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Job Generation and Growth Decomposition Tool

Understanding the Sectoral Pattern of Growth and its Employment and Productivity Intensity

Reference Manual and User's Guide
Version 1.0

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Introduction

Among policymakers, there has been a growing concern with "jobless growth" as a major obstacle for the poor to benefit from the positive growth performance experienced by many countries worldwide. This appears intuitive, as the poor derive most of their income/consumption from work: as employees, as the self-employed, or in subsistence activities. Therefore, the impact of growth on poverty is seen as depending on the extent to which growth generates employment and good earning opportunities. However, if employment growth is achieved at the expense of wage reductions, it may have a meager impact on poverty. Moreover, since in many low income countries the poor cannot afford to be unemployed, policies should be more concerned with raising the income of the working poor, rather than, or in addition to, reducing the unemployment rate. Another recurrent issue for the policy discussion is whether poverty is more effectively reduced by a growth pattern that favors the sectors of the economy in which the poor are found (i.e., Agriculture) in order to enhance employment opportunities or by a pattern that disproportionately advances the sectors in which the poor are not found, so that more of the poor can be drawn into the higher earning parts of the economy.[1] This issue is more important if the poor face extensive barriers to gaining access to the higher earning sectors. In addition the question of how productivity improvements translate into higher earnings for the poor has also been at the forefront of the discussion, does higher growth in output per worker reduce employment growth? Is higher output per worker associated with better employment opportunities? These are all priority questions in the search for shared growth strategies.

Therefore when analyzing how employment generation and productivity growth help determine the effectiveness of growth in reducing poverty, a natural set of questions to ask is: i) how is growth reflected in employment generation and in changes in output per worker, ii) how is growth reflected in the sectoral pattern of growth and employment generation iii) What are the sources of changes in output per worker. Answers to these questions will help to understand whether the pattern or profile of growth observed is conducive to poverty reduction, by pinpointing the sector and factors that should be further analyzed.

The aim of this methodology is to understand how growth is linked to changes in employment, output per worker and population structure at the aggregate level and by sectors. Additionally, it is also possible to disentangle the sources of output per worker growth: either Total Factor Productivity (TFP) growth, movements of employment from one sector to another, or changes in the capital-labor ratio. We will refer to it as drawing a profile of growth.

[1] Achieving economic development by moving people out of the poorer sectors and into the richer ones has been labeled "inter-sectoral shifts." Both the Lewis and the Kuznets models are models of inter-sectoral shifts. These and later contributions are reviewed in Basu (1997).

There are several techniques for decomposing changes in GDP and attributing to each component (employment, output per worker, capital and TFP) or to each sector a share of total observed growth. The methodology presented here uses Shapley decompositions, which is a simple additive method that links changes in a particular component to changes in total per capita GDP, by taking into account the relative size of the sector or component, as well as the magnitude of the change.

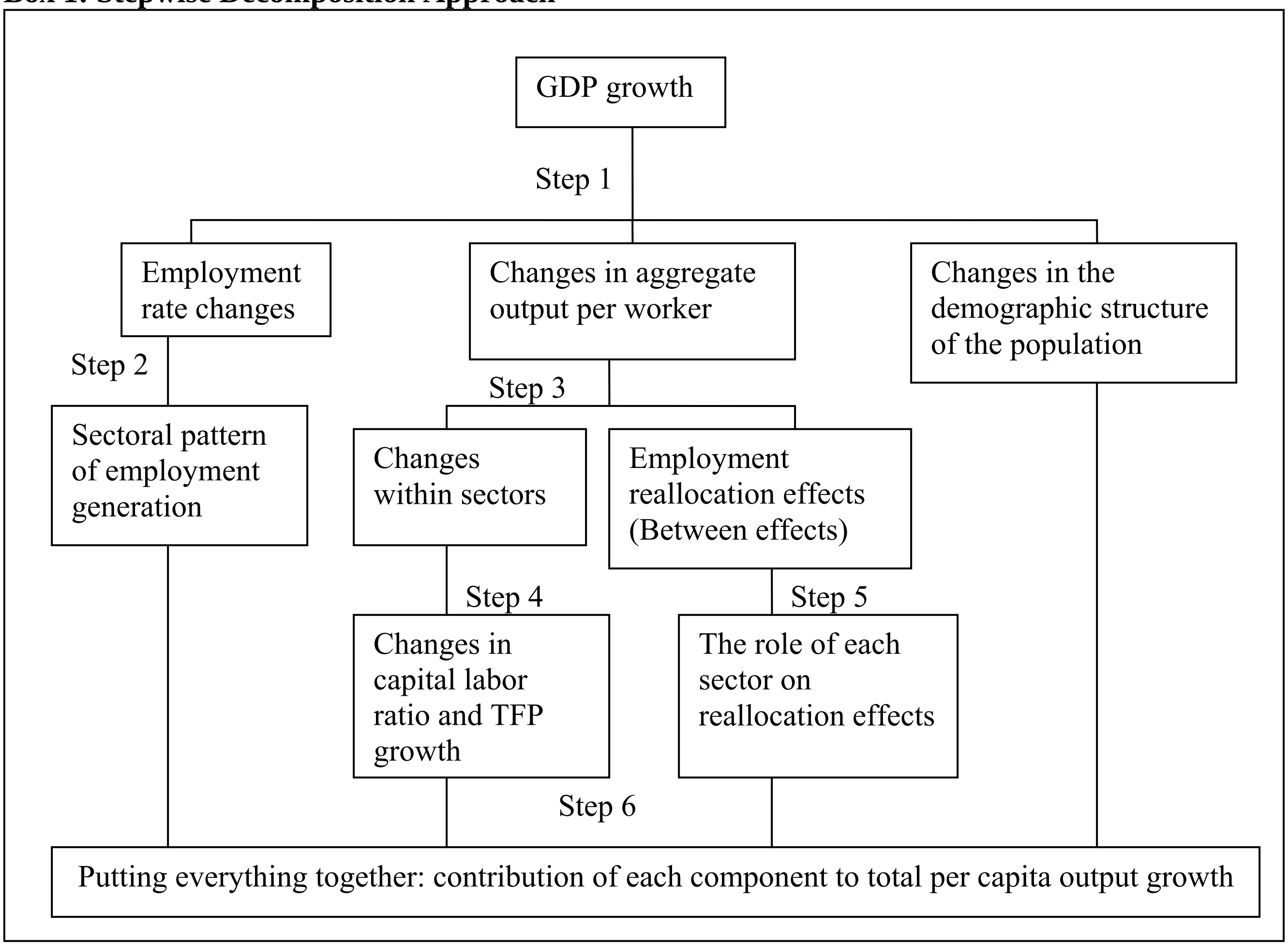
The methodology decomposes GDP growth using several consecutive steps, each step goes further in answering the above questions and the analyst can choose how far to go depending on data availability, among others. In a first step growth in per capita GDP (proxied by per capita Value Added) is decomposed into employment rate changes, changes in output per worker and demographic changes[2]. In the second step employment changes are further decomposed into changes in employment by sectors. The third step decomposes changes in output per worker into changes linked to variations in output per worker within sectors and changes linked to sectoral relocation of workers between sectors. A fourth step goes further in understanding the role played by each sector on the aggregate effect of employment relocation across sectors while the fifth step looks at the role of capital and TFP as sources of changes in output per worker at the aggregate level. A sixth step puts all the elements together, to see how each factor affected total per capita growth. The diagram in box 1 sketches the stepwise decomposition approach.
Some steps are pre-requisite for other steps. In particular, Steps 1, 2 and 3 can be performed independently of other steps, but steps 4 and 5 require step 3 as a preliminary step. Step 6 puts together all of the decompositions chosen by the user. For example if the user only performed steps 1, 2 and 3, the final step will show how much of per capita output growth was linked to employment rate changes, how much to demographic changes and how much to within and between changes in output per worker across sectors.

This note is divided in three sections. In the first section we present a description of the decomposition and its interpretation, and how it can be used to analyze shared growth, with an example for Nicaragua. It is subdivided in six subsections, each describing the decomposition of per capita output growth and of any of its components as illustrated by the steps in box 1. Each subsection is self contained, so that the reader interested in only one of these steps/decompositions can go directly to the corresponding sub-section. The last sub-section (Section 4.6) shows how to nest all the decompositions to show a unified picture. It is useful for anyone wanting to go beyond the aggregate decomposition (step 1).
In the second section we discuss some of the potential problems in interpreting the results of this methodology, and under which conditions care should be exercised.
In the third section we present the Job Generation and Growth Decomposition tool (JoGGs Decomposition), an excel based software that performs the decomposition of GDP growth as explained in this note, using the data provided by users. It generates all the tables presented in this note, and is flexible enough to accommodate the output depending on data availability.

[2] Value Added does not include taxes and subsidies while GDP does, the difference between GDP and Value Added is usually very small. Usually output by sectors from National Accounts does not include these subsidies and taxes, thus it is strictly Value Added.

The final section presents the formulas and the Shapley methodology used for the decomposition, for anyone wanting to go into the details of the formulas. This section is divided in six sub-sections each presenting the formulas used for each of the above mentioned decompositions. All sub-sections are self contained except for the last sub-section (Section 4.6 Putting everything together), which requires the previous sections to understand the notation and the stepwise decomposition sequence.

Box 1: Stepwise Decomposition Approach



1 Profiling growth and interpreting the results: an example for Nicaragua

As mentioned in the introduction the objective of the decomposition is to answer the following questions: i) how is growth reflected in employment generation and in changes in output per worker, ii) how is growth reflected in the sectoral pattern of growth and iii) What are the sources of changes in output per worker.

Although there are several methodologies to answer the question set in the introduction, we believe a simple decomposition approach has some advantages over other methods often used: it presents a unified way of looking at all the components (employment, capital, TFP and sectoral relocation of labor) and it is very sparse in terms of data requirements.

We will describe the decomposition approach by addressing each step of the decomposition separately. The tables and graphs presented in this note are the output of the JoGGs Decomposition tool, using data for Nicaragua

1.1 Step 1: Understanding the aggregate employment and productivity profile of growth

1.1.1 The basic idea

To understand how growth has translated into increases in productivity and employment at the aggregate level and by sectors (or regions), note that per capita GDP, $Y/N=y$ can be expressed as[3]:

$$\frac{Y}{N} = \frac{Y}{E}\frac{E}{A}\frac{A}{N}$$

Equation 1

Or:

[3] The two most common approaches to solve this question are to estimate the employment elasticity of growth, and TFP growth via growth regressions. This method assumes functional forms for output and requires data for several periods in order to estimate, moreover, it rarely takes into account changes in the population structure, which often account for an important share of per capita GDP growth. Another frequently used methodology is to calculate the total employment elasticity of growth as the percentage change in employment over the percentage change in GDP, or the partial elasticity of employment with respect to growth $\partial E * Y / \partial Y * E$, which is obtained by regressing the log of aggregate employment against the log of total GDP, aggregate wages and other controls. There are both conceptual and empirical difficulties with these measures. Conceptually, the employment elasticity of growth looks at changes in the level of employment, not at changes in employment rates. We believe that what matters for poverty reduction is not the absolute number of employed, but the number of employed relative to the labor force: positive employment elasticity might very well be consistent with growing unemployment rates. This is particularly important for developing countries where population growth accounts for an important fraction of labor force growth. From the empirical point of view, the partial elasticity of employment with respect to growth has two difficulties. Arriving at consistent estimates at the aggregate level is a rather difficult task (see Hammermesh 1986, 1993).

$$y = \omega * e * a$$

where Y_i is total Value Added E is total employment, A is the total population of working age and N is total population. In this way Y/E=ω is total output per worker, E/A is the share of working age population (i.e. the labor force) employed and A/N is the labor force as a fraction of total population. We will refer to *e*, as the employment rate[4].

Thus per capita GDP growth can be decomposed into growth associated with changes in output per worker, growth associated with changes in employment rates and growth associated with changes in the size of the working age population. The methodology used here uses Shapley decompositions,. Details of the formulas can be found in the Annex. This decomposition has the advantage of being additive. This means that the total change in per capita GDP will be the sum of the growth attributed to each of its components ω, *e*, and a. Thus if we let $\overline{\omega}$, $\overline{e}$ and $\overline{a}$ denote the fraction of growth linked to each component then the growth rate of an economy can be expressed as:

$$\frac{\Delta y}{y} = \overline{\omega}\frac{\Delta y}{y} + \overline{e}\frac{\Delta y}{y} + \overline{a}\frac{\Delta y}{y}$$

And total growth as:

$$\Delta y = \overline{\omega} * \Delta y + \overline{e} * \Delta y + \overline{a} * \Delta y$$

$\overline{\omega} * \Delta y$ will reflect the amount of growth that would be consistent with a scenario in which the employment rate *e,* had changed as observed but output per worker and the share of population of working age *a* had 'stayed constant'. By saying that *a* and *e*, did not change we do not mean "stayed in their initial year level". There are in fact several ways in which these two components can stay unchanged. They can both remain in the level observed in the initial year, they can both stay at the level observed in the final year, or one of them can stay in the level observed in the initial year and the other stay in the level observed in the final year. Some decompositions only consider the case where both components stay in the level observed in the initial or final year, and thus end up with a residual. What the Shapley decomposition does is that it considers all possible alternatives, and then makes a weighted average of each (with the weights reflecting the number of ways each component can remain *unchanged*), eliminating in this way the residual, which can be very large. Each component thus has the interpretation of a counterfactual scenario.

In the same way $\overline{e} * \Delta y$ will be the amount of growth consistent with a scenario in which output per worker ω, and the share of population of working age *a*, had remained

[4] Strictly speaking the employment rate is measured as the share of population of working age that 'participates' in the labor market, which is employed. Where participation is defined as all those looking for a job or already employed. As we will argue below for low and middle income countries this distinction of who is participating and who is not is rather blurred. Nevertheless, the methodology can be easily extended to include the effects of higher participation rates.

‘unchanged’. The amount of per capita growth linked to demographic changes will be $\overline{a} * \Delta y$ [5].

1.1.2 Data needed

To perform the decomposition we need data on output for two periods, which can be obtained from National Accounts. Growth can be measured either by GDP or by Value Added. Value Added, is roughly the same as GDP but excludes subsidies and taxes. If the analyst is going to perform sectoral decompositions then we recommend using data on Value Added. National Accounts disaggregated by sectors refers to Value Added rather than GDP, so using Value Added rather than GDP will make sure that sectoral disaggregations are consistent with the aggregate ones. Data on employment may come from different sources “Household surveys, Labor Force Surveys or administrative data”, but care should be taken so that employment numbers refer to all the economy and not just to the formal sector or the urban economy. Data on population by ages should come from population census and population projections. A Good source of National Accounts and Population Data is the United Nations or each countries Statistical office or Central Bank (from which the United Nations data is usually collected). Since we want to decompose real growth data on output should be in constant currency.

An often difficult task is to make sure that population data is consistent with data from household surveys. It is often the case that the expansion weights used in household surveys rely on old population census, while population projections may be updated according to new census. In these cases it is important to re-weight or re-scale the household survey data so that it is consistent with the latest population projections.

Table 1 presents the main data used for the aggregate decomposition: Output, employment and populations, as well as employment shares, output per worker, and share of population of working age. Employment data come from Nicaragua LSMS’s, were the expansion weights where rescaled according to the 2005 census information. Data on Value Added at the aggregate level and by sectors comes from Nicaragua’s National Accounts for the years 2001 and 2005, obtained from comes from the Central Bank of Nicaragua, and is

[5] It is often useful to understand the relationship between the traditional employment elasticity of growth and the contribution of the employment rate as calculated by this decomposition method. The employment elasticity of growth is usually calculated as the change in employment over the change in GDP times output per worker ($\Delta E/\Delta Y)*(Y/E_{t=0}$). This elasticity often is interpreted as the contribution of employment to GDP growth (see ILO). Instead, here the term $\overline{e}$, captures the contribution of changes in the *employment rate e* (as opposed to changes in total employment, *E*) to growth in GDP *per capita y* (as opposed to growth in total GDP, *Y*). If there had been no change in the share of population of working age *a,* this component would be calculated as: $\overline{e} \equiv \frac{\Delta e}{\Delta y}\left[\frac{1}{2}\left(\omega_{t=1}+\omega_{t=0}\right)a\right]$. By normalizing the share of population of working age to unity (i.e. setting *a=1),* we would get something that could be interpreted as the ‘arc’ elasticity of the employment *rate* to *per capita* GDP growth. Or how much the employment rate increased as a result of per capita growth. This interpretation as an elasticity suggests (wrongly) that there is causality from output growth to employment growth, as mentioned before these are accounting identities not structural relations. For this reason we prefer to avoid the use of the term elasticity. The differences in both measures highlights the role of population and working age population growth in decomposing GDP growth

presented in Constant Córdobas of 1994 and data on population comes from Nicaragua's statistical office -INEC.

Nicaragua registered a growth rate of 7.14% in per capital Value Added, for the whole period. This growth was accompanied by decreases in output per workers (-1.78), increases in the population of working age (12.5%) and in employment rates (3.6%).

Table 1: Employment, Output, Productivity and Population. Nicaragua 2001-2005

	2001	2005	% change
GDP (value added) (in 1000000's)	25,765	29,495	14.5
Total population	4,812,416	5,142,098	6.9
Total population of working age	2,698,860	3,035,387	12.5
Total number of employed	1,635,185	1,905,702	16.5
GDP (value added) per capita	5,354	5,736	7.14
Output per worker	15,757	15,477	-1.78
Employment rate	60.59	62.78	3.62
Share of population of working age	56.08	59.03	2.95

Source: Table obtained using JoGGs Decomposition tool with data from Nicaragua's Central Bank and Nicaragua's Household Surveys (Encuesta de Medición del Nivel de Vida EMNV).

1.1.3 Results and interpretation

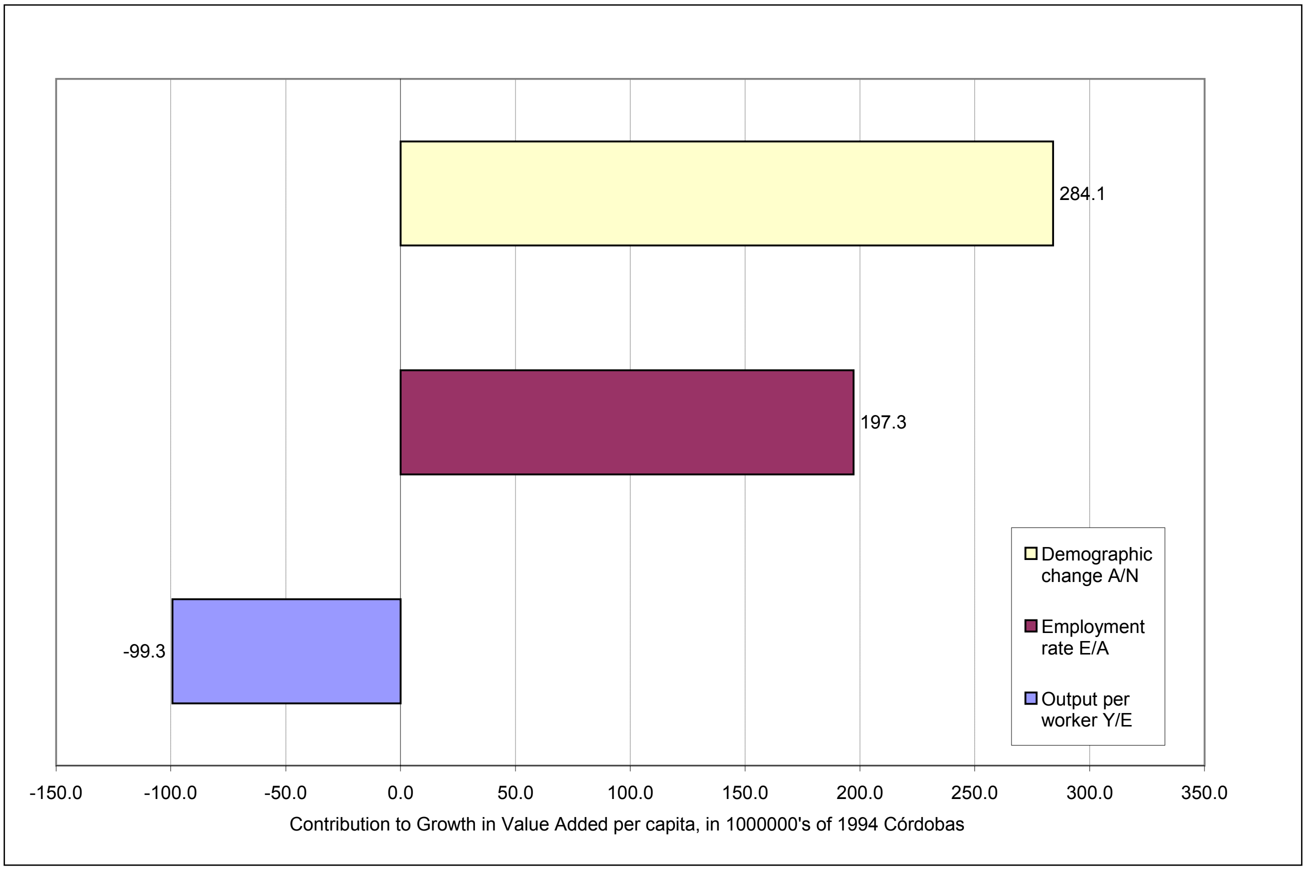
To answer how important was each of these components we perform the Shapley decomposition. Table 2 and figure 1 below illustrate the results of the decomposition of aggregate per capita growth into its main components using the formulas described in section 4. The table shows the contribution in Córdobas of 1994 to absolute observed growth in per capita GDP as well as the percent contribution. The figure illustrates the results in Córdobas of 1994.

Table 2: Decomposition of Growth in per capita Value Added. Nicaragua 2001-2005

	1994 Córdobas	Percent of total change in per capita value added growth
Total Growth in per capita GDP (value added)	382.02	100
Growth linked to output per worker	-99.32	-26.00
Growth linked to changes employment rate	197.27	51.64
Growth linked to changes in the share of population of working Age	284.07	74.36

Source: Table obtained using JoGGs Decomposition tool with data from Nicaragua's Central Bank and Nicaragua's Household Surveys (Encuesta de Medición del Nivel de Vida EMNV).

Figure 1: Aggregate Employment, Productivity and Demographic Profile of Growth. Nicaragua 2001-2005



Source: Figure obtained using JoGGs Decomposition tool with data from Nicaragua's Central Bank and Nicaragua's Household Surveys (Encuesta de Medición del Nivel de Vida EMNV).

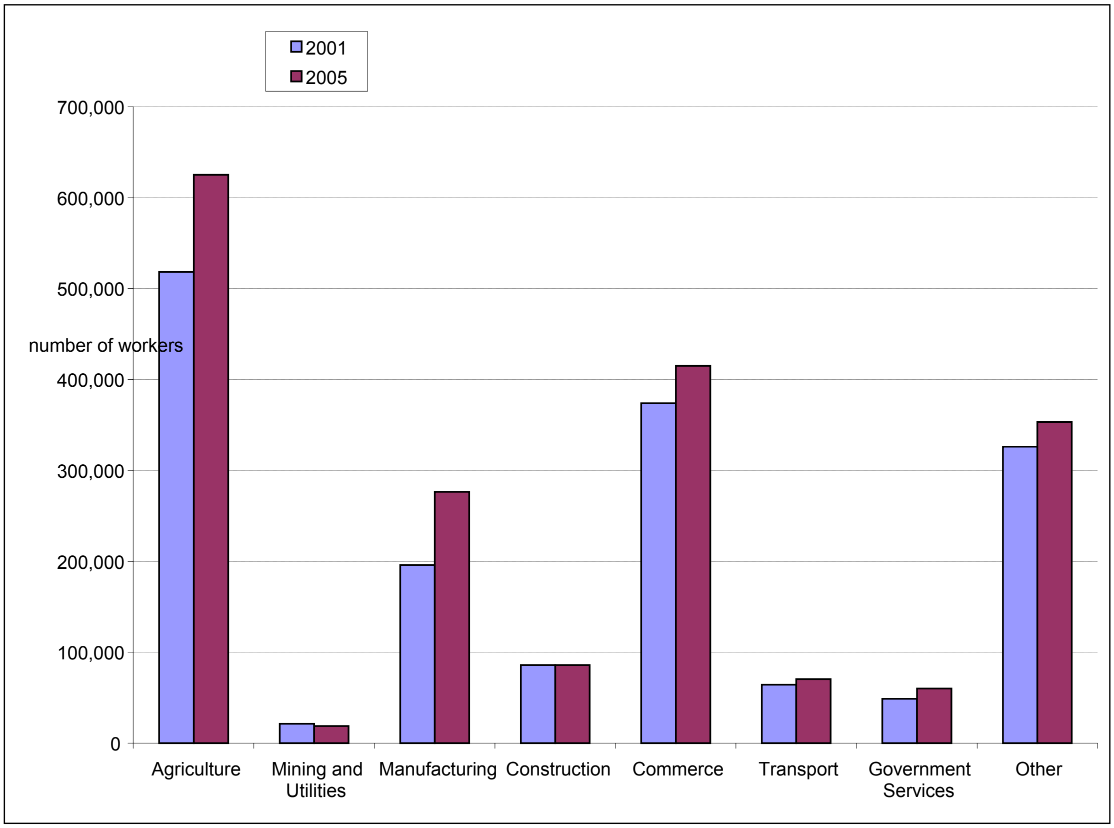
The results suggest that 74 percent of the change in per capita Value Added can be linked to changes in the structure of the population. In other words, had everything else stayed the same, the sole change in the age structure of the population would have generated a growth equivalent to 74 percent of the actual observed growth (i.e., a total growth for the period of 5.3 percent). In other words, there were less dependants (minors and elderly) per each working age adult. Because we are constructing a counterfactual in which we assume that each of these working age adults faced the same employment rate and productivity in both periods, the lower dependency increased per capita output. Changes in employment were also important, accounting for some 51 percent of observed growth, thus growth in Nicaragua was not 'job-less'. This means that if productivity had stayed the same and the number of dependents per working age member had also remained constant, the higher rate of employment would have generated a growth of 3.6 percent. Unfortunately, changes in productivity acted in the opposite direction. Had productivity not changed, observed growth would have been 9 percent, but decreases in productivity meant that growth was 1.6 percentage points lower.

Note that small changes in the share of population of working age have huge effects on total growth. The reason is very simple: the 2 percent growth in the share of population of working age meant that there were 336,526 new entrants in the labor market, of these new entrants we could have expected 62% (208,646 new workers) to find employment at an average productivity for the period of C$15,617, which means roughly 3.2 million more Córdobas of output. On the other hand employment growth of 3.6 meant that, at the average share of working age population, 63 thousand new workers would have been employed at the average productivity of C$15,617, with a much smaller contribution to output growth. This is precisely what this decomposition approach tries to capture: rather than look at the percentage change in each component, it looks at its overall impact, which includes both, the percentage change and its size effect.

Once we have decomposed aggregate employment growth we can go further and i) decompose changes in the overall employment rate *e,* to understand the role played by different sectors and ii) decompose total output per worker ω, to understand the role of capital, Total Factor Productivity and inter-sectoral employment shifts. This last step can be undertaken both at the aggregate level and by sectors, depending on data availability. This amounts to doing a step-wise decomposition: first decomposing aggregate growth into employment and productivity changes and then decomposing employment and productivity changes, into other sub-components.

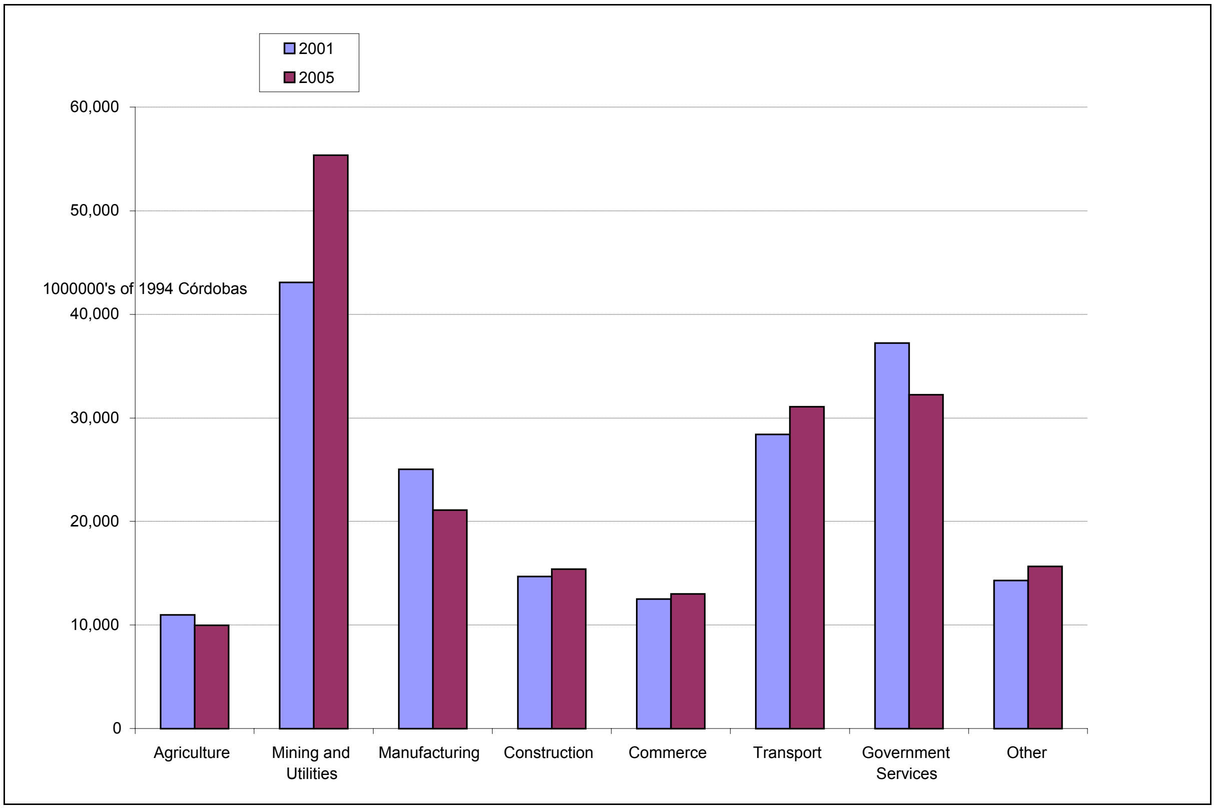
To decompose growth into sectors we need data on employment by sectors and output by sectors. Figures 2a and 2b illustrate employment by sectors and output per worker by sectors, respectively.

Figure 2a: Employment by Sectors. Nicaragua 2001-2005



Source: Figure obtained using JoGGs Decomposition tool with data from Nicaragua's Central Bank and Nicaragua's Household Surveys (Encuesta de Medición del Nivel de Vida EMNV).

Figure 2b: Output per Worker by Sectors, Nicaragua 2001-2005



1.2 Step 2: Understanding the role of each sector in employment generation

1.2.1 The basic idea

To understand the way in which sectors contributed to employment generation and to total per capita growth we can further decompose employment (rate) growth (Δe) by sectors. The easiest is of course to express the total growth in employment as the sum of employment generation in each sector.

$$\Delta e = \sum_{i=1}^{s} \Delta e_i$$

Where $\Delta e_i = \Delta \frac{E_i}{A}$ is just the change in employment in sector *i* as a share of total working age population. This gives a simple measure of which sector contributed more to changes in the employment rate.

Once we understand the sources of growth in the employment rate, we can understand the link of employment growth in sector *i,* to the observed change in per capita output by combining the results in steps 1 and 2. The total contribution of sector *i* will be its contribution to changes in total employment times the contribution of employment rate changes to total growth calculated in step 1. As before this can be interpreted as the per capita growth consistent with a counterfactual scenario, in which all else (productivity, demographics, and employment in the remaining sectors) had all remained unchanged, and the only change had been the observed employment growth in sector *i.*

1.2.2 Data needed

To perform this decomposition the only data needed is employment by sectors and the total population of working age. For the example presented below employment by sectors is obtained from Nicaragua's household survey (LSMS), and population of working age from the source mentioned above.

Table 3 presents the data on employment by sector. The sources of this data are the same as those mentioned above. All sectors except Mining and Utilities and Construction registered absolute growth in the number of employed, but only Agriculture, Manufacturing and Government gained in the share of total employment. Figure 2a illustrates the same data.

Table 3: Employment by Sectors of Economic Activity, Nicaragua 2001-2005

	Total employment			Employment/pop. of working age		
	2001	2005	% change	2001	2005	% change
Agriculture	518,436	625,379	20.63	19.21	20.60	7.25
Mining and Utilities	21,338	18,694	-12.39	0.79	0.62	-22.11
Manufacturing	196,058	276,601	41.08	7.26	9.11	25.44
Construction	86,134	85,984	-0.17	3.19	2.83	-11.24
Commerce	373,994	415,170	11.01	13.86	13.68	-1.30
Transport	64,309	70,567	9.73	2.38	2.32	-2.44
Government Services	48,645	60,018	23.38	1.80	1.98	9.70
Other	326,271	353,291	8.28	12.09	11.64	-3.72
Total	**1,635,185**	**1,905,702**	**16.54**	**60.59**	**62.78**	**3.62**

Source: Table obtained using JoGGs Decomposition tool with data from Nicaragua's Central Bank and Nicaragua's Household Surveys (Encuesta de Medición del Nivel de Vida EMNV).

Total employment grew by 16%, but as a result of the simultaneous growth in the working age population, the employment rate grew by only 3.2%.

1.2.3 Results and interpretation

Table 4a and Figure 3a show the results of the decomposition. The first column of the table shows how the 2.19 percentage points of growth in the employment rate was distributed among the different sectors. Manufacturing and Agriculture are responsible for most of the increase. Note that although the share of working age employed in Agriculture only grew 7.24% compared to the growth in Manufacturing of 25%, the contribution of Agriculture is only slightly less than that of Manufacturing. This is explained by the fact that Agriculture is more than twice the size of Manufacturing. Again the decomposition highlights how, small percent changes in a sector or component, can have big impacts if its relative size is large.

Figure 3a illustrates how the growth of the employment rate of 2.19 percent points was distributed among the different sectors.

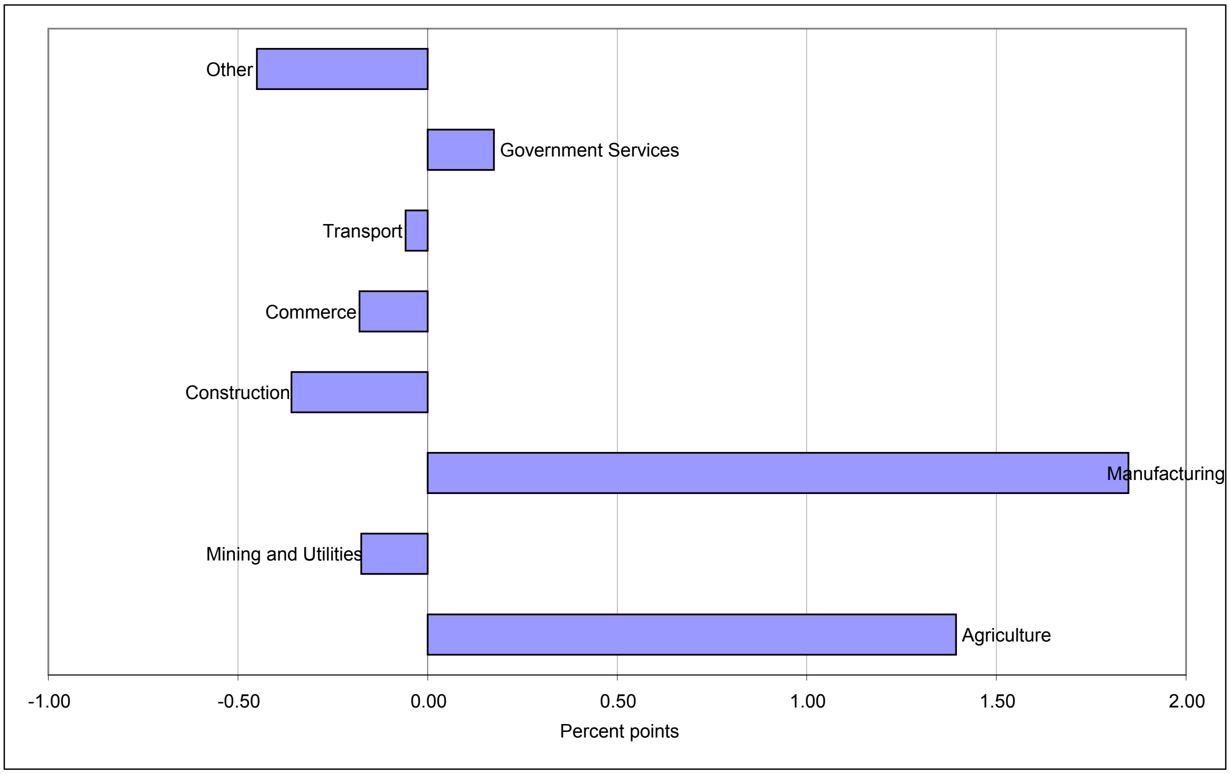
Table 4a: Contribution of employment changes to overall change in employment rate, Nicaragua 2001-2005

	Contribution to change in total employment rate (percent points)	Percent contribution of the sector to total employment rate growth
Agriculture	1.39	63.5
Mining and Utilities	-0.17	-8.0
Manufacturing	1.85	84.2
Construction	-0.36	-16.3
Commerce	-0.18	-8.2
Transport	-0.06	-2.6
Government Services	0.17	8.0
Other	-0.45	-20.5
Total employment rate	**2.19**	**100.0**

Monetary values are 1994 Córdobas

Source: Table obtained using JoGGs Decomposition tool with data from Nicaragua's Central Bank and Nicaragua's Household Surveys (Encuesta de Medición del Nivel de Vida EMNV).

Figure 3a: Contribution of each Sector to Changes in Employment to Population Ratio. Nicaragua 2001-2005.



Source: Figure obtained using JoGGs Decomposition tool with data from Nicaragua's Central Bank and Nicaragua's Household Surveys (Encuesta de Medición del Nivel de Vida EMNV).

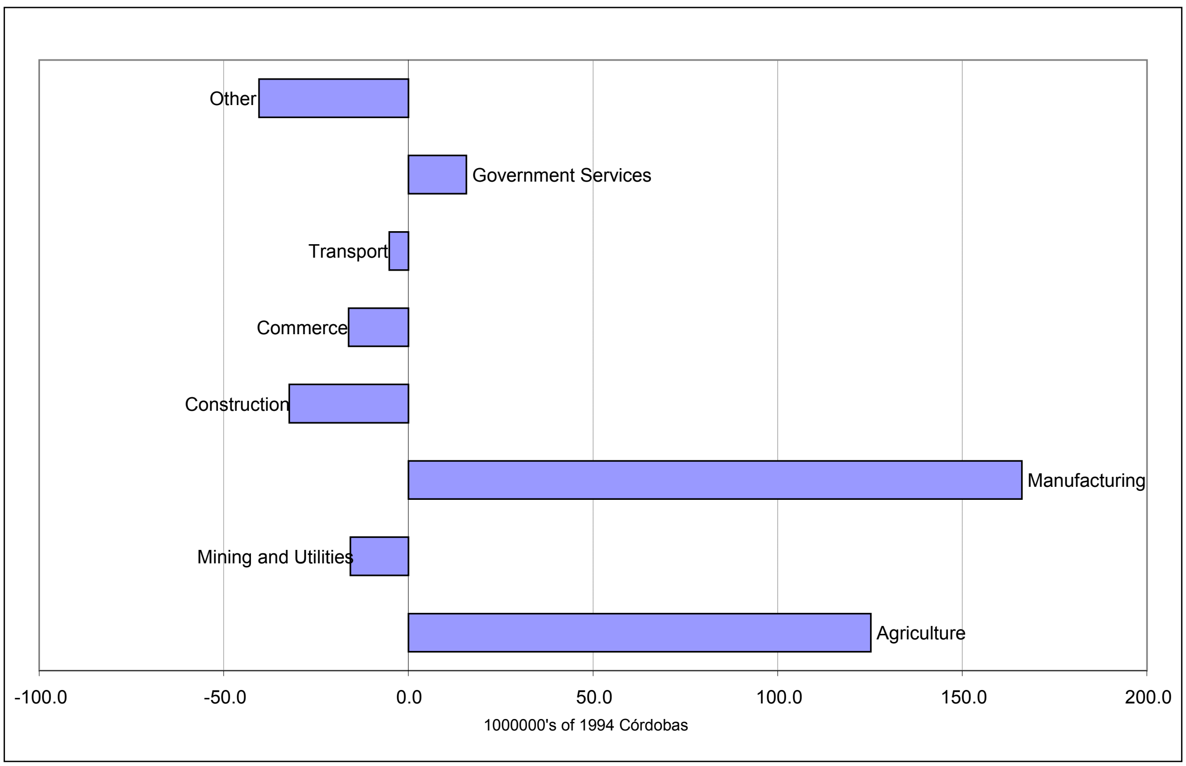
Tables 4b and Figure 3b, show the contribution of sectoral employment changes to growth in *total per capita output*. It is the result of combining steps 1 and 2. Of the $197 Córdobas registered in per capita output, manufacturing contributed with $166 Córdobas and agriculture with $166 Córdobas. In all other sectors employment contracted thus having a negative effect on growth.

The contribution of for example, the manufacturing sector, can be interpreted as the growth which would have resulted in the counterfactual scenario in which the share of working age population, total output per worker, and employment in all sectors other than manufacturing had remained unchanged, but employment in manufacturing had grown as observed. If this had been the case total per capita output would have increased by $166 Córdobas.

Table 4b : Contribution of employment changes to overall change in per capita GDP (value added), Nicaragua 2001-2005		
	Contribution to change in per capita GDP (value added)	Percent of total change in per capita GDP (value added)
Agriculture	125.2	32.8
Mining and Utilities	-15.7	-4.1
Manufacturing	166.1	43.5
Construction	-32.2	-8.4
Commerce	-16.2	-4.2
Transport	-5.2	-1.4
Government Services	15.7	4.1
Other	-40.5	-10.6
Total contribution	**197.3**	**51.6**
Monetary values are 1994 Córdobas		

Source: Table obtained using JoGGs Decomposition tool with data from Nicaragua's Central Bank and Nicaragua's Household Surveys (Encuesta de Medición del Nivel de Vida EMNV).

Figure 3b: Contribution of Change in Employment-to-Population Ratio to Change in GDP (Value Added) per capita, by Sector. Nicaragua 2001-2005



Source: Figure obtained using JoGGs Decomposition tool with data from Nicaragua's Central Bank and Nicaragua's Household Surveys (Encuesta de Medición del Nivel de Vida EMNV).

1.3 Step 3: Decomposing output per worker growth in within sectoral changes and between sectoral changes

1.3.1 Basic idea

We can further decompose output per worker into sectoral employment shifts and changes in output per worker within sectors by noting that:

$$\frac{Y}{E} = \sum_{S} \frac{Y_i}{E_i}\frac{E_i}{E}$$

Or equivalently:

$$\omega = \sum_{i=1}^{S} \omega_i s_i$$

Equation 2

where Y_i is Value Added of sector $i=1 \ldots S$; E_i is employment in sector I; and E is total employment. This means that $\omega_i = \frac{Y_i}{E_i}$ will correspond output per worker in sector *i*,

$s_i = \frac{E_i}{E}$ is the share of sector *i* in total employment. This equation just states that total output per worker is the weighted sum of output per worker in all sectors, where the weights are simply the employment share of each sector.

Using the Shapley approach, changes in aggregate output per worker can be decomposed into changes in output per worker within sectors (also known as within component), and movements of labor between sectors (also refer to as between component). Increases in output per worker within a sector will increase average output per worker. How big the effect is, will depend on the size of each sector (i.e. its share in total employment). On the other hand, relocation of workers across sectors of different productivity levels can increase average output per worker if the final relocation implies that a larger share of workers becomes employed in higher productivity sectors. Section 4.3 presents the formulas for the decomposition.

Once we can trace the growth in output per worker back to its within and between components, we can then calculate the amount of growth in *total* output *per capita* that can be linked to changes in output per worker in sector *i*, and to intersectoral relocation of labor by combining the contribution of each of these components to changes in output per worker, with the contribution of changes in output per worker to total per capita growth (obtained in step 1). As before, the contribution of changes in output per worker within a sector can be interpreted as the total per capita growth consistent with a counterfactual scenario, in which all else (employment rate, demographics, and output per worker in the remaining sectors) had all remained unchanged, and the only change had been the observed change in output per worker in sector *i.* The contribution of the intersectoral shift component can be interpreted as a counterfactual scenario in which the employment rate, the demographic structure of the population and output per worker in each sector had remained unchanged, and labor had reallocated across sectors as observed.

1.3.2 Data needed

To perform the decomposition data on employment and valued added by sector of economic activity is needed. Data on sectoral Value Added can usually be obtained from National Accounts, and employment data from Household Surveys or Labor Force Surveys. Care should be taken that both sources of information refer to the aggregate economy, in particular employment should refer to total employment rather than urban or formal employment alone. National accounts should also capture Value Added including non market activities in the rural sector. Most statistical offices now follow standard approaches to include all market and non market activities in National Accounts (for more details see United Nations National Accounts web site). Additionally, it is important that sectoral definitions in both National Accounts and Household Surveys are consistent. In many cases it will only be possible to analyze the basic disaggregation: Primary, Secondary and Tertiary Sectors.

Table 5 presents the data used for the decomposition in the case of Nicaragua; data sources are the same as those described before: national Accounts and Nicaragua's household surveys. The table shows output per worker for the two years under consideration as well as the percent growth for the period. Agriculture, Manufacturing and Government saw sharp decreases in output per worker.

Table 5: Changes in Output per Worker by Sectors. Nicaragua 2001-2005

	2001	2005	*% change*
Agriculture	10,973	9,988	-8.97
Mining and Utilities	43,097	55,364	28.47
Manufacturing	25,032	21,097	-15.72
Construction	14,701	15,393	4.70
Commerce	12,505	13,005	4.00
Transport	28,418	31,084	9.38
Government Services	37,223	32,239	-13.39
Other	14,308	15,643	9.33
Total output per worker	**15,757**	**15,477**	**-1.78**

Monetary values are 1994 Córdobas

Source: Table obtained using JoGGs Decomposition tool with data from Nicaragua's Central Bank and Nicaragua's Household Surveys (Encuesta de Medición del Nivel de Vida EMNV).

1.3.3 Results and interpretation

Table6a and Figure 4a below; show the results of applying the above formula to Nicaraguan data. The first column of the table shows the contribution of each sector as well as of inter-sectoral employment shifts to the observed growth in total output per worker. The C$279 reduction in output per worker for the period is accounted for by a C$991 reduction from Manufacturing, Agriculture and Government and an increase of C$644 in all other sectors, and an positive effect of inter-sectoral labor relocation of $C67. The fact that inter-sectoral shifts had a positive contribution means that on averge labor moved from lower than average productivity sectors to above average productivity sectors. As we saw in the previous section only Manufacturing, Agriculture and Government increased their employment shares, and among these only Manufacturing has productivity above the average. Thus we can conclude that an important share of growth in output per worker was due to movements of the labor force into Manufacturing. In the next section we will present a methodology that will clarify more precisely the role of each sector on this inter-sectoral shift component.

The second column of Table 6a shows the results as percentage of total output per worker growth. Of the total decrease in output per worker, agriculture accounted for 113.6%, and manufacturing explains 186% of the decrease, meaning that if other sectors had not acted in the opposite direction, output per worker would have deceased 13% and 86% more than what was observed, due to the effects of agriculture and manufacturing, respectively.

Table 6a: Decomposition of Output per Worker into Within Sector Changes in Output per Worker and Inter-sectoral Shifts.
Nicaragua 2001-2005

	Contribution to Change in Total Output per Worker	Contribution to Change in Total Output per Worker (%)
Agriculture	-317.7	113.6
Mining and Utilities	140.2	-50.1
Manufacturing	-521.4	186.4
Construction	33.8	-12.1
Commerce	111.8	-40.0
Transport	101.8	-36.4
Government Services	-152.6	54.6
Other	257.0	-91.9
Inter-sectoral shift	67.4	-24.1
Total change in output per worker	**-279.7**	100.0

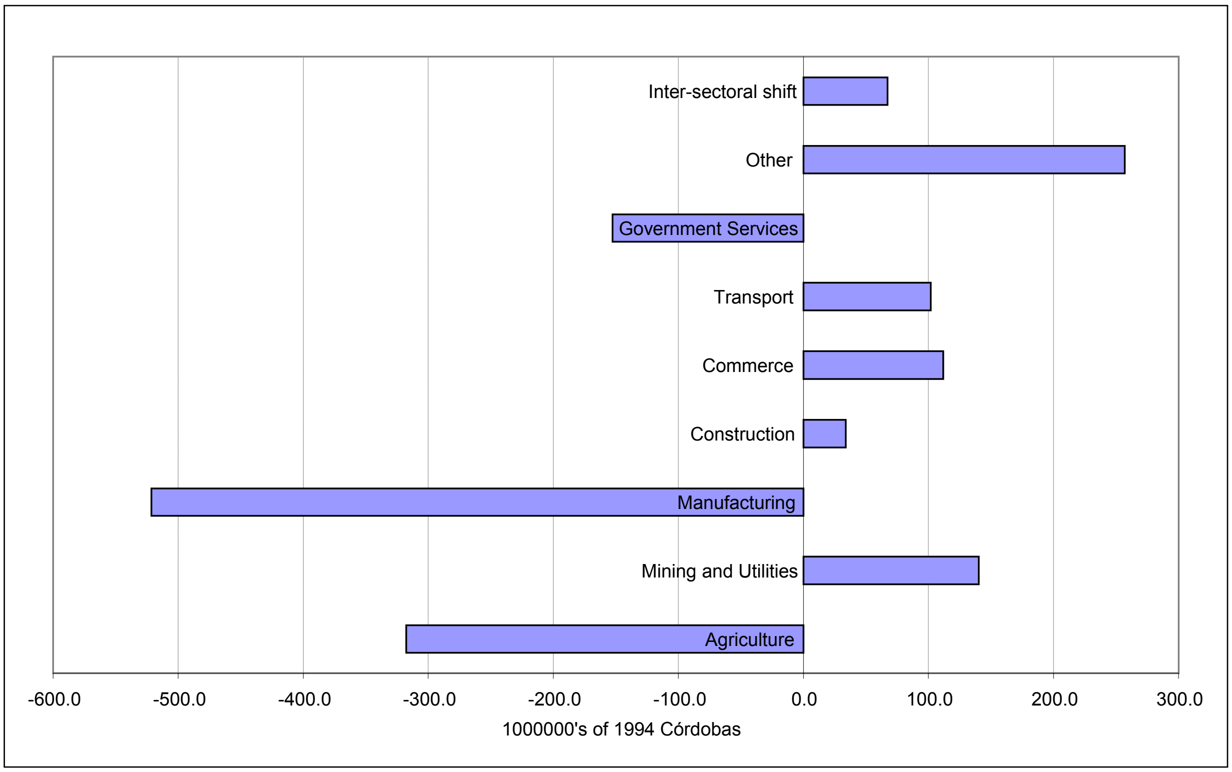
Monetary values are 1994 Córdobas

Source: Table obtained using JoGGs Decomposition tool with data from Nicaragua's Central Bank and Nicaragua's Household Surveys (Encuesta de Medición del Nivel de Vida EMNV).

In summary, Agriculture, Manufacturing and Government Services, all saw decreases in output per worker, and given their large share in total employment had important negative effects on aggregate output per worker. The other sectors exerted a positive effect on average output per worker, with Other Services having a big impact due to its large size. Inter-sectoral shifts, which capture movement of labor between sectors, exerted a positive effect on output per worker, which means that on average labor moved from low productivity sectors to high productivity sectors.

Table 6b and Figure 4b show the contribution of changes in output per Yorker and intersectoral shifts to total growth in *per capita value added*. In other words it is the result of combining the results of steps 3 and 1.

Figure 4a: Decomposition of Growth in Output per Worker: Inter-Sectoral Shift and Within Sectoral Output Growth. Nicaragua 2001-2005



Source: Figure obtained using JoGGs Decomposition tool with data from Nicaragua's Central Bank and Nicaragua's Household Surveys (Encuesta de Medición del Nivel de Vida EMNV).

Table 6b: Contribution of within Sector Changes in Output per Worker and Inter-sectoral Shifts to Change in GDP (value added) per capita. Nicaragua 2001-2005		
	Contribution to change in GDP (value added) per capita	**Percent of total change in GDP (value added) per capita**
Agriculture	-112.8	-29.5
Mining and Utilities	49.8	13.0
Manufacturing	-185.1	-48.5
Construction	12.0	3.1
Commerce	39.7	10.4
Transport	36.2	9.5
Government Services	-54.2	-14.2
Other	91.3	23.9
Inter-sectoral shift	23.9	6.3
Total contribution to change in per capita GDP (value added)	**-99.3**	**-26.0**
Monetary values are 1994 Córdobas		

Source: Table obtained using JoGGs Decomposition tool with data from Nicaragua's Central Bank and Nicaragua's Household Surveys (Encuesta de Medición del Nivel de Vida EMNV).

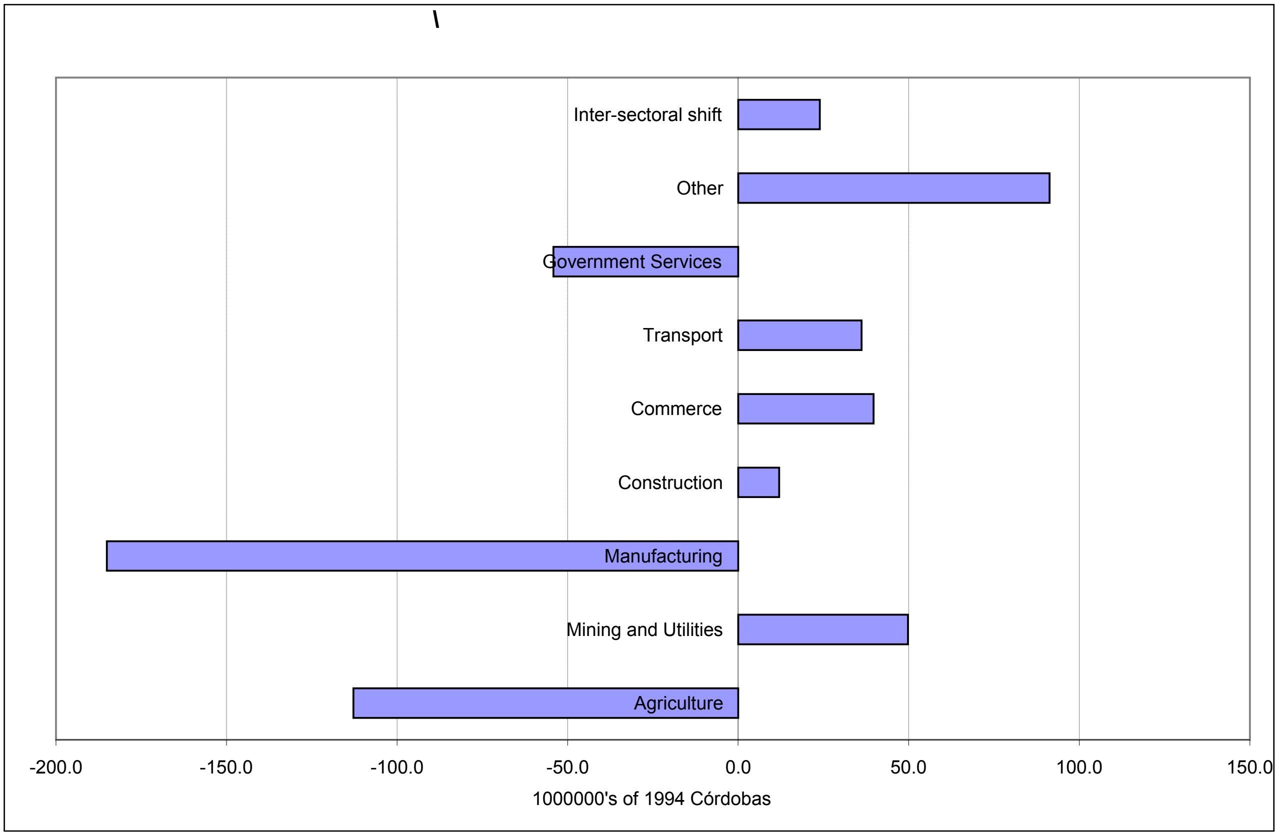
1.4 Step 4: understanding the sources of changes in total output per worker (net of inter-sectoral shifts) at the aggregate level

1.4.1 The basic idea

The previous section decomposed changes in output per worker into changes in output per worker within sectors and changes in output per worker due to movements of labor between sectors with different levels of productivity.

Aggregate and sectoral changes in output per worker ($\Delta\omega$), will capture changes in output per worker, but its interpretation is not so straight forward. Increases in output per worker can come from three different sources: i) increases in capital labor ratio ii) increases in Total Factor Productivity (TFP) and iii) relocation of jobs between bad jobs sectors (low productivity) to good jobs sector (high productivity), which we described above as the between component of growth in output per worker or the labor relocation effects .

Figure 4b: Contribution of Within Sector Output per worker Changes and Inter-Sectoral Shifts to Change in GDO (value added) per Capita. Nicaragua 2001-2005



Source: Figure obtained using JoGGs Decomposition tool with data from Nicaragua's Central Bank and Nicaragua's Household Surveys (Encuesta de Medición del Nivel de Vida EMNV).

To see this, note that under constant returns to scale, if $Y_t=\Phi_t f(E_t,K_t)$ where K_t is the capital stock and Φ_t a multiplicative shift parameter, then output per worker will be $Y_t/E_t= \Phi_t f(1,K_t/E_t)$. Therefore it will capture changes in capital labor ratio K_t/E_t, and changes in the shift parameter, Φ_t. Changes in the shift parameter will be capturing all other sources of growth not due to changes in capital labor ratio, or in other words the Solow residual. It will mainly capture changes in technology and relocation of production between sectors with different productivity levels (inter-sectoral shifts), but it may also capture cyclical behavior of output: firms operating in economic downturns may have underutilized capital, when the demand rises again; it will be reflected as rise in output per worker. From section 1.3 we found that it is possible to isolate the effect of inter-sectoral shifts ($\Delta\omega_B$). We can thus decompose within productivity changes (or productivity changes net of inter-sectoral shifts) into changes due to increases in the capital-labor ratio and the residual, which can be interpreted (with caution) as TFP growth.

If data on capital stock is available then we can assume a particular functional form for the production function and separate the contribution of higher capital-labor ratios and the rest. For example if we are willing to assume that the production function is Cobb-Douglas then:

$$\frac{Y}{E} = \Phi\left(\frac{K}{E}\right)^{1-\alpha}$$

In competitive markets 1-α is the share of payments to capital in total Value Added. It is usually available from national accounts data or if there are enough time series then it can be estimated (see Section 4.4). Once we have an estimate of α, we can calculate total factor productivity as a residual: In the first period it will be:

$$\left(\frac{Y}{E}\right)_{t=0} / \left(\frac{K}{E}\right)_{t=0}^{(1-\alpha)} = TFP_{t=0}.$$

In the second period we need to take into account that part of the change in output per worker due to relocation shifts so that:

$$\left[\left(\frac{Y}{E}\right)_{t=1} - \Delta\omega_B\right] / \left(\frac{K}{E}\right)_{t=1}^{(1-\alpha)} = TFP_{t=1}$$

The term in square brackets is just output per worker in period two net of relocation effects. In this way we are able to see whether changes in output per worker net of relocation effects, were due to increases in capital per worker (K/E) or in total factor productivity (net of relocation effects).

Once we have decomposed changes in output per worker into its two components -TFP and the capital labor ratio- we can calculate the amount of *total per capita growth* that can be linked to each component.

1.4.2 Data needed

To decompose changes in output per worker net of sectoral relocation effects (between component) data on capital *k* and the share of payments to labor α are needed. In addition, the relocation effect or between component, needs to be computed as shown in Section 1.3. This means that data on output and employment by sectors is needed, as well as aggregate capital stocks.

The hardest part is getting or constructing data on aggregate capital stocks. Investment series are usually available from National Accounts, but capital stocks are rather hard to come by. Section 2 discusses some alternatives and its caveats when a good series of capital stock or its share on payments to labor is not available.

For the example shown below we use the average (over the period under analysis) share of payments to labor as the sum of total payments to employees plus 30% of the item defined as mixed income, where mixed income comprises estimated income from self employment and other returns to self employment that may include returns to capital. Because we do not know what proportion of mixed income corresponds to returns to labor and what proportion corresponds to returns to capital we made alternative assumptions. We assume that the share of mixed income that corresponds to returns to labor is between 100% and 30%, where the 30% is the share of profits from constituted enterprises in Value Added. This give values of α in the range of 0.29 and 0.39. We perform the decomposition for both values and find that the story remains the same. We report only the results for α=0.29. It is recommended that when the share of payments to labor α are estimated with strong underlying assumption, the user tests for the sensitivity of the result to different values of α. Reasonable values of α are between 0.3 and 0.5. (For further discussions see http://www1.worldbank.org/prem/PREMNotes/premnote42.pdf)

To construct a capital series for Nicaragua we use the data on capital compiled by Nehru and Dhareshwar (1995), which gives us a capital stock for 1987, we then use the net investment series from Nicaragua's national accounts to construct capital stock series for the years 2001 and 2005 using a perpetual inventory method. For other sources of data and alternative computations see Larson et. al. (2002).

Table 7 illustrates the data used for this decomposition.

Table 7: Data used for Decomposition of Output per Worker, Capital Stocks, Capital Labor Ratio and Share of Capital in Total Income. Nicaragua 2001-2005

	2001	2005	% change
Share of Capital in Total Income (%)	29%	29%	0.00
Capital (000)	77,183	95,278	23.44
Total output per worker	15,757	15,477	-1.78
Output per worker net of inter-sectoral shifts	15,757	15,410	-2.20
Capital Labor Ratio	47,202	49,996	5.92
TFP residual net of inter-sectoral shifts	660	635	-3.85

Monetary values are 1994 Córdobas

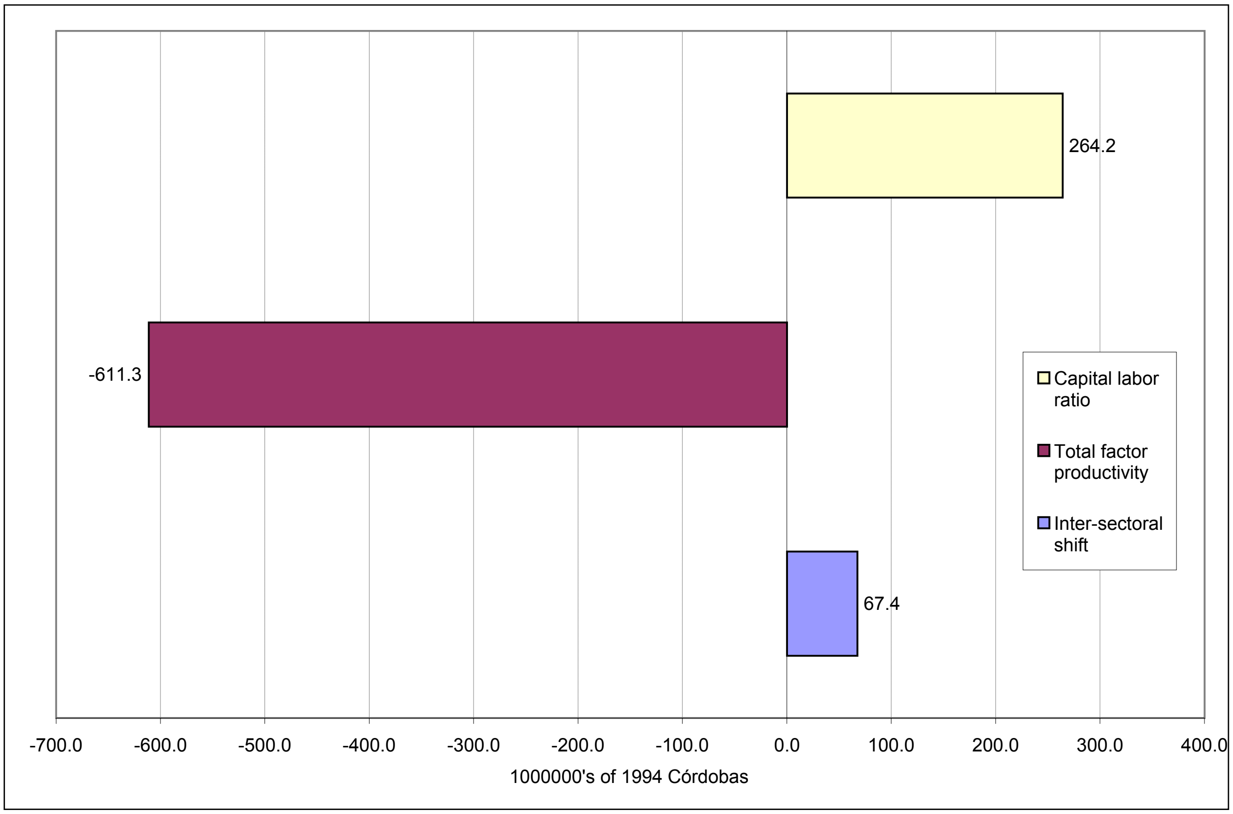
Source: Table obtained using JoGGs Decomposition tool with data from Nicaragua's Central Bank and Nicaragua's Household Surveys (Encuesta de Medición del Nivel de Vida EMNV).

1.4.3 Results and interpretation

Figure 5 show the decomposition of changes in aggregate output per worker for Nicaragua between 2001-2005. It illustrates the role of capital and TFP using the above formulas, as well as the inter-sectoral shifts calculated in step 3.

Total output per worker decreased 1.78 percent. Of this decrease inter-sectoral employment shifts exerted a positive effect on output per worker contributing with $67.4 Córdobas of total productivity growth. The capital labor ratio also increased, contributing an additional $264 Córdobas. But TFP suffered an important reduction more than offsetting the above effects. From this data we can clearly say that TFP changes are responsible for the decrease in output per worker. A natural next step would be to try to understand what were the forces behind TFP decreases.

Figure 5: decomposition of Changes in Output per Worker. Nicaragua 2001-2005



Source: Figure obtained using JoGGs Decomposition tool with data from Nicaragua's Central Bank and Nicaragua's Household Surveys (Encuesta de Medición del Nivel de Vida EMNV).

1.5 Step 5: Understanding the role of inter-sectoral employment shifts.

1.5.1 The basic idea

It is possible to understand further how changes in the share of employment in the different sectors help explain the overall contribution of inter-sectoral shifts to per capita growth or output per worker. A large number of studies have found that structural change, which is movements of labor force shares from low productivity sectors to high productivity sectors, is an important factor behind growth. Increases in the share of employment in sectors with above average productivity will increase overall productivity and contribute positively to the inter-sectoral shift term. On the contrary, movements out of sectors with above average productivity will have the opposite effect. By the same token, increases in the share employment in sectors with below average productivity should reduce growth, while reductions in their share should contribute positively to growth.

Thus if sector *i* has productivity below the average productivity, and decreases its share s_i, its contribution will be positive, that is outflows from this low productivity sector have contributed to the increase in output per worker. If on the other hand, the sector sees an increase in its share, these inflows into this low productivity sector will decrease output per worker and thus have a negative effect on the inter-sectoral shift term. The magnitude of the effect will be proportional to: i) the difference in the sector's productivity with respect to the average and ii) the magnitude of the employment shift.

Once we have calculated the contribution of each sector to changes in output per worker linked to employment relocation effects, we can proceed further and calculate the amount of total per capita growth that can be liked to relocation effects in each sector.

1.5.2 Data needed

For this Section data on employment by sector of economic activity and output per worker is needed. The sources of the data are the same as those used in previous sections, Mainly Nicaragua's Household surveys for sectoral employment and National Accounts for output by sectors.

1.5.3 Results and interpretation

Table 8 illustrates the results of this exercise. The first column shows average output per worker between 2001 and 2005, with the last row of the column showing average output per worker for the whole economy. The second column shows the change in employment shares in each sector. The final column shows the contribution of each sector to the C$67.36 contributed by inter-sectoral employment shifts to total growth in output per worker. Movements into Agriculture (a lower than average productivity sector) had a negative effect in productivity, while movements of labor into Manufacturing, which has above average productivity, raised aggregate productivity (contributed positively to the between component of productivity changes).

Table 8: Understanding the Role of Inter-Sectoral Employment Shifts. Nicaragua 2001-2005

	Average Output per Worker	Change in employment share (percent points)	Sectoral contribution to inter-sectoral shift component
Agriculture	10,481	0.011	-57.07
Mining and Utilities	49,230	-0.003	-108.91
Manufacturing	23,065	0.025	188.01
Construction	15,047	-0.008	4.31
Commerce	12,755	-0.011	31.08
Transport	29,751	-0.002	-32.50
Government Services	34,731	0.002	33.36
Other	14,975	-0.014	9.08
Aggregate	**15,617**		**67.36**
Monetary values are 1994 Córdobas			

Source: Table obtained using JoGGs Decomposition tool with data from Nicaragua's Central Bank and Nicaragua's Household Surveys (Encuesta de Medición del Nivel de Vida EMNV)

Table 9 shows the *percent* contribution of each term to the inter-sectoral shift or between components of productivity changes. Again we can see that Manufacturing played an important role.

Table 9: Decomposition of Inter-sectoral Shifts. Nicaragua 2001-2005

	Direction of Employment Share shift	Contribution to Inter-sectoral Shifts (%)
Sectoral contributions		
Agriculture	+	-84.72
Mining and Utilities	-	-161.67
Manufacturing	+	279.11
Construction	-	6.39
Commerce	-	46.14
Transport	-	-48.24
Government Services	+	49.52
Other	-	13.48
Total Contribution of inter-sectoral shifts		*100*

Source: Table obtained using JoGGs Decomposition tool with data from Nicaragua's Central Bank and Nicaragua's Household Surveys (Encuesta de Medición del Nivel de Vida EMNV)

1.6 Step 6: Putting everything together

1.6.1 Basic idea

Once the above steps are completed the percent contribution of each factor to total changes in GDP per capita can be obtained. A simple example will illustrate how this is done. Assume we want to know what the contribution of TFP changes to per capita GDP growth was. Using step 3 we calculate the percent contribution of TFP growth to total output per worker growth, denote this by $\overline{TFP}^{\varpi}$, and from step 2 we calculated the share of growth of GDP per capita that was linked to changes output per worker, denote this by $\overline{\varpi}$. Thus the share of growth in per capita GDP that can be attributed to TFP changes will be $\overline{TFP} = \overline{TFP}^{\varpi} * \overline{\varpi}$. And the amount of growth that can be linked to changes in TFP will be $\overline{TFP} * \Delta y$. Section 4.6 shows the detailed formulas for all components and sub-components.

1.6.2 Results and interpretation

Table 10a and Table 10b below illustrates the results for Nicaragua, in Percentage contribution and in Córdobas of 1994, respectively. The demographic component accounts for three quarters of all the change. The other 25% is explained by a decrease in output per worker within sectors (-31%), an increase in the share of working age population employed (51%), and a positive effect of labor relocation (6%), which on average moved from low productivity sectors to high productivity sectors.

When looking across sectors the biggest role was played by the Manufacturing (12%) sector and others (services, and finance mainly, 14%).

Sectoral contributions are decomposed into: i) contribution of within changes in output per worker (first column), ii) contribution of changes in employment (second column), and iii) contributions of the sector to the inter-sectoral employment shifts. The final column is the total effect of the sector. Overall, Manufacturing, Commerce, Transport and Other Services contributed positively to growth, while Agriculture, Mining and Utilities, Construction and Government had a negative contribution.

Table 10a : Growth Decomposition. Percent Contribution to Total Growth in GDP (value added) per capita, Nicaragua 2001-2005

	Contribution of within sector changes in output per worker (%)	**Contribution of changes in Employment (%)**	**Contributions of Inter-sectoral Shifts (%)**	**Total (%)**
Sectoral contributions				
Agriculture	-29.53	32.78	-5.30	-2.05
Mining and Utilities	13.03	-4.11	-10.12	-1.20
Manufacturing	-48.47	43.48	17.48	12.49
Construction	3.14	-8.44	0.40	-4.90
Commerce	10.39	-4.23	2.89	9.05
Transport	9.46	-1.37	-3.02	5.08
Government Services	-14.19	4.11	3.10	-6.97
Other	23.89	-10.59	0.84	14.14
Subtotals	*-32.26*	*51.64*	*6.26*	*25.64*
Demographic component	-	-		74.36
Total				100.00
Total % change in value added per capita 2001-2005				**7.14**

Source: Table obtained using JoGGs Decomposition tool with data from Nicaragua's Central Bank and Nicaragua's Household Surveys (Encuesta de Medición del Nivel de Vida EMNV)

Despite the enormous employment growth in Manufacturing, the decrease in output per worker was so large that it more than offset the employment growth. However, shifts of labor into Manufacturing (i.e. the relative size of the Manufacturing sector) and away from other sectors of lower productivity, more than compensates this effect , so that in the aggregate Manufacturing contributed with 12 percent of total per capita growth. Other Services accounted for a non-negligible 14 percent of observed growth of output per capita;

and Commerce and Transport contributed with 9 and 5 percent of the growth, respectively. In all three sectors the effect was mostly due to increases in output per worker. Agriculture, on the other hand contributed negatively to per capita growth, via two different effects, first it saw a decrease in output per worker and second it increased its share of total employment. Given that it has productivity below average this shift toward Agriculture reduced growth.

Table 10b: Growth Decomposition. Contribution to Total Growth in GDP (value added) per capita, Nicaragua 2001-2005

	Contribution of within sector changes in output per worker	**Contribution of changes in Employment**	**Contributions of Inter-sectoral Shifts**	**Total**
Sectoral contributions				
Agriculture	-112.80	125.24	-20.27	-7.82
Mining and Utilities	49.79	-15.71	-38.67	-4.59
Manufacturing	-185.14	166.10	66.76	47.72
Construction	12.01	-32.25	1.53	-18.71
Commerce	39.69	-16.16	11.04	34.56
Transport	36.15	-5.22	-11.54	19.40
Government Services	-54.19	15.72	11.85	-26.63
Other	91.26	-40.46	3.22	54.03
Subtotals	*-123.24*	*197.27*	*23.92*	*97.95*
Demographic component	-	-		284.07
Total change in value added per capita				382.02

Monetary values are 1994 Córdobas

Source: Table obtained using JoGGs Decomposition tool with data from Nicaragua's Central Bank and Nicaragua's Household Surveys (Encuesta de Medición del Nivel de Vida EMNV)

What can we conclude from the pattern of growth in Nicaragua and its potential effect in poverty reduction? Although not sufficient, rises in income per Capita are necessary for poverty reduction. Identifying which sectors and factors are most linked to per capita GDP growth is a first step in identifying where we should look into to understand poverty reduction. The results from Nicaragua suggest that there can be three important drivers in poverty changes. First, the demographic changes of the population are generating a window of opportunity to raise per capita income and thus reduce poverty: there are now fewer dependent per working age adults and this trend is likely to continue. If adults manage to engage in productive activities and sectors, this demographic shift will have an important poverty reducing impact. Second, there has been an influx of workers into agriculture, a sector with below average output per worker, which is contributing negatively to per capita growth, and as such may increase poverty. Understanding the sources of this influx and whether it is responding to better working opportunities or not is an important issue to look into. Why are these workers engaging in agricultural activities and what income are they deriving?, In addition output per worker in Nicaragua seems decreased. Because many of the poor are engaged in agricultural activities understanding the source of this reduction and how it translates into income for the poor is crucial. The final factor that stands out in this Nicaragua example is the influx of workers into manufacturing, which appears to be linked to higher per capita GDP and as such should contribute to poverty reduction. However, manufacturing has also displayed a decrease in output per worker. How well paying are these new manufacturing jobs? Do the poor have access to them? What types of jobs are being created? Where is this growth in manufacturing employment come from? Is it sustainable?.

2 Cautionary notes on interpretation of results

- **Causality**. It is important to highlight that this is an exercise in growth accounting, these are accounting identities and as such do not have a causal interpretation. When we see an increase in the number of employed together with an increase in GDP we can't say that GDP increased because there were more people working or that more people where able to work because GDP grew. That is, both employment and output are equilibrium outcomes, or in other words they are both endogenous variables. Causality can only be given by the model one believes to be generating the underlying movements. Perhaps the only variable that could be considered exogenous, in the short run, is the structure of the population. However in the long run demographic variables also respond to growth. The objective of this exercise is to do some growth accounting, to show how a particular growth is accompanied by employment and productivity growth, and by a sectoral relocation of labor. It is not intended to explain why such a pattern occurred. Its end objective is to pinpoint the sectors and factors that merit further study in the analysis of the links between poverty and GDP growth. The model is not intended either as a forecasting or extrapolation tool.

- **Size effects and sensitivity analysis**. The example for Nicaragua illustrated that small changes in big sectors, or large components can account for large fractions of the change in Per capita GDP. The reason behind this behavior is that the effect of a change in any component (employment rate, demographics or output per worker) or sector is weighted by its relative importance (i.e. size) in GDP per capita. Small changes are more likely to be measurement error. When this error occurs in a large sector or component, it is magnified in the decomposition. When interpreting the results it is important to be aware when small changes are occurring in big sectors and components. For example if there is a very small change in the share of population in agriculture, and agriculture is a large sector, as is often the case in many low income countries, it is important to validate whether such changes occurred with other sources of data, and if possible do sensitivity analysis for other possible observed changes.

- **Interpretation of output per worker declines in sectors with rapidly expanding employment.** It is often the case that sectors that experience rapid employment growth see declines in output per worker. In the short run this is indeed expected as decreasing marginal productivity sets in. Despite this short run decreases in output per worker, the sector may still be generating productivity gains as a whole, if it is a sector with above average productivity or which is experiencing dynamism that may result in future investment and thus higher output per worker in the long run. Thus a short run decrease in output per worker does not necessarily mean stagnating sector in the medium or long run.

- **Capital** is often the hardest data to get. In many cases it is inevitable to work with estimated data, and with assumed capital shares in total payments. A frequent resource when there is no data on capital stock for any point in time is to assume that in a given year the capital stock was a fixed percentage of GDP, and often this percentage comes from ad-hoc assumptions or regional averages. The same is true for the share of capital in total payments, α. When this is the case it is important to test different assumption and compare the results, if several assumptions yield similar stories then results can be considered robust. If on the other hand different assumptions yield very different 'stories', the analyst should be suspicious, and should avoid drawing any conclusions or policy recommendations from the results.

- **Data reliability**. The decomposition is only meaningful if the data used to perform it is reliable. It is important that National Accounts and employment data cover the same universe, that is, the entire population, and all market and non-market output. It is important to understand the source of National accounts and the methodologies used to construct it. Data that relies on 'estimated' or projected sectoral information, will give a distorted picture when paired with observed employment data from household surveys. For example, there might be an important influx of workers to the urban sector due to agricultural crisis during the period of analysis; this influx will most likely be reflected in the household surveys as an increase in employment in sectors predominant in urban areas. However, if sectoral output is 'projected' based on past performance and some 'estimated' growth rate, urban output will inadequately capture the production resulting from these new urban workers. This will tend to bias the change in output per worker downward.

- **Issues with Migration**. Household surveys used to calculate employment figures usually consider non-migrant population only. Two issues might be present i) shifts in migration patterns are not taken into account in census used to construct expansion weight for the household surveys; and ii) immigrants may not be included in the sample either. In the first case, because household surveys use census data to construct the weights used to expand the sample to be representative of the total population, the population from household surveys will be under or overestimated. If there was an increase in outward migration, the survey will show more workers than there actually are and thus underestimate output per worker. The opposite will be true if there was an increase in inward migration. In the second case, temporary immigrants or day workers will increase output but will not be counted among the employed and thus output per worker will be overestimated. Therefore, in countries with significant migration, or with shifts in migration patterns, it is important to be aware of these caveats when analyzing the results: changes in output per worker may be due to migration phenomena.

- **Links between output per worker and earnings**. Analysts are often quick to conclude that because average output per worker has increased, so has average wage; and thus conclude that increases in productivity imply that workers are better off. From an empirical point of view, this is often the case: average output per worker is positively correlated with average wages for aggregate data, across time and across countries[6]. It also holds true within a country across industries. However, these are average behaviors which need no be true in individual countries, for specific periods in time. From a theoretical point of view, it is the (unobserved) marginal product of labor and not the (observed) average product of labor what determines wages. Only in the case of simple Cobb-Douglas technology the average product is proportional to the marginal product. And even in this case, other forces such as bargaining power, minimum wages or monoposony power may drive a wedge between marginal product and wages. If increases in productivity make countries and firms more competitive, and widen their market, labor demand is likely to increase and with it wages. However, if firms or countries face a fixed demand, increases in productivity mean that fewer workers are needed to produce the same amount of output, labor demand may decrease and with it wages. The above framework identifies the changes in output per worker that might potentially increase the earnings of the poor. An important step is to look further into the growing sectors and identify, whether the changes in output per worker have indeed affected wages and whether the poor have had access or not to this wage employment.

3 Using JoGGs decomposition tool

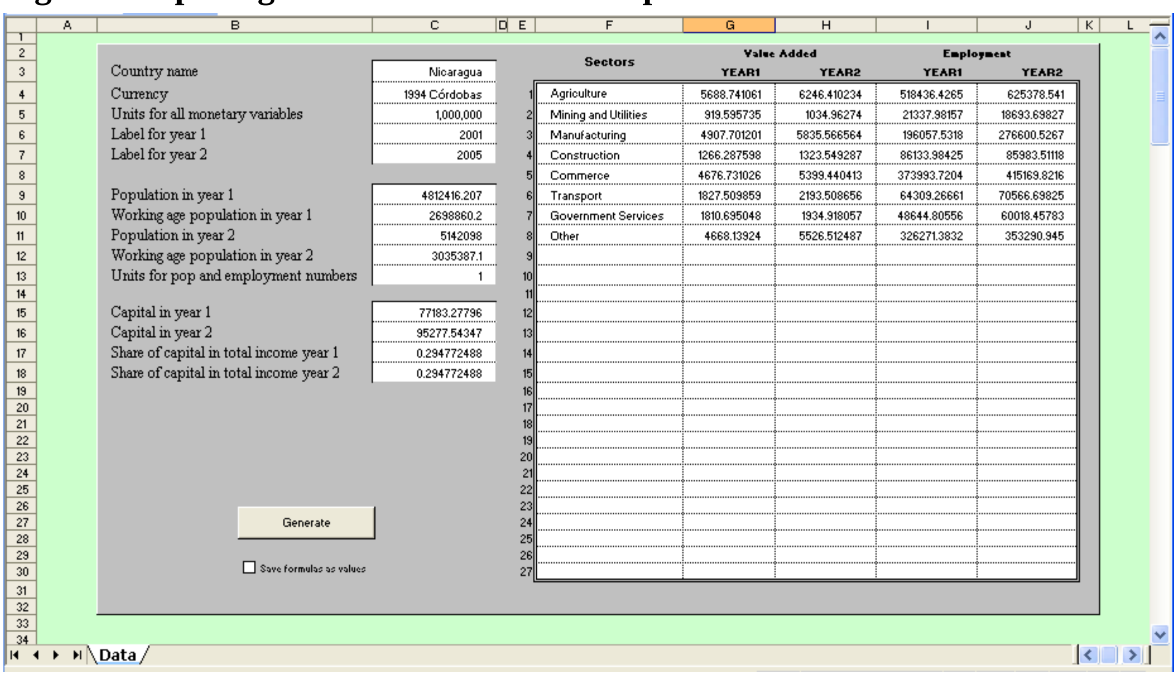
JoGGs decomposition tool –JoGGs for Job Generation and Growth- is an excel based macro-spreadsheet, that allows users to input their data and get all the decomposition results and tables presented in this note.

[6] See Mortensen D. (2005). And Oi and Ison (1999) for evidence on the link between wages and average productivity across firms and sectors; and Rodrik (1998) for evidence on the link between wages and average output per worker across countries and across time

To use the program the user need only open the excel file. The program will prompt a security warning asking whether the user wants to allow for macros. Press "enable macros". Once the spreadsheet is open, you will find a spreadsheet named 'data', which looks as illustrated in Figure 6. The spreadsheet contains the data used for the Nicaragua examples. The user can generate the tables to see how this example works, or can directly input his/her data.

Data should be input in columns C, and columns F to J. In Column C the user will need to provide three sets of information. The first set contains the labels that will appear in the graphs and tables and units of monetary values: The country (Nicaragua in the example), the currency of the monetary values (Constant Córdobas of 1994 in this example), the units of <u>ALL</u> the monetary values (in this case millions) and, the years for which the decomposition is performed (2001 and 2005). The second set refers to population and population numbers. The user will need to provide the total population and the working age population in both years and the units in which this data is being provided. In the example here the population figures are in number of people, and thus 1 (units) is the value provided. Population can be provided in any unit (hundreds, thousands, millions etc.) The third set of data in column C corresponds to capital. The user will need to provide the capital stock in both years and the share of capital in total payments (α). The units in which capital is provided will need to be the same as all other monetary values in the dataset. If no capital information is available this part of the decomposition will be skipped.

Figure 6: Opening Screen of JoGGs Decomposition tool



Country name	Nicaragua
Currency	1994 Córdobas
Units for all monetary variables	1,000,000
Label for year 1	2001
Label for year 2	2005
Population in year 1	4812416.207
Working age population in year 1	2698860.2
Population in year 2	5142098
Working age population in year 2	3035387.1
Units for pop and employment numbers	1
Capital in year 1	77183.27796
Capital in year 2	95277.54347
Share of capital in total income year 1	0.294772488
Share of capital in total income year 2	0.294772488

	Sectors	Value Added		Employment	
		YEAR1	YEAR2	YEAR1	YEAR2
1	Agriculture	5688.741061	6246.410234	518436.4265	625378.541
2	Mining and Utilities	919.595735	1034.96274	21337.98157	18693.69827
3	Manufacturing	4907.701201	5835.566564	196057.5318	276600.5267
4	Construction	1266.287598	1323.549287	86133.98425	85983.51118
5	Commerce	4676.731026	5399.440413	373993.7204	415169.8216
6	Transport	1827.509859	2193.508656	64309.26661	70566.69825
7	Government Services	1810.695048	1934.918057	48644.80556	60018.45783
8	Other	4668.13924	5526.512487	326271.3832	353290.945

Columns F to J are the areas to input employment data and value added data. Column F provides space to indicate the label attached to each row of data. If only aggregate data is available then only one row of data will need to be provided and the label should reflect this (e.g. aggregate economy, or total). The program will perform the decomposition only for the aggregate data (i.e. no sectoral disaggregation). The spreadsheet allows up to 27 sectors. Employment figures should be provided in the same units as population numbers, and value added should be provided in the same units as all other monetary values.

Once all the data has been added, the user only needs to press the 

button and all the tables and graphs will be displayed. The spreadsheet can then be saved as any excel worksheet with a custom file name.

You can save the spreadsheet either as values by selecting the option *'save formulas as values'*, or you can save the worksheet as formulas (if you do not select this option). Leaving this option unselected will allow you to re-generate all the graphs and tables every time you open the spreadsheet. Every time you open the file the data you entered will be saved, and you can make any changes and generate the tables and graphs again. Leaving this option unselected is useful if you are still checking your data, and are likely to modify it. Additionally, if you do not select this option, all tables and graphs will have the underlying formulas, for you to see.

Instead, if you select the option *'save formulas as values'* all graphs and tables will be generated with values instead of formulas. You will no longer be able to make changes to the data and regenerate the tables and graphs. However, selecting this option makes it easier to make format changes. For example, you can add or delete parts of the title with out having to re-write it all. If you do not select the *'save formulas as values'* option and you want to change the title of a table you will need to replace the formula by completely writing the new title you want to use.

We suggest that you work with out selecting this option until you are sure the data is correct and your results make sense. You can then save the file with a name that tells you that this is the 'working' spreadsheet. You can then select the option *'save formulas as values'* save this file with a different name that lets you know these are the final results, and then make all the format changes you wish to do.

4 The Shapley decomposition approach: formulas and methodology

4.1 Step 1: decompose aggregate growth

A simple way of understanding how growth has translated into increases in productivity and employment at the aggregate level and by sectors (or regions), is to perform a simple decomposition of growth in per capita GDP. To do so, note that per capita GDP, *Y/N=y* can be expressed as:

$$\frac{Y}{N}=\frac{Y}{E}\frac{E}{A}\frac{A}{N}$$

Equation 3

Or:

$$y=\omega * e * a$$

where Y_i is total Value Added E is total employment, A is the total population of working age and N is total population. In this way Y/E=ω it total output per worker, E/A is the share of working age population (i.e. the labor force) employed and A/N is the labor force as a fraction of total population. We will refer to *e*, as the employment rate.

Thus changes in per capita Value Added can be decomposed into changes in output per worker, changes in employment rates and changes in the size of the labor force. Using Shapley decompositions this will be equal to:

$$\Delta y=\Delta\omega\left[\frac{1}{3}\left(e_{t=1}a_{t=1}+e_{t=0}a_{t=0}\right)+\frac{1}{6}\left(e_{t=1}a_{t=0}+e_{t=0}a_{t=1}\right)\right]+\Delta e\left[\frac{1}{3}\left(\omega_{t=1}a_{t=1}+\omega_{t=0}a_{t=0}\right)+\frac{1}{6}\left(\omega_{t=1}a_{t=0}+\omega_{t=0}a_{t=1}\right)\right]+$$
$$\Delta a\left[\frac{1}{3}\left(\omega_{t=1}e_{t=1}+\omega_{t=0}e_{t=0}\right)+\frac{1}{6}\left(\omega_{t=1}e_{t=0}+\omega_{t=0}e_{t=1}\right)\right]$$

The first term in the summation will be the contribution of changes in output per worker, the second term the contribution of changes in the employment rate and the third term the contribution to changes in the demographic component.

With this information we can present aggregate growth in terms of each of these components:

- The fraction of growth that can be linked to changes in output per worker
  $$\bar{\omega}\equiv\Delta\omega\left[\frac{e_{t=1}a_{t=1}+e_{t=0}a_{t=0}}{3}+\frac{e_{t=1}a_{t=0}+e_{t=0}a_{t=1}}{6}\right]/\Delta y$$
- The fraction of growth that can be linked to changes in the employment rate
  $$\bar{e}\equiv\Delta e\left[\frac{\omega_{t=1}a_{t=1}+\omega_{t=0}a_{t=0}}{3}+\frac{\omega_{t=1}a_{t=0}+\omega_{t=0}a_{t=1}}{6}\right]/\Delta y$$
- The fraction of growth that can be linked to changes in the share of total population of working age
  $$\bar{a}\equiv\Delta a\left[\frac{\omega_{t=1}e_{t=1}+\omega_{t=0}e_{t=0}}{3}+\frac{\omega_{t=1}e_{t=0}+\omega_{t=0}e_{t=1}}{6}\right]/\Delta y$$

where the bar denotes the fraction of growth explained by the component. In this way percentage growth between two periods can be expressed as:

$$\frac{\Delta y}{y} = \overline{\omega}\frac{\Delta y}{y} + \overline{e}\frac{\Delta y}{y} + \overline{a}\frac{\Delta y}{y}$$

4.2 Step 2: Understanding which sectors contributed most to employment generation.

To understand the way in which sectors contributed to employment generation we can further decompose employment (rate) growth (Δe) by sectors. The easiest is of course to express the total growth in employment as the sum of employment generation in each sector.

$$\Delta e = \sum_{i=1}^{s} \Delta e_i$$

Where $\Delta e_i = \Delta \frac{E_i}{A}$ is just the change in employment in sector *i* as a share of total working age population. Let $\overline{e}_i^e \equiv \Delta e_i / \Delta e$, denote the fraction of the aggregate employment rate change that can be linked to changes in employment in sector *i*. The supra-index *e* makes explicit that it is the contribution to employment growth (as opposed to total per capita growth, contribution to per capita growth have no supra-index).

Once we have decomposed aggregate employment growth we can go further and i) decompose changes in the overall employment rate *e,* to understand the role played by different sectors and ii) decompose total output per worker ω, to understand the role of capital, Total Factor Productivity and inter-sectoral employment shifts. This last step can be undertaken both at the aggregate level and by sectors, depending on data availability. This amounts to doing a step-wise decomposition: first decomposing aggregate growth into employment and productivity changes and the decomposing employment and productivity changes, into other sub-components.

4.3 Step 3: Decompose changes in output per worker by sectors and in between and within components

We can further decompose output per worker into sectoral employment shifts and changes in output per worker by sectors by noting that:

$$\frac{Y}{E}=\sum_{S}\frac{Y_i}{E_i}\frac{E_i}{E}$$

Or equivalently:

$$\omega=\sum_{i=1}^{S}\omega_i s_i$$

Equation 4

where Y_i is Value Added of sector $i=1...S$, E_i is employment in sector i, and E is total employment. This means that $\omega_i=\frac{Y_i}{E_i}$ will correspond output per worker in sector i, $s_i=\frac{E_i}{E}$ is the share of sector i in total employment. This equation just states that changes in output per worker are the weighted sum of changes in output per worker in all sectors, where the weights are simply the employment share of each sector.

Using the Shapley approach, changes in aggregate output per worker can be decomposed as:

$$\Delta\omega=\underbrace{\Delta\omega_1*\left(\frac{s_{1,t=0}+s_{1,t=1}}{2}\right)+\Delta\omega_2*\left(\frac{s_{2,t=0}+s_{2,t=1}}{2}\right)+...+\Delta\omega_S*\left(\frac{s_{i,t=0}+s_{i,t=1}}{2}\right)}_{\Delta\omega_w}+\underbrace{\sum_{i=1}^{S}\Delta s_i*\left(\frac{\omega_{i,t=0}+\omega_{i,t=1}}{2}\right)}_{\Delta\omega_B}$$

Each term $\Delta\omega_i*\left(\frac{s_{i,t=0}+s_{i,t=1}}{2}\right)$ corresponds to the change in output per worker due to changes in output per worker in sector s. The last term in the equation $\Delta\omega_B$ can be interpreted as the change in output per worker due to inter-sectoral employment changes (i.e. net movements of workers between sectors). That is, employment movements from low productivity sectors to high productivity sectors should increase total output per worker, and the flows from high productivity sectors to low productivity sectors should reduce aggregate output per worker. If this last term is negative the relocation of employment by sectors was detrimental to overall productivity growth. Finally, the term $\Delta\omega_w$ corresponds to total changes in output per worker net of relocation effects, which is also referred to as the 'within component'. That is changes in total productivity due to changes in productivity within sectors.

We can then denote the fraction of aggregate output per worker growth that can be linked to growth in output per worker in sector i as $\bar{\omega}_i^{\omega}\equiv\Delta\omega_i*\left(\frac{s_{i,t=0}+s_{i,t=1}}{2}\right)/\Delta\omega$, where again the bar denotes the fact that we are referring to percent contributions, and the supra-index denotes the fact that it is a contribution to growth in aggregate output *per worker* ω, rather than a contribution to growth in output *per capita y.*

Similarly we can define the contribution of within sector productivity growth as $\bar{\omega}_w^{\omega} \equiv \Delta\omega_w / \Delta\omega$ and the contribution of inter-sectoral shifts as $\bar{\omega}_B^{\omega} \equiv \Delta\omega_B / \Delta\omega$

4.4 Step 4: understanding the sources of changes in output per worker (net of inter-sectoral shifts) at the aggregate level.

The previous section decomposed changes in output per worker into changes in putput per worker within sectors and changes in output per worker due to movements of labor between sectors with different levels of productivity.

Aggregate and sectoral changes in output per worker (Δω), will capture changes in output per worker, but its interpretation is not so straight forward. Increases in output per worker can come from three different sources: i) increases in capital labor ratio ii) increases in Total Factor Productivity (TFP) and iii) relocation of jobs between bad jobs sectors (low productivity) to good jobs sector (high productivity), which we described above as the between component of growth in output per worker or the labor relocation effects .

To see the this, note that under constant returns to scale, if $Y_t=\Phi_t f(E_t,K_t)$ where K_t is the capital stock and Φ_t a parameter, then output per worker will be $Y_t/E_t= \Phi_t f(1,K_t/E_t)$. Therefore it will capture changes in capital labor ratio K_t/E_t, and changes in the parameter, Φ_t. Changes in the parameter Φ_t will be capturing all other sources of growth not due to changes in capital labor ratio, or in other words the Solow residual. It will mainly capture changes in technology and relocation of production between sectors with different productivity levels (inter-sectoral shifts), but it may also capture cyclical behavior of output: firms operating in economic downturns may have underutilized capital, when the demand rises again; it will be reflected as rise in output per worker. From section 1.4 we found that it is possible to isolate the effect of inter-sectoral shifts ($\Delta\omega_B$). We can thus decompose within productivity changes (or productivity changes net of inter-sectoral shifts) into changes due increases in capital-labor ratio and the residual, which can be interpreted (with caution) as TFP growth.

If data on capital stock is available then we can assume a particular functional form for the production function and separate the contribution of higher capital-labor ratios and the rest. For example if we are willing to assume that the production function is Cobb-Douglas then:

$$\frac{Y}{E} = \Phi\left(\frac{K}{E}\right)^{1-\alpha}$$

In competitive markets 1-α is the share of payments to capital in total Value Added. It is usually available from national accounts data or if there are enough time series then it can be estimated by taking logs and estimating:

$$\ln\frac{Y}{E} = \ln\Phi + (1-\alpha)\ln\left(\frac{K}{E}\right) + t + \mu$$

Where t is an (optional) time trend capturing technological change and μ is a residual. Once we have a value of α we can proceed to decompose changes in output per worker net of inter-sectoral shifts, into changes in Total factor Productivity and changes in the capital-labor ration.

Once we have an estimate of α, we can calculate total factor productivity as a residual: In the first period it will be:

$$\left(\frac{Y}{E}\right)_{t=0} / \left(\frac{K}{E}\right)_{t=0}^{(1-\alpha)} = TFP_{t=0}.$$

In the second period we need however to take into account that part of the change in output per worker was due to relocation shifts so that:

$$\left[\left(\frac{Y}{E}\right)_{t=1} - \Delta\omega_B\right] / \left(\frac{K}{E}\right)_{t=1}^{(1-\alpha)} = TFP_{t=1}$$

The term in square brackets is just output per worker in period two net of relocation effects. In this way we are able to see whether changes in output per worker net of relocation effects, where due to increases in capital per worker or in total factor productivity:

$$\Delta\omega_w = \Delta k^{1-\alpha}\frac{(TFP_{t=0} + TFP_{t=1})}{2} + \Delta TFP\frac{(k^{1-\alpha}{}_{t=0} + k^{1-\alpha}{}_{t=1})}{2}$$

Where k is simply the capital-labor ratio. The first tem in the right-hand side is the contribution of changes in the capital labor ratio to growth in output per worker net of relocation effects, and the second term is the contribution of changes in TFP.

This means that changes in total output per worker can be expressed as the sum of changes in TFP, changes in the capita labor ratio and inter-sectoral shifts:

$$\Delta\omega = \underbrace{\Delta k^{1-\alpha}\frac{(TFP_{t=0} + TFP_{t=1})}{2} + \Delta TFP\frac{(k^{1-\alpha}{}_{t=0} + k^{1-\alpha}{}_{t=1})}{2}}_{\Delta\omega^w} + \Delta\omega_B$$

As before let $\bar{k}^{\omega} \equiv \Delta k^{1-\alpha}\frac{(TFP_{t=0} + TFP_{t=1})}{2} / \Delta\omega$ denote the share of output per worker that can be linked to changes in the capital labor ratio, $\overline{TFP}^{\omega} \equiv \Delta TFP\frac{(k^{1-\alpha}{}_{t=0} + k^{1-\alpha}{}_{t=1})}{2} / \Delta\omega$ denote the share of growth in output per worker that can be linked to TFP changes $\bar{\omega}_B{}^{\omega} \equiv \Delta\omega_B / \Delta\omega$ denote the share of changes in output per worker that can be attributed to inter-sectoral employment shifts.

4.5 Step 5: Understanding the role of inter-sectoral employment shifts.

It is possible to understand further how changes in the share of employment in the different sectors help explain the overall contribution of inter-sectoral shifts to per capita growth or output per worker. An large number of studies has found that structural change, which is movements of labor force shares form low productivity sectors to high productivity sectors, is an important factor behind growth. Increases in the share of employment in sectors with above average productivity will increase overall productivity and contribute positively to the inter-sectoral shift term. On the contrary, movements out of sectors with above average productivity will have the opposite effect. By the same token, increases in the share employment in sectors with below average productivity should reduce growth, while reduction in their share should contribute positively to growth.
Using the above intuition we can rewrite the intersectional shift term as as:

$$\Delta\omega_B = \sum_{i=1}^{S} \Delta s_i \left(\frac{\omega_{i,t=0} + \omega_{i,t=1}}{2} - \frac{\omega_{t=0} + \omega_{t=1}}{2} \right)$$

The term in parenthesis is the difference between a sector *i*'s productivity (averaged between the two periods) $\frac{\omega_{i,t=0} + \omega_{i,t=1}}{2}$ and the average productivity of all the economy (note there is no sectoral sub-index i, to refer to the aggregate) $\frac{\omega_{t=0} + \omega_{t=1}}{2}$. Therefore, the contribution of sector *i* to the inter-sectoral shifts term will be:

$$\Delta s_i \left(\frac{\omega_{i,t=0} + \omega_{i,t=1}}{2} - \frac{\omega_{t=0} + \omega_{t=1}}{2} \right)$$

Thus if sector *i* has productivity below the average productivity, and increases its share s_i, its contribution will be positive, that is outflows from this low productivity sector have contributed to the increase in output per worker. If on the other hand, the sector sees an increase in its share, these inflows into this low productivity sector will decrease output per worker and thus have a negative effect on the inter-sectoral shift term. The magnitude of the effect will be proportional to: i) the difference in the sector's productivity with respect to the average and ii) the magnitude of the employment shift.

As before we can denote the share of inter-sectoral shift that is explained by sector *i* as:

$$\overline{s}_i^{\omega_B} = \Delta s_i \left(\frac{\omega_{i,t=0} + \omega_{i,t=1}}{2} - \frac{\omega_{t=0} + \omega_{t=1}}{2} \right) / \Delta\omega_B$$

4.6 Step 6: Putting everything together

Once the above steps are completed the percent contribution of each factor to total changes in GDP <u>per capita</u> can be obtained as follows:

Contribution of	**Formula**	Comments
1. Demographic shifts	$\overline{a} \equiv \Delta a \left[\frac{\omega_{t=1}e_{t=1} + \omega_{t=0}e_{t=0}}{3} + \frac{\omega_{t=1}e_{t=0} + \omega_{t=0}e_{t=1}}{6} \right] / \Delta y$	As in step 1

2. Contribution of aggregate changes in output per worker	$\overline{\omega} \equiv \Delta\omega\left[\frac{e_{t=1}a_{t=1}+e_{t=0}a_{t=0}}{3}+\frac{e_{t=1}a_{t=0}+e_{t=0}a_{t=1}}{6}\right]/\Delta y$	As in step 1
3. Contribution of changes in the employment rate	$\overline{e} \equiv \Delta e\left[\frac{\omega_{t=1}a_{t=1}+\omega_{t=0}a_{t=0}}{3}+\frac{\omega_{t=1}a_{t=0}+\omega_{t=0}a_{t=1}}{6}\right]/\Delta y$	As in step 1
4. Contribution of increases in sectoral employment	$\overline{e}_i = \overline{e}^e_i * \overline{e}$ $= \left[\Delta e_i / \Delta e\right] * \overline{e}$	Is calculated as the contribution of changes in employment in sector *i* to total employment rate changes (step 2), times the contribution of employment rate changes to changes in total GDP per capita (step 1)
5. Contribution of changes in output per worker within sectors	$\overline{\omega}_w = \overline{\omega}^{\omega}_w * \overline{\omega}$ $= \left[\left(\sum_{i=1}^{S}\Delta\omega_i * \left(\frac{s_{i,t=0}+s_{i,t=1}}{2}\right)\right)/\Delta\omega\right] * \overline{\omega}$	It's the contribution of *within* sector changes in output per worker to total changes in output per worker (step 3) times the contribution of aggregate output per worker to GDP per capita (step 1)
6. Contribution of intersectoral employment shifts	$\overline{\omega}_B = \overline{\omega}^{\omega}_B * \overline{\omega}$ $= \left[\sum_{i=1}^{S}\Delta s_i * \left(\frac{\omega_{i,t=0}+\omega_{i,t=1}}{2}\right)/\Delta\omega\right] * \overline{\omega}$	It's the contribution of between sector changes in output per worker to total changes in output per worker (step 3) times the contribution of aggregate output per worker to GDP per capita (step 1)
7. Within changes in output per worker in sector i	$\overline{\omega}_i = \overline{\omega}^{\omega}_i * \overline{\omega}$ $= \left(\Delta\omega_i * \left(\frac{s_{i,t=0}+s_{i,t=1}}{2}\right)/\Delta\omega\right) * \overline{\omega}$	It is the contribution of sector *i*'s, within sector change in output per worker to total changes in output per worker (step 3) times the contribution of output per worker to changes in per capita GDP (step1)

8. Contribution of shifts in the share of employment witnessed by sector *i*	$\overline{s_i} = \overline{s_i}^{\omega_B} * \overline{\omega}_B$ $= \left[\Delta s_i \left(\frac{\omega_{i,t=0} + \omega_{i,t=1}}{2} - \frac{\omega_{t=0} + \omega_{t=1}}{2} \right) / \Delta \omega_B \right] * \overline{\omega}_B$	It is the contribution of sector *i*, to the between sector component of changes in output per worker (step5) times the contribution of the between employment shifts component to total GDP per capita (calculated as above in Numeral 6)
9. Contribution of TFP (net of inter-sectoral shifts)	$\overline{TFP} = \overline{TFP}^{\omega} * \overline{\omega}_w$ $= \left[\Delta TFP \frac{(k^{1-\alpha}{}_{t=0} + k^{1-\alpha}{}_{t=1})}{2} / \Delta \omega \right] * \overline{\omega}_w$	It is the contribution of TFP growth to changes in output per worker net of inter-sectoral shifts (step 4) times the contribution of within changes in output per worker to total GDP (calculate above Numeral 5)
10. Contribution of capital labor ratio	$\overline{k} = \overline{k}^{\omega} * \overline{\omega}^w$ $= \left[\Delta k^{1-\alpha} \frac{(TFP_{t=0} + TFP_{t=1})}{2} / \Delta \omega \right] * \overline{\omega}^w$	It is the contribution of changes in the capital labor ratio to changes in output per worker net of inter-sectoral shifts (step 4) times the contribution of within changes in output per worker to total GDP (calculate above Numeral 5)

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