 3 presents these prices.

	Colombia Price		U.S. Price	Colombia/U.S. Ratio
	Pesos	US\$	US\$	Ratio
Standard Concrete Block	1540	0.66	1.23	0.54
Concrete (cubic meter)	190,416	82.0	101.4	0.81
Steel – ½" reinforcing bar (kg)	2159	0.93	0.70	1.32
PVC – 8" sewer pipe (meter)	72690	31.31	12.46	2.51
Copper tubing ½" (meter)	10166	4.38	3.11	1.41
Electrician (hour)	7832	3.37	21.94	0.15
Unskilled Labor (hour)	3131	1.35	13.97	0.10

The Colombia/U.S. price ratio for materials ranges from 0.54 for concrete blocks to 2.51 for PVC pipe. We could not find equipment rental costs, but the ratio is likely to be over 1.0, since Colombia generally imports this equipment. The most basic construction materials (e.g., concrete) are somewhat cheaper in Colombia than in the U.S., while fabricated components,

such as pipe and steel bars, are more expensive. The share of fabricated components in an office building is considerable, so overall it appears that the average price of the material and equipment components of construction is similar in the two countries.

In contrast, unskilled and skilled labor is much cheaper in Colombia than in the U.S., with an hourly wage that is only 10-15 percent of the U.S. wage. These relatively low labor costs in Colombia could make construction prices considerably lower in Colombia than in the U.S., but only if labor is a high proportion of total input costs and Colombian labor productivity is similar to U.S. labor productivity.

The ICP 2011 Global Office [2011] estimates that materials and equipment rental account for about 60% of total non-residential and residential building costs in developed countries and about 80% in developing countries. This means labor costs are 40% of building costs in the U.S. and 20% in Colombia. If the material/equipment costs are the same, then labor costs are 25% of these costs in Colombia and 67% of these costs in the U.S. With these assumptions Colombian labor costs are 38% ( $25/67$ ) of U.S. labor costs. If Colombian wage costs are 12.5% of U.S. costs, then Colombian labor productivity is 33% of U.S. productivity, and the Colombia/U.S. construction price ratio for non-residential buildings is 0.75.

This estimate using the ICP 2011 shares of costs provides an even higher ratio of Colombia/U.S. construction prices than our estimate based on building costs. Camacol [2005a] data indicate that labor costs are only 16% of total office building costs in Colombia. If so, then Colombian labor costs are 19% of material/equipment costs, or  $1/3$  of U.S. labor costs, Colombian labor productivity is 40% of U.S. productivity, and the Colombia/U.S. price ratio is 0.73. This provides a better match to our estimate of the Colombia/U.S. ratio of office building

prices. But no matter how the price ratio is calculated, the ICP 2005 estimated price ratio of 0.33 (or 0.44) appears to be far too low.

The techniques used to construct office buildings in Colombia are undoubtedly more sophisticated than those used to construct residential buildings. In addition, residential structures are likely to have a lower proportion of expensive fabricated materials than office buildings. So the Colombia/U.S. price ratio for residential materials and equipment could be as low as 0.8., which would lower the overall Colombia/U.S. price ratio for residential structures with 20% labor costs to 0.60. Nevertheless, even with this lower cost for materials, this ratio is still greater than the 0.58 ratio estimated by the PWT for 1996 and far greater than the 0.33 ratio estimated in ICP 2005. If we average the estimates using the Camacol [2005a] estimates of the labor share with this estimate, the Colombia/U.S. price ratio is 0.67, very similar to our estimates using the Colombian/U.S. office building cost data.

## **V. Office Building Construction Prices in 1996**

Another potential concern is that the Colombia/U.S. ratio for construction prices in 2005 might be unrepresentative of other countries if construction prices in Colombia were unusually high or construction prices in the U.S. were unusually low in 2005. As a check on this possibility we estimate the Colombia/U.S. price ratio for office buildings in 1996 using the same methodology used earlier to estimate this ratio in 2005. In the Colombian cost estimates we include a higher share for land costs/construction company profits than in 2005 because Colombia was experiencing a real estate boom in 1996.

Our results are shown in Table 4. In these estimates the overall average of the Colombian/U.S. price ratios for the three buildings in 1996 was 1.01. These results show that the 2005 ratio of prices is not unusually high. The ratio in 2005 is much lower than in 1996 when a real estate boom was underway in Colombia. Our review of construction component prices in 1996 (not shown) also confirmed that the Colombia/U.S. ratio of prices for construction components also was higher in 1996 than in 2005. Since the U.S. was in a construction boom in 2005, U.S. prices in 2005 may have been unusually high, making the Colombia/U.S. ratio of prices in 2005 unusually low.

<b>Buildings in Colombia</b>	<b>Centro Empresarial Dann</b>	<b>Centro de Negocios Alcalá</b>	<b>Centro Profesional El Cruzero</b>
Area/office - sq. m.	46	50	38
Number of offices	195	74	64
Total Area - sq. m.	8970	3700	2432
Price/sq. m. in Col. pesos	1700000	1400000	1600000
Pesos/US dollar in 2005	1037	1037	1037
Price/sq. m. in US\$	1639	1350	1543
Sales Commission (% of total)	7	7	7
Land Cost (% of sale price)	23	23	23
Total Adjustment (%)	-30	-30	-0.30
Adjusted Price/sq. m. in US\$	1147	945	1080
<b>U.S. Cost Estimate</b>			
Total area - sq. meters	13005	13005	13005
Cost/sq. meter	923	923	923
Adjustment for scale	1.06	1.15	1.19
Site preparation costs (%)	1	2	3
Adjusted cost/sq. m.	959	1083	1131
Price ratio - Colombia/US	1.20	0.87	0.96

## VI. Conclusions

The construction price ratio in developing countries relative to developed countries declined dramatically in ICP 2005 relative to earlier versions of the ICP. This decline in relative prices raised the adjusted share of GDP attributed to investment in developing countries in PWT 7.0, which raised the capital/output ratio in these countries. This change eliminates the traditional positive cross-sectional relationship in the PWT data between GDP/capita and the capital/output ratio. The change raises the issue of whether the changes in construction prices in ICP 2005 are valid.

In this paper we investigate whether the Colombia/U.S. ratio of construction prices in ICP 2005 is consistent with our own estimates of this ratio for multi-story office buildings. We find that it is not. While we find that this ratio is about 0.7, ICP 2005 found that this ratio is only 0.33, or less than half as much.

We also examine whether the Colombia/U.S. ratio of building component prices in 2005 is consistent with the ICP price ratio, and again we find that it is not. The only component of building costs that is much lower in Colombia than in the U.S. is labor costs, and the ICP 2011 estimated share of these costs in total building costs are too low to explain a Colombia/U.S. construction price ratio of 0.33, or even of 0.44, which is the expected price ratio in ICP 2005 for countries with GDP/capita like Colombia and the U.S.

We also perform a less-detailed analysis of the Colombian/U.S. ratio of construction prices in the residential sector using building component prices. We estimate a Colombia/U.S. ratio of construction prices in this sector of about 0.6. We also provide an analysis of the

Colombian/U.S. ratio of prices for office buildings in 1996 to investigate whether the estimated ratio in 2005 is unusually high, and we find that it is not. The Colombia/U.S. ratio of building prices in 1996 was considerably higher than in 2005. We conclude that something is not right with the construction prices for developing countries in ICP 2005.

ICP 2011 will provide a new set of prices for 2011, and these prices will become the basis for future versions of the PWT. But if the ICP 2005 prices are incorrect, they will continue to cause a bias in analyses that utilize PWT economic data for the 1996 to 2011 period.

Since the ICP 2005 prices were created using a complex series of models, regional assumptions about productivity and construction techniques, and proprietary prices for building components, there is no public documentation for the prices estimated for individual countries and no way for users to evaluate the validity of these prices. We hope that the documented results we present here will encourage the ICP staff to investigate whether there is a problem with the methodology used to estimate construction prices in ICP 2005 , and if there is, that they will provide revisions to these prices as soon as possible.

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