Productivity Level Database for Latin America:

Estimating Industry Purchasing Power Parities for Output and Inputs

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Abstract

The LAKLEMS productivity level database presents a comparison of relative industry productivity levels and competitiveness in Latin America. It presents data on the PPPs (or relative price levels) of output and capital, labour and intermediate inputs at the industry level in Latin America. It also provide data on the relative levels of output and inputs and labour and total factor productivity. In this article, we first outline the methodology and data sources for estimating the purchasing power parities (PPPs) of inputs and output at the industry level in Latin America. We also present the methodology for estimating relative levels of output and inputs and labour and total factor productivity that makes use of the estimated PPPs. The estimates of relative productivity levels in Latin America are presented in this article. Those estimates are preliminary and presented to solicit comments and feedbacks so that the improvement can be made in the future revision to those estimates. The content and coverage of PPPs and LAKLEMS productivity level database are also presented in this article.

1. Introduction

The LAKLEMS productivity level database presents a comparison of relative industry productivity levels and competitiveness in Latin America. It presents data on the PPPs (or relative price levels) of output and capital, labour and intermediate inputs at the industry level in Latin America. It also provide data on the relative levels of output and inputs and labour and total factor productivity. In this article, we document methodology and data sources used for estimating the relative prices or PPPs of industrial output, intermediate inputs and value added, and capital and labour input for Latin America and for estimating the relative levels of output and inputs and productivity.

This version of the LAKLEMS productivity level database presents data at the sector level for eight economies of Latin America (Chile, Colombia, Costa Rica, El Salvador, Honduras, Mexico, Peru and the Dominican Republic) from the period 1990-2018. It complements the growth and productivity accounts component of the LAKLEMS project documented in Hofman et al. (2016) by providing comparative levels of output, inputs and productivity. It provides important information on the difference in the level of labour productivity and output between LA economies and allocates those differences between the difference in input and the difference in the level of technology or total factor productivity (TFP).

The comparison of levels of output, inputs and productivity is based on the volume index of output and inputs. For that purpose, the nominal values of output and inputs are deflated by purchasing power parities (PPPs) to remove the difference in relative prices between economies, where the PPPs reflect price relatives that show the ratio of the prices in national currencies of the same good or service or same inputs in different economies and the PPPs must be estimated first before estimating relative levels of productivity.

The methodology for estimating PPPs and the relative volume index of output, inputs and productivity levels was developed by Jorgenson and Nishimizu (1978) and Jorgenson, Kuroda, and Nishimizu (1987) which provided a level comparison of output, inputs and productivity between the United States and Japan at both total economy level and industry level. That methodology is recently adopted and extended for constructing the Groningen Growth and Development Centre (GGDC) Productivity Level database, which provides a level comparison of

output, inputs and productivity at a detailed industry level for a set of thirty OECD countries. It is also used for the level comparison of output, inputs and productivity between Canada and the United States and several other studies ((Baldwin, Gu and Yan, 2008, Schreyer 2007).

The rest of the article is organized as follows. Section 2 presents the methodology for estimating PPPs of gross output, intermediate inputs and capital and labour input. Section 3 presents the methodology for estimating the relative levels of gross output, intermediate inputs, capital and labour inputs and productivity levels and outlines the level accounting methodology that decomposes the difference in labour productivity into the difference in TFP and input intensity. Section 4 presents the data sources. Section 5 presents the main estimates from the database. Section 6 presents the content and coverage of the PPPs database and KLEMS productivity level database. Section 7 concludes and highlights main challenges and potential future work for improving the PPP estimates and productivity level database.

2. Methodology for Estimating PPPs of Output, Intermediate Inputs, Capital and Labour Inputs

This section presents the methodology for constructing PPPs for gross output, intermediate inputs, capital input and labour inputs.

The PPPs for output and intermediate inputs at the industry level are derived from an aggregation of relative prices at detailed product level, using as weights the nominal values of various outputs that the industry produce for output PPPs and the nominal values of inputs that the industry use to produce the outputs for intermediate input PPPs.

The PPPs for labour input at the industry level are derived from an aggregation of relative hourly compensation across various types of workers using weights based on their total labour compensation, whereas workers are dis-aggregated by education, experience and gender to take into account the difference in productivity between various types of workers. The PPPs for capital input at the industry level is aggregated from data on relative user costs of capital and capital stock by various asset types.

As industries produce a large number of products and use a large number of goods and services as intermediate inputs and employ different types of capital assets and different types of labour in the production process, individual PPPs at the product level and at the detailed input level

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have to be aggregated to obtain the PPPs for gross output, intermediate inputs, capital and labour input of an industrial sector. For that purpose, we will use CCD multilateral Tornqvist aggregation (Caves, Christensen and Diewert, 1982).

For this methodology, an artificial reference economy is created as an average of all economies in the data set, and this reference economy is then used as a bridge when making all binary comparisons between two economies. The CCD index is transitive and is base-economy invariant in the sense that all economies are treated symmetrically.

Alternatively, one country can be chosen as a benchmark for comparison and all other countries are compared with that benchmark country. However, this bilateral index is not transitive and is sensitive to the choice of benchmark country. Therefore, the CCD multilateral index is chosen for constructing PPPs and LAKLEMS productivity level database.

<u>PPPs for gross output, intermediate inputs and value added</u>

Let i denote a product of industry output, the PPPs or relative price of gross output in country c is defined as follows:

$$PPP\_GO_c = \sum_i \hat{v}_{ic} \left(\ln p_{ic}^{GO} - \overline{\ln p_i^{GO}} \right) ,$$

Where,

- PPP_GO_c : the PPP of gross output for country c, expressed in domestic currency relative to the price level of an average country,

- p_{ic}^{GO} : the relative price of output i in country c, expressed in domestic currency relative to the US dollars,

- $\overline{\ln p_i^{GO}}$: the geometric average of the price of output i over all countries indexed by

  c=1,..,N and N is the number of countries, $\overline{\ln p_i^{GO}} = \left(\sum_{c=1}^{N} \ln p_{ic}^{GO} \right) / N$,

- $\hat{v}_{ic} = \left(v_{ic} + \sum_c v_{ic} / N \right) / 2$, where v_{ic} is the nominal share of output i in total nominal output of an industry in country c.

The relative price of output i in country c, expressed in domestic currency relative to the US dollars p_{ic}^{GO} : is obtained from ICP project (World Bank, 2015). The same formula is used to estimate PPPs for intermediate inputs (denoted by PPP_II).

The PPPs for value added (PPP_VA) is estimated using double deflation and estimates of PPPs of gross output and intermediate inputs. There is a departure from EUKLEMS. Here we adopt the CCD index for double deflation, while EUKLEMS used a mix of CCD and EKS where CCD index is used for estimating PPPs of output and intermediate input and the EKS index is used for the double deflation of value added.

For value added, two alternative PPPs can be used: one based on the deflation of gross output and intermediate input PPPs (in a procedure known as double deflation) and one based on gross output PPP only (single deflation). The choice of the single deflation over double deflation is based on the view that there are inherent measurement errors and large variability that are often associated with double deflation. Nevertheless, for LAKLEMS, the estimates based on double deflation are found to be sensible and robust. Therefore, the double deflation for value added is adopted for LAKLEMS.

In the productivity and growth accounts such as the LAKLEMS database, productivity is examined from the producer perspective: output is valued at basic price that excludes net product tax, and transport and trade margins, while inputs are valued at purchaser price that includes net product taxes, and transport and trade margins. To be consistent with the growth accounts, the PPPs of output for the level comparison reflects the relatives of basic prices for gross output and the PPPs for inputs are the relatives of purchaser prices for capital, labour and intermediate inputs.

For LAKLEMS, the PPPs for gross output, intermediate inputs, and value added at the industrial sector level are aggregated from PPPs at the level of 72 products that comprise industry output and industry intermediate inputs (Table 1). The PPPs at the industrial sector are then aggregated to the total economy using the CCD aggregation.

PPPs of Labour Input

PPPs (PPP_c^L) or the relative price of labour input is the price of labour input in a country in domestic currency compared with the average price of the average economy and it can be written as:

$$PPP\_L_c = \sum_l \hat{v}_{lc}\left(\ln p_{ic}^L - \overline{\ln p_i^L}\right),$$

Where,

- PPP_c^L : PPP of labour input for country c, expressed in domestic currency relative to the average price of labour input in an average country.

- p_{lc}^L: the hourly compensation of worker type l in country c, expressed in domestic currency.

- $\overline{\ln p_l^L}$: the geometric average of hourly compensation of worker type l over all countries indexed by c=1,..,N and N is the number of countries. $\overline{\ln p_l^L} = \left(\sum_{c=1}^{N}\ln p_{lc}^L\right)/N$.

- $\hat{v}_{lc} = \left(v_{lc} + \sum_c v_{lc}/N\right)/2$, where v_{lc} is the nominal share of worker type i in total labour compensation of an industry in country c. $\left(\sum_c v_{lc}/N\right)$ is the average of that share in all economies.

For LAKLEMS, labour is cross classified by gender (male and female), age group (15–29, 30–49, and 50 and over) and skill levels (low skilled, medium skilled, and high skilled) for a total of 18 types of workers (Table 2).

If hours worked is homogeneous and no distinction is made between the different types of workers with different marginal product or hourly compensation, the PPPs or the relative price of labour input will be equal to the ratio of hourly compensation in domestic currency between the two countries. The PPPs of labour input takes into account the difference in the skill mix of hours worked in the two countries. Essentially, difference in the hourly compensation in the two countries may reflect the difference in the skill mix in the two countries and the PPPs of labour input controls for the difference in the skill mix between two countries.

PPPs of Capital Input

Capital input is the flow of capital services derived using capital assets in a period, and the price of capital input reflects the user cost of using capital assets over a period. Therefore the PPPs PPP_c^K of capital input is the relative user cost of capital input in a country in domestic currency compared with the user cost of the average economy and it can be written as:

$$PPP\_K_c = \sum_k \hat{v}_{kc} \left(\ln p_{kc}^K - \overline{\ln p_k^K} \right) ,$$

Where,

- PPP_c^K : PPP of capital input for country c, expressed in the user cost in domestic currency relative to the average user cost of capital input in an average country.
- p_{kc}^K : the user cost of capital asset k in country c, expressed in domestic currency.
- $\overline{\ln p_k^K}$: the geometric average of the user cost of capital asset k over all countries indexed by c=1,..,N and N is the number of countries. $\overline{\ln p_k^K} = \left(\sum_{c=1}^N \ln p_{kc}^K \right) / N$.

- $\hat{v}_{kc} = \left(v_{kc} + \sum_c v_{kc} / N \right) / 2$, where v_{kc} is the nominal share of asset type k in total capital compensation of an industry in country c. $\left(\sum_c v_{kc} / N \right)$ is the average of that share in all economies.

For LAKLEMS, capital assets are classified into 8 asset types (table 3), residential structures, no-residential structures, transportation equipment, M&E, other products and 3 information technology and communication products (computing equipment, communication equipment, and software. The same depreciation rates are used to estimate capital stock for those 8 assets for all LA economies to provide comparability of capital stock estimates.

The user cost of capital for asset type k in a country c is estimated using the exogenous rate of return and it can be estimated as:

$$p_{kc}^K = p_{kc}^I (\delta_k + \gamma),$$

where p_{ic}^{I} is the investment price of capital asset k in country in c in domestic currency relative to the US dollars, δ_k is the depreciation rate for asset type k and γ is the real rate of return which is assumed to be 4%.

The investment price of assets is from the ICP project (World Bank, 2015). For the estimation of the PPPs of capital input, we distinguish five asset types that include ICT, transportation equipment, other M&E, residential structures and non-residential construction. That is because data on PPPs for investment goods are limited from the ICP and no PPPs for separate categories ICTs are available from the ICP.

3. The Level Accounting and KLEMS Productivity Level Database

In this section, we outline the construction of KLEMS productivity level database that makes use of PPPs of output and inputs, and provide the level accounting of labour productivity difference between countries.

The construction of KLEMS level database starts with the construction of the KLEMS level database in the benchmark year (2011 for this database). This includes the relative levels of output, intermediate input, capital and labour input and TFP and labour productivity levels at the sector level for benchmark year 2011. These relative levels of output, inputs and productivity in benchmark year are then extrapolated to other years using the growth rates of those variables. The relative volume measure of gross output in the benchmark year in country c is derived from deflating the nominal value of gross output in domestic currency by the relative price or PPPs of gross output in a country c.

$$Q\_GO_c = GO_c / PPP\_GO_c,$$

Where Q_GO_c is the relative volume of gross output in benchmark year and PPP_GO_c is the PPPs of gross output, and GO_c is nominal output in domestic currency.

Similarly, we can calculate the relative volume of intermediate inputs and value added:

$$Q\_II_c = II_c / PPP\_II_c, \text{ and}$$

$$Q\_VA_c = VA_c / PPP\_VA_c,$$

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Where II denotes intermediate inputs and VA denotes value added.

The relative volume measure of labour input in the benchmark year in country c is derived from deflating the nominal value of labour input (which is labour compensation in domestic currency) by the relative price or PPPs of labour input in a country c.

$$Q\_L_c = LAB_c / PPP\_L_c,$$

Where LAB denotes labour compensation in domestic currency.

Similarly, the relative volume measure of capital input in the benchmark year in country c is derived from deflating the nominal value of capital input (which is capital compensation estimated using exogenous rate of return specification of user cost estimation) in domestic currency by the relative price or PPPs of capital input in a country c.

$$Q\_K_c = CAPE_c / PPP\_K_c,$$

Where CAPE is the nominal capital compensation based on the exogenous rate of return estimation of user cost formula. It is equal to capital stock times the user cost of capital, which is equal to $p_{kc}^K = p_{kc}^I(\delta_k + \gamma)$, where γ is exogenous rate of return in real terms.

It should be noted that the capital income estimated using the exogenous rate of return might differ from the capital income in the KLEMS database that reflects ex post capital income and is calculated residually as the difference between nominal value added and labour compensation. The difference may reflect the unmeasured inputs such as intangibles and natural inputs and excess profits (Schreyer 2004).

The relative TFP levels can be based on gross output or value added. The relative TFP level based on gross output involves the comparison of gross output and capital, labour and intermediate inputs and is calculated as follows:

$$\ln MFP\_GO_c = (\ln Q\_GO_c - \ln Q\_GO) - 0.5(shgoK\_c + shgoK)(\ln Q\_K_c - \ln Q\_K)$$
$$- 0.5(shgoL\_c + shgoL)(\ln Q\_L_c - \ln Q\_L) - 0.5(shgoII\_c + shgoII)(\ln Q\_II_c - \ln Q\_II)$$

The variables $shgoK_c, shgoL_c, shgoII_c$ are the share of capital income, labour income and in intermediate inputs in nominal gross output in country c. $shgoK$, $shgoL$, $shgoII$ are average share of capital, labour and intermediate inputs in gross output in all countries.

The variables $\ln Q\_GO, \ln Q\_K, \ln Q\_L, \ln Q\_II$ are the geometric averages of the volumes of gross output, capital input, labour input and intermediate inputs in all countries.

The relative TFP level based on value added involves comparison of value added and capita and labour inputs are calculated as follows:

$$\ln MFP\_VA_c = (\ln Q\_VA_c - \ln Q\_VA) - 0.5(shvaK\_c + shvaK)(\ln Q\_K_c - \ln Q\_K)$$
$$- 0.5(shvaL\_c + shvaL)(\ln Q\_L_c - \ln Q\_L)$$

The variables $shvaK, shvaL$ are the share of capital income and labour income in value added.

The relative TFP level involve comparison of output with all inputs. However, the most commonly used productivity measure is the partial productivity measure such as labour productivity for international comparison. This is generally defined as an output measure divided by hours worked. The labour productivity level based on gross output is estimated by dividing the relative volume of gross output by hours worked. The labour productivity level based on value added can be estimated by dividing value added by hours worked.

$LPGO_c = Q\_GO_c / H_c$, and

$LPVA_c = Q\_VA_c / H_c$,

LPGO is labour productivity based on gross output, LPVA is labour productivity based on value added and H is hours worked

Finally, the relative levels of labour productivity are related to the relative levels of TFP and relative levels of capital and labour compensation according to the level accounting equation:

$$(\ln LP\_VA_c - \ln LP\_VA) = 0.5(shvaK\_c + shvaK)(\ln KPH_c - \ln KPH)$$
$$+0.5(shvaL\_c + shvaL)(\ln LPH_s - \ln LPH) + (\ln MFP\_VA_c - \ln MFP\_VA)$$

Where KPH is capital service per hour worked and LPH is labour input per hour worked. According to the level accounting, relative levels of labour productivity can be decomposed into

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the difference in capital intensity, difference in labour composition and relative MFP level differences.

Similarly, we can relate labour productivity level based on gross output to MFP level based on gross output and the difference in intermediate input per hour worked, capital input per hour worked and labour composition.

As a final step for preparing the KLEMS productivity level database for all years, the estimates of output, inputs and productivity levels in the benchmark year are to be extrapolated to all other years using the gross rates of output, inputs and productivity over time.

4. Data Sources

For this version of LAKLEMS productivity level database, the year 2011 is chosen as benchmark year for calculating PPPs and relative levels of PPPs and productivity. The choice of the reference year is based on the availability of the relative price data for the LA economies. The data on the relative prices used to estimate PPPs for output and intermediate inputs are obtained from the International Comparison Program (ICP). The ICP is a worldwide statistical initiative that estimates purchasing power parities (PPPs) to compare real GDP and its expenditures components (consumption and investment) across participation economies. The ICP program for reference year 2011 covers 199 economies that includes 8 LA economies covered in the LAKLEMS database on PPPs.

The two main data sources used for estimating the PPPs of gross output, value added and intermediate inputs are the supply use tables (SUTs) and PPPs at the basic headings from the ICP.

The PPPs are available at the basic heading level (155 products) for year 2011 from the ICP. The PPPs are expressed in domestic currency per unit of US dollar.

The supply use tables (SUTs) for Chile, Colombia, Mexico and Costa Rica are from OECD data base on SUTs. The SUTs provide data for 72 products and for 72 industries for Chile and Mexico. For Colombia, the level of industry aggregation is more aggregated, but the level of product aggregation is at 72-product level.

The supply use tables for Dominica Republic, El Salvador, Honduras, and Peru are obtained from LAKLEMS. For those countries, the tables are rectangular and the number of products are more than number of industry in the SUTs. To convert those tables to square tables as in the OECD database, the market share assumption is used. For Honduras, the number of products are small and therefore they are directly mapped to OECD LAKLEMS products.

In sum, the SUTs are available at 72 product and 72 industry levels are most countries (Table 1). To estimate PPP for gross output, intermediate inputs, and value added at the industry level, we work with those 72 product level. For that purpose, the 72 products in the SUTs are mapped to the 155 basic headings in the ICP data to obtain PPPs for those products. While most products in the SUTs are mapped to ICP basic headings, there are 14 products in the SUTs are not mapped to ICP data (Table 4). Those products are primarily used as intermediate inputs. That is because the ICP only provides information on the relative prices of products that are used as final consumption as the purpose of ICP program is to measure real GDP from the expenditure or final demand side and it does not provide data on the relative prices of products that are used for intermediate inputs. Those products not matched to ICP basic headings include forestry, mining products, metals products, chemicals and etc. For most of those products that are traded on international markets, we used exchange rates as proxy for those PPPs. For other products, we use GDP deflator as a proxy.

Another complication arises when the multiple products at the basic heading level is mapped to one product used for estimating industry PPPs. For example, the products at the basic headings such as rice, Fresh or chilled vegetables, Fresh or chilled potatoes Frozen are mapped to the products of agriculture, hunting and related services used at the SUT product level. The aggregation of the product headings to the SUT products are based on the expenditure data at the national level that is available from ICP. Ideally, the aggregation should be based on the production and intermediate inputs data for the estimation of PPPs for output and intermediate input. But such data are not available

In the KLEMS database, gross output is valued at basic price and intermediate input is valued at purchaser price. The relative prices in ICP reflects the market price or purchaser price. To calculate PPPs for gross output, the PPPs from ICP needs to be converted to basic prices by peeling off the tax and transport margins as in Jorgenson, Kuroda, and Nishimizu (1987),

Inklaar and Timmer (2008) and Baldwin, Gu and Yan (2008). To calculate PPPs for intermediate inputs, the ICP PPPs can be used as the valuation is the same between ICP and the KLEMS productivity database (purchaser price). Those margins rates and tax rates are available from the SUTs.

The data used for estimating the PPPs of labour input consist of the hourly compensation and hours worked by types of workers, which are available from the LAKLEMS growth accounts. The data used for estimating the PPPs of capital input consists of capital stock by assets types, which are available from the LAKLEMS growth accounts and relative price of investment assets that are available from the ICP.

5. Content and Coverage of LAKLEMS productivity level database

The LAKLEMS productivity level database presents data on the PPPs (or relative price levels) of output and capital, labour and intermediate inputs at the industry level for eight LA economies for the reference year 2011. It also provides data on the relative levels of output and inputs and labour and total factor productivity for the total economy and 9 major industry sectors over the period 1990 to 2016. The nine industry sectors are the level of the industry aggregation at which LAKLEMS database is constructed (Hofman et al. 2016).

Economies covered

- Eight LA economies: Chile, Colombia, Costa Rica, El Salvador, Honduras, Mexico, Peru and the Dominican Republic

Sectors covered: total economy and 9 sectors of the total economy

- Total economy TOT
- Agriculture, hunting, forestry, and fishing AtB
- Mining and quarrying C
- Total manufacturing D
- Electricity, gas, and water supply E
- Construction F
- Wholesale, retail trade, and hotels and restaurants GtH
- Transport and storage and communication I

- Finance, insurance, real estate, and business services JtK
- Community social and personal services LtQ

Relative prices (PPPs) of output and inputs for 2011

- PPP_GO   PPP for gross output
- PPP_II   PPP for intermediate inputs
- PPP_VA   PPP for value added (double deflated)
- PPP_L   PPP for labour
- PPP_K   PPP for capital

Nominal value all in local currency, 000s, unless specified otherwise

- GO   Gross output at current basic prices
- II   Sectoral intermediate inputs at current purchase prices
- VA   Gross value added at current basic prices
- LAB   Labour compensation
- CAP   Capital compensation
- HOURS Total hours worked in thousands

Volume index, levels in US dollars, in 000s, unless specified otherwise

- Q_GO gross output
- Q_II,   intermediate inputs
- Q_VA value added
- LP_VA   Gross value added per hour worked, US dollar per hour worked
- LP_GO   Gross output per hour worked, US dollar per hour worked
- MFP_VA   Total factor productivity (value added based), relative to average = 1
- MFP_GO   Total factor productivity (Gross output based), relative to average =1
- LAB_QPH   Labour input per hour worked, US dollar per hour worked
- CAP_QPH   Capital input per hour worked, US dollar per hour worked

6. Main results

In this section, we present some main results of the PPP database.

Table 5

PPPs of gross output, intermediate inputs and value added, 2011, US dollar= 1

	Chile	Colombia	Costa Rica	Dominican Republic	El Salvador	Honduras	Mexico	Peru
Gross output								
Tot	350.98	1174.92	342.63	20.46	0.52	10.74	7.67	1.58
AtB	445.78	1352.54	548.44	21.54	0.79	13.06	7.67	1.71
C	413.46	1322.41	371.14	31.67	0.58	12.28	7.67	1.96
D	347.25	1240.30	371.81	26.13	0.63	12.96	7.67	1.82
E	345.98	904.88	181.68	19.14	0.35	12.13	7.67	1.26
F	284.59	992.28	270.61	16.86	0.44	8.00	7.67	1.33
GtH	346.91	1166.28	329.05	18.00	0.56	11.19	7.67	1.62
I	293.88	1166.41	216.78	15.48	0.26	7.43	7.67	1.26
JtK	300.02	821.70	217.61	14.74	0.38	6.34	7.67	1.05
LtQ	470.61	1694.89	730.52	23.03	0.69	15.04	7.67	2.16
Intermediate inputs								
Tot	337.71	1098.37	299.87	19.68	0.52	9.68	7.67	1.48
AtB	350.79	1158.00	341.35	21.75	0.58	10.77	7.67	1.55
C	300.43	1095.13	260.83	18.40	0.48	8.96	7.67	1.39
D	366.85	1110.95	339.51	21.58	0.58	10.88	7.67	1.58
E	384.74	1018.16	284.49	19.88	0.54	10.78	7.67	1.52
F	307.98	1068.60	304.05	19.77	0.50	7.55	7.67	1.52
GtH	302.98	1040.01	265.92	17.12	0.45	8.39	7.67	1.33
I	308.61	1122.60	254.41	18.37	0.46	9.15	7.67	1.48
JtK	303.48	965.04	224.03	14.98	0.43	7.50	7.67	1.15
LtQ	312.26	1039.46	263.79	17.56	0.47	8.73	7.67	1.33
Value added								
Tot	361.76	1237.14	379.44	20.83	0.51	11.82	7.67	1.64
AtB	557.89	1543.80	881.02	21.92	1.03	15.40	7.67	1.87
C	465.43	1400.51	431.43	48.82	0.62	13.88	7.67	2.23
D	328.68	1584.54	456.15	36.82	0.75	19.97	7.67	2.47
E	317.90	804.96	115.45	17.46	0.23	19.35	7.67	1.04
F	265.19	934.52	239.60	10.20	0.39	8.59	7.67	1.17
GtH	367.86	1214.59	369.32	17.32	0.63	13.01	7.67	1.79
I	287.36	1243.88	189.36	13.06	0.15	6.14	7.67	1.09
JtK	299.74	782.40	216.77	14.72	0.37	6.03	7.67	1.03
LtQ	532.71	1969.60	977.91	24.96	0.78	17.64	7.67	2.50
Addendum								
Exchange rate, 2011	483.67	1848.14	505.66	38.11	1.00	18.90	12.42	2.75
GDP PPP, 2011, ICP	348.02	1161.91	346.74	19.45	0.50	9.91	7.67	1.52

Source: Authors' calculation.

Table 5 presents the PPPs of gross output, intermediate inputs and value added for year 2011. For the total economy, PPPs for value added are similar to the ones from the ICP that reflects the PPPs from the final demand side of GDP. This is re-assuring as our estimates of PPPs are estimated from the production side, using double deflation.

There are inter-industry differences in the PPPs of gross output, intermediate inputs and value added across industries due to the difference in industry output and intermediate inputs. This suggests that it is important to estimate PPPs at the industry side if we want to have accurate estimates of industry productivity levels.

Table 6 presents the PPPs of labour input and capital input for 2011.

Table 6

PPPs of capital and labour inputs, 2011, US dollar = 1

	Chile	Colombia	Costa Rica	Dominican Republic	El Salvador	Honduras	Mexico	Peru
Capital input								
Tot	357.14	1214.85	329.90	21.21	0.54	10.31	7.67	1.64
AtB	342.46	1268.49	362.91	24.18	0.56	11.09	7.67	1.83
C	433.37	1342.37	350.98	22.72	0.56	10.64	7.67	1.74
D	341.54	1347.89	372.50	25.34	0.62	11.73	7.67	1.88
E	418.70	1296.92	325.84	21.97	0.57	10.36	7.67	1.65
F	318.95	1393.41	410.15	25.41	0.64	12.04	7.67	1.97
GtH	406.80	1437.00	353.39	22.66	0.59	11.90	7.67	1.85
I	377.38	1423.77	422.48	24.46	0.66	13.19	7.67	2.02
JtK	271.51	1009.30	283.06	17.98	0.47	8.52	7.67	1.40
LtQ	456.66	1304.95	315.98	21.55	0.54	10.32	7.67	1.56
Labour input								
Tot	136.15	581.89	208.05	11.55	0.30	5.87	7.67	0.84
AtB	725.66	1199.69	534.95	15.87	0.54	17.05	7.67	2.07
C	82.77	673.37	116.32	37.78	0.70	3.52	7.67	2.08
D	157.79	757.09	249.47	18.91	0.44	8.54	7.67	1.10
E	47.03	465.06	194.22	13.50	0.29	10.01	7.67	0.91
F	147.32	831.66	248.57	26.49	0.30	5.97	7.67	1.47
GtH	302.55	903.43	343.11	20.51	0.35	8.76	7.67	1.31
I	120.06	520.56	208.24	6.67	0.35	8.63	7.67	0.95
JtK	61.98	735.48	190.06	14.37	0.41	9.86	7.67	1.27
LtQ	190.70	390.56	138.43	6.06	0.23	2.34	7.67	0.45

Source: Authors' calculation.

The PPPs of capital input mainly reflect the PPPs of investment, while the PPPs of labour input mainly reflects the difference in hourly compensation between industries. The differences between the PPPS of capital and labour input and investment price and hourly compensation are due to the difference in asset mix and skill mix between the countries.

Table 7 presents labour productivity level in 2016 that is measured in US dollar per hour worked. Mexico and Chile have the highest labour productivity levels, while Honduras and El Salvador have the lowest labour productivity levels.

Table 7

Labour productivity in 2016, US dollar per hour worked

	Chile	Colombia	Costa Rica	Dominican Republic	El Salvador	Honduras	Mexico	Peru
Gross output per hour worked								
Tot	51.98	26.97	28.18	22.88	12.15	13.36	44.98	18.16
AtB	27.62	8.67	9.23	8.68	3.40	5.00	17.06	4.31
C	145.40	200.12	101.57	269.60	42.34	9.81	174.01	121.66
D	81.32	48.45	52.55	36.18	17.55	26.00	83.14	32.50
E	187.51	194.38	67.89	107.09	125.35	113.02	133.73	111.55
F	61.01	49.41	41.34	53.64	15.86	9.22	28.65	23.68
GtH	28.76	11.57	15.79	17.23	5.19	7.05	29.36	8.68
I	72.93	23.72	54.19	39.72	47.49	22.27	46.76	29.32
JtK	146.70	62.62	79.54	63.16	43.32	37.71	116.39	61.65
LtQ	18.27	16.39	9.61	8.45	6.70	8.19	22.64	9.20
Value added per hour worked								
Tot	28.53	13.57	13.99	13.25	6.82	5.65	25.78	9.21
AtB	10.78	4.90	2.88	5.54	1.48	2.54	11.02	2.76
C	80.38	147.81	46.66	120.96	25.22	4.45	145.03	75.46
D	29.94	12.25	14.39	10.06	5.04	3.40	22.49	7.21
E	88.85	90.98	60.35	42.71	117.13	14.76	71.33	74.51
F	31.70	19.69	15.36	44.25	9.07	3.75	16.69	12.39
GtH	15.62	6.00	7.84	11.31	2.67	3.76	22.71	4.70
I	37.21	11.12	32.12	33.04	42.38	12.00	29.74	14.58
JtK	107.61	48.95	58.77	47.89	32.72	26.84	95.13	42.49
LtQ	11.83	8.19	5.35	5.59	4.48	5.24	16.64	4.98

Source: Authors' calculation.

Table 8 presents relative TFP level in 2016 that is measured against an average economy constructed as the geometric average of the eight LA economies.

Table 8

Relative TFP in 2016, geometric average = 1

	Chile	Colombia	Costa Rica	Dominican Republic	El Salvador	Honduras	Mexico	Peru
MFP based on gross output								
Tot	1.09	0.89	0.98	1.01	0.95	0.87	1.26	1.00
AtB	1.24	1.07	0.88	1.43	0.57	0.98	0.94	1.14
C	0.74	1.20	1.45	1.00	1.01	0.48	1.23	1.29
D	1.24	1.00	0.96	0.92	0.92	0.84	1.13	1.04
E	0.93	0.88	1.09	0.95	1.97	0.47	0.98	1.30
F	0.87	1.24	0.92	1.38	0.91	0.64	1.15	1.11
GtH	1.36	0.83	1.11	0.97	0.67	0.98	1.22	1.02
I	0.78	0.57	1.21	1.02	1.76	0.84	1.11	1.11
JtK	1.44	1.01	1.03	0.79	0.91	1.36	0.77	0.89
LtQ	1.24	0.75	0.60	1.01	0.99	0.95	2.30	0.82
MFP based on value added								
Tot	1.17	0.81	0.98	1.03	0.91	0.75	1.52	1.01
AtB	1.39	1.14	0.72	1.85	0.38	0.98	0.97	1.29
C	0.67	1.27	2.07	0.85	1.11	0.30	1.23	1.67
D	1.85	1.01	0.92	0.86	0.80	0.51	1.50	1.12
E	0.92	0.83	1.44	0.98	4.05	0.12	1.05	1.85
F	0.73	1.55	0.77	2.61	0.80	0.36	1.27	1.21
GtH	1.65	0.72	1.18	0.99	0.51	0.96	1.42	1.03
I	0.63	0.35	1.25	1.09	3.25	0.70	1.18	1.23
JtK	1.63	0.98	1.14	0.72	0.87	1.50	0.70	0.83
LtQ	1.34	0.65	0.53	1.02	1.00	0.95	3.04	0.74

Source: Authors' calculation.

The TFP levels for Mexico and Chile are above average. The TFP levels for Costa Rica, Dominican Republic and Peru are about the average, while the TFP level of other countries are below the average.

Table 9

Relative capital input and labour input per hour worked in 2016, geometric average = 1

	Chile	Colombia	Mexico	Peru	Costa Rica	Dominican Republic	El Salvador	Honduras
Capital input per hour worked								
Tot	1.44	1.13	2.37	0.61	1.13	1.03	0.55	0.66
AtB	3.17	0.76	4.72	0.35	0.88	0.32	1.25	0.71
C	1.73	2.38	3.17	0.91	0.30	3.73	0.30	0.25
D	1.10	1.05	1.98	0.50	1.78	1.32	0.63	0.61
E	1.09	2.21	1.27	0.60	0.64	0.69	0.43	2.86
F	1.94	0.60	0.88	0.60	1.53	1.30	1.00	0.82
GtH	1.19	0.80	4.74	0.49	1.26	1.87	0.51	0.37
I	2.29	1.18	1.40	0.40	1.02	0.90	0.66	1.11
JtK	0.50	0.76	4.19	1.30	0.83	1.63	0.95	0.38
LtQ	1.04	1.78	2.43	1.13	1.02	0.37	0.37	1.40
Labour input per hour worked								
Tot	2.98	0.46	0.91	0.95	1.37	1.22	0.74	0.68
AtB	1.03	0.43	1.46	0.87	1.32	2.00	0.92	0.73
C	5.13	0.66	0.75	0.90	1.42	1.10	0.68	0.41
D	3.06	0.42	1.01	0.95	1.46	1.02	0.69	0.79
E	5.85	0.31	0.88	1.06	0.96	0.96	0.78	0.82
F	4.58	0.37	0.98	0.86	1.42	1.12	0.64	0.68
GtH	1.74	0.40	1.16	0.87	1.00	1.89	1.01	0.76
I	3.26	0.47	0.95	0.73	1.37	2.25	0.52	0.58
JtK	9.96	0.49	0.79	0.75	1.62	1.02	0.55	0.38
LtQ	1.52	0.54	0.85	1.10	1.77	1.04	0.79	0.90

Source: Authors' calculation.

7. Conclusions

In this technical documentation, we have presented the methodology and data sources for estimating the purchasing power parities (PPPs) of inputs and output at the industry level in Latin America. We have also presented the methodology for estimating relative levels of output and inputs and labour and total factor productivity that makes use of the estimated PPPs. The estimates of relative labour and total factor productivity levels in Latin America are presented in

this article. Those estimates should be viewed preliminary and are presented to solicit comments and feedbacks so that the improvement can be made in the future revision to those estimates.

Our work has also highlighted many data challenges for constructing the KLEMS productivity level database.

The PPPs of output and inputs are sensitive to the level of dis-aggregation for output and inputs. Ideally, the increase in the product details will improve accuracy of the estimates of PPPs and relative productivity levels.

The ICP provides data on PPPs for products that are used for final expenditures. No data are available for products that are used for intermediate inputs. Progress needs to be made to collect PPPs for intermediate products to improve the accuracy of relative productivity levels. A recent attempt that combine ICP data and unit costs from the production survey from the national statistical agencies to estimate PPPs for productivity level comparison is Inklaar and Timmer (2016).

The PPPs for investment goods need to be expanded to include more investment goods such as information and communication products. The other challenge is related to PPPs of services such as health and education and no-market services. The improved estimates of PPPs for those service products are needed to have accurate estimates of productivity levels for those service industries.

The comparability of output and inputs needs to be carefully examined for constructing KLEMS productivity level database. We will need to carefully examine the concept, survey and estimation methods used to estimate those variables. We hope that our estimates will serve as starting point for those improvement.

We would like to mention potential future improvement and revision to the database.

The benchmark year chosen for this version of the database is 2011. The PPPs may be sensitive to the benchmark year as the product and input mix change over time. The accuracy of the productivity estimates for more recent years require the updating of the benchmark year.

The usefulness of the database will improve as the number of countries (especially major trading partners and productivity frontiers such as the United States) are expanded.

References

Baldwin, J. B., W. Gu and B. Yan. 2008. "Relative Multifactor Productivity Levels in Canada and the United States: A Sectoral Analysis," *Canadian Productivity Review*, Statistics Canada.

Caves, D. W., L. R. Christensen, and W. E. Diewert. 1982. "Multilateral Comparisons of Output, Input and Productivity Using Superlative Index Numbers." Economic Journal 92: 73–86.

Hofman, Andre, Matilde Mas, Claudio Aravena, and Juan Fernandez de Guevara. 2016. "LAKLEMS: Economic Growth and Productivity in Latin America," in *The World Economy, Growth or Stagnation*, edited by D.W. Jorgenson, K Fukao and M.P. Timmer, Cambridge University Press.

Inklaar, R., and M. P. Timmer. 2008. "GGDC Productivity Level Database: International Comparisons of Output, Inputs and Productivity at the Industry Level." GGDC Research Memorandum GD-104, Groningen Growth and Development Centre, University of Groningen.

Inklaar, R., and M. P. Timmer. 2013. "Using Expenditure PPPs for Sectoral Output and Productivity Comparisons in Measuring the Real Size of the World Economy: The Framework, Methodology, and Results of the International Comparison Program—ICP. Washington, DC: World Bank.

Jorgenson, D.W., M. Kuroda, M. and M. Nishimizu. 1987. "Japan-U.S. industry-level productivity comparisons, 1960-1979," *Journal of the Japanese and International Economies*, 1, pp. 1- 30.

Jorgenson, D. W., and M. Nishimizu. 1978. "U.S. and Japanese economic growth, 1952-1974: An international comparison," *Economic Journal*, 88, no. 352 (December): 707-26.

Schreyer, P. (2004), 'Measuring multi-factor productivity when rates of return are exogenous," OECD.

Schreyer, P. (2007), International comparisons of levels of capital input and productivity, German Economic Review, 8, pp. 237–254.

World Bank (2015). Purchasing Power Parities and the Real Size of World Economies: A

Comprehensive Report of the 2011 International Comparison Program. Washington, DC:

World Bank.

Annexes

Table A1. The list of products used for PPP calculation

Sequential number	Products
1	Products of agriculture, hunting and related services
2	Products of forestry, logging and related services
3	Fish & other fishing products, aquaculture prod., support serv. to fishing
4	Coal and lignite
5	Crude petroleum and natural gas
6	Metal ores
7	Other mining and quarrying products
8	Mining support services
9	Food, beverages and tobacco products
10	Textiles, wearing apparel, leather and related products
11	Wood & prod. of wood & cork, exc. furniture, of straw & plaiting materials
12	Paper and paper products
13	Printing and recording services
14	Coke and refined petroleum products
15	Chemicals and chemical products
16	Basic pharmaceutical products and pharmaceutical preparations
17	Rubber and plastic products
18	Other non-metallic mineral products
19	Basic metals
20	Fabricated metal products, except machinery and equipment
21	Computer, electronic and optical products
22	Electrical equipment
23	Machinery and equipment n.e.c.
24	Motor vehicles, trailers and semi-trailers
25	Other transport equipment
26	Furniture and other manufactured goods
27	Repair and installation services of machinery and equipment
28	Electricity, gas, steam and air conditioning
29	Natural water, water treatment and supply services
30	Sewerage services, sewage sludge, waste collection & management serv.
31	Buildings and building construction works
32	Constructions and construction works for civil engineering
33	Specialised construction works
34	Wholesale and retail trade and repair serv. of motor vehicles & motorcycles
35	Wholesale trade services, except of motor vehicles and motorcycles
36	Retail trade services, except of motor vehicles and motorcycles
37	Land transport services and transport services via pipelines
38	Water transport services

39	Air transport services
40	Warehousing and support services for transportation
41	Postal and courier services
42	Accommodation services
43	Food and beverage serving services
44	Publishing services
45	Audiovisual and broadcasting services
46	Telecommunications services
47	Computer programming, consultancy and related serv., Information serv.
48	Financial services, except insurance and pension funding
49	Insurance, reinsurance & pension funding services, exc. compulsory S.S.
50	Services auxiliary to financial services and insurance services
51	Imputed rents of owner-occupied dwellings
52	Real estate services excluding imputed rents
53	Legal, accounting, head offices services, management consultancy serv.
54	Architectural and engineering services, tech. testing & analysis services
55	Scientific research and development services
56	Advertising and market research services
57	Other professional, scientific and tech. services and veterinary services
58	Rental and leasing services
59	Employment services
60	Travel agency, tour operator & other reservation services & related serv.
61	Security & investigation serv., serv. to buildings & other business support
62	Public administration and defence services, compulsory S.S. services
63	Education services
64	Human health services
65	Residential care services, social work services without accommodation
66	Creative, arts, entertainment, library, museum, other cult. serv., gambling serv.
67	Sporting services and amusement and recreation services
68	Services furnished by membership organisations
69	Repair services of computers and personal and household goods
70	Other personal services
71	Services of households as employers of domestic personnel
72	Undifferentiated goods and services produced by private HH for own use

Table A2. Worker Types in LAKLEMS

Characteristics	Categories
Gender	Female, Male
Age	Aged 15–29, Aged 30–49, Aged 50 and over
Education	Low skilled, Medium skilled, High Skilled

Table A3. Asset types in LAKLEMS

Broad asset categories	Asset type
Total construction	Residential structures
	Total non-residential investment
Non-information and communication equipment (ICT) M&E	Transport equipment
	Machinery and equipment
	Other products
ICT	Computing equipment
	Communications equipment
	Software

Table A4. The list of products that have no information on PPPs from ICP

Products of forestry, logging and related services
Metal ores
Other mining and quarrying products
Mining support services
Paper and paper products
Printing and recording services
Coke and refined petroleum products
Chemicals and chemical products
Rubber and plastic products
Basic metals
Wholesale and retail trade and repair serv. of motor vehicles & motorcycles
Wholesale trade services, except of motor vehicles and motorcycles
Retail trade services, except of motor vehicles and motorcycles
Undifferentiated goods and services produced by private HH for own use