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The Anarchy of Numbers: Understanding the Evidence on Venezuelan Economic Growth

Francisco Rodríguez

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WESLEYAN UNIVERSITY

Department of Economics
Public Affairs Center
238 Church Street
Middletown, CT 06459-007

Tel: (860) 685-2340
Fax: (860) 685-2301
http://www.wesleyan.edu/econ

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Abstract: This paper studies Venezuelan economic performance from 1950 to 1998. We show that there exist wide divergences in many commonly used estimates of GDP growth and discuss the sources of those differences. We show that the choice of base year and linking techniques are crucial for the diagnosis of economic growth, and argue that the aggregate GDP and TFP growth numbers are distorted by cuts in oil production that came about as a result of the country adopting the OPEC strategy of exploiting market power during the 1970s. We argue that non-oil growth and TFP numbers represent more adequate measures of economic performance and that, while far from satisfactory, these do not deviate significantly from those of other Latin American countries.

Keywords: Economic growth, National accounts, Growth accounting, Oil exporting economies, Latin America, Venezuela.

1. Introduction

Cross country studies of economic growth coincide in putting Venezuela at the bottom end of the distribution of economic performance. According to the Penn World Tables' (Mark 6.1) chain weighted GDP index, Venezuela's growth performance ranked 104th out of 110 countries for the 1970-98 period. Its growth collapse, at an annual rate of –1.53% a year, is only exceeded in magnitude by those of Zimbabwe, Madagascar, Mozambique, Niger, the Central African Republic, and Nicaragua. Jones (1997, p. 22) cites Venezuela's growth record to make the case that growth disasters can be impressive even if they don't occur in Africa. Textbooks and survey articles commonly present tables of worst-performing economies (in order to contrast with the best-performing "growth miracles") in which Venezuela is invariably included.[1]

[1] See, for example, Barro and Sala-i-Martin (2004, Table 12.1) or Temple (1999, Table 2).

References to Venezuela's poor growth record in order to promote particular theories of growth are pervasive. Sachs and Warner (1995, p. 2) use Venezuela as a case of an oil-rich nation that "went bankrupt" in order to motivate their hypothesis of a negative association between natural resource abundance and economic growth, Easterly (2001, p. 264) cites the Venezuelan decline in GDP in support of the idea that inequality is harmful for growth, but Becker (1996) believes the same growth performance actually shows that economic freedom is essential for growth. The country's dismal growth numbers are also bound to have an effect on appraisals of its productivity growth: in a recent comprehensive study, Loayza, et al. (2002) provide several measures of TFP growth for twenty Latin American countries, with Venezuela consistently occupying one of the last three places in the region.[2]

These results have spurred a growing literature devoted to explaining Venezuela's growth performance. Rodríguez and Sachs (1999), Hausmann (2001) and Bello and Restuccia (2002) are some recent examples. They all present some type of calibration exercise to attempt to explain Venezuelan growth performance. The explanations posited by these papers are diverse – overreaction to natural resource booms, increase in credit risks, high levels of government intervention. Yet they all coincide in identifying Venezuela as a case of an anomalous growth collapse that requires a special explanation.

In this paper, we show that the conclusions of all of these exercises are heavily dependent on one commonly disregarded but very important element in empirical research: the source data set chosen. We show that alternative methodologies for the construction of GDP indices yield considerably different results, with the differences so high as to seriously question the validity of *any* growth calculations. The result has been a virtual "anarchy of numbers", where research results are almost completely dependent on the data used to support them. Before attempting to take further steps in searching for explanations for the Venezuelan growth collapse, some sense has to be made out of these widely disparate growth numbers. Our paper is an attempt to begin to put order in this anarchy by accounting for and explaining the differences between alternative indicators, while also proposing an interpretation of what these divergences are actually telling us about Venezuelan economic performance.

[2] Similar results had been derived earlier by Elías (1990)

One simple example will suffice. Suppose you are asked to write on Venezuelan economic growth during the 1970s and know nothing about it. You might decide that the first logical step would be to look at the data on constant price GDP from the Venezuelan Central Bank. If you did that, you would conclude that Venezuela did okay during the seventies, with an annual per capita growth rate of 0.62%. It would not seem to be a star economy, but at least it was growing, you might say. Now suppose instead that you were tipped off by a colleague to the existence of the Penn World Tables, with their cross-country comparable data on GDP growth. If you use that data, you would conclude that Venezuela's annual per capita GDP growth rate was –2.79% during that decade. That is, you would find a country that experienced a dramatic growth collapse.

Our paper will argue that there are three key differences in the way that GDP series are constructed that lead to divergent conclusions about Venezuelan economic performance. In the first place, there are differences in the primary data used. In the second place, there are differences in the techniques used to link series with different base years. Third, there are differences in the base year used to value different sectors. These differences can and do exist in many other countries, but they wreak havoc with the Venezuelan data because of the profound structural economic changes that occurred in Venezuela during the first and second oil booms.

We explore two solutions to the problem of divergent data. The first one is to carefully select the superior data from the existing array of statistics, in order to construct plausible ranges of growth performance for different subperiods and estimate upper and lower bounds on Venezuelan TFP growth using these intervals. A second approach is to concentrate on the analysis of non-oil GDP. The rationale for this solution is the fact that much of the decrease in Venezuelan GDP is attributable to the cutbacks in oil production that the country carried out during the seventies and early eighties. These cutbacks in oil production produce falls in oil sector GDP despite the fact that they implied higher relative prices of oil and higher living standards for the nation. Much of Venezuela's negative GDP growth during the 1968-84 period is not a result of poor economic performance, but rather simply a result of the fact that the country, along with other OPEC members, was using its market power in order to raise its level of real income. We show that non-oil growth and TFP numbers paint a picture that is very far from the utter growth collapse that aggregate economy numbers indicate. They do not turn Venezuela into a growth miracle, but they do show a picture of an economy that does not look all that different from the rest of the region.

The rest of the paper proceeds as follows. Section 2 presents existing GDP estimates and derived TFP estimates and documents the substantial differences among them. Section 3 discusses the reasons for the differences in growth estimates and constructs a range for the most plausible estimates of GDP and TFP growth. Section 4 shows why even these ranges may imply inadequate intervals for GDP and TFP growth and motivates the concentration on non-oil economic performance. In that section we also show that non-oil GDP and TFP growth rates seem to tell a different story from that of the basket-case economy suggested by much cross-country growth research. Section 5 discusses some implications for future research. An appendix proves an important property of linked GDP series that is used in the paper.

2. How large is the collapse? Contrasting estimates of Venezuelan GDP and TFP growth

2.1 Economic growth

Existing statistics on Venezuelan GDP do not give a uniform picture of the extent or timing of the Venezuelan growth collapse. The difference between the upper and lower bounds of annual per capita GDP growth for the 1970-1998 period is of 1.65 percentage points. Although none of these series paint a picture of a prosperous economy, the choice of series with which to measure Venezuelan GDP marks the difference between a stagnant economy and an economy in free fall.

Table 1 presents aggregate GDP growth figures for three subperiods of the 1950-98 period. Although some of this data is available further in the future, our choice of 1998 as the end date is guided by an attempt to separate out the effect of the broad ranging economic and political transformations affecting the country after the election of Hugo Chávez and the adoption of a new Constitution in 1999. This table presents 14 alternative estimates of GDP, which range from official Central Bank estimates to estimates calculated by independent observers and by international institutions.

The first three columns correspond to the official series published by the Banco Central de Venezuela (BCV), and elaborated according to the various versions of the UN's Systems of National

Accounts (1968, 1993).[3] Each of the series has a different base year: 1957 for the 1950-68 period, 1968 for the 1968-84 period, and 1984 for the 1984-2002 period. The BCV is currently in the process of estimating a new 1997 base year series, which has not yet been made available to the public.

The next five columns show different ways in which the BCV data can be combined to form a continuous series. Column 4 is a simple aggregate linked series, as suggested by United Nations (1993, p. 426). In contrast, series 5 and 6 are constructed as the sum of the individual sector linked data and thus preserve additive consistency[4] For example, suppose we want to link a series with base year r with one that has base year t, where $r<t$. In that case, we use the following formula:

$$GDP_{lt}^{s} = \begin{cases} \sum_i GDP_{lti}^{s} = \sum_i GDP_{cri}^{s} \left(\frac{GDP_{cti}^{t}}{GDP_{cri}^{t}} \right) & s < t \\ GDP_{ct}^{s} & s \geq t \end{cases} \qquad (1)$$

where GDP denotes Gross Domestic Product, superscripts s and t refer to the year of the series, while the subscripts c and l denote respectively the original series in constant prices and the linked series, and the subscripts r and t refer to the two alternative base years. The i subscript denotes the type of economic activity (agriculture, manufacturing, etc). Equation (1) thus expresses a linked constant price GDP series as the sum of the linked sectoral GDPs. Each of these linked sectoral GDPs is arrived at by multiplying GDP for that sector for a given year at base year r prices by the implicit deflator of that sector for the year of base change (t), that is, by the proportion between GDPs measured at each base year prices in the year of the base change.[5] The difference between columns 5 and 6 is that the former uses 1968 as base year, while the latter uses 1984.

Columns 7 and 8 show two more methods through which the series can be linked. Column 7 shows a linked series where the subcomponents (corresponding to the i subscripts in equation (1)) are the

[3] The Instituto Nacional de Estadística's (1999) estimates are used to calculate per capita GDP, except for the cases in which the per capita series is estimated directly by the authors.
[4] For the purposes of this calculation, the categories "Services imputed to financial institutions", "Import rights" and "Adjustment for exchange rate unit" are dealt with as separate productive sectors.
[5] This method effectively combines in the ratio of the two GDPs two sources of variation: (1) Changes between prices in year r and in year t, and (2) Changes in the composition of the goods basket, captured by the difference between nominal year t GDPs corresponding to each base year. It is possible to separate these two sources of variation and assign the latter proportionately to the years between t and r. Such an exercise does not produce results which are fundamentally different from those reported.

components of aggregate demand which make up GDP: consumption, investment, government spending, and net exports. This is in contrast with the indicators shown in columns 5 and 6, where the subcomponents are sectors of production. Column 8 shows a Fisher chained index which allows the weighting of growth rates to vary according to the prices of each good for each particular year. Chained indices are generally recommended as a mechanism to get away from arbitrary choice of base year. However, one drawback of using it for the Venezuelan case is that it requires disaggregated information on nominal GDP, which is not available for Venezuela previous to 1968.[6]

The last six columns of Table 1 present series which have been produced by other authors, using the BCV data as a basis for their calculations. Columns 9 and 10 present the well know Penn World Tables or Heston, Summers and Aten (2002) data (henceforth PWT) of per capita GDP in international dollars, adjusted for variations in purchasing power parity. There are several differences between the PWT data and the BCV data. PWT attempts to compare actual production valued at international prices and for that purpose uses price and expenditure estimates for 31 basic sectors taken form the 1996 benchmark studies for the United Nations' International Comparisons Programme (ICP). Therefore the PWT data genuinely has another base year which is 1996. PWT merges the 1996 information with the growth rates for each type of expenditure taken form the National Accounts data. Therefore, PWT is an expenditure linked series, akin to that of column 7 but distinct from the production linked data of columns 5 and 6. PWT present two series – a traditional Laspeyres series (column 9) and a quasi-chained GDP index (column 10), for which the variations of the subcomponents of aggregate demand are weighted by the share in current price GDP but net exports are valued at 1984 prices.

In column 11 we show the World Bank's World Development Indicators (2002) data for constant price GDP. According to World Bank (2002), this is a production-linked series. The very high correlation of this series with our 1984 production-linked data suggests that a similar methodology was used.

Columns 12 and 13 show the 1968 and 1984 base series constructed by Asdrubal Baptista (1995, 2000). Baptista's series are production linked data linked according to methods not significantly different from those of columns 5 and 6. However, Baptista also uses non-BCV information to build his sectoral

[6] See Rodríguez (2004) for a fuller discussion of the issues involved in the construction of this index.

GDP indices. For example, Baptista uses data from reports published by the Ministry of Energy and Mines (MEM) on profits and wages in the industry to rebuild his indicators of value added.[7] It is important to note that this information was available to the BCV staff when they produced their data, and that the MEM data has not been systematized according to the UN's system of national accounts. Baptista also revises the BCV data on construction and commerce, sectors to which he makes substantial adjustments. For example, the 1968 construction GDP estimated by Baptista is only 28.9% of BCV's estimate, and its growth rate for the 1968-84 period is –0,15%, whereas BCV's is 1.59%. In general, Baptista overestimates oil GDP growth while he underestimates non-oil GDP growth relative to BCV.

The last series we show is that of Maddison (2001), which is also widely used. It is important to point out that Maddison's series is one of the least consistent of those shown, because it links GDP indices derived from three different series. Maddison uses an early version of Baptista (1991) for the period up to 1969 and merges it with World Bank (1993), an early version of the WDI, for the 1970-92 period. After 1992, Maddison uses CEPAL (various years), which is nothing more than the BCV's data. Thus Maddison mixes BCV data with a production linked series and with a series that has non-BCV information. The Maddison estimate appears to add no new information to the other series used, and we will therefore not devote much further attention to it.

What Table 1 shows is that how you view Venezuela's growth experience depends on what data you use to measure it. A newcomer to the country who decides to look at the Central Bank's data and link the aggregate data (as the UN's 1993 SNA manual recommends) will find a country whose per capita GDP grew at an annual rate of 1.07% between 1950 and 1998, and where living standards on the eve of the twenty-first century were two thirds higher than at mid-century. If instead he were to draw his data from the Penn World Tables, he would find a country in which living standards had only increased by 16% over the same period, and if he were unlucky enough to build a data set by linking the expenditure data he would actually find a country in which per capita GDP was *lower* in 1998 than in 1950. The difference is even more striking if the observer decides to look at the 1970-98 period, perhaps after being tipped off that the country is believed to have undergone a growth collapse during the period. The Central Bank data

[7] Baptista (personal communication).

appears to indicate that the country's GDP has stagnated during this period, with 1998 GDP only slightly lower than 1970 levels, whereas according to the PWT or the expenditure-linked data, the country's economy appears to be in free fall, losing more than a third of its per capita GDP in 28 years. The data is near useless to evaluate shorter subperiods. According to Baptista's series at 1968 prices; Venezuela underwent something of an economic miracle between 1970 and 1976, with its per capita GDP growing at a rate of 3.45% annually, and increasing by 22.5% in just six years. The Penn World Tables, however, espouse another opinion: they tell us that the country's per capita GDP *fell* at an annual rate of 3.62%, accumulating a loss of living standards of 19.8% in the short six year period.

2.2 TFP growth calculations.

These differences in growth performance obviously imply a very broad range of potential TFP etsimtes. Tables 2 and 3 show these calculations for homogeneous and heterogeneous factors over time periods associated with the BCV's base year changes (1950-68, 1968-84,1984-1998). The homogeneous factor calculation in Table 2 takes the capital stock estimates from Hofman (2000), who builds them using BCV data by the perpetual inventory method.[8] The labor force statistics are taken from INE and correspond to the occupied labor force. Capital shares are calculated from the nominal national accounts BCV data, proportionately assigning the change observed when there is a base year change to the years between the base years at a constant geometric rate. Given that this decomposition is not available before 1957, we use the 1957 value of the capital share for the 1950-56 period. The minimum and maximum value for estimated TFP growth correspond to the ranges of GDP growth in Table 1 for the corresponding subperiods. [9] The first subperiod (1950-68) presents a range that is between a near-zero and positive though not extraordinary TFP performance. In any case, the contribution of capital accumulation exceeds that of productivity growth, while the labor force participation rate actually shrinks. This pattern changes in the 1968-84 period, when the strong rate of capital accumulation continues and even accelerates somewhat, but the country experiences a collapse in TFP. Although the range of TFP growth estimates is again very broad (between -5.21% nd -2.40%), they all point towards a very negative productivity growth

[8] Hofman estimates pre-1950 investment using Baptista's pre-1950 GDP estimates.
[9] In all of our growth accounting exercises, we use growth rates of per capita variables. This convention does not affect the estimate of productivity growth and makes interpretation in terms of conventional growth theory easier.

performance. Labor force participation rates start growing, but its contribution to economic growth is negligible. After 1984, the economy starts experiencing positive TFP growth again (though still not very high), but now accompanied by a steep fall in the capital stock. During this period, labor force participation starts growing, beginning to make a significant contribution to growth.[10]

The collapse in TFP during the 1968-84 period is so steep that average TFP growth rates for the 1950-98 period turn out to be negative, spanning a range between -1.36% and -0.18%. Table 3 tells a similar story, now with our calculations taking into account heterogeneities in human and physical capital. Regrettably, we lack information on human capital before 1960, so our decomposition starts in that year. We show the contributions of three different types of capital stock (residential, machinery and equipment and non-residential) and four types of human capital according to the completed level of education (no education, primary, secondary and higher). The physical capital stock data is from Hofman (2000) and the education data is from Barro and Lee (2000). In order to calculate factor shares we must have an estimate of the return of each type of capital and labor. For the capital stock, we use the Hall-Jorgenson (1967) formula to determine the real return:

$$\frac{r_j}{p} = \frac{p_j}{p}\left(i - \hat{p} + \delta_j\right) \tag{2}$$

where the j subscript denotes different types of capital, , p is the economy's price level, p_j is the price of capital j, $\hat{p}$ is the inflation rate and δ_j the depreciation rate for capital j. The factor share for each type of capital will be:

$$\frac{r_j k_j}{\sum_i r_i k_i}\alpha = \frac{p_j\left(i - \hat{p} + \delta_j\right)k_j}{\sum_i p_i\left(i - \hat{p} + \delta_i\right)k_i}\alpha . \tag{3}$$

In order to estimate these shares, we will use the implicit GDP deflator for each type of capital good for p_j, and take the depreciation rates for each type of capital estimated by Hulten and Wykoff

[10] This has to do with a strong increase in female participation rates during the nineties. See Martinez and Ortega (2003).

(1981). For the real interest rate $i - \hat{p}$, we use the average real loan rate for commercial and universal banks from 1962-2002.[11]

Labor shares for each type of human capital are simple given by:

$$\frac{w_j l_j}{\sum_i w_i l_i}(1-\alpha).$$

In this case, we estimate w_j directly from the households survey of the Nacional Institute of Statistics. This data is available from 1975 on; previous to 1975 we use the estimated 1975 factor shares in labor income to estimate the share of each factor in total income.

The results shown in Table 3 confirm the general story told by Table 2: strong TFP growth before 1968, a virtual TFP collapse during the 1968-84 period, and respectable TFP growth from 1984 to 1998. The effect of taking into account the heterogeneity of the factors of production is to raise TFP growth rates when they are positive, and to lower them when they are negative.[12] This is a consequence of the fact that positive TFP growth occurs simultaneously with a faster increase in the levels of high-return factors of production.

There are two readily apparent yardsticks with which to measure estimated Venezuelan TFP growth. One is world TFP growth. Prescott (2002) has argued that a reasonable estimate for the rate of growth of technology, and thus the rate of expansion of the production possibilities frontier, is 2% a year. A more conservative estimate is average TFP growth for Latin America. Loayza (2002) estimates this at 0.38% for the 1960-00 period, with the maximum rate in the region belonging to Chile (1.69%). Against any of these comparisons, Venezuela's average TFP growth rate for the 1960-98 period, which according to our estimates is at most -0.21%, falls short.

Whatever the yardstick, the calculations in Tables 2 and 3 pose a serious question about the validity of TFP statistics. Can we really take them to mean that Venezuela's level of productivity fell at an

[11] In principle it would have been desirable, following Hsieh (2003), to use the trend real interest rate, but that series turns negative after 1987.

[12] This also appears to be true for the 1950-68 period measured as a whole, because the contribution of the physical capital stock goes down from 1.59% to 0.93% once heterogeneity of the capital stock is taken into account, implying that the unexplained component should be higher.

annual rate between 2.40% and 6.08% during the 1968-84 period? Can we really believe that the country's Production Possibilities Frontier shifted inwards by between 32.2% and 63.3% in a 16 year period? What are the profound changes in the country's political and economic institutions that are associated with such a momentous change in productivity that coincides with a period during which Venezuela was widely viewed as one of the most stable democracies in the developing world[13]? We differ a fuller answer to this question to section 4.

3. Putting Order into Anarchy: Understanding the Differences in Growth Numbers.

3.1 Causes of variations in data

Any attempt to analyze Venezuelan growth has to get past the first hurdle presented by the data just shown. The differences between alternative data sets are so vast that they render most types of quantitative analysis, such as growth decompositions, arbitrarily dependent on the choice of series. In what follows, we discuss the reasons for these differences, and try to narrow down the range of estimates by selecting the data that we believe to be more appropriate. For this discussion, we subdivide the data in three subperiods, corresponding to the different base years periods in the original data (1950-68, 1968-84, and 1984-98), a decision that allows us to distinguish more clearly the effects of base year changes in the different linking techniques.

The 1950-68 period is perhaps the one for which this comparison is simplest. As Table 1 shows, most of the series present an average growth rate between 2.4 and 3.0 percent, painting a picture of a relatively prosperous economy. Only Baptista and Maddison give lower estimates. Since Maddison uses an earlier version of Baptista data up to 1969, their coincidence is not surprising. The same story is told by the correlation matrix among the different series, shown in Table 4. The bulk of the correlations are above .9, and the minimum is 0.7467. The lowest correlations are precisely between the Baptista and Maddison data on the one hand and the rest of the data on the other. If we take out these series, the minimum correlation is 0.9512.

[13] Karl, 1987.

The difference between Baptista data and all the other indicators for this subperiod corresponds to the already mentioned fact that Baptista does not fully use BCV information, but rather recalculates GDP data for some sectors with his own independent estimates. Most of the differences betzeen the Baptista and the BCV data comes from reestimation of the oil and the construction sector.

Excluding the Baptista and Maddison data for this subperiod leaves us with a range between 2.48% and 3.02%, which we see as reasonable. As non-oil growth was higher than oil sector growth during this period (see section 4), weighting by the much higher relative price of oil brings down growth somewhat for this period. Regrettably it is impossible to build a chained index for this period given the lack of availability of reliable nominal GDP data, but the general price stability shown by the set of GDP deflators that are available seems to indicate that the 1957 base year data would be a good approximation to what a chained price index would give.

Things get much harder when one looks at the 1968-84 subperiod. As evidenced in Table 5, the correlations among the different indicators are generally poor - some are even negative - and, as we also saw in Table 1, the differences between average growth rates are also substantial.

It is illustrative to start by noting that the few high correlations that exist are high basically by construction. This is the case among the two PWT series (more on this below), among Maddison and WDI (which is due to the fact that Madison uses an earlier version of WDI from 1970 to 1992), between the 1984 production linked series and the WDI data (which also uses 1984 as base year), and between the Baptista base 1968 and the BCV's simple linked series (which share the same base year despite some data differences)

On the other hand, the only negative correlations in the table correspond to PWT or expenditure linked data. PWT's correlations with base year 1984 data are positive though not very high. They are, however, higher than the correlations with the chained index and substantially higher than those with the 1968 data. In this respect, it is interesting to note that PWT's 1996 price structure should be closer to 1984 prices than to 1968 prices, with the chained series being somewhere in the middle. What is striking, though, is the very high correlation (0.97) between the PWT series and the expenditure linked data.

The story told by the correlations is confirmed by Figure 1, which plots the evolution of the alternative series for the 1968-84 period, where all the data has been scaled to the same value in the base year. Aside from the large divergences in the magnitude of the expansion between the start of the period and the mid-seventies, as well as the subsequent fall, one qualitative difference is apparent that marks apart the PWT and the expenditure linked data from the rest. These three series share a peak in 1970, while the rest peak in 1977 (the chained index is another exception, peaking in 1974, but this is due to the fact that at the beginning of the series it mimics the base 1968 data but later on it behaves more like the base 1984 data).

Putting aside for a moment the expenditure linked and PWT data, we see that most of the variation among the remaining series can be explained by the different value given to the petroleum sector when different base years are used. Between 1968 and 1984 the implicit deflator of petroleum GDP grew 3.11 times faster than the deflator of the non-petroleum sector. During this time, production of Crude Petroleum and Natural Gas fell by 48.2% while that of Petroleum Refining fell by 31.4% Evidently, valuing oil sector GDP at 1984 prices will weigh this fall more heavily and therefore bring down the estimate of total GDP. In order to get an idea as to the quantitative magnitude of this effect, Figure 2 shows the effect of valuing oil GDP at different price levels, while holding fixed the valuation of all other sectors at 1984 levels. Note that as the price of oil falls, the variation of the series obtained is qualitatively similar to that observed for the different series shown in Figure 1. Indeed, when we make the relative price of oil equal its 1968 level (0.32 times the 1984 price) we obtain a series that is very similar to the 1968 base year series, despite the fact that all other components of GDP are valued at 1984 prices. The correlation between the two series is 0.9961.

One should also pay attention to the fact that the Baptista series show a growth behavior that is consistently superior to that of the BCV data, given a base year. The main reason for this is that, as we pointed out previously, Baptista reestimates oil GDP. Baptista’s GDP growth for this period is – 0.73%, substantially higher than the - 3.77% that is reported by the national accounts. This makes Baptista produce a higher growth rate than BCV for the whole period. The effect is somewhat attenuated by the fact that he also estimates a lower growth rate for non-oil GDP in the period under study. (3.60%, in contrast to the

BCV's 3.97%)[14]. The difference between the Baptista growth rate and that of the series constructed directly using the BCV data is, of course, much higher at 1984 prices, when the petroleum sector receives a higher weight, than at 1968 prices. Despite these differences, Baptista's series show the same qualitative behavior than other series – growth up to 1977, followed by a decline, with aggregate growth rates much lower when we value them at 1984 prices.

What about the PWT series? There are two important facts about these series. One of them is the strong difference between their behavior and that of most other series. The other one relates to the great similarities between the chained series and the Laspeyres (1996) constant price series. One would expect that, given the role of relative prices in our explanation for differences among series, there should be marked differences between a chained price index and a 1996 Laspeyres index. We shall deal with both these issues in turn.

First there is the question of the similarity of the series. This is actually a characteristic of the whole PWT data set: the average absolute value of the differences between the chained and the Laspeyres series for all countries is 0.61%. The fact is that PWT values the three basic components of aggregate demand (Consumption, Investment and Government Expenditure) at international prices and, absent huge swings in these variables, the relative prices of these series will be insufficient to cause great changes in demand. Now this may appear paradoxical as an explanation of why they're similar for the case of Venezuela: Isn't it the case that the international price of oil changes dramatically between 1968 and 1984, and shouldn't that variation produce a variation in the GDP data as different prices are used? Yes, but the fact of the matter is that there is no difference between the valuation of oil exports between the PWT chained and Laspeyres indices, because in both series net exports are valued at 1996 prices. Here is a not too well know fact about the PWT data: it is only the domestic components of aggregate demand (consumption, government expenditures and investment) that are effectively chained. Net exports are

[14] This difference is caused mainly by the fact that Baptista reestimates construction GDP in order to make it consistent with his estimates of growth in the capital stock of residential and non-residential structures. The reestimation of Baptista assumes that for each bolívar that is invested in this sector, 0.68 Bs. of value added is produced. This fixed ratio is taken from the observed relation in the national accounts statistics from 1984 on. (Baptista, 1991, p. 44), The inconsistency with the Central Bank figures is due to the fact that the relation is much lower (0.4) in the 1968 base year data. Given the strong fall in investment in structures after 1977, Baptista's method overestimates the fall in GDP from 1977 on. We do not see a strong reason to adopt Baptista's recalculation over the BCV figures, especially since they do not add new information.

valued at base year (1996) prices. This is done because the share of net exports can be positive or negative, effectively making its individual growth rates meaningless. But its main implication is that the chained data do not take account of the most important change in relative prices occurring in Venezuela during the period under study.

What then is the source of the difference between the PWT data and the rest of the national accounts series? Potentially, there could be several differences, namely (1) PWT's valuation at international prices (2) their use of 1996 as base year, and (3) the fact that the PWT data are expenditure and not production linked. Although any of these factors may contribute to the variation, the high correlation and similarity of qualitative behavior – with the peak of GDP in 1970 - between the PWT data and the expenditure linked data suggest that the expenditure merger is making most of the difference for this subperiod (though not necessarily for other subperiods). Indeed, aside from the correlation between the two PWT series, the correlations between the PWT series and the expenditure linked series are the highest of Table 2.

Therefore, the most substantial differences between GDP series for the 1968-84 period come from a choice of method for linking the data. It is important to remember that expenditure based GDP and production based GDP are equivalent by construction *for a given base year*. However, they can vary when we are attempting to link two series with different base years. An aggregate of linked series is not equivalent to the link of the aggregates, and if we partition GDP up in different ways the sums of the linked series for each partition may differ substantially. [15]

In general, a linked series is simply an approximation to the underlying constant price series which we would like to calculate but cannot. If we had information on the production of each individual good for all time periods, then it would simply be a matter of valuing the value added of each of those goods at the prices of the base year that we want to use to construct a uniform series. This is precisely what statistical agencies like Venezuela´s Central Bank do when they calculate constant price GDP. Typically, however, we only have constant price series for aggregates of these goods for periods previous to the year when the

[15] See United Nations (1993), chapter 16, for a discussion.

base is changed. Valuing these aggregate series at the new base year implies an assumption that the movements of prices for all goods contained in those aggregates have been similar.

In the appendix we prove that the accuracy of the approximation given by linking GDP series from different base years will depend on the similarity between the goods that are grouped within each category. In particular, if GDP is partitioned into groups in a way that the goods belonging to each group have similar movements in prices, then the upper limit of the approximation error will be small. This error will increase when dissimilar goods are included in the same groups of the partition.

One direct implication of our result is that the quality of the approximation given by linking GDP series will depend on how similar (in terms of similarity in changes over time in their price levels) are the goods belonging to different groups of the partition that is used. The worst approximation will be that which is given by linking the aggregate GDP series, since it groups widely dissimilar goods. However, in order to compare one alternative partition (such as that based on categories of expenditure) with another one (such as that based on sectors of production) we will have to know how similar or dissimilar (in terms of price movements) are the goods that are grouped within each category.

Table 6 reports average yearly deviations from the sectoral price level for the components of the production and aggregate demand partitions for which we have sufficiently disaggregated price data. The results confirm the intuition that the goods that are grouped according to the production partition have a greater amount of similarity between their price movements: their average yearly deviation from the sectoral index is 2.81%, as compared to that of the components of the aggregate demand partition, which is 3.65% This is of course a partial result which is restricted to the sub-sectors for which there is sufficient data to carry out this comparison, but it suggests that the additional approximation error incurred by using the aggregate demand partition can be as large as 0,73%, which is similar to the difference of 0,8 percentage points between the production linked and the expenditure linked BCV data.

The differences between the series are again much reduced after 1984. The range between minimum and maximum growth in this period falls to six tenths of a percentage point. The correlations among the series, shown in Table 5, tell a similar story. The lowest correlation is 0.75. Note that in this subperiod the correlation between PWT and the expenditure linked series falls somewhat, suggesting that the deviations between PWT and the rest of the series has to do with other differences than the fact that PWT is expenditure linked. These could include the control for purchasing power parity or the use of 1996 ICP survey or the base prices.

The high correlations are not out of line with what we would expect. Changes in relative prices after 1984 (as well as before 1968) were relatively minor, and the petroleum sector does not experience the large swings in production that were seen in the previous period. Changes in the composition of non-oil GDP are more important in determining the relative performance according to the measurement of the different series. Furthermore, many of the series start to look alike because the primary data is much more similar. This is the case of Baptista, who makes many less revisions to the post 1984 data than he does in previous periods.

3.2 Can we find reasonable ranges for growth and TFP?

The wide divergences in the diagnosis of the Venezuelan growth experience that can be arrived at by using different data sources suggest the possible solution of trying to select a subset of data sources that may give a more coherent picture of growth. In order to do this one would have to separate the higher quality data from the rest of the series. This may be done by judging existing estimates based on their three main sources of differences.

First, there are differences in the primary data between those that use only BCV information and those that use other sources of primary data. In the case of Baptista (and, by association, in the case of Maddison, who uses the Baptista data), we do not see a compelling argument for accepting his revisions of the national accounts data, given that the statistics he used were available to the BCV when the national accounts statistics were constructed and that in any case they are not filtered according to the SNA methodology. Given these differences, and given that the Baptista data for many periods occupy some of the extreme bounds of the available estimates, we suggest excluding his data from the restricted data set. This also means excluding the Maddison data.

Second, there are differences that arise from the fact that some series are linked on the expenditure side and others are production side linked data. These generate strong differences in the evaluation of growth during the 1968-84 period, where there are important price and structural changes. In this sense, it is important to bear in mind that, for the reasons discussed above, an expenditure linked series should only be used if the production linked series cannot be constructed. The choice of this technique by the authors of PWT must be traced to the fact that many countries do not have detailed production side data of their national accounts and that the sectors reported tend to vary through time and countries. However, when a production linked series is available, it provides a much closer approximation to recalculation of GDP with a new base year, which is effectively what we are trying to approximate. These reasons lead us to propose excluding the expenditure linked data from consideration. We do this fully aware of the relevance of the PWT data for cross-country comparisons. However, the main reason for which the PWT data is relevant for cross-country empirics – its valuation at international dollars – is not the reason for why it differs from the other series. This is clearly shown by its high correlation to the expenditure linked series, which is valued at constant bolivars. We do not deny the value of PWT for cross country comparisons, but we do believe that the BCV data gives a more reasonable approximation to the behavior of the Venezuelan economy during the period under study.

Last, there are the differences between series arising from the different relative price of oil sector GDP that is used to value them. In this sense, and despite the fact that there are important differences in growth performance arising from this choice, we do not see clear grounds to pick one price over another. An argument could be built for using the chained price series, but even here it would not be clear that we want to value the 70s collapse in oil production at the very short lived relative price of oil of that decade. We shall return to this argument later, as we believe there is a simpler way to get away from the issue of the appropriate price at which to value oil. However, there seems to be no compelling argument for choosing one base year (or even a chained series) over another.

The range of estimates of GDP and TFP growth produced by excluding the Baptista and expenditure-linked data is shown in Table 8. Although the range of variation is still considerable for some subperiods, this decision helps us get a less blurry picture of Venezuelan economic growth. Whether this exercise gives us a satisfactory approximation to an evaluation of Venezuelan economic performance depends on the use that we want to put this data to. If the objective is to have a ball-park estimate of Venezuelan performance for different subperiods, the ranges shown in Table 8, while still somewhat wide, paint a pretty consistent picture of economic performance for different subperiods. If the objective is to have data that can be used for calibration exercises, in which a difference of one percentage point can easily mean the difference between a good and a bad fit of the model, the ranges shown in Table 8 would appear to be still too broad.

A possible check on our restricted range of TFP growth estimates can be gotten by estimating dual TFP growth rates. As shown by Hsieh (2003), total factor productivity growth can also be estimated as a weighted average of the rates of growth of real wages and the real return on capital, where the weights used should be factor shares. For the Venezuelan case, dual TFP has an added benefit: It does not depend on observed GDP growth. Therefore presenting dual estimates of TFP allows us to get away from the issue of picking an adequate series to measure GDP.

There are of course also disadvantages to using dual TFP, among which the existence of reliable indicators of real wages or returns to capital are foremost. With respect to real wages, high quality data from the National Institute of Statistics' Households Survey is available after 1975. The stronger problems refer to the returns on capital. There are no long-run series with which we can measure the return on capital. The Caracas Stock Exchange is small and marginal with respect to the rest of the economy, and the bulk of its transactions actually refer to government papers: the total volume of operations with private titles reached only 148 million dollars in 2002, or 0.1% of GDP. The only candidate for long-run return on capital is the loan interest rate that we have already used above to estimate factor shares. For the reasons discussed above, we use the average 1962-02 loan rate to calculate the returns on each type of capital implied by the Hall- Jorgenson formula (equation 15). Note that this implies that the variations in the return to capital will come from variations in the relative prices and shares of each type of capital good.[16]

The estimates presented in Table 9 correspond to the 1975-98 period. We do not attempt to further disaggregate this period because our assumptions on the relative price of capital imply that the dual estimate must be taken if anything as an indicator of long-run trends, and as a check on our primal TFP estimates. Indeed, in this sense the results are quite positive, with the dual estimate of TFP growth of –

[16] This does not mean that our calculation of the rate of return on capital is dependent on the rate of return implicit in national accounts, because the latter depends on producers' surplus and not on capital goods deflators.

1.73% being within the range of primal estimates. This fact is comforting, as it serves as an independent confirmation of our TFP results.

4. What's the use of aggregate GDP? Economic performance in the petroleum and non-petroleum sectors

4.1 TFP and market power.

The fall that we have observed in aggregate TFP is strongly influenced by the steep fall in Venezuelan oil production that occurred during the seventies. In 1968, Venezuela's oil production was 3.6 million barrels a day; by 1984, it was down to 1.8 million b/d. This occurred despite the fact that both employment and the level of the capital stock in the oil industry were higher in 1984 than in 1968. Given the weight of petroleum in total GDP, this steep fall in the production of oil combined with non-falling levels of inputs, will produce a decrease in measured TFP which will affect the aggregate economy TFP figures. In principle, there is nothing wrong with this: if indeed the economy became less productive in producing petroleum, and petroleum makes up an important part of GNP, we would like that to be captured in our TFP estimates. However, the fall in Venezuelan oil sector productivity occurs at the same time in which a substantial transformation was occurring in the world oil market and in the way that Venezuela participated in it. The market changes that were occurring can have important effects on the measurement of productivity.

To fix ideas, remember that a crucial assumption of the growth accounting decomposition is the fact that the economy is on the frontier of its Production Possibilities Set, also called the Production Possibilities Frontier (PPF). A Production Possibilities Set, usually represented by the relation $F(y,x) \leq 0$, where y denotes a vector of inputs and x a vector of products, denotes a range of productive possibilities of which only some are efficient. It is only when the firm can be trusted on to select only those efficient points that the Production Possibilities Set becomes a Production Function $F(y,x) = 0$, and that we can meaningfully infer shifts in the PPF from observed changes in factor usage and production.

The essence of the growth accounting exercise is to separate changes in *y* and *x* from shifts in the PPF: shifts in production that cannot be explained by shifts in the factors of production are taken to come from shifts in the PPF.

Such an exercise loses validity if the economy is not on the PPF. Now one crucial assumption to ensure that a firm is on its PPF is that it be a price taker in the product markets. Generally, if the firm is not a price taker, its not being on the PPF becomes a real possibility[17]. This is much more than a technical curiosity, because it can be argued that the most important transformation that occurred in the Venezuelan oil industry during the 1970s is that it went from being a price taker to participating actively in price-setting mechanisms.

We illustrate this through a simple example. Let *x* and *y* both be scalars. Therefore the firm produces one product with one input. The argument is easily generalizable to the case of multiple products and factors. Suppose also that *y* is fixed at the level $y = y_0$. This corresponds to a short run situation, where the input has already been acquired. The very simple FPP is represented in Figure 3, where the FPP is the point $\hat{x}$.

A price taking firm will definitely produce $\hat{x}$. This is because, given that its inputs are fixed at y_0, the marginal cost of using them (up to y_0) is zero, and therefore given any positive price of x, it will be profitable for the firm to produce the maximum quantity of x that it can. A price setting firm, however, will not react the same way. Given a marginal cost of zero of using installed factors of production, the price setting firm can pick a level of output lower than $\hat{x}$ (say x_m) if that is the level of output that maximizes income. In other words, the price setting firm will choose *x* to solve the Kuhn-Tucker condition:

$$R'(x) \geq 0 \text{ and } R'(x)(x - \hat{x}) = 0$$

where *R(x)* is the revenue function for the firm. If *R'(x)=0* and *R''(x)<0* for $x < \hat{x}$, the firm can select a point that is inside its PPF.

[17] See Fisher and Shell (1988), p. 63.

The case of fixed factors of production is directly relevant to understand what happens to a firm that undergoes a transformation in which it passes from being a price taking firm to following price setting behavior. Typically, given that the production level of a monopoly is lower than that of perfect competition, this firm will find that the factors of production bought by the price taking firm allow a level of production that is higher than the optimal one for it and therefore also likely to be higher than those that maximize income. Therefore, it would not be surprising to see this firm lowering production to a level inside its PPF, in order to raise prices and profits, at least during the time that it takes it to adjust to its new lower desired level of factor usage.

In the long run, the assumption that there are fixed factors of production is no longer sensible and even a price setting firm will adjust its level of factor use in order to minimize costs. Therefore, one would expect to see the firm to slowly settle upon its (new) PPF and for productivity to rise. However, there is a very relevant exception to this argument. It corresponds to the case in which the price-setting conduct of the firm comes not from the fact that it has substantial price setting power by itself but that it forms part of a cartel that tries to replicate collusive behavior. In that case, the firms that participate in the collusive agreement will try to maintain levels of excess capacity in order to have bargaining power within the cartel. This result was first established by Benoit and Krishna (1987), who showed that all duopoly equilibria with collusion imply the existence of excess capacity. The reason is that the existence of a stable collusive agreement requires that participants have enough excess capacity to punish their associates if they deviate from the collusive agreement. Otherwise, it would be optimal for participants to enter the collusive agreement and then violate it by raising production levels.[18]

These examples are much more than mere technical curiosities. They are actually an accurate description of what happened to Venezuela and other OPEC countries during the 1970s. This is the period during which oil exporting countries grouped under OPEC started to make use of their control over production levels in order to raise or sustain high prices, and in which OPEC actually becomes the

[18] See also Brock and Scheinkman (1985) and Davidson and Deneckere (1990). The latter show that the level of excess capacity is growing in the level of collusion, and cite the OPEC cartel as an example that illustrates the behavior predicted by their model.

coordination arrangement for that collusive agreement. The use of excise taxes and reference prices, coordinated through the OPEC meetings, was followed by successive nationalizations of oil industries and the explicit use of production reduction accords by OPEC. In other words, between the seventies and eighties, the majority of OPEC countries pass from acting as price takers to forming part of a multi-country collusive accord in which the bargaining power of each country is strongly related to its production capacity. Theory predicts that in that case we should see the emergence of excess capacity and a fall in measured productivity levels.[19]

4.2 TFP calculations for oil and non-oil GDP.

In Tables 10 and 11 we present growth decompositions of oil and non-oil GDP growth for the three subperiods under study. The oil capital stock has been estimated by the perpetual inventory method using gross fixed investment data from the BCV national accounts for 1950-98, and from Salazar Carrillo (1976) and Rangel (1969) for 1925-1950, with the 1920-25 amounts estimated in proportion to output. The estimates were built with the same methods and parameter assumptions as the Hoffman (2000) data that we used in Tables 2 and 3, so that the data are strictly comparable. Furthermore, this allows us to calculate the non-oil capital stock as the difference between the two series. Employment data in the oil sector is from Ministry of Energy and Mines (Various years). Employment in the non-oil sector is not subdivided by level of education, so that we can only estimate the effects of allowing for heterogeneity in the capital stocks. We present TFP estimates for 1968 and 1984 price linked series.

It is comforting to observe that the differences in growth rates arising from using different base years are much reduced when one concentrates on oil and non-oil GDP, confirming again that the great differences arising in aggregate GDP growth rates are caused by differences in the relative prices at which oil sector GDP is valued. For the oil sector, the choice of base year (or chain weighting) is practically irrelevant for the magnitude of growth rates, whereas for the non-oil sector, it appears quantitatively

[19] It is possible to argue that the fall in production had to do with disinvestment in exploration prior to nationalization. In this sense, it is important to point out the following: (i) Even if the fall in production was due to disinvestment previous to 1976, a price taking industry not subject to production constraints would have recouped the lost capital stock by investing strongly after 1976 in order to raise production levels back (ii) If the loss of production was all due to disinvestment, we would not expect to see a strong fall in TFP, as disinvestment affects production through a fall in the capital stock (iii) The decline in Venezuelan oil production between 1973 and 1985 50,1% is similar to that of all of OPEC (47,1%).

relevant only for the 1984-98 period, and even there the range between maximum and minimum GDP growth is only 0.8 percentage points. With respect to the overall evaluation of the economic growth record in the non-oil sector, the data puts it between 1.3 and 1.5 percentage points. Note that this performance, although not stellar, is much less disastrous than its aggregate GDP performance for the same period. The same applies to the period of the country's "growth collapse", from 1970 to 1998, where the range of growth rates indicated by these series is [-0.06,0.35]

The data also show that the productivity collapse during the 1968-84 period is driven by the very steep fall in petroleum sector GDP, which fell by approximately seven percentage points annually during the 1968-84 period. Non-oil TFP growth during this period is also low (between –1.39% and –1.59%). However, it is in the range of the TFP collapses occurring during the debt crisis in Latin America. Loayza et al.'s (2002), for example, calculate an average rate of TFP growth for Latin America for the 1980s of -1.29%.

5. Concluding remarks

This paper has made two points about Venezuelan economic growth. The first one is that the conclusions to be drawn about it depend crucially on what data is used. Alternatively credible series, which have been regularly used by academics writing on Venezuela, can give widely divergent conclusions with respect to Venezuela's growth experience. The second one is that growth of the Venezuelan economy should be analyzed by looking at GDP and TFP growth in the non-oil sector. While this fact has been recognized by other authors, Venezuela is often studied in the context of cross-country comparisons of aggregate GDP, with the oil and non-oil sectors combined. Such is the case of the studies that refer to Venezuela's growth collapse cited in the introduction to this paper. The comparisons underlying many of these studies, by systematically underestimating Venezuelan economic performance, can be highly misleading.

We believe the data show that Venezuela is not a basket case; it is simply a poor-performing Latin American economy. The distinction can be relevant for much of the analysis of Venezuelan economic performance that is commonly carried out. For example, the Venezuelan economy is commonly characterized as a laggard reformer and its reform experience is often linked by commentators to its poor growth experience.[20] Our numbers, however, show that TFP growth during this period in the non-oil sector was not too different from the Latin American average. Indeed, our numbers point to the fact that Venezuela's low growth in the nineties was caused by a collapse in investment, which may have been driven by declining oil rents. A more complete analysis of these hypothesis is the center of our current research.

The analysis presented here may also have implications for the study of the growth experiences of other oil-exporting and resource-abundant countries. For example, it is widely recognized that the economic performance of oil exporting countries is poorer than what one would expect. A literature on the "resource curse" has developed around this fact. The poor economic performance of oil exporters is one of the driving forces behind the story that natural resource abundant economies grow more slowly[21] It would be interesting to analyze whether the slow growth of oil exporting countries is a statistical artifact driven by the changes in the levels of petroleum production.[22] In this respect, it is important to remember that most of the oil exporting economies usually associated with this result are members of OPEC, who saw their per capita oil production levels (though not their income) fall considerably during the seventies and eighties.

This analysis has intentionally taken 1998 as the ending point of our study. The reason is simple. Venezuela *has* experienced an enormous growth collapse form 1998 to 2003. By the end of 2003, per capita GDP is estimated to have fallen by 25.8% over this five year period. This collapse in growth is strongly related to the political, economic and social changes experienced by Venezuela during the Chávez administration, which have fundamentally altered the relationship between civil society, market actors, and the State. We believe that it is easier to understand Venezuela better if we separate this period of recent changes from the 1950-98 period. A full analysis of economic changes in Venezuela during the Bolivarian revolution is also left for future analysis[23].

Appendix: An important property of linked GDP series

[20] See Naím (1993), Lora (2001) and Monaldi et al. (2004).
[21] See for example Gelb 1988, Sachs and Warner, 1999, Tornell and Lane 1999, Auty 2001b.
[22] Auty (2001a) finds that Saudi Arabia, also commonly seen as a poor performing oil exporting country, experienced very high non-oil TFP growth rates during the nineties.
[23] On this see Rodríguez, 2002.

Many long run series for macroeconomic indicators are derived from linking individual constant price series with different base years. Such a method is common in applied work and is used extensively in this paper. The purpose is to obtain an approximation to constant price data valued at a uniform base year. However, little is known about the quality of this approximation. This appendix proves an important property, namely that the quality of the approximation will depend on the similarity of the goods making up the partition of the series that is linked, in a way that will be made precise.

First of all we present some definitions. Let there be I goods in the economy. Let x_{it} denote the quantity of good i produced in period t and p_{it} denote its price. Let p_t and x_t be indices of production and quantity, that is, solutions to the equation

$$p_t x_t = \sum_{i=1}^{I} p_{it} x_{it} \ . \qquad \text{(A1)}$$

Let X be the IxT matrix containing all observations of production of each individual good at each moment of time:

$$X = \begin{pmatrix} x_{11} & x_{12} & \dots & x_{1I} \\ x_{21} & x_{22} & \dots & x_{2I} \\ \dots & \dots & \dots & \dots \\ x_{T1} & x_{T2} & \dots & x_{TI} \end{pmatrix} . \qquad \text{(A2)}$$

A *partition* P of X is a set of matrices $P_1 \ldots P_K$ such that $X = (P_1 \quad P_2 \quad \dots \quad P_K)$, where P_i has dimension k_i x T, where $1 \leq k_i \leq T$. Therefore, a partition of X subdivides X into K groups of goods, where each matrix P_i contains information on the production of each of the k_i goods contained in that group for every period of time.

We say that partition P is characterized by δ-similarity if and only if whenever goods m and j belong to the same P_i matrix then:

$$\underset{m,j,t,r}{Max} \frac{\frac{p_{mt}}{p_{mr}}}{\frac{p_{jt}}{p_{jr}}} \leq \delta \ . \qquad \text{(A3)}$$

In other words, δ-similarity requires that the variation between the relative price of any two goods between any two years is at most δ when those two goods belong to the same group of the partition. This condition implies that all gods that are grouped together must be sufficiently close from an economic point of view that their prices move in similar magnitudes and directions.

Armed with these definitions, we can go on to study the properties of linking series with different base years. Assume we would like to have a Laspeyres quantity index that solves (A1) for base year *b*. That is, we would like to calculate:

$$x_t = \sum_i p_{ib} x_{it} \ . \tag{A5}$$

However, we are only able to calculate (A5) for years $t \geq b$. For years $t < b$, we have instead Laspeyres price indices evaluated at $t=0$ for each of the *I* groups of partition *P*. Therefore, our *P*-linked series will be:

$$x_t^{\,l} = \begin{pmatrix} \sum_i p_{ib} x_{it} & t \geq b \\ \sum_{l=1}^{k} \eta_{b0}^{\ l} \sum_{i \in P_l} p_{i0} x_{it} & t < b \end{pmatrix} \tag{A6}$$

where $\eta_{b0}^{\ l} = \dfrac{\sum_{i \in P_l} p_{ib} x_{ib}}{\sum_{i \in P_l} p_{i0} x_{ib}}$. The *P*-linked series is therefore identical to the base *b* series after year *b*. Before year *b*, however, we are unlikely to have data on production at year *b* prices. For those years, the *P*-linked series uses Laspeyres constant price series valued at year *0* for each group of partition *P*, but rescales those series in proportion to the change in the price level index for that group between years *0* and *b*.

Obviously, (A6) is no more than an approximation to (A5) for $t<b$. The crucial question is how good an approximation it is. Define the *approximation error* as:

$$A^l = x_t^{\,l} - x_t \quad \text{for} \quad t<b \tag{A7}$$

It is obvious that the approximation error for $t \geq b$ will always be zero, so in order to distinguish the quality of approximations we Then we can establish:

Proposition: Consider two alternative partitions of the same *X* matrix, *P1* and *P2*. Let *P1* be characterized by δ_1-similarity and *P2* be characterized by δ_2-similarity, with $\delta_1<\delta_2$. Then the maximum approximation error for *P1* will be strictly smaller than the maximum approximation error for *P2*.

Proof: Using (A5), (A6) and (A7), and the definition of $\eta_{b0}{}^{l}$, we get:

$$A^l = \sum_{l=1}^{k}\sum_{i\in P_l}\left(\frac{\sum_{j\in P_l} p_{jb}x_{jb}}{\sum_{r\in P_l} p_{ro}x_{rb}}p_{io} - p_{ib}\right)x_{jt}$$

Using the definition of δ-similarity, this implies that:

$$A^l \leq \sum_{l=1}^{k}\sum_{j\in P_l}\left(\delta\frac{p_{ib}}{p_{i0}}\frac{\sum_{j\in P_l} p_{j0}x_{jb}}{\sum_{r\in P_l} p_{ro}x_{rb}}p_{io} - p_{ib}\right)x_{it} = \sum_{l=1}^{k}\sum_{i\in P_l}\delta p_{ib}x_{it} = \delta x_t$$

so that the approximation error is directly proportional to δ times the underlying index (which is the same for all partitions), establishing the result.

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Table 1: GDP growth, 1950-98, alternative indicators.

Source	Banco Central de Venezuela								PWT		WDI	Baptista		Maddison
	Oficial series			Derived series										
Series	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Base year	1957	1968	1984	-	1968	1984	1984	-	1996	1996	1984	1968	1984	-
Method				Simple linked	Production linked	Production linked	Expenditure linked	Production Chained	Expenditure linked	Expenditure chained	Production linked	Production linked	Production linked	Various primary sources
1950-68	3.02%			3.02%	2.66%	2.48%	2.43%		2.95%	2.85%		1.59%	2.29%	1.76%
1968-84		-0.37%		-0.37%	-0.37%	-1.75%	-3.12%	-0.34%	-2.12%	-2.21%	-1.33%	-0.31%	-1.27%	-1.08%
1984-98			0.22%	0.22%	0.52%	0.22%	0.18%	0.00%	-0.07%	-0.07%	0.23%		0.36%	0.28%
1950-98				1.07%	1.02%	0.41%	-0.08%		0.38%	0.31%			0.54%	0.38%
1970-98				-0.27%	-0.13%	-0.98%	-1.78%	-0.42%	-1.46%	-1.53%	-0.70%		-0.63%	-0.62%

Table 2: TFP growth with Homogeneous Factors

	Growth		Productivity		Capital		Labor force	
	Minimum	Maximum	Minimum	Maximum	Growth	Contribution	Growth	Contribution
1950-68	1.59%	3.02%	0.04%	1.47%	3.01%	1.68%	-0.29%	-0.13%
1968-84	-3.12%	-0.31%	-5.21%	-2.40%	3.49%	1.95%	0.32%	0.14%
1984-98	-0.07%	0.52%	0.40%	0.99%	-1.78%	-1.11%	1.70%	0.64%
1950-98	-0.08%	1.11%	-1.36%	-0.18%	1.77%	1.10%	0.49%	0.19%

Table 3: Growth with Heterogeneous Factors

	Growth		Productivity		Capital stock						
	Minimum	Maximum	Minimum	Maximum	Residential		Machinery and equipment		Non Residential		Total
					Growth	Contribution	Growth	Contribution	Growth	Contribution	
1950-68	1.59%	3.02%	.	.	6.10%	0.14%	1.35%	0.63%	3.05%	0.21%	0.98%
1960-68	0.76%	2.91%	2.34%	4.49%	3.02%	0.08%	-2.71%	-1.28%	0.21%	0.01%	-1.19%
1968-84	-3.12%	-0.31%	-6.08%	-3.27%	3.88%	0.15%	4.57%	2.02%	2.59%	0.20%	2.38%
1984-98	-0.07%	0.52%	0.89%	1.48%	-2.79%	-0.12%	-1.92%	-0.94%	-1.19%	-0.11%	-1.17%
1950-98	-0.08%	1.11%	.	.	2.77%	0.08%	1.47%	0.76%	1.66%	0.13%	0.97%
1960-98	-0.68%	0.48%	-1.37%	-0.21%	1.24%	0.04%	0.65%	0.34%	0.69%	0.05%	0.43%
	Labor Force										
	No Education		Primary		Secondary		Higher		Total		
	Growth	Contribution	Growth	Contribution	Growth	Contribution	Growth	Contribution			
1950-68	.	.	.	.	.	.	.	.	.		
1960-68	0.20%	0.03%	6.07%	0.38%	-5.20%	-0.87%	4.90%	0.07%	-0.39%		
1968-84	-4.79%	-0.65%	6.20%	0.83%	-0.01%	0.00%	10.10%	0.41%	0.59%		
1984-98	-4.31%	-0.26%	1.43%	0.26%	-0.17%	-0.02%	3.18%	0.22%	0.21%		
1950-98	.	.	.	.	.	.	.	.	.		
1960-98	-3.56%	-0.35%	4.41%	0.49%	-1.16%	-0.15%	6.46%	0.27%	0.26%		

Table 4: Correlation matrix for alternative GDP series, 1950-68

	BCV simple linked (*)	BCV production linked 1968	BCV production linked 1984	Maddison	PWT chained	PWT Laspeyres	Baptista 68	Baptista 84	WDI 95 (**)	BCV expenditure linked
BCV simple linked (*)	1									
BCV production linked 1968	0.9978	1								
BCV production linked 1984	0.9693	0.9732	1							
Maddison	0.8574	0.8612	0.9296	1						
PWT chained	0.9907	0.9834	0.9527	0.8316	1					
PWT Laspeyres	0.9932	0.9864	0.9512	0.822	0.9989	1				
Baptista 68	0.8332	0.8349	0.8855	0.9513	0.821	0.8067	1			
Baptista84	0.8413	0.8365	0.8768	0.9154	0.8481	0.8317	0.9845	1		
WDI 95 (**)	0.9769	0.9836	0.98	0.7714	0.9576	0.9531	0.9033	0.9595	1	
BCV expenditure linked	0.9762	0.9658	0.9518	0.8732	0.9883	0.9829	0.8609	0.8848	0.9667	1

(*) Same as BCV base 57 for this period
(**) Unlike the rest of the table, this row/column corresponds to the period of availability of the WDI series, which starts in 1960.

Table 5: Correlation matrix for different GDP series, 1968-84

	BCV simple linked (*)	BCV production linked 1984	BCV chained	Maddison	PWT chained	PWT Laspeyres	Baptista 68	Baptista 84	WDI 95	BCV expenditure linked
BCV simple linked (*)	1									
BCV production linked 1984	0.6174	1								
BCV chained	0.9110	0.6528	1							
Maddison	0.7567	0.9362	0.8509	1						
PWT chained	-0.0119	0.7514	0.1036	0.5823	1					
PWT Laspeyres	-0.0477	0.7274	0.0686	0.5514	0.9991	1				
Baptista 68	0.9522	0.4598	0.9329	0.689	-0.1572	-0.1925	1			
Baptista84	0.8968	0.7958	0.9543	0.933	0.2724	0.2375	0.8773	1		
WDI 95	0.6582	0.9686	0.7580	0.9847	0.684	0.6562	0.5677	0.8766	1	
BCV expenditure linked	0.0814	0.822	0.2227	0.6756	0.9722	0.966	-0.0542	0.3994	0.776	1

(*) Same as BCV base 68 and production linked 68 for this period.

Table 6: Average deviations from sectoral price index, 1984-1999

	Indicator	**Average yearly deviation from average price**
Demand partition		
Consumo	Consumer Price Index	0.0339
Importaciones	Wholesale Price Index	0.0355
Exportaciones	Export Price Index	0.0367
Production Partition		
Agricultura	Producer Price index	0.0285
Industria	Producer Price index	0.0277

Table 7: Correlation matrix for different GDP series, 1984-98.

	BCV simple linked (*)	BCV production linked 68	BCV chained	Maddison	PWT chained	PWT Laspeyres	Baptista 68	Baptista 84	WDI 95	BCV expenditure linked
BCV simple linked (*)	1									
BCV production linked 68	0.8742	1								
BCV chained	0.9304	0.7467	1							
Maddison	0.9822	0.8303	0.8928	1						
PWT chained	0.8627	0.829	0.9161	0.777	1					
PWT Laspeyres	0.8523	0.8325	0.9027	0.7629	0.999	1				
Baptista 68(**)	0.8832	0.9491	0.8230	0.8445	0.923	0.9287	1			
Baptista 84	0.9857	0.9247	0.8790	0.9731	0.8288	0.8202	0.9286	1		
WDI 95	0.9978	0.8812	0.9379	0.9788	0.8709	0.8595	0.8855	0.9868	1	
BCV expenditure linked	0.995	0.8634	0.9364	0.9711	0.8802	0.8715	0.8733	0.9725	0.99	1

(*) Same as BCV base 68 and production linked 84 for this period.
(**) Unlike the rest of the table, this column/row refers to the period of availability of the Baptista 68 data, which ends in 1995

Table 8: Restricted range for GDP and TFP growth

	GDP Growth		TFP – Homogeneous Factors		TFP – Heterogeneous Factors	
Period	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
1950-68	2.48%	3.02%	0.93%	1.47%	.	.
1960-68	1.19%	2.31%	0.87%	1.99%	2.77%	3.89%
1968-84	-1.75%	-0.34%	-3.84%	-2.43%	-4.71%	-3.30%
1984-98	0.00%	0.52%	0.47%	0.99%	0.96%	1.48%
1950-98	0.41%	1.11%	-0.87%	-0.22%	.	.
1960-98	-0.41%	0.48%	-1.25%	-0.36%	-1.10%	-0.21%

Table 9: Dual TFP growth

	Productivity			Real wages									
	Primal		Dual	No Education		Primary		Secondary		Higher		Total	
	Min	Max		Growth	Contribution	Growth	Contribution	Growth	Contribution	Growth	Contribution	Growth	Contribution
1975-98	-1.84%	-1.09%	-1.73%	-4.37%	-0.45%	-5.01%	-0.70%	-6.01%	-0.56%	-5.75%	-0.32%	-4.27%	-2.02%

	Return to capital							
	Residential		Machinery and equipment		Non Residential		Total	
	Growth	Contribution	Growth	Contribution	Growth	Contribution	Growth	Contribution
1975-98	0.69%	0.03%	0.39%	0.18%	0.69%	0.09%	0.51%	0.29%

Table 10:Oil Sector TFP growth

	Economic growth		Productivity				Capital stock				Labor force
	1968 prices	1984 prices	1968 prices		1984 prices		Total	No Residential	Residential	Machinery and Equipment	
			Homog.	Heterog.	Homog.	Heterog.					
1950-68	1.66%	1.69%	5.25%	6.30%	5.28%	6.32%	-2.72%	-1.68%	-1.16%	-5.66%	-6.86%
1968-84	-6.95%	-6.94%	-6.77%	-7.71%	-6.75%	-7.69%	-0.16%	-1.02%	-0.90%	2.42%	-0.34%
1984-98	2.51%	2.49%	-0.24%	-0.46%	-0.26%	-0.48%	4.32%	4.07%	3.50%	4.90%	-2.40%
1950-98	-0.96%	-0.95%	-0.09%	-0.06%	-0.08%	-0.05%	0.18%	0.22%	0.29%	0.11%	-3.38%

Table 11: Non-oil sector TFP growth

	Economic growth		Productivity				Capital stock				Labor force
	1968 prices	1984 prices	1968 prices		1984 prices		Total	Non Residential	Residential	Machinery and Equipment	
			Homog	Heter	Homog	Heter					
1950-68	3.01%	3.27%	0.84%	1.33%	1.10%	1.59%	4.77%	5.37%	6.32%	3.03%	-0.18%
1968-84	0.79%	0.73%	-1.39%	-1.62%	-1.45%	-1.68%	3.89%	3.25%	3.93%	4.76%	0.32%
1984-98	0.31%	-0.49%	1.11%	1.16%	0.31%	0.36%	-2.58%	-2.27%	-2.85%	-2.78%	1.72%
1950-98	1.48%	1.33%	-0.03%	0.36%	-0.19%	-0.04%	2.33%	2.43%	2.85%	1.91%	0.54%

Figure 1: Per capita GDP index, alternative indicators, 1968-84

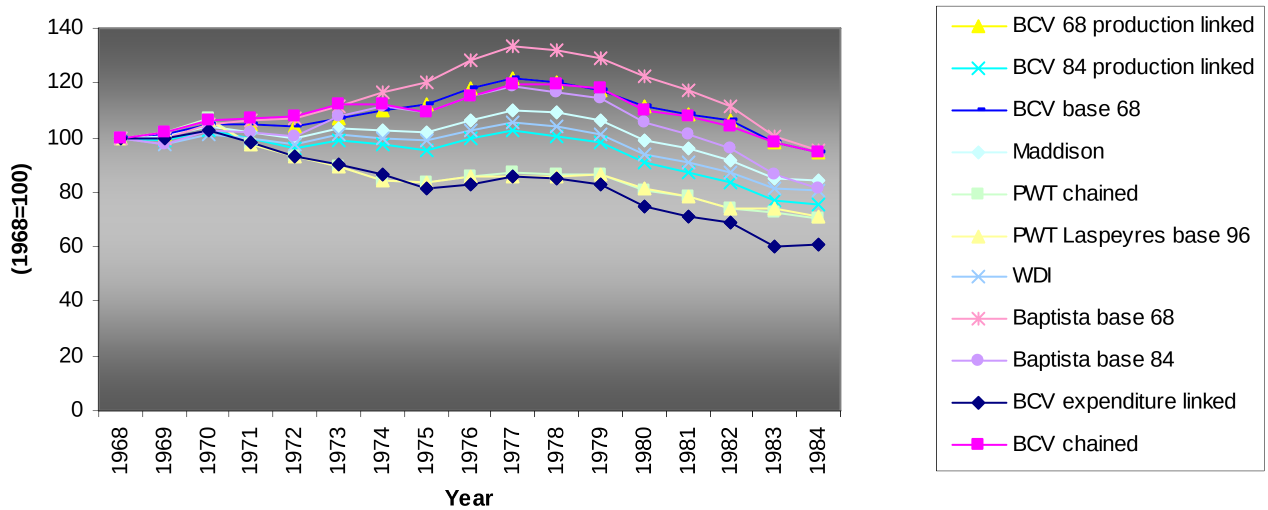

Figure 2: Evolution of GDP for different oil price levels

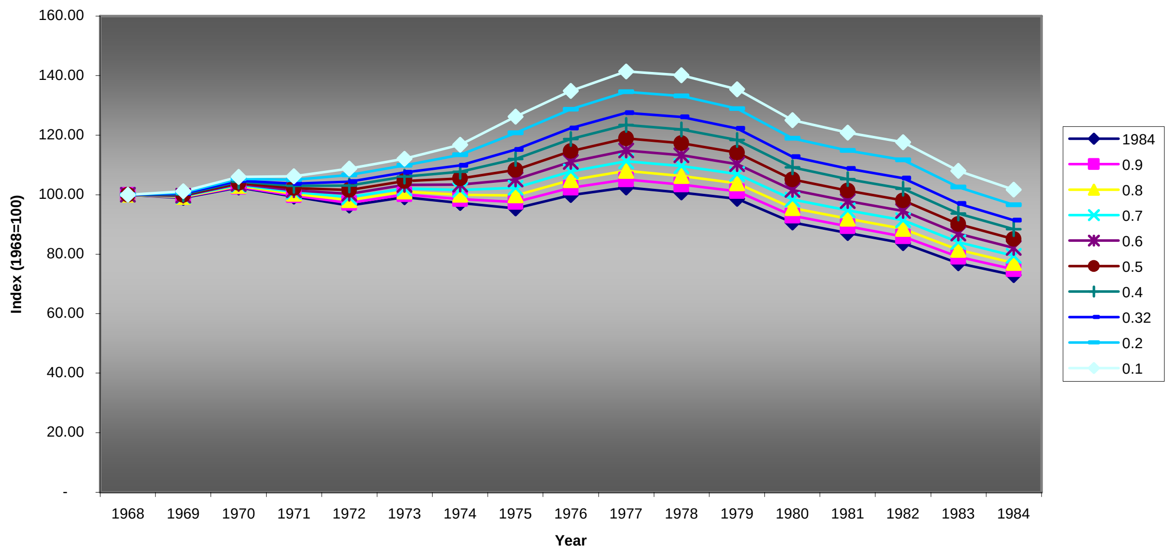

Figure 3: Ppf And Production, One Good One Factor Example