WHAT WE TALK ABOUT WHEN WE TALK OF *PRODUCTIVITY*?

Warning to non-experts on frequent misleading uses of productivity measures

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'Productivity', a key issue in the political arena

The common understanding for 'Productivity' is quite straightforward: Its value increases if a company either produce more of some goods or services with the same resources (personnel and the rest of productive factors), or produce the same quantities of good and services with less of some of the resources. Or a given mix of both types of moves, including trade-offs between favourable and unfavourable moves. In the above quite intuitive formulation –which, broadly coincides with experts'- you may substitute 'a company' by 'any organisation producing goods or delivering services', or by an 'industry' or economic sector, or by the entire country (the whole of its sectors).

Newspapers and media in general talk frequently on productivity. For example, in terms of ".. *the problem of our economy is that productivity is comparatively low/is-lagging-behind* (and here the figure for a productivity index referred to the country)". Or *"…There is a need for serious reforms be undertaken addressed to increase productivity, in order our economy become more competitive and so …*"; or *"..industry's Unions and Employers Association representatives agreed finally on an increase on salaries for this year equal to the last year increase in productivity less half a point. The agreement comes subject to ..*".

In any case, data on productivity levels –at sector or country level- have last years become one familiar component in the media news and in socio-political debate. Do those data on productivity (usually referred to *labour* productivity) talk us actually of productivity in the sense stated at the beginning, which is the implicit meaning media and experts transmit about? Surprisingly the answer is: not actually. That in spite of the fact that those data are presented as out-of-discussion, since the acknowledged source for them are some official statistics institution, national or international, as Eurostat –for the EU countries-, OECD, BLS (US), .. etc. .

By way of example: According to Eurostat, the EU's country with the highest *labour productivity* level in 2013 was Luxembourg: 163,9; and the following one in the ranking was Ireland (135,5). Quite below appear Germany (107), France (116) and Spain (111), for

example[1]. One certainly gets surprised by reading that Luxembourg workers are about 64% more efficient that German workers. Where are those Luxembourg's set of factories or services companies whose employees work with a so much productivity (that is, producing so much more goods o delivering so much more services per-person) that their German counterparts? Direct observations show that obviously this is not the case. The above *productivity* differences, 163,9 vs. 107 are against all evidence [2]. Or the above indexes do not refer actually to the common-knowledge concept of productivity stated at the beginning – in spite they being so used in the media and the political arena.

Then, what do actually mean those 'productivity indexes' for such and such country? How are they in fact calculated by the specialised agencies (first the nationals ones, then the Eurostat, OECD, etc.)?

The present notes, written for non-professionals, try to answer such questions. They start by presenting a summary on the way economists and statisticians calculate the more frequently used productivity measures, at enterprises level -namely, *Total productivity* and *Labour productivity*- which are the conceptual basis. And then, attention is driven to how their adaptations to sector ('industry') and whole-country level are calculated by statistics agencies. This allows finally to discuss and make clear the real meaning of these indexes, and so to prevent against the frequently misleading use and interpretation of productivity statistical data in the media and the socio-political arena which lead to distorted conclusions regarding the real world.

How productivity indexes are calculated

Let us start by underlining the dominant idea regarding the topic: that productivity is something directly connected to the economic growth of the country -usually measured by the increase in the Gross Domestic Product (GDP) per-capita. That idea would go like that: the increase in GDP-pc depends mainly on the overall economy's productivity increase; that in turn results from each economic sector's productivity increase; and for each sector the increase depends on its companies' productivity increase.

According to that, the starting step would be how productivity is defined and measured at firms' level. And then how the aggregation process to sector and country levels is done. So, let us start by how productivity is measured at enterprise level.

[Though you might want to skip the following point on *Total factor productivity*, going right away to the next one, *Labour productivity*; your getting the essential of the latter will not come substantially affected].

The basis: Overall productivity index at companies' level (TFP),

The usual productivity measures for a company, in experts works, are the *Total Factor Productivity* (TFP) index, and the (partial) *Labour Productivity* index. The former stands however for the 'proper' productivity measure. It is the most used in experts studies and academic papers.

[1] Eurostat data for ten and five years before show similar values and differences.

[2] The above Eurostat figures represent: Making the mean of labour productivity indexes for the whole EU-countries equal to 100, which is the corresponding figure for each of them. Thus, in 2013 Luxembourg's productivity level would be 63,9 % above EU's mean, France's would be 16% above, Germany 7% above, etc.

Its basic definition is in fact the one in the paragraph at the beginning; though made it operative through a given, not-simple, formula, because the reality to measure is in fact complex. To start with, the usual in the business world is that a firm produce not just one but a lot of different 'products'; and use more than just one 'factor' –that even in the rare cases of enterprises producing just only one product (as an only-milk farm, for example). And it is also quite usual that from period to period the units of its different 'products' show changes of different sign (increases and decreases), simultaneously to changes of different sign in the units of the 'factors' contracted or used. All that makes that to get a single figure for the concept of 'productivity of company C in year Y' is not any simple.

Broadly speaking, the standard TFP formula for a given period comes to be a quotient in which the numerator is a weighted sum of the units of the different goods or/and services produced (invoiced) by the firm, and the denominator a weighted sum of the units of work and of the other factors contracted or consumed. Those weights being usually the respective products' and factors' prices in a given, past, reference period. Those prices are then taken as parameters (kept as constants) for calculating the TFP indexes for different, subsequent periods. (You may see a proper description of that standard formula in Annex 1).

In any case, the calculation outcome consists in a serie of TFP figures, for each of the periods under calculation; by way of example: $TFP^{year\ 2012}$=1,34; $TFP^{year\ 2013}$=1,42; $TFP^{year\ 2014}$= 1,38. Though the figures we will more likely find in the reports are not those *absolute* values properly said but its respective rates of change from period to period,

rate of change in 2013 = $(TFP^{year\ 2013} - TFP^{year\ 2012}) / TFP^{year\ 2012})$ → (1,42–1,34)/1,34= 0,06; (+ 6%)
≡ $(TFP^{year\ 2013} / TFP^{year\ 2012}) - 1$ → (1,42/1,34)-1 = 0,06
rate of change in 2014 = $(TFP^{year\ 2014} / TFP^{year\ 2013}) - 1$ → (1,38/1,42)-1= -0,028; (-2,8%)

albeit calculated in an alternative, more sophisticated, way -which gives however similar values (specially for moderate changes, between 1 to 8%)

rate of change in 2013 = $ln(TFP^{year\ 2014} / TFP^{year\ 2013})$ = +0,058
rate of change in 2014 = $ln(TFP^{year\ 2014} / TFP^{year\ 2013})$ = - 0,028

This 'sophisticated' alternative has the advantage for the experts and practitioners that it can also be calculated as the difference between the rate-of-change-in-the-aggregated-of-'products' (outputs) and the rate-of-change-in-the-aggregated-of-'factors' (inputs). Thus, what we may more frequently find in experts' reports or articles on productivity measures for such and such company is a calculation process consisting in some kind of approach[3] to the above rates of change, for 'the-aggregate-of-outputs' and for 'the-aggregate-of-inputs'. Thus, following the example, such calculation could give for 2014 something like*: Average rate of change in Products (+7,6 %) – Average rate of change in Factors (+10,4%) = Change in Productivity (-2,8%)*.

Are these experts' *TFP measures* applied to such and such company the starting data for, throughout aggregation processes, to calculate the productivity –o its change- for a whole industry or economic sector, and then for the whole country? Not actually; though it can be said that TFP measures lends the inspiring background. In any case, that rather (unavoidable) complex way of calculation is not the starting point for determining the productivity measures

[3] Rarely the expert have available the detailed required data from the firm (the respective units and prices for each different product and factor, for such and such year) as for actually carrying out the 'real' calculation of these two rates.

referring to industries (sectors) and countries we can find in wide audience publications and official statistics [4].

The starting point for sector or country level productivity measures we can read in the press -whose sources use to be publications by institutions as Eurostat or OECD-- is something simpler, based in the *Labour productivity*, mimicking the calculation of it at enterprises level.

To read more about TFP →

The star: Labour Productivity

It is the other usual productivity measure at companies' level. Quite easier of being determined than *TFP*. And more widely used among practitioners and in wide audience publications. It is defined as *the quotient between a company's total output and the volume of its workforce*, and technically labelled as *Labour partial*[5] *productivity*. That rather general concept, has in practice different translations/ interpretations. Among the more usual ones:

[type A] [type B]

$$LP = \frac{Sales^{(*)}}{N.\ of\ \ Employees^{(**)}}\ ,\ \text{or}\ \frac{N.\ of\ \ Units\ \ sold^{(***)}}{N.\ of\ \ Employees^{(**)}}, \ldots; \qquad \frac{Value\ \ Added^{(*)}}{N.\ of\ \ Employees^{(**)}}$$

Which, in turn, we can find applied in different versions:

(*) , either at current or at constant prices;

(**) , either as just *contracted people* or '*N. of full time equivalent'*; also some times: *N. of Total hours worked*

(***), only viable in the scarce cases where the analysed company produce a single output (f.e. Hl. of milk)

As far as ***Value added***, it is calculated –broadly speaking- as the sum of personnel-costs plus company's profits. [6]

These *Labour productivity* measures enjoy a great appeal from people at reading productivity analysis papers or reports: these indexes sound as less 'abstract', more directly understandable that the 'professional' *TFP*. At least at a first glance, though the shortfalls and drawbacks from using those *LP* indexes are well known:

Regarding type 'A' ones, because 1) they imply to assign all the basket of outputs to one of the inputs, work –independently of how the units of the rest of inputs (equipments, subcontracted services, energy, etc.) have changed from period to period; which leads to figures of an uncertain –if not misleading- meaning. And 2) the last-decades-accelerated trend to mechanisation, automation, and outsourcing –which imply that 'work' is progressively substituted by other factors (equipments, energy consumption and outsourcing services)- makes that the numerator tends to increase over time while denominator keeps constant or decreases. As a consequence, this type 'A' measures tend to show a persistent increase across time even if employees efficacy and ability in their job be the same; which makes them not significant as productivity measures.

[4] Among other things, because to calculate the above rates for all the companies of even a single industry would have huge information-costs: To get the number of units for each output and for each input of each company, as well as of their respective prices –provided such companies would be willing to disclose that information. Obviously –and that is much more determining- companies consider that kind of internal data as strategically confidential. And, of course, in a market economy they have not any obligation of delivering them to a statistics agency.

[5] 'Partial' because it relates the whole output with only one of the inputs: Labour.

[6] A more refined definition of Labour productivity at-constant-prices, based on the terminology of TFP, is also becoming popular among experts. See further foot note 10 in annex.

And as far as type-B measures, because the value-added-per-employee will necessarily appear higher for a company operating with high margins –thanks to enjoy some market power- in comparison with another company that face hard competitive pressure and therefore operates with lower margin rates. Even if their respective employees are equally productive and smart. Thus, the former company will get higher profits per-employee and may also pay higher salaries; so, it will show higher value-added-per-employee. Therefore, for comparisons among different companies, a higher *value-added-based LP* index not necessarily means higher productivity properly said.

However, on the side of advantages, it is easy to see that to apply a type B *Labour Productivity formula* to an industry or economic sector, or to the whole economy, is something much more easy, feasible and straightforward that in the case of a *TFP* measures. Let us see the application of LP idea at those upper levels.

(Labour) Productivity measures at sectors and countries' level

Most of the data we may read on productivity at sectors or countries level refers to LP; and, more specifically, to *Labour-Productivity-based-on-value-added* (*LPva*) in its version of:

$$\text{LPva}_{\text{sector '...'}} = \frac{\text{Value added, at-constant-prices}}{\text{(average) N. of Employees, } full-time-equivalent} = \frac{VA}{E};$$

for a given period 'x'; (year, semester, …..)

It is easy to calculate for a given economic sector by taking the usually available national statistics. Thus, in the case of the numerator, raw data on the value added for (all the companies included in) a sector can be drawn from the Value Added Tax (VAT) national system. And as far as denominator, regular employment statistics use to come detailed by sectors.

Then, if this *LP* is calculated for all economic sectors, an average for the whole economy may then be determined. However, this overall *LP* measures at country level may also be (and usually are) calculated directly: By taking national-level statistics for employment, for the denominator. And by determining, for the numerator, the total value added at national level as from the VAT system statistics; which, broadly speaking, is equivalent to the Gross Domestic Product (GDP) [7]. In any case, Labour productivity at country level is usually defined as:

$$\text{LP (va € per person), whole country} = \frac{\text{Gross Domestic Product, at-constant-prices (GDPcp)}}{\text{Total N. of Employees f\_t\_e (annual average)}} \equiv \frac{\text{VA}}{\text{E}}$$

However, Eurostat data-base, for example, does not made properly available the above absolute (in €) data values for the EU countries but just comparative indexes:

[7] More precisely, GDP is defined as the sum of value added over all sectors, but adding taxes and deducting subsidies on final products.

Table 1

Comparative Labour Productivity (value added €, per person), between EU countries:

Country	2007	2013
Average EU (27 countries)	100	100
Some countries' data:		
Luxembourg	179,7	163,9
Ireland	136,2	135,5
France	115,4	116,-
Germany	108,2	107,-
Spain	103,-	111,2
:		
Greece	95,3	92,7
Bulgaria	37,4	43,4
:		

$[\ LP(va\ €)^{Country\ 'X'} / LP(€)^{Average\ for\ EU\ countries}\ ] \times 100$

Source: Data from Erostat's table "Labour productivity per person employed" (ESA95), as published in the Eurostat web as of June 2015.

And these are the data that has been mentioned at the beginning of these notes: Luxembourg appearing surprisingly as the country with the highest (labour) productivity; and Spain having surpassed Germany (!).

What it does is available in absolute (€) values from Eurostat is a variant of the LPva ratio: (**€** ***per hour worked***). Thus, following with the above countries-example:

Table 2

Labour Productivity, value added; € per hour worked *, for some EU countries:

Country	2007	2013
Average EU (27 countries)	31,4 €	32,2 €
Some countries' data:		
Luxembourg	64,9	58,2
Ireland	45,1	48,8
France	44,9	45,6
Germany	42,-	42,8
Spain	28,5	32,1
:		
Greece	21,5	20,2
Bulgaria	4,3	4,9
:		

(*) ***VA/E***; ***VA*** measured as GDPcp; ***E*** measured as 'Total N. of hours worked'

Source: Data taken from Eurostat's table "Real Labour productivity per hour worked (€)", [nama_aux_lp], as published in the Eurostat web data-base as of June 2015.

Again –be at sector or country level-, half of the times the data we will find in economic newspapers or in the original statistical sources –f.e., Eurostat (EU) or OECD publications- will not refer to the above absolute, monetary values (so much € in the year, per person, or per hour worked) but to the corresponding change of those values from period to period. Changes which we may find expressed either in terms of *index* or in terms or *rate*. Thus, in the case of *index* (of change, over time) option, it will have been calculated as (taking, by way of example, year 2005 as initial, reference year):

LP i *= **Labour Productivity** index of change: for Year 2013'* $= \dfrac{(VA/E)^{Year\ 2013}}{(VA/E)^{Year\ 2005}} \times 100$;

[so, f.e. a value of 104,5 would mean that the productivity of the Sector (or of the Country) –measured as Value added at constant prices, per Employee (full time equivalent)- has increased 4,5% since 2005.]. [8]

Thus, following with the example:

Table 3

LP (index), **Labour Productivity** index of change, for some EU countries:

Country	2005	2007	2013*
Average EU (27 countries)	100,-	103,6	106,4
Some countries' data:			
Luxembourg	100,-	103,-	92,3
Ireland	100,-	102,4	110,7
France	100,-	103,-	104,5
Germany	100,-	105,4	107,2
Spain	100,-	102,2	115,-
:			
Greece	100,-	108,7	102,-
Bulgaria	100,-	106,-	121,6
:			

(*) For each country: [VA-€-per-hour-worked Year 2013] / [VA-€-per-hour-worked Year 2005] x 100

Source: Data taken from Eurostat's table "Real Labour productivity per hour worked (for each country, Year 2005 value =100)", [nama_aux_lp], as published in the Eurostat web data-base as of June 2015.

Which tells us the same story than the previous table 2, though in a different way. Thus, f.e., that France would have increased its Labour Productivity from 2007 to 2013 in around 1,5 %, and that Greece would have saw it decreased in around 6,1%.

Having read till here, you might have got the idea that it seems to be some contradictions between the messages the above tables 1 and 2 give to us. For example, that according table 1 Germany's labour productivity would be lower than Spain's, but according table 2 it would be just the opposite. So, you would have every right to ask, which is the good conclusion and why such contradiction?

The short answer is that table 1 refers to *Value Added* (VA) in terms of € per person employed, and table 2 in terms of € per hour worked. And the non-so-short answer (since the

[8] You might also find the same ratio expressed in the equivalent terms of,

$$\textbf{LP } i = \frac{(VA^{Year\ 2013}/VA^{Year\ 2005})}{(E^{Year\ 2013}/E^{Year\ 2005})} \times 100; \equiv \frac{VA\ index}{E\ index} \times 100; \text{ for Year 2013, 2012, ..etc.}$$

(on the right, the more usual way of calculating it by national statistics agencies: As the quotient between the *Value added* ***index***, and the *Employees* ***index)***.

And when the option is the *rate* (percentage) of change, it may come calculated either in the usual way or in the 'sophisticated' one of,

$$LP\ r = \textbf{Labour Productivity}\ \text{rate (\%) of change for period 'x'} = \ln\frac{(VA/E)^{Year\ 2014}}{(VA/E)^{Year\ 2013}}; \times 100$$

Since –as pointed out before- it allows for the useful possibility of expressing the same value also as the difference between the rate of change of the VA and the rate of change of the E:

$$\ln(VA^{Year\ 2014}/VA^{Year\ 2013}) - \ln(E^{Year\ 2014}/E^{Year\ 2013})$$

That is, putting it in a narrative way: *LP r =* ***Labour Productivity*** *rate (%) of change =*

= (% of change in the Value Added, c.p.) – (% of change in Employees, f.t.e.)

former one does not clarify that much) would imply first to ask to Eurostat helpdesk services for additional data on the relationship between their 'hours worked' data and 'person employed' data, as well as more detailed information regarding their respective determinations for value-added data. To tell the truth, I have not done that job when writing these notes; neither I would expect the analyst responsible of the Economy section of a newspaper –even an international one- would do it before writing her/his article about. Let us just keep with the conceptual conclusion: that data on productivity we may read some times in a report or in the media referring apparently to the same label –f.e., *labour productivity*- may have in fact different meanings. And not a minor, piecemeal, difference, but one that may change the conclusions regarding comparative productivity levels among countries, or when comparing across years for a given country.

In summary, and by way of examples: why the above 'official' data make appear Luxembourg –against all evidences- as the EU's country with the highest labour productivity? Is Spain's labour productivity in 2013 higher o lower than Germany's? Is Spain's labour productivity about 20% higher than Greece's (table 1) or about 59% (table 2)?

What those *Labour Productivity* indexes actually tell –and can't tell- to us

In summary, as it can be seen from the above, the usual *labour productivity* index at country level measures in fact some kind of average of the net income (personnel costs, included variable compensation, plus company's profits) per employee the country's companies get in a given period. Put it schematically,

$$LP\ (va) = \frac{\text{Personnel Costs (Salaries \& other compensations; Social Security charges)} + \text{Company profits}}{\text{N. of Employees}}$$

Which is different from the very idea of workers (or companies') productivity -efficacy level, or commercialised units per unit of work-, as it is argued below:

Thus, if a high proportion of the employees of a given company -as, f.e., an investment bank- are rather executive officers (EO), very well paid, then the company's value added per-employee will be notoriously high. Of course, any high executive, including the ones with a total annual compensation (fixed salary plus bonuses) in the range of million/s €, is statistically speaking, an employee.

Consequently, when in a given economic sector most of its companies show the above features, the average value added per-employee calculated for that sector will be quite, quite higher compared to other more common commercial or industrial sectors' in the same country.

Finally, if in a given country, those sectors with a so heavy-weight of very well paid EO have a dominant weight in the country economic activities, then that country will statistically appear as with a value-added-per-employee (i.e., GDP per-employee) quite higher than other countries with a more mixed composition of 'ordinary' industrial, commercial and services sectors.

So, here we have an explanation for the paradox of Luxembourg appearing in the statistics as the EU country with the highest (*labour) productivity*: The dominant Luxembourg economic activity comes from financial and legal services companies, working for companies and investors from abroad. Most of the Luxembourg's economic activity relates to investment banks, specialised financial services, and convenience-sites of foreign companies. The proportion of EO (banking managers, investment agents, specialised consultants, … etc.) in the firms established in the country are dominant. Compensation paid to these EO –big salaries, plus even bigger bonuses- tend to be several times the average compensation of an EU specialised industrial worker. And foreign firms with convenience-site in the

country use to mean -statistically speaking- firms established in the country, declaring important profits but few employees, if anyone.

Therefore, it is not properly true that the productivity of Luxembourg employees be so much high as statistics show. Or, put it in another way, in fact LP statistics do not say to us that Luxembourg employees' productivity be so much higher than their French or German counterparts; though certainly that is how many analyst, experts and wide audience media 'read' and *use* those statistics. What those *labour productivity* statistics figures actually say to us is that, for Luxembourg, the sum of total compensation paid to employees (plus SS charges) plus companies profits (= the total value added), divided by the number of employees, gives (surprisingly, for a close-to-fiscal-paradise country?) a comparatively very high amount of Euros.

In any case, nothing to do with the proper idea of employees' productivity.

More in general, let us consider an economic sector whose companies enjoy comparatively high margins –which means they hold some kind of sale-prices' power. That situation allows companies to get high profits and also to pay high salaries to employees. Therefore, the simple fact of sector's companies holding some prices/market power will make that such sector display a higher value-added-per-employee (='labour productivity' index), even if the average efficacy (actual productivity) of their respective employees is the same than in other sectors that not enjoy so generous rates of margin.

Moving to the upper level: If a country where most of its economic sectors enjoy higher margin rates compared to other countries' –that is, that the former have some kind of international prices/market power-, such country will show a higher *labour productivity* index, in spite of the fact that the efficiency, training, etc. of its work force may be on average the same that in those other countries.

Specifically in the case of Eurostat data, it must be pointed out that the calculation for countries' Labour Productivity do not take for the denominator the 'N. of Employees full-time-equivalent' as standard definition do but just the total number of Employees, be their dedication full or part time [9]; (likely due to lack of homogeneous data on full-time-equivalent for all the 28 EU countries). Therefore, the LP index for an EU country with a comparatively high proportion of part-time employees will appear (in table 1), artificially, something lower. Probably, the contradictions pointed out before regarding the LP figures for Germany, Spain and Greece have to do with these different specific variants of making calculations.

A lower labour productivity *index may mean just that the country's average salaries are comparatively lower regarding other countries*. Let us illustrate that with the following sketch:

> A big German (or French) carmaker have one of its factories in Portugal. There, workers salaries are significantly lower than in Germany (or France) -which probably was a reason for the carmaker opening that factory in Portugal. The workers of such factory work with the same real productivity than their German (or French) counterparts –which is hardly surprising since they are working with the same equipments and technology (robotic chains) and have received the same training for that. However, when calculating the *labour productivity index* for the Portuguese factory we will end with a value lower than for the carmaker's factories at home –just because the Portugal lower salaries.

Thus, the simple fact that average salaries in country A be lower than in country B –all the rest the same (including real employees' productivity)- will make that A appear in the international statistics with a lower *labour productivity index* than B.

[9] Labour productivity per person employed (ESA95);
http://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&language=en&pcode=tec00116&plugin=1

Worsening of labour conditions generates higher LP indexes. The 2007/8-onwards economic crisis has brought substantial reductions in employment –f. e. in Spain, among other EU countries. In parallel, or as a consequence, job conditions have tended to get tougher -especially en terms of *real* working time per week higher than contracted, and companies growing to apply changing job-schedules ('flexibility'). All that due mainly to widespread of shorter-term contracts as well as to a growing employees' uncertainty regarding their current job position be held. As long as this process has been significant for Spain, f. e., we could easily predict that its LP indexes will have improve along 2011-2014, since such worsening of job conditions means that the numerator of the LP index will have decrease less in proportion than the denominator. And, indeed, table 3 above seems to come to confirm such prediction.

In summary: The productivity level –i.e., the degree of efficacy, qualification, training, and know-how of employees, managers included- is one of the elements that improve companies' net income per person (value added; which then comes divided between employees' costs and company profits). Against the common implicit understanding, the usual Labour Productivity indexes do not measure in fact the former but the latter. I. e., they measure a result (effect) not one of its determining elements (con-cause).

However, the mainstream discourse before, f.e., a low figure for the LP index of a given country is that that country should take measures for improving its workers productivity.

To read more about *Productivity measures at countries level* →

ANNEX 1:

Back to main text →

To read more about ..*Productivity indexes' basis*

The basic productivity index: *Total Factor Productivity*, at enterprise level:

These lines are written under the objective they be understandable for non-experts, without having to get into the formulae. What the formulae say are put also in common language within the text. The mathematical expressions are just for the sake of being precise or of avoiding ambiguities (as well as a deference to expert readers)[10].

The TFP formula –for the usual case of a company using different types of personnel, of materials, of services, etc. (different factors, or inputs) for providing to market a given basket of goods or services (different products, or outputs)- goes like this:

$$TFP^{x} = \frac{\left| O^{x} \cdot p \right|_{i}}{\left| I^{x} \cdot k \right|_{j}} ,$$

Where,
x = measured period (f.e., year 2014, quarter, 2014-3rd, … etc.);
O = Number of units of output 'i', the company has sold during such period 'x'
I = Number of units of input 'j' the company has used (consumed or contracted) during such period; i.e., of each type of employees, of materials, of equipments, of services, energy, … etc.
p = weight assigned to output 'i' ; usually it is taken as that the price of such output in a given reference period, '0'.
k = weight assigned to input 'j'; usually it is taken as that the price-cost of such input for the same reference period, '0'.

Parallel vertical bars, $\left| \ldots \right|$, stand for *summation*: for all company's products (i = 1,2 … n), in the numerator; for all inputs or factors (j = 1,2… m), in the denominator.

Thus, the units of company's products (O_i) and of resources it used (I_j) in a given period are the variables; and p_i and k_j are parameters. And, certainly, it is easy so see that such TFP index respond to the productivity concept stated at the beginning: if, f.e., the number of units of one of the products this year is something higher that previous year's, keeping all the rest unchanged, then the above TFP index will show an increase; and the reverse regarding a decrease in the units of just one of the factors, keeping unchanged the rest of variables. And –what is most important- the formula also allows for taking into account the real-life complexity: companies' activity showing –for a given period- changes of different sign in products, as well in factors, simultaneously.

In any case, the above index is the standard measure and terminology in experts' papers. And it merits pointing out that in its usual applications (i.e., taken as parameters the ones described above) TFP is in fact, as it can be seen, a quotient between two monetary values: Value of all the outputs (sales), at constant prices –numerator-, and value of all the inputs (total costs), also at constant prices –denominator [11]. Hence, for a normal situation of a given

[10] For a more complete, handbook-like, presentation on TFP, it could be seen Vergés, 2014 http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2491164 , pp. 27-36.

[11] For some curious reasons, this fact –which among other things facilitates the reading of the formula's quantitative results by non-experts- tends not to be acknowledged in experts' papers, when not rejected by them with contempt.

private company (that be operating at profits) we must expect its value be something higher than 1 [12].

However, what is most likely you to find in studies, articles and economic reports is not the above TFP measure but its *rate of change*, from period to period. Though not calculated in the usual way, [$r=(TFP^{x}/TFP^{x-1})-1$], but as $r=ln(TFP^{x}/TFP^{x-1})$; and usually expressed in percentage terms (the resulting values multiplied by 100).

The latter, let us say sophisticated way of calculating the rate (or %) of change, gives approximately the same value that the former, the ordinary way. But it has a very useful property: it allows to be also expressed –and calculated- as the difference between the average rate-of-change of Outputs and the average rate-of-change of Inputs

$$r^{x} = \ln \sum_i \left(\frac{O^{x}}{O^{x-1}} \right)_i v_i - \ln \sum_j \left(\frac{I^{x}}{I^{x-1}} \right)_j a_j$$

Where coefficients ***v*** are calculated as the share of each output in the total sales of the company in period (x-1); and coefficients ***a*** as the share of each inputs in the total costs of the company for the same period; (in both cases, values at constant prices). (hence, $\Sigma v_i = 1$, and $\Sigma a_j = 1$)

To put it in another way:

r.100 = % of change in Total Factor ***Productivity*** *=*

= (average % of change in Outputs) – (average % of change in Inputs);

And, last step, if we modify slightly the calculation for the above both averages by applying Törnqvist-like weights as coefficients v and a , then we end with the perhaps more popular expression in Productivity literature [13]:

$$r^{x} = \sum_i v_i^{*} \cdot \ln \left(\frac{O^{x}}{O^{x-1}} \right)_i - \sum_j a_j^{*} \cdot \ln \left(\frac{I^{x}}{I^{x-1}} \right)_j ;$$

Where: $v^{*}_i = (v_i{}^{x} + v_i{}^{x-1}) / 2$; $a_j^{*} = (a_j^{x} + a_j^{x-1}) / 2$

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To read more about → Limitations and shortcomings when using TFP measures

→ The attempt to calculate TFP indexes at *sector* and *country* level

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[12] In connexion with that, the TFP terminology is also applied to a refined definition of *Labour productivity* at-constant-prices, which comes gaining appeal among experts

$$'Net'\,Labour\ \ productivity \equiv NLP^{x} = \frac{\left| O^{x} \cdot p \right|_i - \left| I^{x} \cdot k \right|_{j,\neq work}}{\left| I^{x} \cdot k \right|_{work}}$$

where, as it can be seen, the numerator fits with the overall definition of value added: *Sales at-constant-prices (c.p.) less Total Costs (c.p.) except the ones of work*. And the denominator is precisely the *costs of work*.

[13] Which you might find also expressed in a more 'compact' notation, as:

$$r^{x} = \sum_i v_i^{*} \cdot \hat{O}_i - \sum_j a_j^{*} \cdot \hat{I}_j$$

(And, of course, you may find also that authors denote outputs, inputs, etc. with letters different than in here).

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To read more about … *Productivity indexes at country level*:

The attempt to calculate TFP indexes at *sector* and *country* level

A better alternative to the dominant *Labour Productivity* indexes?

Looking at national or international statistics on productivity –which are based, as has been commented, on *Labour (value-added) Productivity* indexes- we may find some times also some reference to *Total Factor Productivity*. In that case in terms of *index of change*. It merits to point out that, while such measure is kind of adaptation of the TFP-index-of-change concept from the literature on productivity at company level we have seen at the beginning, it is in fact defined –or, at least, calculated- for sector or/and country level in a quite different way, and therefore has a different meaning.

Thus, we may find in Eurostat databases some data on 'TFP' (indexes of change) at countries' level. The explanatory part of these data refers to OECD methodology[14]. And according to that, the index of change of *'TFP'* –also referred as 'Multi Factor Productivity', MFP- for a given country is defined as: A weighted mean of the *'MFP'* index-of-change for the different economic sectors of the country , being the weights the share of each sector in the whole economy in terms of value added.

Therefore, the key issue becomes in fact which is the (OECD) formula for the index of change of MFP for a given economic sector, of a given country. However, in that point, when going to talk about the calculation formula, it is defined in a rather most-conceptual-than-operative fashion. Which leaves the issue open, not quite precise. The following lines are an attempt to summarise that not-quite-precise OECD setting:

- Firstly, 'multifactor' idea is in fact (super)simplified in the OECD manual to just 'two-factors-productivity': "Labour" and "Capital".
- Then the so called *'MFP' index* –or, more properly, the composite *'Labour & Capital' productivity index*- is defined just as an extension of the definition of the *Labour productivity index* seen before:

  (for a given economic sector or 'industry', and a given period, 'x'):

  "Joint Labour-&-Capital-Productivity" index of change = $L\&CP = \dfrac{VA\ index}{(E\ index)^{sl} \cdot (K\ index)^{sk}} \times 100$

  Where:

  ***K** index* is the 'Capital index of change', mimicking conceptually the Labour index of change, ***E** i*, we have commented before (*Employees index*, *E*; in footnote 8):

  $K\ i = K^{period\ 'x'} / K^{period\ 'x-1)}$;

  $K^{period\ x}$ *being the value of the Capital consumed/used* during the period 'x' by the sector's companies.

  Exponent ***sl*** is the weight assigned to factor 'labour' for the above calculation; and exponent ***sk*** is the weight assigned to factor 'capital'; being *sl + sk* = 1.

[14] "Measuring Productivity – OECD Manual. Measuring of aggregate and industry-level productivity growth", OECD, 2001. http://www.oecd-ilibrary.org/industry-and-services/measuring-productivity-oecd-manual_9789264194519-en

That is, the denominator is a given mean of the *labour index of change* and the *capital index of change*. More precisely, it is a geometric weighted mean; or, in other terms, a Törnkvist index.[15]

[The OECD proposal for the above weights, ***sl*** and ***sk*** , are some given (debatable) definitions of the share of 'factor labour' and 'factor capital', respectively, in the total amount of value added]

It merits to note that the above formula is mathematically equivalent to a more direct-meaning one: a given mean of the *Labour Productivity* index (**LP** i) and the *Capital productivity* index, defining the latter as: ***CP*** *i = VA i/K i*. Thus:

$$L\&CP = LP^{SL} \cdot CP^{SK}$$

- Therefore, for calculating the *L&CP* formula, it is previously required to measure in some way the 'capital consumed/used' within the sector in each period, so to calculate the corresponding index of change, *K i* , or the corresponding 'Capital productivity' index, *CPi*; (besides to assign some values to parameters *sl* and *sk*).

  And here it lays the big issue. How to measure those *K* units. The flow of 'factor Capital *consumed//used',* during each period, by all the companies that make up the sector under measurement. Because measuring such ***K*** certainly is not a straightforward issue.

- Regarding this conceptual-statistical problem, when dealing with it in the referred manual, *K units* is just defined as 'capital services'. Yet the operational definition of this concept remains also rather open, not precise. The manual offers comments on several possibilities, but more in the way of a paper for an academic debate that a manual for practitioners. However, it could be understood from the text that they are implicitly referring just to companies' *amortisation* or *depreciation* costs from the *fixed assets* they have used during the period, plus some complementary amount in terms of financial costs that could be associated to the investment such assets imply for the respective companies. Tough, contradictorily, in other parts the text even suggests that the index of change of the *stock* of capital (total fixed assets) could be taken as a acceptable 'proxy' for *Ki*, which do refers to the *flow* of 'capital services' (!).

Taking into account the above, it must be concluded that when national or international statistics agencies engage nevertheless in determining *MFP* indexes *(L&CP* indexes, in fact), they must come obliged to make estimates and to use proxies in order to calculate the annual indexes of change of *capital services* as well as for determining a value for the *capital services'* share it in the total value added (***sk*** parameter) [16]. Therefore, the meaning –and hence the usefulness- of the resulting figures for such a MFP measure are doubtful.

In summary, and as it follows from the above, the task of quantifying the flow of 'capital services' of a sector for a period requires in any case a set of arbitrary assumptions. And the same happens for determining the weights ***sl*** and ***sk*** of the *L&CP* formula. That makes that the figures of 'Multi-factor Productivity', (or, more properly, 'Joint Labour & Capital Productivity') resulting from the formula, and found in statistics agencies' publications, be of uncertain meaning, low reliability, if not misleading as a 'total productivity' measure for comparing among countries. And hence those data are of doubtful usefulness.

[15] Why to use a so sophisticated average is not actually argued in the OECD methodology manual. Neither it is easy to deduce the rationale or virtues of such a specific option, beyond the well known fact that statisticians are traditionally fond of Törnkvist indexes.

[16] When reviewing specific tables labelled as TFP data in Eurostat on-line databases, f.e., it is rather impossible to find around information regarding which is the specific formula and/or the statistical variables' definitions they have taken for quantifying 'Capital Services' for a given sector of a given EU country.

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To read more about …*Productivity calculation in practise*

Shortcomings and drawbacks in current use of productivity measures, at companies' level

Let us go here more in deep regarding the actual meaning and current use –and misleading use- of the standard TFP measures, in productivity studies at companies' level. The core issue that justifies that is the following one:

> In public debates on the need for increasing country companies' productivity it is usually implicit the simplified vision that productivity improvements will come from increases in output per work-hour; which are supposed to result from improvements in the effectiveness of workers' job. And in turn that higher effectiveness is supposed to come from either better workers' qualification or better production-activities' organisation.
> However, a closer view shows that most of the times increases in productivity are rather the result of companies' increasing *mechanisation & automating* -which implies basically: ∇ input 'work', Δ input 'equipments' (or 'capital'), and Δ input 'energy'- or/and *outsourcing* -which basically leads to Δ input 'subcontracted services', ∇ work, ∇ capital, and ∇ energy.
> And the standard way (formulae) for measuring a firm's overall productivity (TFP) is not in fact thought for registering such reality.

Mismatching between the formulae and the real world

Total Factor Productivity measure (formula) is designed under the assumption –rooted in the mainstream economic theory- that the set of goods or services (outputs) delivered by a company to market is the same across time; and that are just the respective units of each of the outputs what changes from period to period. And the same is implicitly assumed regarding the inputs: That the set of inputs for producing the outputs is a given one; being the respective units consumed/used/contracted of each input what may change across periods.
Those changes are what the respective units –of outputs and of inputs- what the TFP definition is designed to compute.

However, in the real world the composition of a company's basket of outputs comes subject to frequent significant changes across years: entering new products, dropping of others adapting to market demands, ..etc. And the same happens regarding the set of inputs (due to technical innovations, cost-reducing company's decisions, etc.). That makes that the application of the TFP measure in practice be then 'forced'; usually by way of introducing 'proxy' variables or/and additional assumptions. Which leads to TFP values with a degree of uncertainty (lack of confidence) regarding its actual meaning higher than experts are willing to acknowledge.

The outputs side:

Regarding the outputs side, one major cause for a company changing its composition is a big business topic: Products innovation. While it is an old feature in capitalism analysis (Schumpeterian entrepreneur; risk's retribution) it keeps being at present the a-b-c of companies' success (as synonymous of 'actual' efficiency?): Companies' permanent

searching for new products, or types of *, in order to improve profits. Consequently, the company's set of outputs uses to change almost every year. Some new ones are added to the production-commercial line and others dropped out. In five years time the nature of the company's outputs that make up the basket of its 'overall output' may have become so different that the application of the standard formula might make no sense –since the measure is based on the assumption that the basket of outputs are the same from period to period .
[*: Remark on 'different/new outputs': Either in companies practice and in TFP formulae application, two car models in a carmaker catalogue –by way of example- with different features (and therefore, cost) –and therefore, different sale price- are for all purposes two 'different outputs']

In summary, the rationale of the standard TFP measures is based -regarding its numerator- on 1) assuming a company has a given stable set of outputs, and that therefore the only thing to capture is how their respective quantities have changed from a period to the following one. And 2) to add up these outputs quantities weighting them, fore each period, with the same parameters: the set of selling prices of a given period $(p^0)_i$. But the referred dynamics of product innovation breaks that assumption. As a consequence, a methodological practical problem arises: when a new product enters into a period list, there is not a previous reference price for it; but it would be needed for carrying out the referred adding up calculation (TFP's numerator; or the equivalent when calculating directly rates of change).

The inputs side:

Empirical observation shows us that productivity increases -in the sense of the standard TFP measure at company level- result mainly from changes in inputs composition, decided by the company in order to get reductions in its total costs (for a given basket of outputs). That means usually 1) increasing *mechanisation & automating* -which implies basically ∇ input 'work', Δ input 'equipments' (or 'capital'), and Δ input 'energy'; or/and 2) *outsourcing* - which basically implies Δ input 'subcontracted services', ∇ work and of the rest of factors. And these changes would, of course, be reflected in an increase in the TFP measure for the period since –remember- denominator figure in the formula is in fact total-costs-at-constant-prices.

The above remark regarding what it must be understood by 'a new/different output', in the productivity-measuring context, also applies to inputs. By way of example: If a company decides to outsource some of its activities, a new input begins to enter into the company's inputs set. Even if it is not the first outsourcing of the company: To outsource activity 'a' is to contract a kind of service different in nature from the one regarding outsourcing activity 'b'; among other things, the respective units and prices will likely be absolutely disparate. In such a case, in applying the TFP formula (regarding the denominator, in this case) we will lack the 'price of the reference period' to be used as a parameter for that new input. And that will force us to make some assumption about. And as a consequence the resulting TFP figure will have a low degree of confidence; which may easily lead to misleading conclusions.

What TFP actually tell to us

TFP may vary because market trends, aside from company's productivity-properly-said

Let us consider the case when the only change from previous period is a reduction in the quantity/ies of some output because a fall in demand. Then, the standard measure will show a reduction in productivity, when, however, the whole company - employees and managers- may have been operating with the same efficiency than before. In that case what will actually be measuring TFP is just that the company has not had time enough –in the measuring period-

for adjusting downward contracted inputs; basically its workers but also 'fix' inputs as equipments and buildings.

In other words, productivity is always measured in terms of commercialised output –not produced output. That is so mainly because informational limitations: For external observers (which is the situation for professionals engaged in productivity calculations and studies), companies' sales figures are the only information it may be expected to get regarding its basket of outputs for a given period, since the sources to work on are –in the best case scenario- their annual reports and accounts. And that constrain is even harder when productivity expert is forced to work on secondary data sources (f.e., the Fortune's 500 bigger companies, sector's yearbooks, …) as, in the other hand, it is so frequent.

Beyond TFP: Is it actually a good indicator for a company's 'good economic performance'?

Productivity (TFP) is taken as synonymous of company's efficiency. But firm's efficiency in a broad sense ('good economic performance') depends among other things on its managers' ability in a matter which has not reflection on the standard productivity calculations: the price policy and commercial bargaining success in a dynamic and more-or-less competitive environment. A good performance in that part of a company's management means, crudely speacking, to get better (higher) prices to charge for outputs, as well as better (lower) prices to pay for inputs –while keeping the rules for contracting. Taking that into account, since standard productivity calculation (TFP) is based on using constant prices –which, as we have seen, technically are told 'weights'- the resulting productivity figures may give a not satisfactory measure of the actual overall firms' efficiency.

However, that shortcoming may be overcome combining productivity measures with the humble measure 'rate of margin':

A good practical solution: Mixing Productivity and Margin measures

The *rate of margin* of a company is used also as an efficiency measure. And it does gather the effect of the prices policy and the commercial (selling and purchasing) bargaining success; as well as the effects of productivity changes. In fact, it is easy to demonstrate that the rate or margin value can be expressed as a function of three main variables: the TFP figure, the average sale-prices index of change, and the average index of change of purchasing/contracting-prices. You might want to see a description of that important business relationship in http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2500686 , pp. 53-54

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