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Natural Resource and Human Capital as Capital Services and its Contribution to Sustainable Development and Productivity
KLEMS + N (Natural Capital) Approach

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Abstract

Commodity prices boom during the first decade of 21st century impact on Natural Resource Dependent Economies by a significant consumption and GDP growth. However, present terms of trade reversion cast several doubts on the sustainability of their prosperity. Domestic Savings, human capital formation, productivity and management of natural resource abundance during the boom are key variables to sustain future economic growth in case of terms of trade reversion. But Growth Accounting and Balance Sheet Vulnerability analysis does not usually include Natural Capital contribution to growth. The economic literature in terms of Dutch Disease and Resource Curse was not based on common metrics. Stiglitz-Sen-Fitoussi (2009) report put issues about how to measure welfare, environmental and growth sustainability at the heart of the debate.

The System of National Accounts does not take into account some environmental assets and unproved resources and also human capital in the assets boundary that has important role in welfare and growth sustainability, mainly because of difficulties on empirical measures.

This paper propose a methodology to measure Natural and Human capital as wealth as capital services inputs in a symmetric and consistent approach with produced assets (KLEMS+N, capital, labor material, service and natural inputs). Main findings for oil and gas dependent group are reported. Evidence of Resource Curse is mixed. Despite high wealth effects during commodities prices boom, genuine savings did not increase, endangering their future growth sustainability. But GDP growth of oil and gas dependent countries accelerates during the recent commodities boom thanks of productivity dynamics, although these findings within the group were was heterogeneous. Measured productivity of oil and gas dependent economies was negative biased if oil and gas inputs are excluded from growth accounting.

The new welfare and growth sustainable asset boundary proposed allowed inclusion of natural and human capital in the core of SNA responding questions of Stiglitz-Sen-Fitoussi about overconsumption, sustainability of development and productivity.

1. INTRODUCTION

Natural Resources are one of the main components of National Wealth of several developing countries and a key determinant of their Growth Profile.

The recent commodities price boom raised several controversies about the sustainability of economies depending on natural resources. How relevant were their wealth effects? How significant was their impact on income distribution and social welfare? Did it change their growth profile? Were the boom-related rents reinvested in other assets? How did productivity perform during the boom in order to compensate the drop in competitiveness due to domestic currencies appreciation? What type of human capital and how much job creation can be associated to a natural resource-led growth pattern? What are the effects of current management of natural resource abundance on sustainable development and the welfare of future generations?.

Academic literature has pointed out successful as well as failure cases of growth profile of natural resource dependent economies. Economic literature refers to failure cases asl "Resource curse" and "Dutch disease". The discovery of new abundant non-renewable resource allows an increase in exports softening of fiscal budget constraints, and a consumption boom financed by higher natural rents. The cost may be a drop of domestic savings, appreciation of domestic currencies, productivity slowdown and deindustrialization. Furthermore, high extraction rates from exhaustible resources during prosperity era could erode growth, welfare and environmental sustainability. The successful experience of Canada, Australia and Nordic countries are well-known cases of the so-called "staples theory". Successful are explained by the ability of taking advantage from externalities and the upgrading of the valued added chain of natural resource activities and efficient management of natural resource rents towards more diversification of the economy[2].

Natural Resource management was again under debate thanks to Joseph E. Stiglitz, Amartya K. Sen, and Jean-Paul Fitoussi (2009) for the Commission on the Measurement of Economic Performance and Social Progress. They call for a shift of the focus of economic measurement from production toward "people's well-being". One of their main recommendations is to include issues of environmental, development and welfare sustainability in the SNA and GDP.

Since then, several important international organizations and researchers has been taking note of Stiglitz-Sen-Fittoussi Report agenda. Many years before Stiglitz-Sen-

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[2] See for example, Coremberg (2010) for Latin America case, Blomström, M. y Kokko, A. (2007) for Nordic countries. Classics research on Resource Curse and Dutch Disease are Corden, W. M. (1984), Sachs and Warner (1997) and Matsuyama , K. (1992). Also Hirschman (1958) and Watkins, M. H. (1963) about value added chain effects of natural resource.

Fittoussi Report, World Bank (2011) -based on Clemens and Hamilton (1999), Atkinson and Hamilton (2003) and Hamilton and Hartwick (2005)- research developed an important research on Wealth Accounting, including natural capital and the so called genuine Savings taking into account the effects of natural resource depletion, education and real investment on national income. OECD (2011, 2013) has proposed several initiatives in order to measure and analyze well-being and the leadership to support the development of the balance sheets in a wider number of countries. Most recently, the adoption by the United Nations Statistical Commission in February 2012 of the System of Environmental-Economic Accounting 2012 Central Framework (SEEA 2013) was focused on the measurement of environmental assets and natural resources. Waves project about natural capital accounting, supported by an outstanding list of countries, public, private, civil society and international organizations.

Jorgenson, Landefeld and Nordhaus (2006), Jorgenson (2011), Jorgenson and Slesnick (2014) developed a new arquitecture of national accounts including non-markets activities, human capital and income distribution that allows to amplify production and asset frontier to measure welfare and sustainability. Their approach is compatible and consistent with KLEMS productivity and SNA08. Since Corrado, Hulten and Sichel (2005) (2006) proposal to include intangibles in a symmetric way with produced capital goods. Corrado, Haltwanger and Sichel (2005) Van Ark and Hulten (2007) and Mas and Quesada (2015) are important examples for harmonized public intangibles in Europe, as well as the uropean SPINTAN (Smart Public intangibles) project. Furthermore, on July 2013, the BEA recognized R&D and the creation of entertainment, literary, and artistic originals as investment in US national accounts.

These initiatives and academic literature take into account several aspects of natural resource on the economy as welfare, balance sheet and income. However, there are few contributions related to the impact of natural capital on growth accounting, and even less treatment of natural capital side by side with human capital and produced capital. ERS-USDA-Eldon Ball et.al. (2012) is a seminal research on source of growth to agricultural sector for US including land as an input adjust by quality. Similar methodology was applied for Argentinean agricultural productivity, Ball, Costa and Coremberg (2011). The Centre of Studies of Living Standards (2003), has analyzed source of growth and productivity for natural resource industries for Canada.

Despite natural capital is one of the main key variables that could explain growth profile of natural resource countries at macroeconomic level, there are few examples on measurement source of growth on non-renewables intensive sectors but they do not usually include natural capital as input. The exclusion of natural capital contribution in natural resource dependent economies could bias Multifactorial Productivity (MFP) performance of nations. ARKLEMS+LAND project is an exception, due to the development of a methodology and estimation of Source of Growth for Argentina, which extend KLEMS methodology for treatment land and subsoil assets as service inputs in

the context of WorldKLEMS iniciative to measure growth profile of world economy[3]. Brandt, Schreyer and Zipperer (2013) seminal paper constitutes a milestone in order to obtain a standard of measuring productivity with natural non-renewable capital, showing important results for OECD countries and South Africa, Chile and Russia.

Economic literature treated several aspects of natural resource impact on the economy: wealth, income accounts and growth accounting but without an integrated approach that includes those features in compatible way as the case of produced capital in the SNA. Human capital suffers the same inconsistency treatment in several economic research. Moreover SNA does not include human capital in assets frontier. But there were some agreement of research based on SNA of how to treat human capital as wealth and as input in growth accounting. Jorgenson and Fraumeni (1989) approach is the milestone metrics of Human Capital as Wealth as Gary Becker-Jacob Mincer sense[4]. BLS (1993), Jorgenson, Gollop and Fraumeni (1987), OECD (2001) and EUKLEMS (2007) project are standard metrics of how to measure human capital as input services in growth accounting.

This paper has two objectives. First, propose an integrated treatment (KLEMS+N) of natural and human capital in order to enlarge the scope of SNA allowing respond cocerns of Stiglitz-Sen-Fitoussi report about welfare and environmental sustainability. Second, present an application of the methodology to analyze key indicators of a possible Resource Curse of oil and gas dependent countries during the recent commodities boom.

The paper is structured as follows. Section 2 discusses the focus of SNA08 about economic assets boundary and proposed how to amply SNA assets frontier to include Human Capital and Natural Capital side by side with Produced Capital in the National Balance Sheet. Third section discusses how different types of capital should be measured in national balance sheet and production accounts and proposed a methodology that we called KLEMS+N in order to measure capital services by capital type, compatible with wealth metrics. Section 4 shows main results of testing the KLEMS+N methodology proposed here for oil and gas resource dependent economies (wealth, genuine savings and productivity performance). We analyzed the link between the findings and Resource Curse hypothesis during the recent commodities boom. Finally, the last section presents conclusions.

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[3] See Jorgenson (2012) and Coremberg (2012) (2015).
[4] See Fraumeni et. (2009) for China case, Coremberg (2010) for Argentina, Serrano and Pastor (2002) for Spain, Thrinh et.al. (2004) for New Zeland, ABS (2004) for Australia.

2. WHAT CAPITAL SHOULD BE MEASURED: Enlarging the Asset Boundary of the SNA

It is of the utmost importance to identify the asset boundary that defines the measurement of capital. Following Hulten (2004 and 2005a,b), in order to measure capital, the discussion should distinguish "what should be measured" from "how it should be measured" in order to avoid what Koopmans called "measurement without theory".

SNA08 is the canonical reference to determine what should be measured as capital. This methodology adopts an ownership rights perspective: the coverage of the assets is limited to those that are subject to property rights, i.e., those used in an economy activity, from which their owners can perceive profits by holding or using them in any economic activity. Both SNA08 and OECD (2009) include the traditional capital assets in the asset boundary: tangible capital assets (machinery, constructions, cattle for reproduction, etc.), but also intangible assets (software, purchase goodwill, patents, etc.), and natural resources (subsoil assets, agricultural land) subject to ownership rights.

However, unproved reserves or fuel deposits not discovered yet, or not exploited under current technologies and relative prices, are beyond the scope of the SNA. Non-economic natural assets may appear in the universe of economic assets in case of transfers from natural resources to economic uses. Some examples are the following: a) the transfer of land and terrains to economic uses, discover of new subsoil deposits that are non-economic but technical recoverable, b) the conversion of wild forests into agricultural land or c) the conversion of the natural reserve of fish into a reserve under economic control.

SNA08 asset boundary is compatible with Hicksian income definition: "the maximum amount which can be spent during a period of time if there is to be an expectation of maintaining intact the capital value of prospective returns"...; it equals Consumption plus Capital accumulation."[5] This criteria excludes assets when they are not subject to economic transactions or do not provide monetary surplus or profits. The set includes durable goods, human capital, and natural resources that are not subject to property rights (natural forest, non-cultivated wild fish, non-economic environmental assets, etc)[6]. According to SNA08, durable goods are excluded because they do not belong to the output frontier. Human capital is excluded because "…It is difficult to envisage "ownership rights" in connection with people, and even if this were sidestepped, the question of valuation is not very tractable". Some environmental assets of the same type as those within the boundary but are of no economic value. The following figure shows the Asset type classification according to SNA08 asset boundary. XXX

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[5] Hicks (1939), Jorgenson, Nordhaus, Landefeld (2006)
[6] SNA08, paragraph 3.46 to 3.49.

SNA 08 ASSET BOUNDARY

NON FINANCIAL ASSETS

PRODUCED ASSETS

Fixed Assets

- Intellectual Property Products
- Mining and Oil Exploration
- Software and Databases
- Originals of literature and artistic works
- R&D
- other

- Dwellings
- Non Residencial Construction and Infrastructure
- Machinery and Equipment
- Transport Equipment
- ICT
- Cultivated Assets
- Other

Inventories

- Raw Materials and supplies
- Work in progress
- Finished Goods
- Goods to resale

Valuable objects

- Precious stones and metals
- Antiques and other valuable objects
- Others

NON PRODUCED ASSETS

Natural Capital Economic Resources

- Land
- Subsoils Assets: Proved Reserves
- Cultivated Biological Economic Resources
- Enviromental Economic Resources
- Other

Contracts, leases and licences

- Net purchase Goodwill and Marketing Assets

NATIONAL WEALTH = NON FINANCIAL ASSETS + INTERNATIONAL INVESTMENT POSITION

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NET FINANCIAL ASSETS/LIABILITIES AMONG RESIDENTS = 0

Reserve Assets	Money and Deposits	Securities and Other Debt Holdings	Loans	Stocks and Investment Funds	Others
Monetary Gold Currency	Money Deposits	Short and Long Term	Short and Long Term	and other participations	Commercial Credits and advances Insurance Technical Reserves

+

INTERNATIONAL INVESTMENT POSITION

EXTERNAL FINANCIAL ASSETS	EXTERNAL FINANCIAL LIABILITIES

BY INSTITUCIONAL SECTOR:

FINANCIAL CORPORATIONS
NON FINANCIAL CORP
HOUSEHOLDS
GOVERNMENT
REST OF THE WORLD

NATIONAL WEALTH

Other Assets Outside Wealth SNA boundary

- Durable Goods owned by Households
- Non Economic Natural Resources
- Human Capital

SNA08 BOUNDARY-ownership criteria
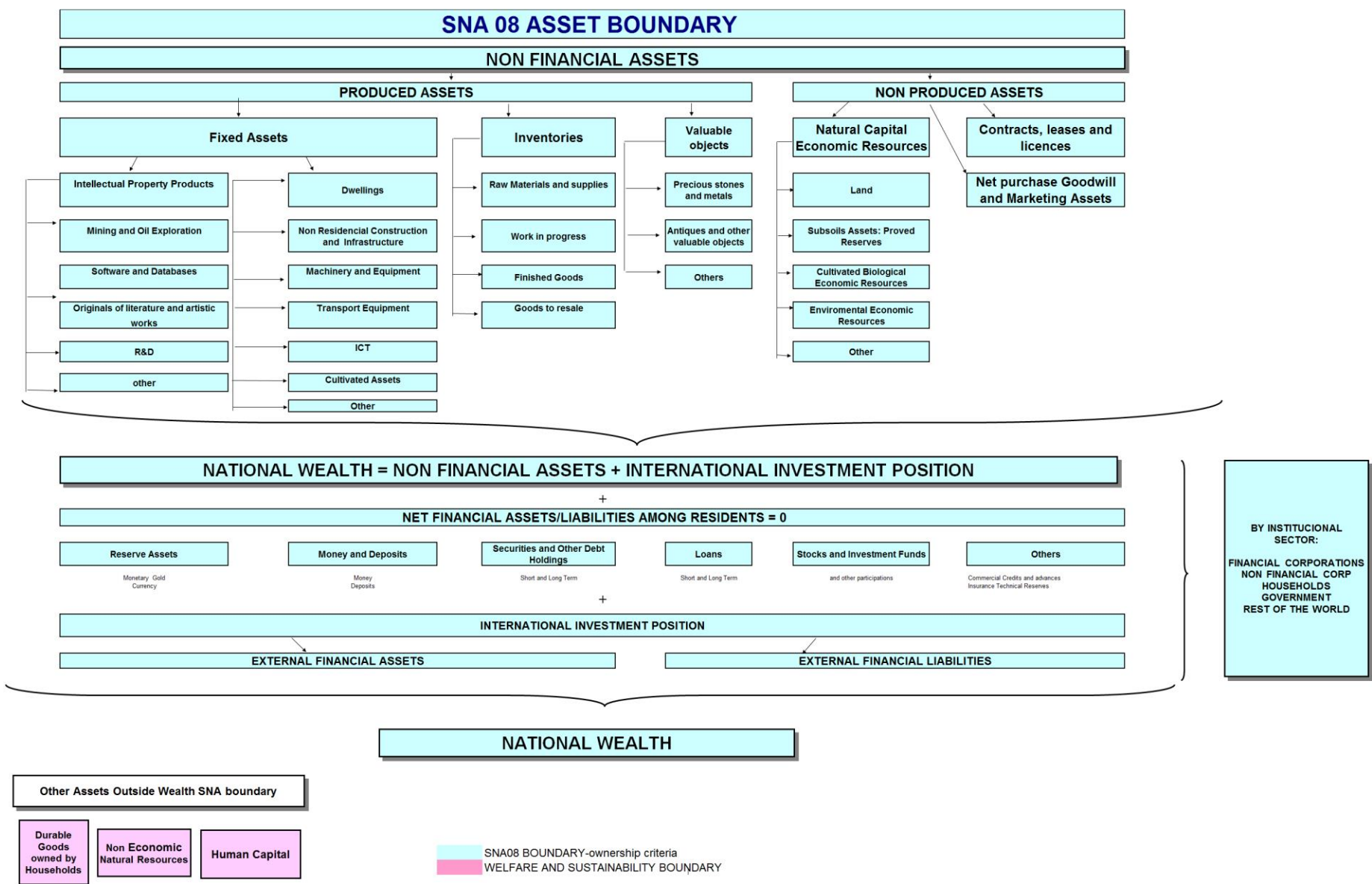WELFARE AND SUSTAINABILITY BOUNDARY

Figure 1: SNA08 ASSET BOUNDARY

SNA08 boundary includes traditional fixed produced capital as residential and non-residential construction, ICT, machinery and cultivated assets as well as intellectual property capital: R&D, mining and oil and gas exploration, software, and databases, originals. Non-produced assets are also included in the specific case of natural capital under well-defined ownership rights: land, proved reserves, cultivated biological and environmental economic resource. It also includes net purchase of marketing assets, and goodwill under general contracts, leases and licenses. In the case of patents, the SNA93 has defined them as non-produced assets, but SNA08 considers them as produced assets (R&D). More important is to point out that SNA93 includes "intangible assets" but SNA08 replaced them with the concept of "intellectual property products" in the sub-set of produced assets, but not in the sub-set of "non produced assets. It is noteworthy because they do just "disappear" when there is a case for intangibles inclusion not only as a satellite account but mainly in official national accounts, as we will analyze soon in this section. Nevertheless, consumer durables goods, human capital and non-economic environmental and natural assets have important impact on economic growth and welfare sustainability.

Since long time ago, economic literature has envisaged human capital as a key component of national wealth and a relevant source of GDP growth. Shultz (1961), Becker (1964), and Mincer (1974) pioneered the research on the activities that increase the individuals' stock of knowledge and experience, considering them as investments in human capital. By analogy with the economic theory of investment in physical capital, the human capital theory suggests that people invest in human capital in order to increase their future well-being. More precisely, investment in human capital via time allocation in formal and informal education implies a sacrifice of present consumption in order to improve the expected future income profile (or permanent income), which can increase future consumption.

Furthermore, several exogenous and endogenous growth models analyze howt human capital contributes to economic growth. There human capital has a positive contribution to total factor productivity growth of any economy, because of the effect of externalities (Lucas 1988) as well as through the recognition that its factor remuneration is greater as the one traditionally quantified in its share in income once workers' skills differential returns were taken into account (Mankiw, Romer, Weil 1992). Economic literature as Romer (1986, 1990) has pointed out the role of the skilled workers in R&D activities to sustain economic growth. This type of labor force generates externalities and increasing returns beyond the sectors where workers are located; linking the capacity of generating innovation, learning by doing, increasing returns, variety in inputs and outputs as Aghion & Howitt (1998), Young (1998) and Jones (1999)). This is why the measurement of changes of labor composition turns out to be very relevant in growth accounting. If labor input is not disaggregated by attributes (sector, gender, age, education, etc.), its contribution to economic growth could be underestimated, leading to a positive bias in measured MFP. Likewise, human capital externalities and complementarities should be included in TFP.

EU-KLEMS, OECD and Groningen and Conference Board productivity databases include labor composition change as an input is nowadays a standard growth accounting. From the pioneer research by Jorgenson-Fraumeni (1989), some consensus emerged on how human capital should be included in the asset and production boundary but also how should be measured. If we expand the SNA boundary, setting aside ownership rights criterion, towards a more integrated approach, Human Capital should be included in SNA asset boundary, not only because is a key variable that determines living standards but also is a key input in production boundary.

Unproved technical recoverable mineral resource, land with no economic value, fish, water and other bio-physical resources that have no ownerships rights but have important impact on environmental and welfare sustainability has been considered as an important issue in the System of Environmental-Economic Accounting 2012 Central Framework (SEEA Central Framework) by the United Nations Statistical Commission in 2012. As emphasized by the Stiglitz-Sen-Fittoussi Report, environmental assets are a key variable of economic growth sustainability.

Jorgenson, Landefeld and Nordhaus (2006), Jorgenson (2011) and Jorgenson and Schlesnik (2014) propose a new national accounts arquitecture which integrates production, productivity, income, balance sheet, welfare and environmental issues in a unique and consistent accounts system. The purpose of this new arquitecture has been reached with the adoption of Fisherian (or utility-based) national income perspective. In Fisherian terms, national income is defined as the maximum amount that a nation can consume while ensuring that members of all current and future generations can achieve an expected lifetime consumption or utility level as high as current consumption or utility.

Asset frontier should be expanded to a more exhaustive criterion if an intertemporal approach was adopted. Jorgenson (1995a) considers investment "as the commitment of current resources in the expectation of future returns, implying that these returns can be internalized by the investor". Corrado, Hulten, and Sichel (2005, 2006) consider "all expenses in postponed consumption as investment. In other words, investment is any use of resources that reduces present consumption in order to increase it in the future". Applying this symmetry principle, Corrado, et al. (2005, 2006) includes several intangible assets side by side with produced capital: software and database, acquired knowledge through R&D and non-scientific innovation activities, brand, purchase goodwill, patents and expenses in human capital formation. Mas and Quesada (2014) have recently applied the symmetrical principle and found that intangible inclusion duplicate US investment and represents nearly 50% of standard gross capital formation in EU.

If we apply Fisherian intertemporal criteria and symmetry principle, SNA could widen the assets frontier to items excluded by the ownership principle: specifically, human capital, and non-produced capital not subject to ownership rights but with impact on well-being and sustainable growth. This asset definition is compatible with Stiglitz-Sen-Fittousi report, which pointed out that national accounts must focus on welfare instead of production. Several "non-economic" natural assets provide key services to households'

well-being and are extremely relevant to analyze environmental sustainability. In addition, Human capital is a key asset that provides future perspective of better welfare and living standards. According to this new perspective, national accounts should include all market and non-market activities and stocks at scarcity prices and other dynamic features that affect production[7]. Applying the Hulten-Jorgenson symmetry principle, to Human and Natural Capital, like in the intangible capital case, both types of capital should be included in the core of capital account of the SNA.

The following figure shows how the scope of capital expands to assets that are directly linked with welfare and growth sustainability.

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[7] As pointed out by Weitzman (1976) and Nordhaus (2000), under idealized conditions, the output-sustainability correspondence principle, Hicksian and Fisherian income are identical.

WELFARE AND SUSTAINABILITY GROWTH ASSET BOUNDARY (KLEMS+N approach)

NON FINANCIAL ASSETS

PRODUCED ASSETS

Fixed Assets

Intangibles
- Mining and Oil Exploration
- Software and Databases
- Originals of literature and artistic works
- R & D
- Investment in Firm-Human Capital Formation
- Marketing Assets: purchase goodwill, brand equity, design and advertising , etc.
- HUMAN CAPITAL
- other
- Goodwill (include expectations of future earnings, urban land market value and overlapping other intangible assets and human capital)

Tangibles
- Dwellings
- Non Residencial Construction and Infrastructure
- Machinery and Equipment
- ICT
- Transport Equipment
- Cultivated Assets
- Durable Goods owned by Households

Inventories
- Raw Materials and supplies
- Work in progress
- Finished Goods
- Goods to resale

Valuable objects
- Precious stones and metals
- Antiques and other valuable objects
- Others

NON PRODUCED ASSETS

Natural Capital

Economic Resources
- Subsoils Assets: Proved Reserves
- Non-Cultivated Biological Economic Resources
- Enviromental Economic Resources
- Land

Non-Economic Resources
- Subsoils Assets: Unproved Reserves
- Non-Economic Biological Resources
- Non-Economic Enviromental Resources
- Other

Intangibles
- Leases and other transferable contracts
- Other

NATIONAL WEALTH = NON FINANCIAL ASSETS + INTERNATIONAL INVESTMENT POSITION

NET FINANCIAL ASSETS/LIABILITIES AMONG RESIDENTS = 0

Reserve Assets	Money and Deposits	Securities and Other Debt Holdings	Loans	Stocks and Investment Funds	Others
Monetary Gold Currency	Money Deposits	Short and Long Term	Short and Long Term	and other participations	Commercial Credits and advances Insurance Technical Reserves

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INTERNATIONAL INVESTMENT POSITION

EXTERNAL FINANCIAL ASSETS	EXTERNAL FINANCIAL LIABILITIES

BY INSTITUCIONAL SECTOR:

FINANCIAL CORPORATIONS
NON FINANCIAL CORP
HOUSEHOLDS
GOVERNMENT
REST OF THE WORLD

NATIONAL WEALTH

SNA08 BOUNDARY-ownership criteria
WELFARE AND SUSTAINABILITY BOUNDARY

Figure 2: WELFARE AND SUSTAINABILITY ASSET BOUNDARY (KLEMS+N approach)

Welfare and Sustainability Boundary generates several new assets appears and changes assets classification in comparison with SNA08.

Thanks to the adoption of symmetry principle, all assets are classified as tangibles and intangibles, produced and non-produced. Marketing assets, firm-specific human capital formation, organizational expenses, previously classified as non-produced capital, are now produced capital. Moreover, human capital appears as an asset in this new boundary definition. It is worth to point out that this classification could be controversial. According to SNA08[8], human capital is recognized as a non-produced asset only in the case of contracts of football players: when the football club are selling or buying the exclusive right to have a player working for it. Under this new classification, all workers have implicitly human capital when firms or governments contract them.

Another controversial issue emerges at including firms' goodwill as an asset (not only net goodwill purchases) in this new boundary. If we consider the market value of firms as an asset, goodwill and marketing assets represent the market value of the institutional unit. Under the SNA08 methodology they are valued only when they are sold. This approach, instead considers the present stock value of those types of assets. Marketing firm expenses, firm-specific human capital formation and other organizational outlays are now investment instead of intermediate inputs as well as intangible capital stocks.

Other relevant assets encompassed by this new boundary definition are the non-economic natural resources. Unproved reserves as well as non-cultivated biological resource, natural forest, water resource with no ownership and non-monetary environmental assets should be considered within this boundary according to well-being and growth sustainability analysis.

Other issue is how to value these assets taking into account their role in national wealth and as an input. The following section discusses and proposes an integrated methodology of how to measure the different types of capital goods.

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[8] Parragraph 17.368

3. HOW CAPITAL SHOULD BE MEASURED: A KLEMS+N integrated approach

Thanks on the recommendations of by the Canberra II Expert Group (mainly included in the OECD Manuals) meeting and approved by the United Nations Statistical Commission at its February-March 2007, the price and quantity of capital services were included in the 2008 SNA. The OECD manuals on Measuring Capital and Measuring Productivity provided the standards of measurement methodology[9]. Main focus of the Manual is on produced capital. The purpose of this section is to integrate Produced, Human and Natural Capital in the national balance sheet and production account subject to symmetric principle and propose a methodology of how to measure every type of capital as well as capital services in a consistent approach.

3.1 Capital in National Balance Sheet

As OECD (2009) has pointed out, every non-financial asset is both a factor of production and a means of storing wealth.

SNA08 adopts the general principle of valuation of assets into balance sheet by their market prices. As proposed by the SNA08 and OECD (2009), capital stock as net capital must be valued at replacement or second hand market prices[10]. This issue is relevant, because wealth effects registered through changes in national balance sheet is a key variable of Balance Sheet fragility, household permanent income analysis as well as natural resource dependent countries growth profile during commodity prices boom or bust.

National Balance Sheet could be analytical express as:

$$(1)\ W = KP + KH + KN + IIP$$

W: national wealth
KP: produced capital (tangibles and intangibles)
KH: human capital
KN: natural capital
IIP: international investment position

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[9] See OECD (2009) and (2011).
[10] As pointed out by Hulten and Wycof (1981) and Coremberg (2009) there is not always have market prices so they must replicate them as for example by hedonic prices econometric estimation which is no exempt of several measurement issues.

As we will see in next section, this is the wealth counterpart of KLEMS+N (capital, labor, energy, material and service + natural capital) inputs to obtain growth accounting decomposition.

If we applied general principle of SNA08 of assets valuation by market prices to the assets included into the welfare and sustainable growth boundary produced capital but also human and natural capital must be also value by their market prices or by replicating its equivalent.

3.1.1 Produced Capital as Wealth

Following the OECD Manual[11], produced capital must be valued at reposition equivalent costs (net capital stock concept) when it is considered as part of Wealth. In order to obtain the value of capital as wealth in the national balance sheet, urban land must be added because buildings and dwelling units are usually valued at construction costs in the case of net capital stocks measured by national accounts.

Analytically, produced capital as wealth is:

$$(2) KP^W = KP^{net}_{otherNonICT} + KP^{net}_{ICT} + KP^{net}_B * \left(\frac{Pm}{Pc}\right)$$

Where every variable express produced capital wealth as the sum of net produced capital stocks by type: information software and telecommunications goods (ICT), and buildings (residential and non-residential) net stocks[12].

3.1.2 Human Capital as Wealth

The new boundary includes human capital as an economic asset. It is worth to point out that when SNA08 and OECD (2009) explain what is capital service, as we will see in the following subsection, main analogy between service input provided by capital stocks is the hours worked or labor services provided by workforce and user costs and wages are respective service prices. So if the market price of net produced capital stock is the present value of future flows of capital services value by user costs, there must be an equivalent wealth valuation for human capital.

Today, the standard wealth valuation of human capital is the Jorgenson-Fraumeni (1996a) approach. According to it, human capital is valued in line with Gary Becker's economic theory of human capital as a function of the expected returns that an individual can generate in the labor market throughout his working life. This method takes into account not only the present labor income but also future income that the worker can potentially earn thanks to of his formal education and job experience.

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[11] See OECD 2009.
[12] Adjusted by the Tobin q ratio between market price of buildings units and its equivalent replacement cost of construction).

According to the permanent income method, the individuals who potentially work and study have all the time expectations of two possible future income streams: one corresponding to going on in the same education cohort and the other corresponding to the probablity of change to the following educational attainment, analytically:

$$(3) \quad lli_{g,a,e_i,t} = w_{a,e_i,t} * o_{a,e_i,t} + \left\{ \begin{array}{l} (1 - \sum_{j \in E} \sum_{t \in T} se_{a,e_i,t}^{j,t}) * o_{a+1,e_i,t} * VPS_{a+1,e_i,t} + \\ + \sum_{j \in E} \sum_{t \in T} se_{a,e+1_i,t}^{j,t} * o_{a+t,e+1_i,t} * VPS_{a+t,e_j,t} \end{array} \right\} \frac{(1+g)}{(1+r)} * sr_{a+1,e_i,t}$$

lli$_{gaet}$: life labor per capita income by genre, age and education

w: current wage

g: Expected growth rate of labor income

r: discount rate

a: age

e$_i$: educational stratification by group I

se: probability of change of educational skill, being e$_i$ of education at the age of t

O$_{gaet}$: Probability of being employed or employment rate of the strata g, a, e, t

sr: survival probability

Human capital wealth is the life per capita income of the population n stratified by gender, age and education:

$$(4) \quad KH^W_t = \sum_{g,a,e} lli_{g,a,e_i,t} n_{g,a,e_i,t}$$

3.1.3   Natural Capital as Wealth

Maintaining symmetry principle, Natural Capital should be valued by their market price. Since just like any other asset, the market price should represent the present value of productive services that it provides. Likewise, not all the non-produced assets have observable market prices. This is the case of mineral resource for there is no general agreement related to the methodology of valuation of non-produced wealth and its productive services.

In the case of land, World Bank (2011) valuates agricultural land by the capitalization of rents estimated as price net of costs using a common rate of discount for all countries. That approach is applied in the case of subsoil assets by imputing expected net present value of the provided future services. However, this is not necessarily consistent of general focus of SNA08: market prices principle. For the case of subsoil assets, which are essentially non-market assets, like gas, oil and other mineral deposits the application of net present value formula is unavoidable. However, it must be taken into account that natural resource countries has very different rate of discount for subsoil projects generally higher than the common rate of discount applied by World Bank due to country risk and

idiosyncratic risk of the mineral activity. For the case of land, market prices should be taken into account in order to valuation. World Bank instead of taking into account land market prices, applies capitalization of land rents (price of agricultural commodities net of costs) but market prices of land could be a multiple of the capitalization of rents, in function of implicit rate of discount of rental leases and land characteristics.

In order to maintain the symmetry principle, land must be valued at market prices. In the case of subsoil assets, market prices could be replicated by net present value approach but taking into account idiosyncratic parameters by country and type of resource. The shortcoming of present value formulas, like those used by the World Bank, is the assumption of a constant flow of future rents. But, as pointed out by some recent literature[13], the value of subsoil assets is completely dependent of those assumptions, which could not be standard. For example, for the case of forecast rent in the present value formula, if we take into account Hotelling rule about future upside trend of prices of non-renewable resource vs Prebich-Singer theorem about downward trend of commodity prices, subsoil wealth will be completely different. Same inference about what rate of discount must be applied (social vs private, etc.).

$$(5) KN^W = K_{Land}^W + K_{subsoil}^W \text{ where}$$

$$(6) K_{Land}^W = \sum_i p_i^{land} * ha_i$$

The land wealth consists of crop and pastures areas valued at the market price of land by hectares by each region i.

$$(7) K_{subsoil}^W = \sum_{n=t}^{t+T-1} \sum_i \frac{r_j^S q_j}{\left(1+\rho_j^S\right)^{n-t}}$$

The subsoil or mineral wealth are the present value of future flows of production q by unit rent r^S discounted at the discount rate ρ by asset type and T is the lifetime of the resource

The ideal sequence of the estimation of national wealth is this[14]:

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[13] Arrow, Dasgupta, Goulder, Munford and Oleson (2012), Schreyer and Obst (2014) and Stiglitz-Sen-Fittousi Report (2009)

[14] See the following figure.

	INTERNATIONAL INVESTMENT POSITION ***	NATIONAL WEALTH
	FARMING LAND (MV) SUBSOIL ASSETS (NPV)		
	HUMAN CAPITAL+OTHER INTANGIBLES			
	URBAN LAND				
NET PRODUCED CAPITAL STOCK	TANGIBLE NET PRODUCED CAPITAL STOCK	TANGIBLE WEALTH PRODUCED CAPITAL STOCK MV	WEALTH PRODUCED CAPITAL STOCK MV	NON-FINANCIAL ASSETS	NATIONAL WEALTH

NET PRODUCED CAPITAL STOCK		TANGIBLE NET PRODUCED CAPITAL STOCK	TANGIBLE WEALTH PRODUCED CAPITAL STOCK MV	WEALTH PRODUCED CAPITAL STOCK MV	NON-FINANCIAL ASSETS
Machinery and Equipment	RC				
Transport Vechicles	RC				
ICT	RC				
Residential Buildings	RC				
Non Residential Buildings	RC				
Infraestructure	RC				
Other agricultural construction	RC				
Capital Livestock	MV				
Agricultural cultivated assets	MV				
Inventories	MV				

RC: equivalent replacement cost
MV: Market Value
NPV: net present Value
*** IIP bonds, stocks and other securities at market value

Figure 3: Sequence of Estimation of National Wealth

National Wealth turns out to be the sum of non-financial assets value at market prices (or equivalent) plus international investment position.

1. Tangible Wealth Produced Stock is computed after the adjustment of usual Net Produced capital stock by Urban Land through revaluation of building structures by Tobin Q ratio.

2. Wealth Produce Stocks is obtained after adding human capital wealth and other intangibles assets

3. Non-Financial Assets is the sum of wealth produced stocks and natural capital: adding land wealth at market prices and sub soil assets by present value of future total rents.

4. Addition of International Investment Position

   =National Wealth

3.2 Natural and Human Capital as Input in Growth Accounting

One of the main innovation of SNA08 is the inclusion of a chapter about productivity issues that summarizes EU-KLEMS experience on productivity measurement at industry level. Following OECD Canberra Group II: "On the Measurement of Non-Financial Assets", one of the most important innovations of SNA08 is the inclusion of capital services in the core of national accounts. When capital stock is considered as a primary input that contributes to output, capital must measure as capital services[15].

Following the approach proposed in this paper, natural and human capital should be treated in the same way as produced capital in capital accounts. Taking into account SNA08 analogy and OECD (2009): flows of capital and labor input are perfectly symmetric when capital input is rented.

3.2.1 Produced Capital as Service Input

OECD Measuring Capital Manual (2009) established user cost as weights of different types of capital in aggregate capital services measurement. User costs may be measured by either an exogenous or an endogenous approach. As pointed out also by Diewert, Harrison and Schreyer (2004), there are benefits and costs of these different approaches. Ideally, if we have a rent market by every type of capital, we could apply "rent market equivalent" approach to value capital services; as it was applied in Coremberg (2004) cited by OECD (2009). This is precisely the approach that this research adopt and adapt for the case of human and natural capital.

Following OECd (2009), produced capital service input formula is:

$$(8) \quad \frac{K_t^P}{K_{t-1}^P} = \prod_{i=1}^{n} \left(\frac{K_{it}^P}{K_{it-1}^P} \right)^{\frac{1}{2}(v_{it} + v_{it-1})}$$

$$Vi,t = \frac{u_{i,t}^K K_{i,t}}{\sum_n^n u_{i,t}^K K_{i,t}}$$

$$u_i(t) = [r(t) + \delta_i - \rho_i(t)] P_i(t)$$

Vi,t: user cost weights

u_i: user cost by produced capital type

P_i: capital good deflator

ρ_i: expected capital gains

r(t): internal rate of return

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[15] OECD (2009) Measuring Capital provides methods to measure price and quantities components of capital services but mainly focused on produced capital

3.2.2 Human Capital as Service Input

One of the important goals of human capital measurement is to gauge human capital stock in terms of present productive capacity of the population. Productive human capital expresses the present productive capacity of the labor force as an input of the production function of a firm, industry or country.

Standard Measures has been established for measuring labor input in growth accounting. The indicator of labor composition change, called "labor quality index", was proposed by BLS (1993) and Jorgenson, D, Ho, M. and Stiroh, K. (2005) for the United States. Schwerdt &Turunen (2007) did it for the European Union Case. OECD (2001), as well as the EUKLEMS (2007) project has established the standards fo measurement of productivity in Europe, US and other OECD countries and now WorlKLEMS initiative, Jorgenson (2012).

Labor composition change indicator is the difference between labor input measured by the stratification of characteristics of the workers and jobs, weighted by their relative wages, and a measurement of raw labor by the simple addition of unweight hours worked. Labor input is measured by the following index:

(9)
$$\Delta \ln L = \sum_j \bar{s}_{j,t} \Delta \ln H_{j,t} \qquad s_{j,t} = \frac{W_j H_{j,t}}{\sum_j W_j H_{j,t}}$$

Where L is the labor input (differentiated), H is hours worked, sj are the weights of each worker's attributes and jobs characteristics in the labor income structure of the total labor input in the economy.

The labor composition change index results from the difference between differentiated labor input growth and a raw labor growth (for example: non-differentiated hours worked' growth):

(10)
$$\Delta \ln L^Q = \bar{\alpha}_L (\Delta \ln L - \Delta \ln H)$$

Workers with better attributes receive a higher weight (more experience, better educational levels, etc.) but also better jobs if the stratification also includes jobs characteristics (informal vs salaried workers, etc.). Hence, the contribution of human capital to economic growth, and also to labor productivity growth, is measured by the growth of labor composition change index.

This human capital services metrics is the only indicator compatible with human capital wealth. Human capital services are weighted by current wages by workers characteristics and human capital wealth is weighted by the present value of wages by type. Taking another step forward to more symmetry analogy, it must be pointed out that OECD (2009) and SCN08 use the example of labor services to explain how to value capital services with

a symmetric principle: user cost is the price of capital services and wages is the price of labor services.

3.2.3   Natural Capital as Service Input

Natural Capital is not only the main input of natural resource dependent industries but also a key variable that contributes with their services to GDP growth of natural resource dependent economies. The symmetric principle applied to natural capital demands to obtain a quantity and price metrics for their services compatible with their wealth concept. Quantity service is harvested area in the case of land and volume of extracted material from deposits that enters the production process in the case of subsoil assets. Following the general approach of valuing produced capital services by user cost, natural capital services must be valued by their rents. User costs for land services are directly land rents which information could be measured by rent market equivalent approach, taking into account market payments for the use of land.

$$(11) K_{Land}^S = \sum_i r_i^{land} * ha_i$$

Where S superscript means service concept, rland is the rental market price of land which is the user cost equivalent of land prices taking into account the proper rate of discount compatible with the land capital as wealth of equation (6).

But for subsoil assets, there are not usual rent prices statistics as in the case for land rents. There are some alternative methods to obtain subsoil rents:

1. Rent imputation approach: followed by World Bank (2006) (2011), subsoil rents could be obtain as the price of the material net of extraction costs.
2. Residual approach: as it is pointed out in Coremberg (2009), subsoil rents could be obtain as a residual between gross operating surplus of natural resource intensive sector and its produced capital services. Produced capital services of this sector could be obtained by imputing the average rate of return of total capital stock to the capital stock of the sector.

$$(12) K_{subsoil}^S = \sum_j r_j^S q_j \quad \text{,which comes from equation (7).}$$

Finally, the contribution of subsoil resources and land to GDP growth is the growth of the natural capital services weighted by the share of rents in the GDP.

3.3 Natural and Human Capital in Income Accounts

If we recognized, natural and human assets as economic assets, we must adjust income measures by the effects of those types of capital.

National savings can be invested in produced capital and in natural and human capital. Furthermore, gross macroeconomic indicators as gross domestic product, gross investment and gross national savings must be adjusted to obtain net values adjusted by depreciation of produced assets and by natural capital depletion, when the main purpose is to get an appropriate measure of income to consumption and welfare sustainability,.

The equation for Adjusted Net Savings or Genuine Savings (Sg) and Adjusted Net National Income (NNY), following the World Bank-Hamiltion (2011) proposal is[16]:

(13) $Sg = S - \delta_{KP}w KP^W + I_{KH}w - \delta_{KN}w KN^W$

(14) $NNY = Y - \delta_{KP}w KP^W + I_{KH}w - \delta_{KN}w KN^W$

S: gross national savings

Sg: genuine savings

δ_{KPW}: depreciation rate of productive capital

I$_{KHW}$: education investment

δ_{KPW}: natural capital capital depletion rate

Y: gross national income

This metrics for income focus on well-being could be included to enlarge SNA flow accounts thanks and compatible with the welfare and growth sustainability KLEMS+N assets boundary.

So present consumption path could only be sustainable if national savings plus education investment is enough to not only compensate depreciation of produced assets but also natural capital depletion and degradation and pollution damages.

According to World Bank (2006) (2011)-Hamilton empirical literature, several countries show negative or very low genuine savings as a symptom of the so called Resource Curse: an unsustainable GDP growth path characterized by the exhausting of non-renewable assets rents during commodities price booms, instead of reinvesting them in other assets. Some of these stylized facts will be checked with the KLEMS+N general methodology for oil and gas countries.

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[16] Pollution damages could be also added to the formula. According to World Bank (2011), human capital obsolescence is not explicitly treated.

3.4 The Symmetric Principle in practice

Thanks on the symmetric principle, KLEMS+N approach could enlarge the scope of capital to a wider asset SNA boundary. This allows the inclusion of intangibles, and human and natural capital, as "capital", including environmental assets with no property rights. If this approach applies to human and natural capital the same analogy principle as OECD (2009) and SNA08 do for produced capital services, every type of capital stocks could be value as wealth as service inputs in a consistent way with standard and compatible methods as proposed as the following table:

Table1: Capital Stocks by concept, type and methods

variables	TOTAL	Produced Capital	Human Capital	Natural Capital	Land	Subsoil Assets
		KP	**KH**	**KN**	**K$_{land}$**	**K$_{subsoil}$**
Wealth		Net Produced Capital at equivalent replacement costs adjusted by Urban Land	Lifetime per capita Income of Population at workage by Jorgenson-Fraumeni Approach	Natural Capital at market prices	Land at market prices by area	Subsoil Assets by Net Present Value of Future total rents
	(15) $W = KP + KH + KN + IIP$	(2) $KP^W = KP^{net}_{otherNonICT} + KP^{net}_{ICT} + KP^{net}_{B} * \left(\frac{Pm}{Pc}\right)$ (2) $KP^W = KP^{net}_{otherNonICT} + KP^{net}_{ICT} + KP^{net}_{B} * \left(\frac{Pm}{Pc}\right)$	(4) $KH^W_{\ t} = \sum_{g,a,e} lli_{g,a,e_i,t}\, n_{g,a,e_i,t}$ (4) $KH^W_{\ t} = \sum_{g,a,e} lli_{g,a,e_i,t}\, n_{g,a,e_i,t}$	(5) $KN^W = K^W_{Land} + K^W_{subsoil}$	(6) $K^W_{Land} = \sum_i p^{land}_i * ha_i$	(7) $K^W_{Land} = \sum_i p^{land}_i * ha_i$
Services		Produced Capital value at user cost by type	Labor Composition Change	Natural Capital Services Inputs	Land Areas value by unit rents	Material Extracted value by unit rents
		(8) $\dfrac{K^P_t}{K^P_{t-1}} = \prod_{i=1}^{n} \left(\dfrac{K^P_{it}}{K^P_{it-1}}\right)^{\frac{1}{2}(v_{it}+v_{it-1})}$ $Vi,t = \dfrac{u^K_{i,t} K_{i,t}}{\sum_n^n u^K_{i,t} K_{i,t}}$ $u_i(t) = [r(t) + \delta_i - \rho_i(t)] P_i(t)$	(9) (10) $\Delta \ln L^Q = \bar{\alpha}_L (\Delta \ln L - \Delta \ln H)$ $\Delta \ln L = \sum_j \bar{s}_{j,t} \Delta \ln H_{j,t}$ $s_{j,t} = \dfrac{W_j H_{j,t}}{\sum_j W_j H_{j,t}}$		(11) $K^S_{Land} = \sum_i r^{land}_i * ha_i$	(12) $K^S_{subsoil} = \sum_j r^S_j q_j$
Income	Sg	$S - \delta_{KPW} KP^W$	I_{KH^W}	δ_{KPW}		

4. APPLYING KLEMS+N TO RICH OIL AND GAS COUNTRIES

4.1 Are Oil and Gas dependent countries rich?

As Heal (2006) inquires, how could we reconcile the stylized fact that oil countries has an important wealth in subsoil assets but at the same time, except few cases (Norway, Canada), the majority of oil, and gas dependent economies are poor-low wellbeing resource-exporting countries. Economic literature documents the "Resource Curse", discussing how and why natural resources abundance should not automatically translate in improvements of living standards. Moreover, some of these countries during the recent positive commodities prices cycle, consumption boom, productivity slowdown, domestic savings drop and some signals of the so called "Dutch Disease" as appreciation of domestic currency and de-industrization could erode the sustainability of their future GDP growth paths.
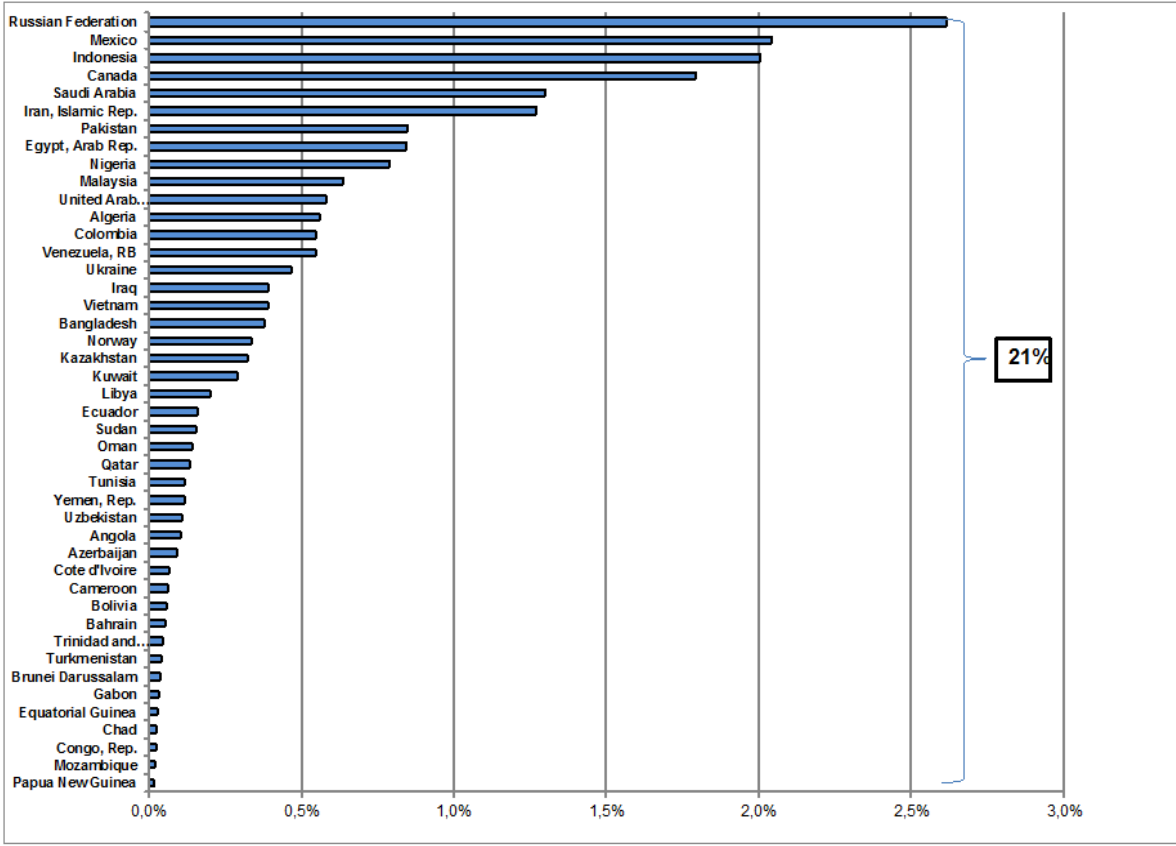
Oil and gas dependent countries are an outstanding case for applying KLEMS+N approach proposal. First, it is important to define Oil and Gas dependence. This research adopts World Bank (2011) criteria as countries where oil and gas rents were above 5% of GDP in 2005. Oil and gas country group have an oil and gas rents share of 35% of their gdp. It is important to point out that several countries that are big players in oil and gas world markets have an above the average share, as Angola, Saudi Arabia, Russia, Iran, Venezuela, Algeria and Nigeria.
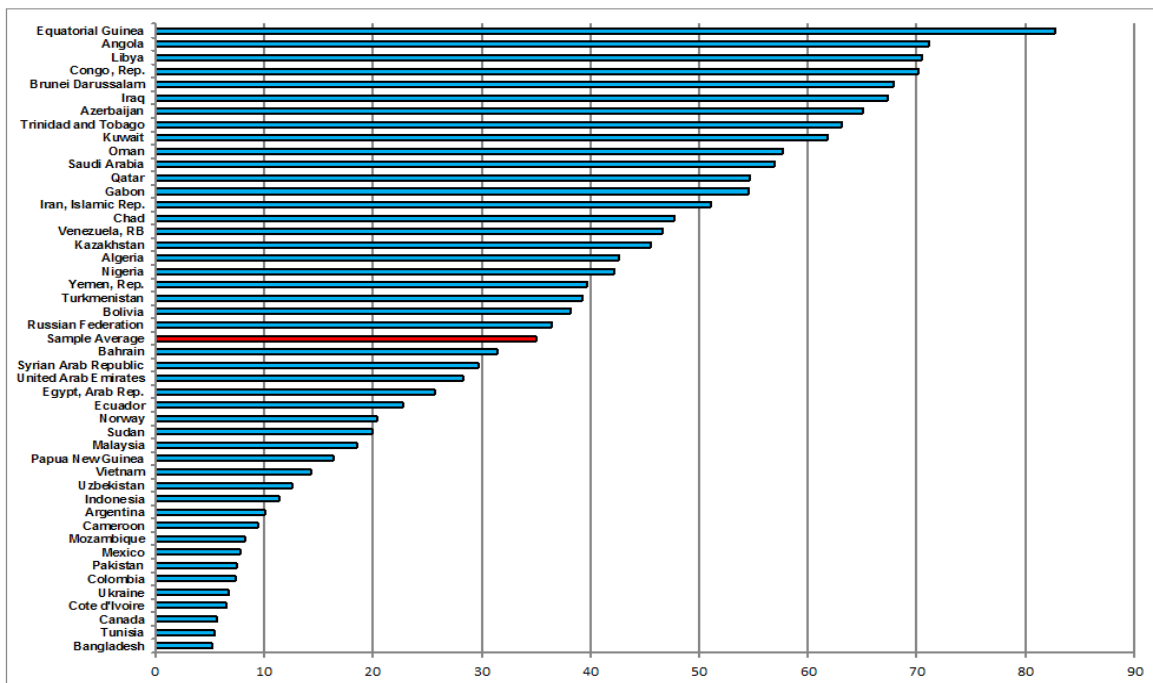
*Figure 4: Share of Oil and Gas Rents in Oil and Gas dependent countries GDP. Source: World Bank*

This definition must be distinguished for oil and gas producers or oil and gas main exporters at the world economy. For example, China and USA are important oil and gas net importers and producers. But the definition of Oil and gas dependence is in accordance with natural resource dependence as economic literature about Resource Curse and Dutch Disease define of a country which main income resource become from non-renewable natural resource extraction. The last one is directly related with the magnitude of natural resource rents on GDP, exports and fiscal revenues.

Oil and gas dependent countries share a 21% of World GDP at ppp prices according to World Bank data. Russian Federation, Mexico, Indonesia, Canada, Saudi Arabia, Iran account for almost 50% of this total.

Figure 5: Share of Oil Natural Gas dependent countries group in the World GDP at ppp prices, 2005. Source: World Bank data.

Oil and gas dependent countries are subject to terms of trade shocks due to energy prices booms and busts. In the last decade, oil and gas prices showed a significant upward trend that has apparently reached to the end, as it is shown in the following figure.
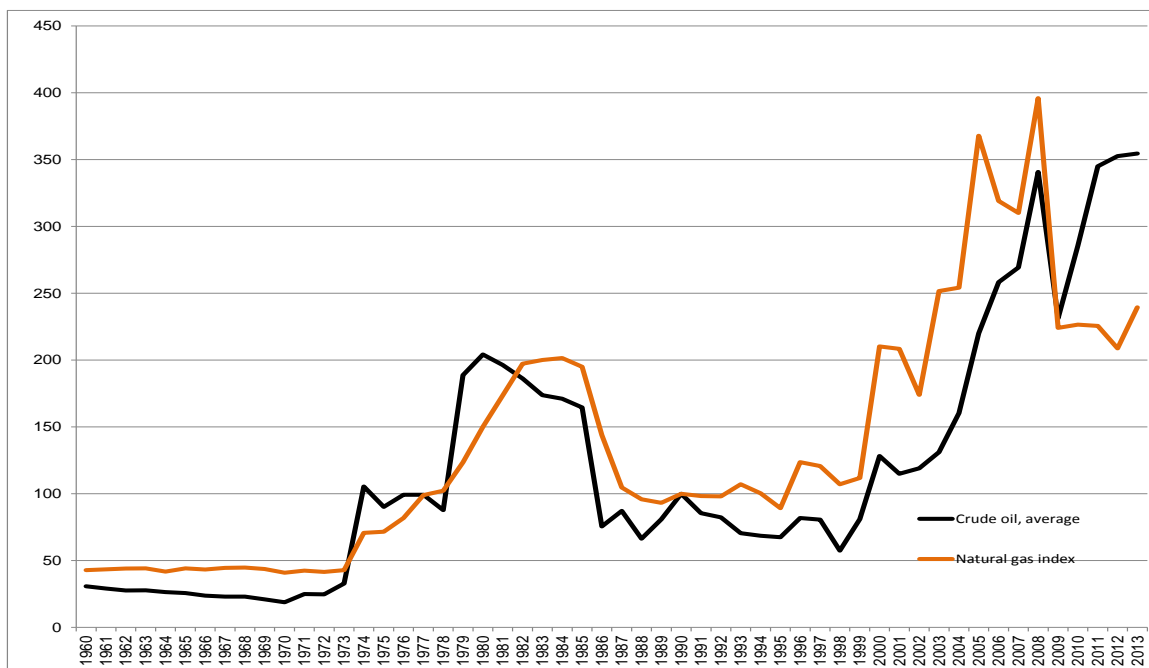
Figure 6: Crude Oil average price and Natural Gas real price Index-2010 US dollars (1990=100) based on World Bank data.

The KLEMS+N methodology allows to assess if oil and gas dependent economies showed some important signals of Resource Curse during the recent oil and gas prices boom: wealth effects, domestic savings and productivity performance behavior during the last commodities boom.

4.1.1   Methodology

Oil and Gas wealth are estimated by applying equation 7 to the series as it is shown in the following table:

Table2: Oil and Gas Wealth data source summary			
	Variable		
	Oil and gas unit costs	Oil and gas Unit Rents	Oil and gas unit Rents
Period	1990-2012		
Data Source	US Energy Information Administration	British Petroleum Statistical Review 2014 Workbook	
Countries Covered	Algeria, Angola, Arab Emirates, Argentina, Azerbaijan, Bahrain, Bangladesh, Bolivia, Cameroon, Canada, Colombia, Côte d'Ivoire, Ecuador, Egypt, Indonesia, Iran, Iraq, Kazakhstan, Kuwait, Malaysia, Mexico, Mozambique, Nigeria, Norway, Oman, Pakistan, Russia, Saudi Arabia, Sudan, Syria, Trinidad & Tobago, Tunisia, Turkmenistan, Ukraine, Uzbekistan, Venezuela, Vietnam, Yemen.		

The methodology is similar to World Bank (2011). We define wealth as the present value of rents from oil and gas extraction taking into account the lifetime of proved reserves and using a common discount rate, equivalent to social discount rate as it is define by the World Bank. However, this research departs from World Bank in an important methodological issue: the lifetime of proved reserves is not capped to 25 years for all countries and assets. This research focus on wealth valuation taking into account the intergenerational well-being, allowing the present value formula and rate of discount give lesser weights to future rents obtained in extended horizons[17].

4.1.2   Main Results

Wealth of Oil and Gas richer countries at 2005 was u$S 93.320 billons. Nearly, u$S 57877 per capita and a ratio of 14,8 of gross national income (GNI).

Table3: Wealth of Oil and Gas dependent countries group				
Wealth	Level	Per Capita	W/GNI	GNI per Capita
	US$ billions			
Oil and Gas countries	93.230	57.877	17,3	3.348
OECD	556.552	583.490	16,5	35.370
Low Income	4.452	6.441	16,3	396
Middle Income	143.410	32.617	15,7	2.076
High Income	574.904	567.802	16,6	34.237
World	786.519	128.927	17,8	7.254

Source: KLEMS+N Method applied on World Bank Data and British Petroleum Statistical Energy Workbook 2014

W: Wealth

GNI: Gross National Income

The estimation take into account all types of assets estimation by World Bank (2011) for 2005 year, but take into account our estimation of oil and gas subsoil assets as weatlh. Oil and gas dependent countries income per capita is 61% higher than average middle income group. Their wealth per capita is 77% higher than wealth of middle income group. But our countries group under analyses wealth and gni per capita are only 10% of

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[17] There some important issues on debate with this methodology to be analyzed in the next future. First, equation 7, assumes that future rents are constant. As pointed out by Stiglitz, Sen and Fittousi (2009), Arrow et.al. (2013) and Schreyer and Obst (2014), there is no reasons to assume that markets and extracting firms or a public planner make decisions looking only at the current price or an average of recent realizations to project their expected values. Moreover, commodity prices are not only volatile but also have supercycles, as pointed out by Erten and Ocampo (2013), so Prebisch-Singer issues could be a reasonable for downward long run price cycle for some commodities and also technological innovations. For other hand, Hotelling rule for non-renewable resources valuation could support upward price trends.

those average high income group figures. It is worth to point out that the ratio wealth/ income are very similar between countries group.

KLEMS+N total wealth per capita is 17% higher than World Bank. But main difference was based on oil and gas wealth estimations. According to the following table, oil and gas wealth is 2 and 3 times the level estimated by World Bank (2011). The gap is due exclusively because KLEMS+N does not make any cap of 25 years of lifetime subsoil reserves horizons.

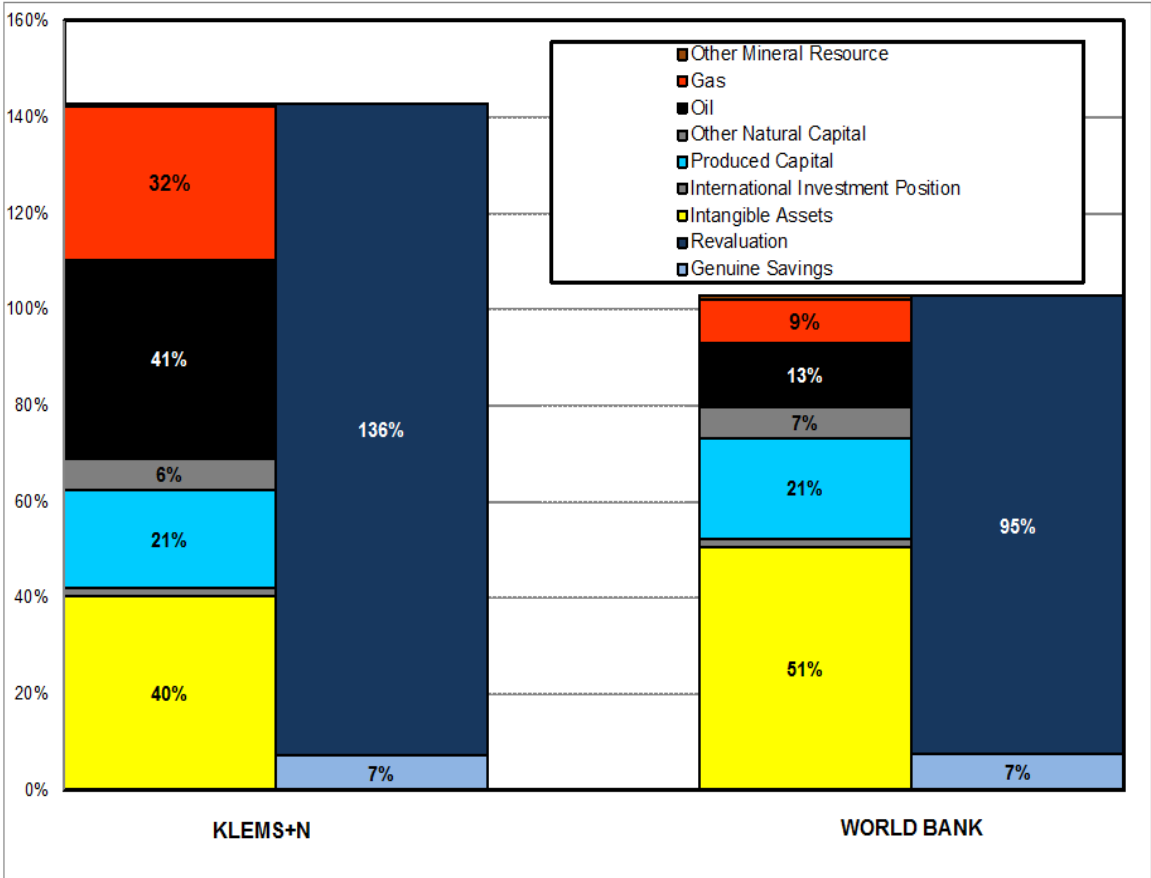| Table4 Oil and Gas Wealth of Oil and Gas dependent countries group for 2005 -u$s billons-		
	Oil	Gas
WORLD BANK	8.273	3.900
KLEMS+N	19.449	13.475

According to the following table, our estimation of oil and gas countries wealth are not only higher than World Bank (2011) but also change their composition.
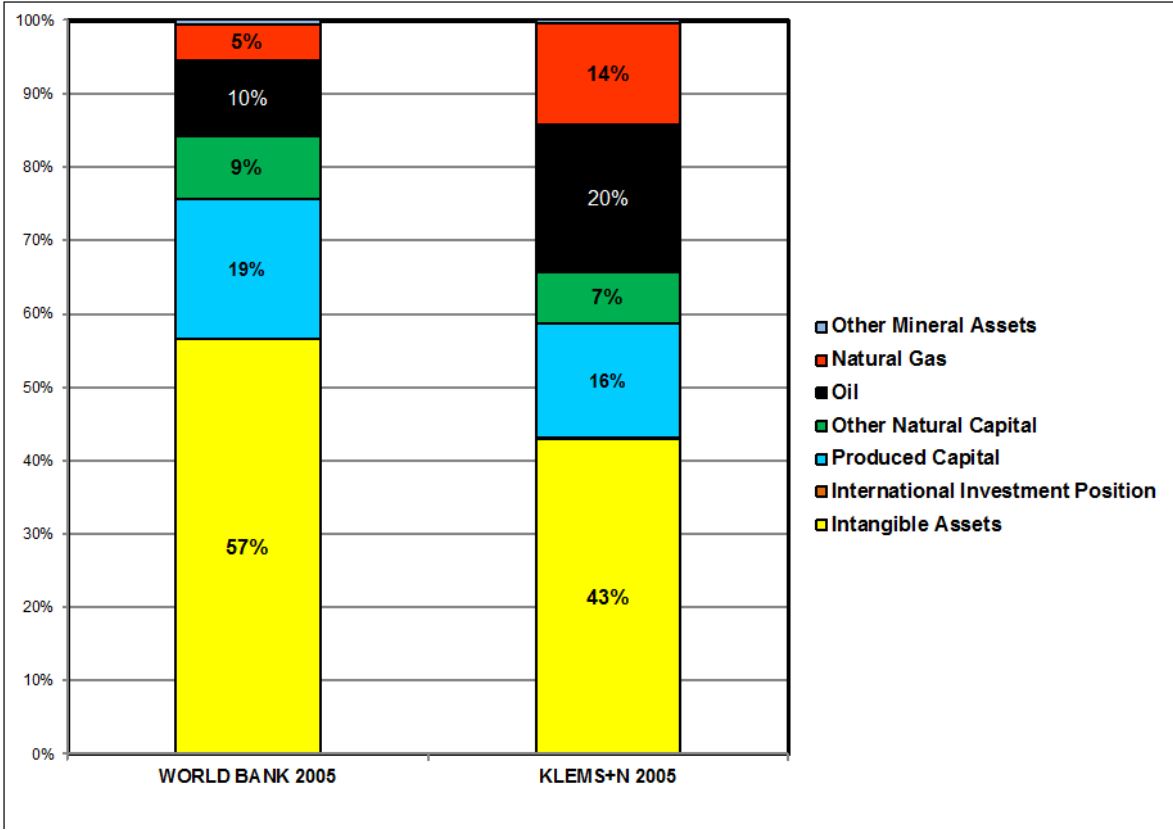
Figure 7: Wealth composition of Oil and Gas countries group 2005, World Bank and ARKLEMS estimation.

KLEMS+N estimation of Oil and Gas wealth are higher than World Bank in 2005. Gas represents 14% of the total wealth of oil and gas group, and oil assets a 20% instead of 5% and 10% of World Bank database, respectively.

The diagnoses of wealth growth profile of oil and gas dependent countries are also completely different. National Wealth growth was 143% from 1995 to 2005 according to KLEMS+N oil and gas wealth estimation. But it only grew 103% according to World Bank figures. The difference was exclusively due to greater oil and gas growth by KLEMS+N approach. One of the main findings is that energy wealth change is the key variable of national wealth performance of oil and gas group. Leaving intangible assets aside, oil and gas contributes nearly with the 50% of change of wealth, instead of only 22% according to World Bank. Another important finding is that under recent commodities price boom, wealth/revaluation effects, rather than genuine savings, explain nearly 100% of wealth changes in oil and gas dependent countries.

Figure 8: Wealth Change of Oil and Gas countries group 2005, World Bank and KLEMS+N estimation.

The following section will analyses what are the engines behind the meager performance of genuine savings of oil and gas dependent economies.

4.1.1 Unproved Shale and Conventional Oil and Gas Resource

Section 4 showed the main results of applying methodology adopted in order to estimate oil and gas wealth. As discussed in section 2, KLEMS+N welfare and sustainability assets boundary also includes other assets that are not recognized as economic assets by the SNA08 based on ownership principle. But unproved reserves and other environmental assets are key variables that impact on environmental, well-being and growth sustainability of nations.

One important resource, shale gas and oil formations are excluded from British Petroleum Energy data source which reports only conventional proved reserves.

According by the U.S. Energy Information Administration (EIA) in its Technically Recoverable Resource report (RRTT (2013)), 32% of the total estimated natural gas resources of the world are in shale formations, while 10% of estimated oil resources are in shale or tight formations. World wide, there are 95 shale basins and 137 shale formations.

As RRTT (2013) pointed out, shale production boom in US and Canada since 2000 is one of the main determinants of recent drop of oil and natural gas prices. Natural gas domestic drop after US recovery from global financial collapse is linked to recent shale gas developments. Shale gas and oil have proven to be quickly extract in large volumes at a relatively low cost. Oil and shale gas resources have revolutionized U.S. oil and natural gas production, providing 29 percent of total. U.S. crude oil production and 40 percent of total U.S. natural gas production in 2012. US energy imports and current account deficit has recently substantially reduced thanks on shale extraction.

It is important to distinguish technically recoverable resource form an economically recoverable resource. RRTT (2013) defined technically recoverable resources as the volumes of oil and natural gas that could be produced with current technology, regardless of oil and natural gas prices and production costs. Economically recoverable resources are resources that can be profitably produced under current market conditions. The economic recoverability of oil and gas resources depends on three factors: the costs of drilling and completing wells, the amount of oil or natural gas produced from an average well over its lifetime, and the prices received for oil and gas production.

Technically recoverable shale resource estimations are necessarily prospective. Prospective shale formations rarely cover an entire basin. Technically recoverable resources are determined by multiplying the risked in-place oil or natural gas by a recovery factor[18]. The RRT (2013) methodology synthetically consists of:

1. Conducting preliminary geologic and reservoir characterization of shale basins and formation(s).
2. Establishing the areal extent of the major shale gas and shale oil formations.

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[18] See RRTT (2013) for more detail on estimations methodology of risk and factors for determining prospective areas and their quality and quantity prospective output.

3. Defining the prospective area for each shale gas and shale oil formation.
4. Estimating the risked shale gas and shale oil in-place.
5. Calculating the technically recoverable shale gas and shale oil resource.

Although technically recoverable shale resources are prospective calculus subject to subjective expectations and probabilities estimations of experts, this should not be left outside oil and gas potential wealth according to KLEMS+N welfare and growth sustainability boundary. Their exclusion could affect sustainability analysis of both oil and gas dependent economies, and those that are net consumers of oil and gas.

Yet if we adopted a more conservative prospective estimation, shale formations have an important impact at country level. As pointed out by Navajas (2014), for example, the estimations of technically recoverable resource by RRTT (2013) by EIA in the case of "Vaca Muerta" in Argentina, which is the third shale gas and fourth shale oil technically recoverable resource of the world shale basin, are too optimistic. If we take into account US reference factors, Argentina will not became a gas world player but has the potential of enlarge her gas reserves horizon and its spare capacity.

The following table summarizes the impact in word oil and gas resource of including unproved technical recoverable conventional and shale resources:

Table5: Technical Recoverable Subsoil Resources					
		January 1, 2013 estimated proved reserves	2013 EIA/ARI unproved shale X technically recoverable resources (TRR)	2012 USGS conventional unproved X TRR, including reserve growth	Total technically recoverable resources
Oil	millions of barrels	1.642.354	345.000	1.369.610	3.356.964
Oil	Share of total	48,9%	10,3%	40,8%	100,0%
Oil	Increase over Proved Reserves		21%	83%	204%
Gas	Trillion cubic feet	6.839	7.201	8.842	22.882
Gas	Share of total	29,9%	31,5%	38,6%	100,0%
Gas	Increase over Proved Reserves		105%	129%	335%

Source: Own Estimations based on RRTT (2013)

Total world oil proved reserves for 2013 was 1642354 million barrels but if we add shale oil unproved TRR, total TRR could increase 21%; and if we add conventional unproved TRR, TRR could increase another impressive 83%. So total TRR could be duplicated if those technically resources will become economically recoverable.

The potential valuation of unproved TRR would show an impressive nonlinear increase of total oil and gas wealth because T, time to exhaustion, will duplicate. Although, the inclusion of unproved TRR in wealth accounts is not a free-discussion issue, the impact of unproved technical recoverable resource on potential growth is undeniable, so there would

be no discussion about the inclusion of unproved TRR as capital on KLEMS+N assets boundary. Some agreement should be reached in further research between experts of how this capital should be value.

4.1.2 Human Capital in Mexico

Section 3 describes de methodology adopted to estimate human capital as wealth. As we discussed in section 2, the welfare and sustainability assets boundary also includes human capital as an economic asset.

World Bank (2001) implicitly includes human capital as part of intangible capital without any direct estimation[19]. The World Bank estimates intangible capital as a residual between tangible wealth estimations by type and total wealth as present value of future GDP.

As Coremberg (2010) proposed, intangibles, mainly human capital, which is the main asset that explains the market value of the firms, should be estimated by asset type, above all after research experience about intangibles measurement by type as it is cited in section 3.

Taking into account one of the biggest players of oil markets, human capital wealth for Mexico is estimated by Jorgenson-Fraumeni approach by equation (3) and (4) in order to assess changes in the level, composition and performance of wealth per capita.

The following table details the database and assumptions made by this research:

Table6: Human Capital Wealth of Mexico data source summary					
	Variable				
	Labor Income and Labor Force	Enrollment Rate	Discount Rate	Labor Productivity (wage future pattern)	Survival Probability
Data Source and Assumptions	CEDLAS database (based on Household Survey-INEGI)	Own Estimations based on Household Survey-INEGI	Same as World Bank (2011) for Total Wealth	TED Labor Productivity by Hours Worked (1950-2012)	INEGI

Lifetime labor income per capita shows the same typical form of several research cases:

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[19] World Bank (2011) includes a separate chapter of human capital in China made by Barbara Fraumeni with the same focus as we will apply for Mexico.
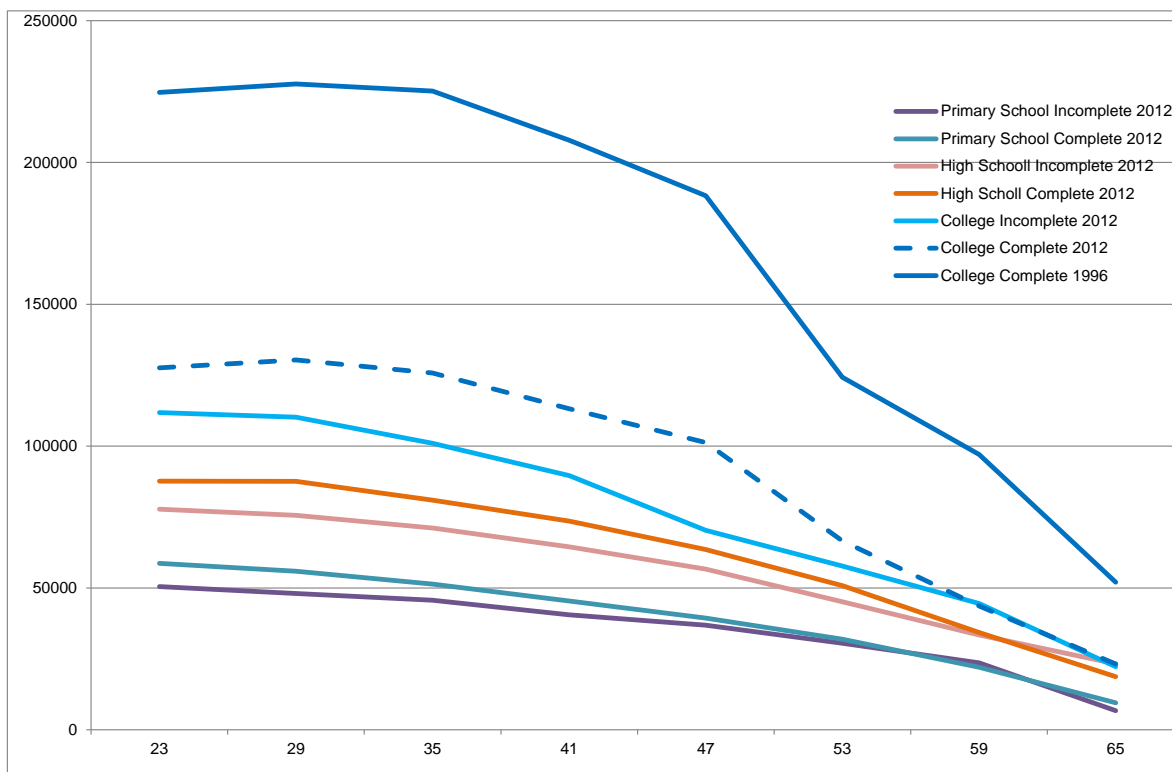
Figure 9: Life labor per capita income of Mexico for males by educational attainment and age group (15-23 years, 24-29, 30-35, 36-41, 42-47, 48-53, 53-59, 60-65.

An impressive finding is the difference between complete college and others and lower educational degrees, which is larger than other cases [20]. The other important finding is the severe drop of lli for every educational attainment, above all for college degree, as shown in the previous figure. Moreover, the ratio of human capital to gross national income at current dollars plunged down from 14 in 1996 to 7. This is because human capital wealth grew 2.5 % annual rate from 1996 to 2012, but gni grew 6.6% (5.3% per capita+1.3 population).

The key variable behind this impressive trend is the depreciation of male human capital. Life labor per capita income for males decrease at -0.7% but women grew at impressive 4.3% annual rate. Population growth by genre was the same: 1.3%.

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[20] See Fraumeni et. (2009) for China case, Coremberg (2010) for Argentina, Serrano and Pastor (2002) for Spain, Thrinh et.al. (2004) for New Zeland, ABS (2004) for Australia.
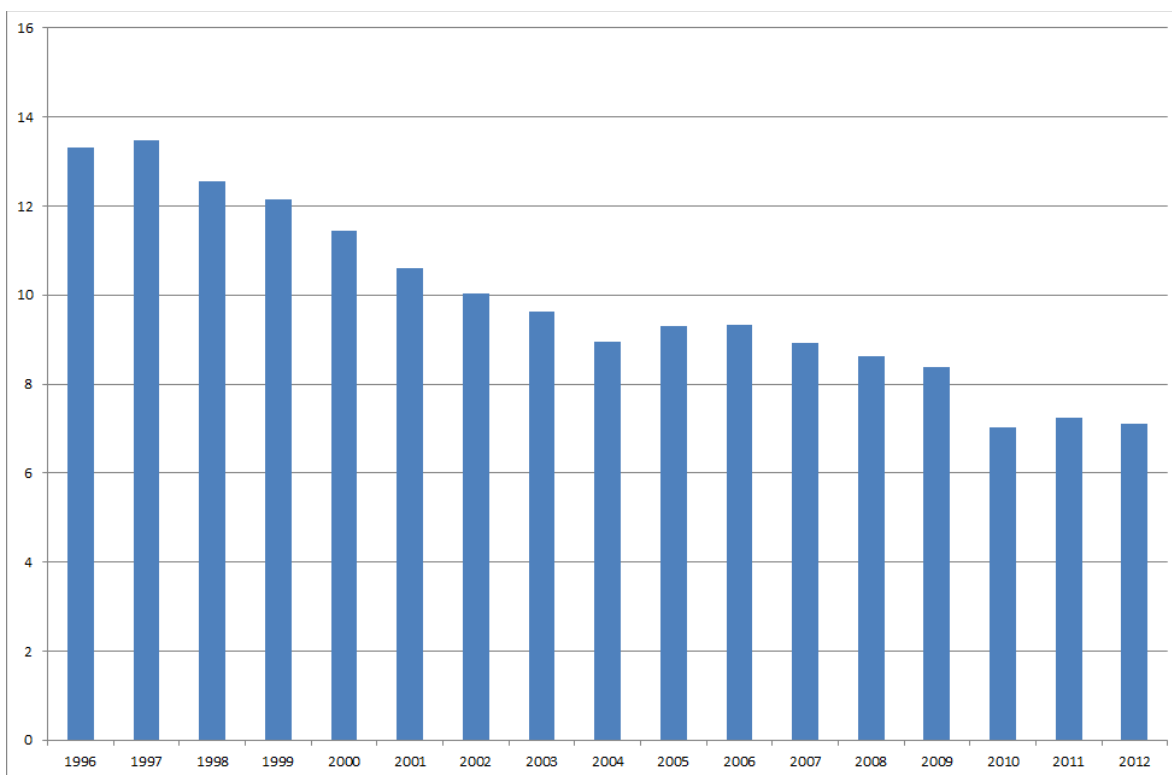
Figure 10: Ratio of Human Capital/GNI of Mexico 1996-2012

The following table shows the difference between our estimation of human capital following J-F approach with total intangible capital estimated by World Bank (2011) as a residual between total wealth as present value of future GDP and estimates of produced and natural capital.

Table : HUMAN CAPITAL VS INTANGIBLE CAPITAL OF MEXICO -billons of current dollars-			
	1995	2000	2005
World Bank Intangible Capital	6.011	9.763	10.980
KLEMS+N-Human Capital*	6.506	6.656	7.716

Source: own estimations of human capital based on J-F approach. * 1996

The difference could not be directly attribute to the estimated intangible stock performance as a residual based on discounted expected values of future GDP instead of trying to identify the different types of intangibles..
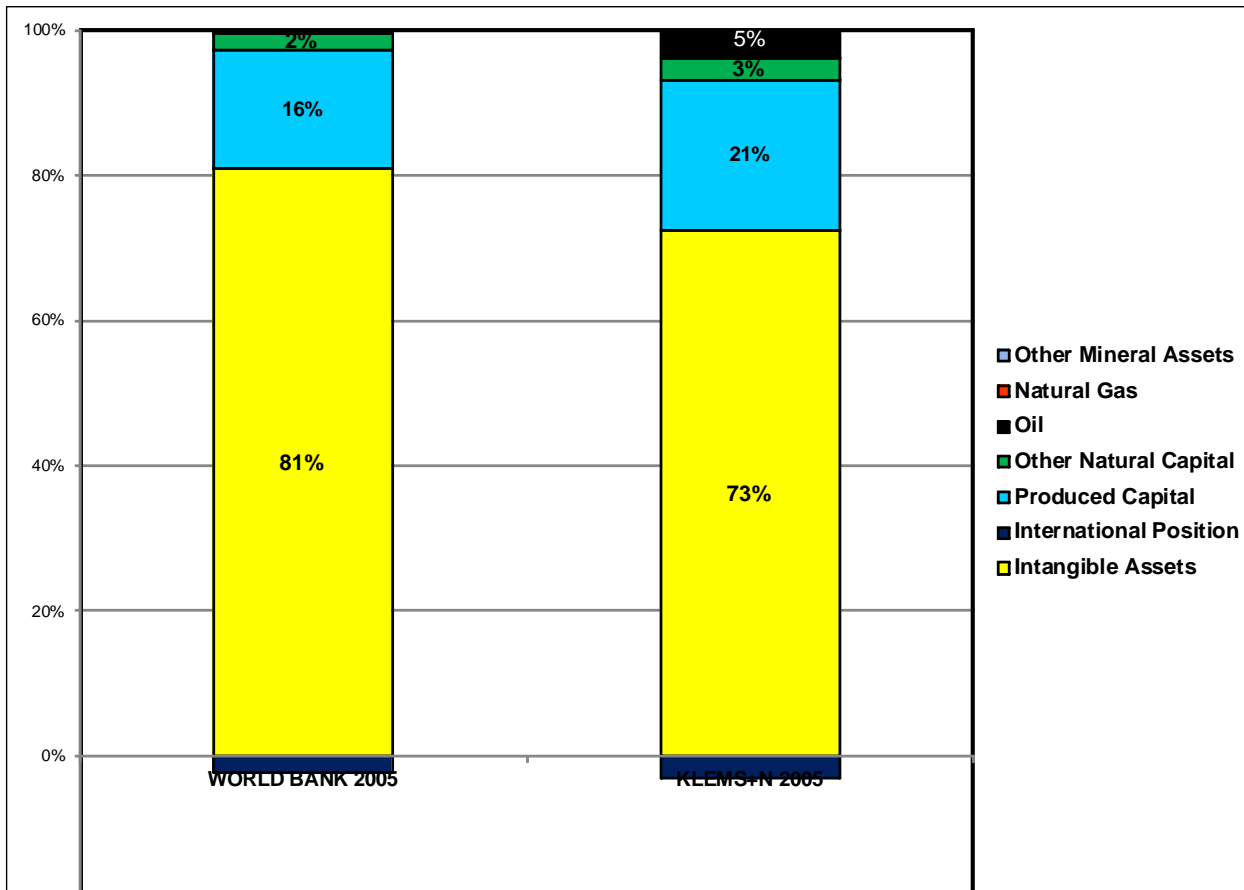
Figure 11: Wealth Composition of Mexico 2005, World Bank and KLEMS+N estimation.

Moreover, KLEMS+N show that the share of human capital in Mexico is almost the same as intangible capital residual estimation by World Bank (73% instead of 81%). Besides, oil and gas which is almost 2% of the total by World Bank estimation, increase its share to 8% of the total with KLEMS+N approach.

So, human capital takes the place of almost the total intangible capital World Bank version. As pointed out by Coremberg (2010), human capital overlaps intangible capital.

The contributions to change of wealth also completely change. According to the following figure, total wealth according to KLEMS+N estimations of oil, gas and human capital wealth (keeping produced and other natural capital World Bank estimations) grew only 26% from 1995 to 2005 instead of 72%(World Bank). The contribution of oil and gas wealth to change of the wealth of Mexico that was almost negligible for World Bank change to 6% of the total. Intangible capital which contributes of nearly 90% of the total change of Mexico wealth, but in KLEMS+N estimation, human capital decrease to 56%.
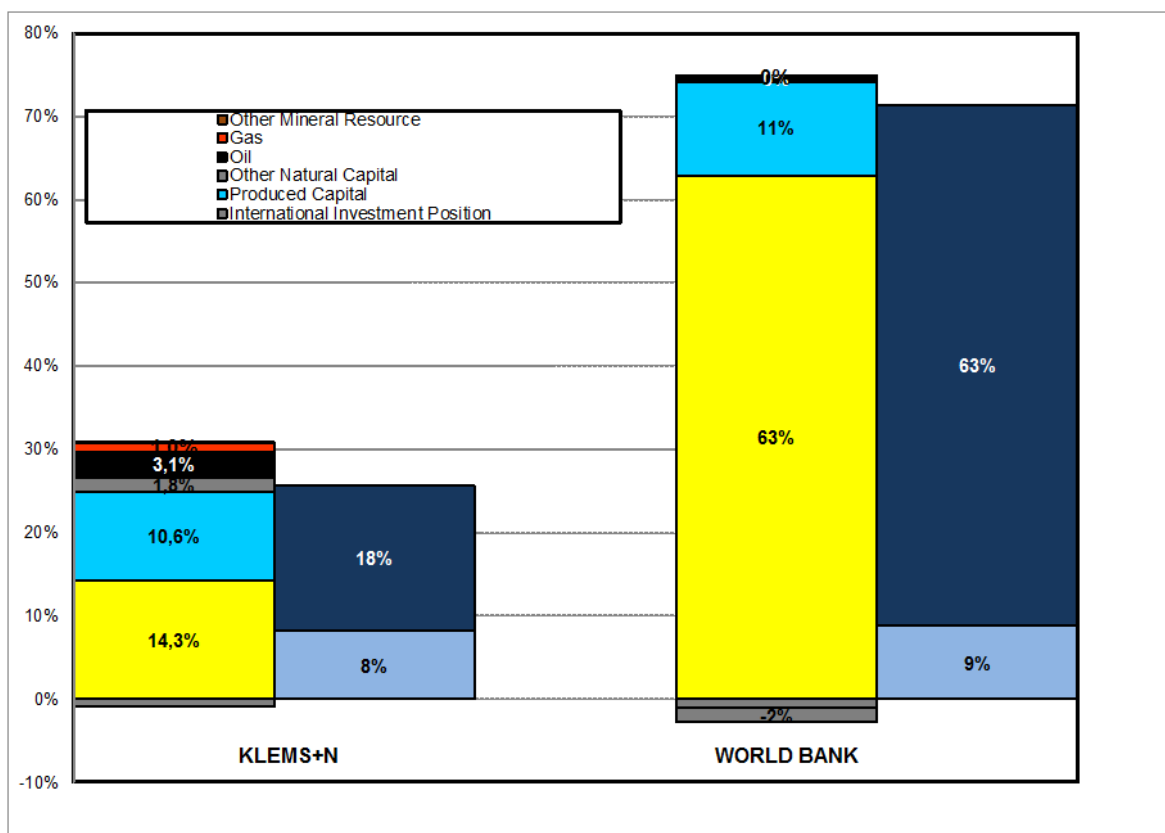
Figure 12: Change of Wealth of Mexico 2005, World Bank and KLEMS+N estimation.

The recommendation could be the explicitly measurement of intangibles by type taking into account recent research as we discussed in section 3 instead of recurring to residual estimation based on present value of GDP or consumption path.

## 4.2 Genuine Savings of Oil and Gas richer countries

As we have seen before, one of the key signals of a possible Resource Curse of natural resource dependent country is a drop of domestic savings during a commodity prices boom. Oil and gas dependent countries group is a perfect example to test this.

First of all we must discuss what the relevant macroeconomic savings indicator is. The macroeconomic savings concept must be according to Hicks income definition: "the maximum amount which can be spent during a period of time if there is to be an expectation of maintaining intact the capital value of prospective returns"...; it equals Consumption plus Capital accumulation"[21]. However, according to KLEMS+N welfare and sustainable assets boundary, in order to reach sustainable consumption and capital accumulation and Jorgenson-Hulten definition, investment must include not only

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[21] Hicks (1939), Jorgenson, Nordhaus, Landefeld (2006)

investment on produced capital but also human capital, natural capital depletion and pollution damage. The compatible flow concept for this boundary for income and savings accounts is genuine savings.

Those adjustments are outstanding in the case of oil and gas group, according to World Bank (2011) series. National gross savings for the group was 26% during 1990-2008 period. But after depreciation, net national savings drop to 15%. Investment in education increase the measure towards to 19%. After taking into account energy depletion, genuine savings rate of oil and gas countries group was only 8% and net of pollution damages only 7%[22].
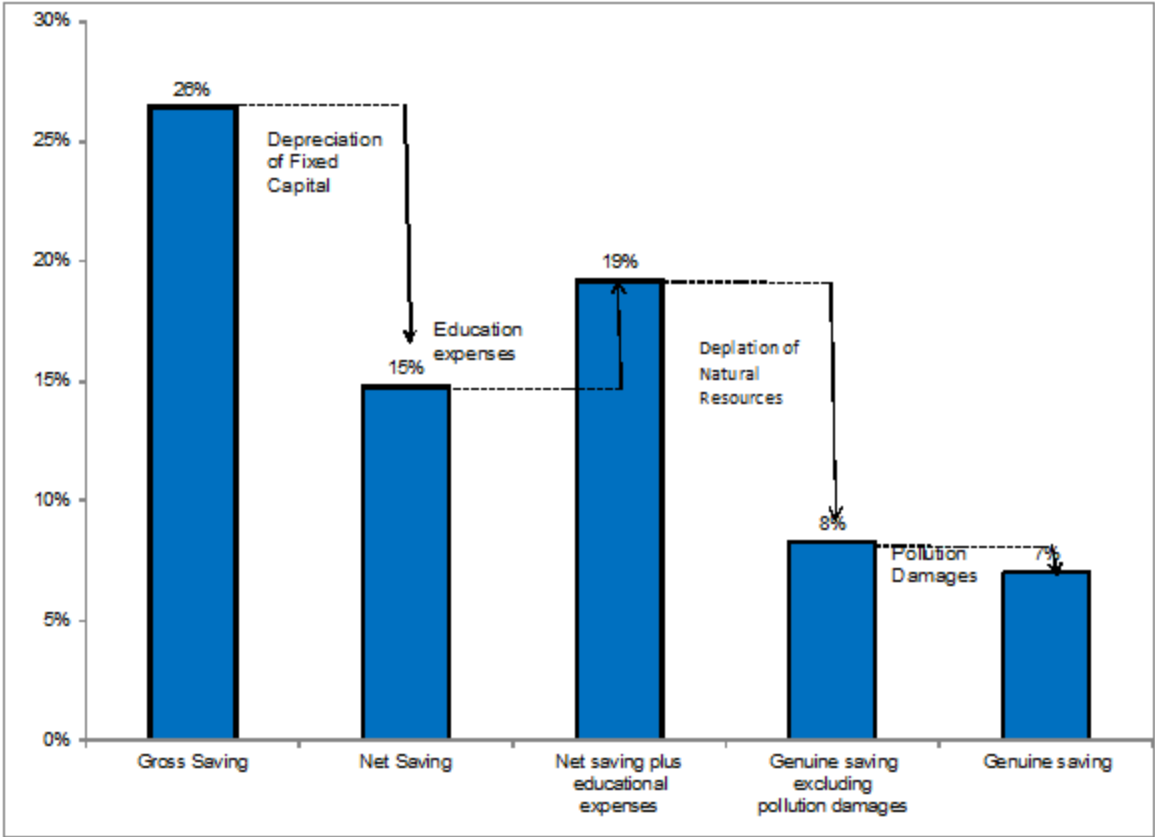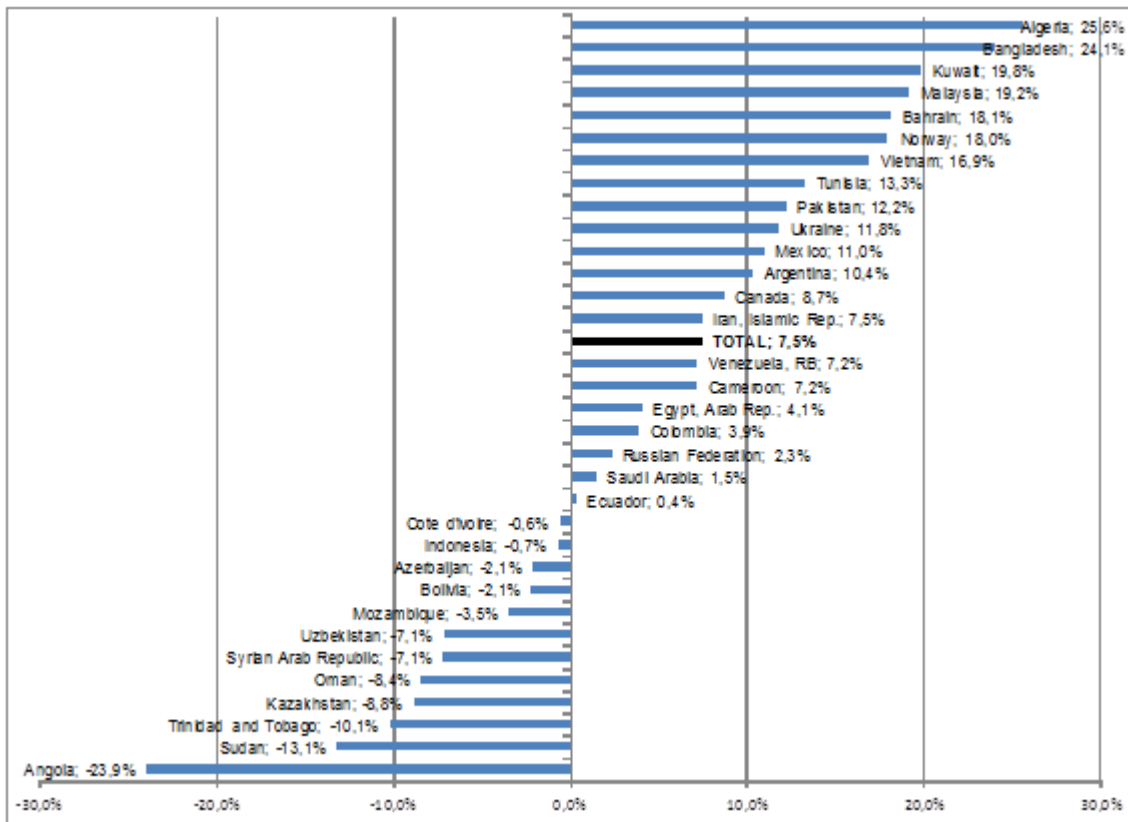

Figure 13: Components of Genuine Savings for Oil and Gas countries group 1990-2008 (% of Gross National Income). Source World Bank (2011).

Genuine savings rates are heterogeneous within the oil and gas dependent countries. An important finding to point out is that mostly all big oil exporters and gas producers have genuine savings rate under the average of the total group: Venezuela and Egypt; or very lower rates as Russia, Saudi Arabia and Ecuador or directly negative rates as Indonesia, Bolivia or Angola.

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[22] Forest + Mineral depletion and Pollution damage add nearly 1% average to the adjustment. Carbon shares have a non-relevant share of energy depletion (oil and gas).
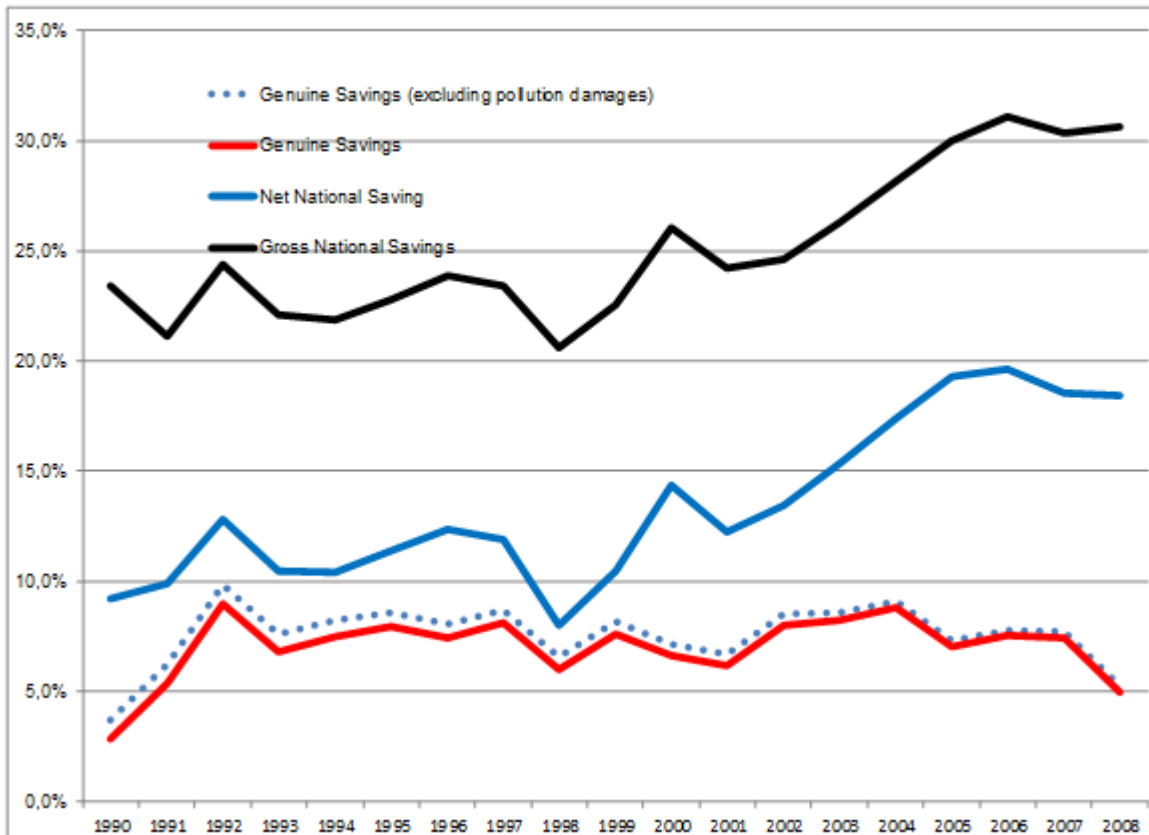
Figure 14: Ranking of Genuine Savings for Oil and Gas countries group 2007 (% of Gross National Income). Source World Bank (2011)

The apparent paradox of Resource Curse are now reflects by the figures: oil and gas dependent economies have wealth per capita is 77% than the average middle income group (61% in terms of gross national income per capita). At the same time, big producers and exporters have lower or negative genuine savings rate.

Regarding to the performance of gross national savings rate without considering genuine savings metrics, there was no a drop of domestic savings during the oil and gas prices boom after 2002. Gross savings of the group increase during the boom from 23% (1990-1998), 24% (1998-2002) to 30% (2002-2012) of gross national income. At a first sight, there was no signal of Resource Curse. However, most of the increase of gross savings during booming years has been compensated by energy depletion, so genuine savings in effect was approximately 7% during all the period, not only during negative phase of price cycle 1990-2002 but also during positive phase. So,

Figure 15: Genuine Savings for Oil and Gas countries group 1990-2008. (% of Gross National Income). Source World Bank (2011)

Most of the rents generated by the oil and gas prices boom after 2002, have been consumed: a clear signal of Resource Curse.

The following section will apply KLEMS+N approach to growth accounting to check another key signal of Resource Curse of oil and gas countries during the commodities prices boom: productivity slowdown.

4.3 KLEMS+N Growth Accounting for Oil and Gas richer countries

4.3.1   Methodology

The exclusion of Natural Capital from growth accounting could impact in an important bias of measured MFP, especially of those countries where natural resource intensive sectors have an important share of the GDP. As pointed out by ARKLEMS+LAND methodologyas it is pointed out by Coremberg (2011) (2012a) (2015), Schreyer (2010) and Brandt, Schreyer and Zippeper (2013) the exclusion of non-produced assets could bias measured MFP. During natural resource boom, productivity growth could be upward biased if natural capital service input is not taken into account in growth accounting. Otherwise, when

natural capital extraction declines, productivity could be underestimated if this input is not explicitly measured.

Following Brandt, Schreyer and Zippeper (2013) seminal paper, if there is an important unobservable or non-measured variable, growth accounting is measured only by traditional inputs (ICT and non-ICT capital and labor+ labor quality), so multifactor productivity (MFP) measured could be bias.

Traditional MFP is

$$\frac{d\,lnMFP}{dt} = \frac{d\,lnY}{dt} - \sum_{i=1}^{N}\frac{u_i K_i}{C'}\frac{d\,lnK_i}{dt} + \frac{wL}{C'}\frac{d\,lnL}{dt}$$

Where $C' = wL + \sum_{i=1}^{N}u_i K_i$, is the total input costs of primary inputs (labor compensation and produced capital services inputs by type value at user costs at macroeconomic level, and Y is the GDP.

However, when natural capital is considered, different types of natural capital must be included in the growth accounting formula valued at its user costs. Like in the previous section, when growth accounting exercise is applied from the point of view of market, the price of natural inputs must be marginal unit rents.

Following Brandt, Schreyer and Zippeper (2013), generalized multifactor productivity (GMFP) is now:

$$\frac{d\,lnGMFP}{dt} = \frac{d\,lnY}{dt} - \sum_{i=1}^{N}\frac{u_i K_i}{C}\frac{d\,lnK_i}{dt} + \sum_{i=1}^{M}\frac{u_{N_j}K_{N_j}^S}{C}\frac{d\,lnK_{N_j}^S}{dt} + \frac{wL}{C}\frac{d\,lnL}{dt}$$

Where total costs now include M natural capital services inputs valued at its user costs.

If user cost is measured exogenously, then:

$$\frac{dlnGMFP}{dt} = \frac{dlnMFP}{dt} + \frac{u_N K_N^S}{C}\left(\frac{dlnZ}{dt} - \frac{dlnK_N^S}{dt}\right)$$

Where, dlnZ/dt is the growth of weighted primary inputs in the total original costs C'.

If GMFP growth for countries where user cost of capital is calculated endogenously:

$$\frac{dlnGMFP}{dt} = \frac{dlnMFP}{dt} + \frac{u_N K_N^S}{p_y Y}\left(\frac{dlnK}{dt} - \frac{dlnK_N^S}{dt}\right)$$

MFP is biased if natural input has an important dynamic and contribution. If natural input grows above K and L (exogenous user cost case) or K (endogenous user cost case), measured productivity was overestimated. Contrary case, when natural capital grows less than inputs, measured productivity by traditional inputs was negative biased.

We test the methodology for oil and gas dependent countries. One of the most important issues is if MFP performance has been enough strong to support resilience to export prices reversal, and evade possible negative consequence of Resource Curse on growth sustainability. This section shows some findings of KLEMS+N growth accounting for oil and gas countries as proposed in this research.

4.3.2 Data Source

This research adjusts Total Economy Database (TED) from The Conference Board for inclusion of oil and gas service inputs for main oil and gas dependent economies. The measurements of oil and gas service are the fluid extraction from oil and gas proved reserves. So original notation of natural capital services could be simplified to $K_N^S = q_N$ which is the material extraction from oil and gas proved reserves and user costs of oil and gas is equivalent to unit rents $u_N = r_j^S, (j = oil, gas).$; as it was defined above.

Table7: KLEMS+N for Oil and Gas Richer countries data source summary				
	Variable			
	MFP, KICT, Knon ICT, L, inputs weights	L share adjusted	Oil and gas extraction	Oil and gas Rents
Data Source	TED database	Pen World Tables-World Bank and ILO	British Petroleum Statistical Review 2014 Workbook	US Energy Information Administration
Countries Covered	Oil and Gas dependent countries group	Idem as defined by table 1, but also includes Arab Emirates, Iraq, Turkmenistan, Qatar, Yemen[23]		

TED database labor compensation was estimated by multiplying wages for total workers including employees and self-employees. For countries with no labor share, TED applies a 50% for emerging and developing economies because in those economies capital is relatively scarce, and its return is high. According to TED methodology, labor is cheap compared to advanced countries, leading to a lower labor share. Moreover, much depends on the labor share that is allocated to self-employed, especially in emerging and developing economies where this fraction of the workforce is still relatively large. But this procedure could be not applied to the case of natural resource dependent economies where resource rents are important and could share between 5% to 50% of GDP as in the case of several energy dependent economies. Moreover, self-employees could be important in quantity but their mixed income per income could be high but labor income imputed income could be lower according to lower wages of these types of economies. In those cases, we adjust L shares by Penn World Tables and ILO database, checking also national accounts data.

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[23] The effect of inclusion of these countries on total wealth and gdp of the group is negligible.

The TED database measures the user cost of capital endogenously, so total capital compensation is the Gross Operating Surplus (GOS), which belongs to national accounts estimation as a residual from income minus labor compensation. Share of non-ICT capital is the difference between GOS and ICT capital user cost imputation. However, as user cost is calculated endogenously, keeping ICT capital user cost imputation by TED, the share of produced KnonICT is upward biased because the rents of natural capital are not included in the measurement.

If GMFP growth for countries where user cost of capital is calculated endogenously as in TED database[24], then:

$$\frac{d\ lnGMFP}{dt} = \frac{d\ lnMFP}{dt} + \frac{u_N Q_N}{p_Y Y}\left(\frac{dlnK_{nonICT}}{dt} - \frac{d\ lnQ_N}{dt}\right)$$

There are three possible cases:

I. $dlnK_{nonICT} < \frac{d\ lnQ_N}{dt} \rightarrow \frac{d\ lnGMFP}{dt} < \frac{d\ lnMFP}{dt}$. If natural resource service growth rate is higher than the volume change of KnonICT, traditional MFP was positive biased. Actually, GMFP is less dynamic.

II. $dlnK_{nonICT} > \frac{d\ lnQ_N}{dt} \rightarrow \frac{d\ lnGMFP}{dt} > \frac{d\ lnMFP}{dt}$. The natural resource service growth rate is lower than the volume change of K non ICT, MFP is negatively biased. So effective GDP growth is higher.

III. $dlnK_{nonICT} \cong \frac{d\ lnQ_N}{dt} \rightarrow \frac{d\ lnGMFP}{dt} \approx \frac{d\ lnMFP}{dt}$. If both included and non-included inputs grow at the same rate, there could be no bias in measured MFP.

4.3.3 Main Results

We estimate Aggregate MFP following TED methodology. The MFP of oil and gas richer countries shows an important correlation with oil and gas prices.

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[24]See Brandt, Schreyer and Zippeper (2013) for analytical conditions for estimating GMFP under exogenous and endogenous user cost.

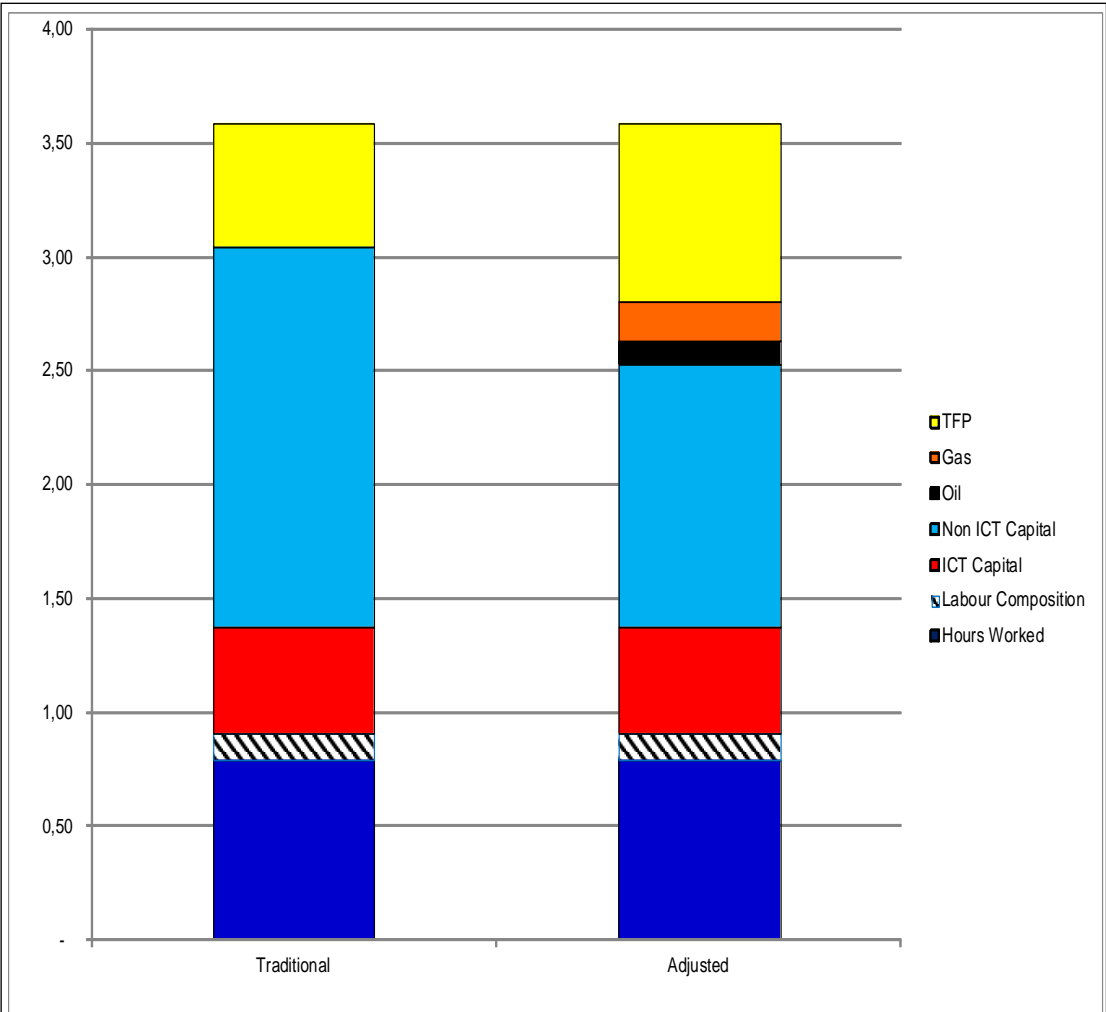| Table8: Oil and Gas Growth profile 1990-2012				
Growth	1990-1998	1998-2002	2002-2012	1990-2012
Gross Domestic Product	2,1	4,4	4,6	3,6
Contribution of Labor Quantity	0,7	0,9	0,8	0,8
Contribution of Labor Composition	0,1	0,1	0,1	0,1
Contribution of KNONICT	1,1	1,2	1,3	1,1
Contribution of KICT	0,2	0,6	0,7	0,5
Contribution of Oil Services	0,1	0,1	0,1	0,1
Contribution of Gas Services	0,1	0,2	0,2	0,2
Generalized Multifactor Productivity	-0,3	1,4	1,4	0,8
Oil Prices	-6,7	20,0	11,5	5,9
Natural Gas Prices	0,9	12,9	1,8	3,4
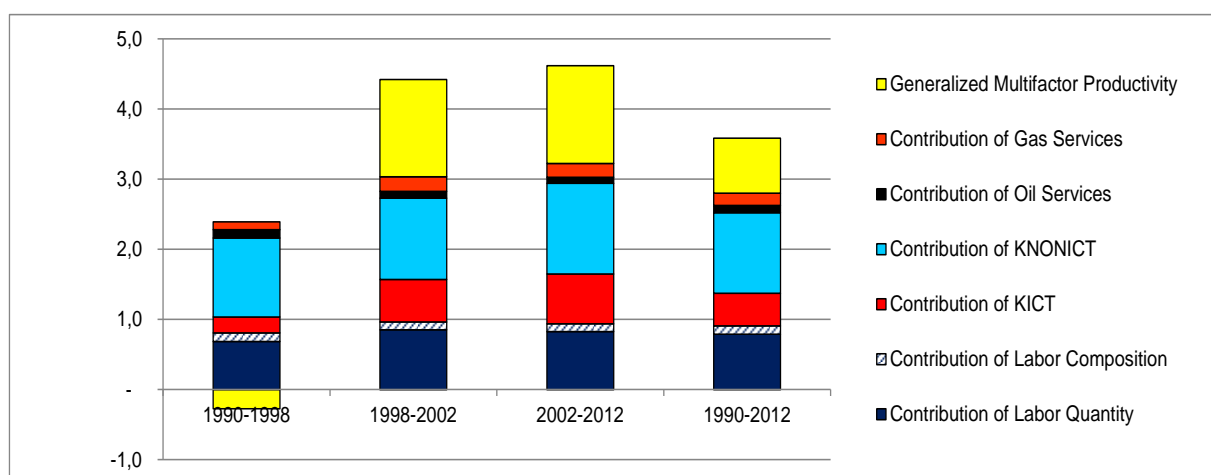
Figure 16: Growth Profile of Oil and Gas richer countries 1990-2012. KLEMS+N methodology based on TED database, USEIA and British Petroleum Workbook.

GDP growth of the oil and gas group was 3,6% average annual rate from 1990 to 2012. Growth profile was based mainly on factor accumulation based on KnonICT capital, KICT, Labor quantity which shares nearly 70%. But GMFP contributes with 20% of GDP. It is worth to point out that oil and gas services input was 10%.

Source of Growth of the oil and gas dependent countries could be decomposed by period according to oil and gas prices. 1990-1998 corresponds to going on negative cycle of prices after oil prices shocks of the end of 1970 decade reaching a minimum level until 1995-1998. 1998-2002 is the partially stagnated period which could not retakes a strong positive trend at high rates after dot.com crisis of the beginning of 21st century, which is one of the main fundamentals under the so called "*drinks effects*" (Tequila Mexico, Russia vodka, Brazil Capirina and later Argentina Tango effect). 2002-2012, is a clear example of commodity prices boom.

GDP of Oil and gas countries group grew 2,1 % annual rate during negative price cycle. Growth profile was extensive based mainly on factor accumulation than on GMFP. But 1998-2002 and 2002-2012 GDP growth accelerates towards to 4,5 % annual rate thanks to GFMP acceleration. GFMP performance change from negative trend, -0,3% to 1,4% during the positive phase of price cycle thanks on less relative contribution of oil and gas service input which drop from 11% during negative price cycle to 6% during 2002-2012.

During 2002-2012, GDP growth profile was extensive according to traditional growth accounting of traditional primary inputs. However, after the inclusion of natural resources, GMFP grew more than original one because oil and gas service inputs grew less than K non ICT (our case I). Hence, the growth pattern of richest oil and gas countries was more intensive in MFP dynamics.

Figure 17: Growth Profile for Oil and Gas richer countries 1990-2012, traditional and KLEMS+N methodology

The adjustment of MFP was exceptional for the majority of the oil and gas dependent countries. According to the Figure 10, differences between MFP and GMFP for the group were small or negative from 1990 to 2004. Since 2005, differences are outstanding positive mainly due to increases in the rents share weight due to prices more than fuel extraction. Similar results was founded for some OECD countries by Brandt, N., P. Schreyer and V. Zipperer (2013), but adjusting by total minerals. This demonstrates that oil and gas contribution was relevant during recent commodity prices boom. Oil and gas richer countries adjust to this positive shock with important productivity dynamics.
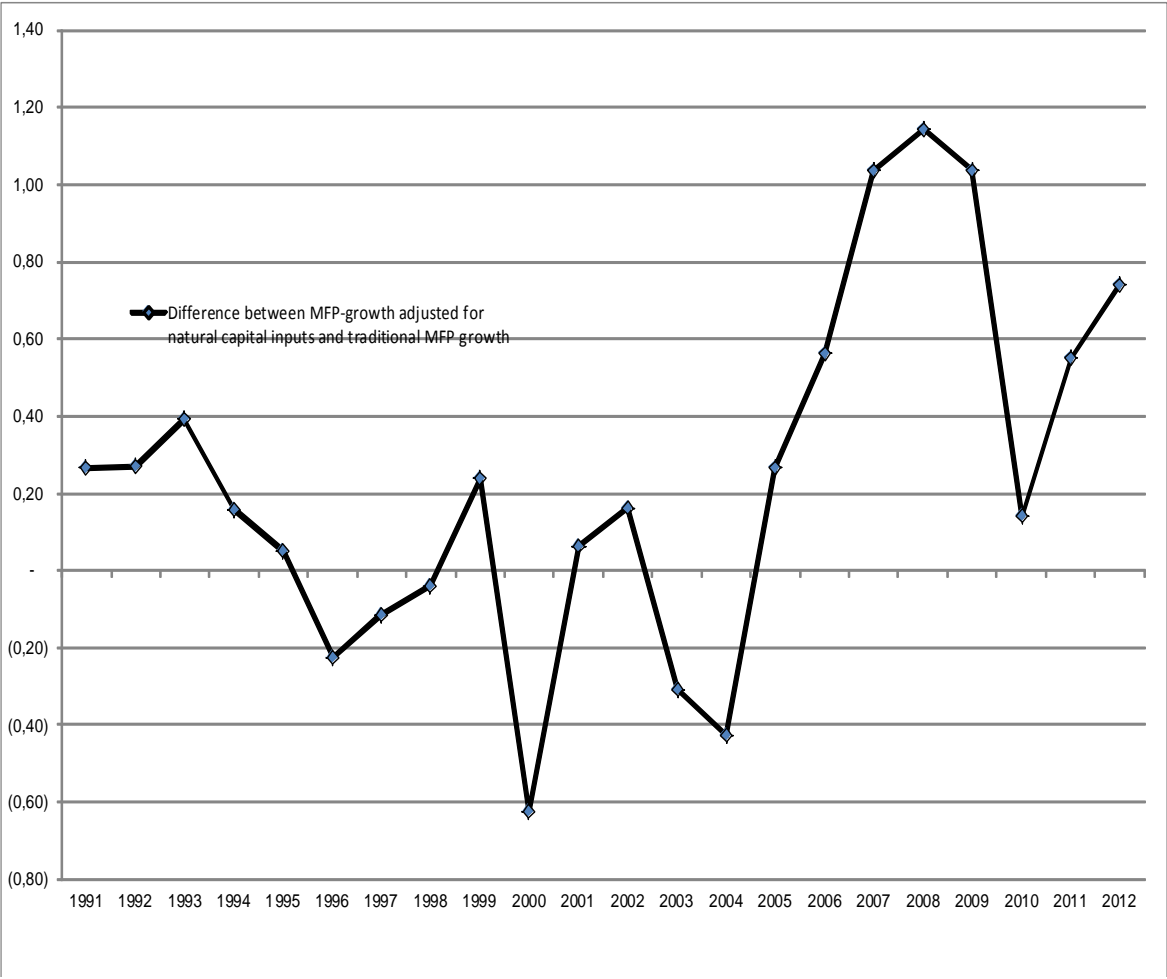
Figure 18: Difference between MFP and GMFP growth 1990-2012

However, oil and gas richer countries growth profile hide important heterogeneities between them. As observed in the next figure, not all the countries reacts with an increase in productivity during the prices boom. The figure shows that there is not a clear country pattern between the GMFP and their adjustment by natural resource inclusion.
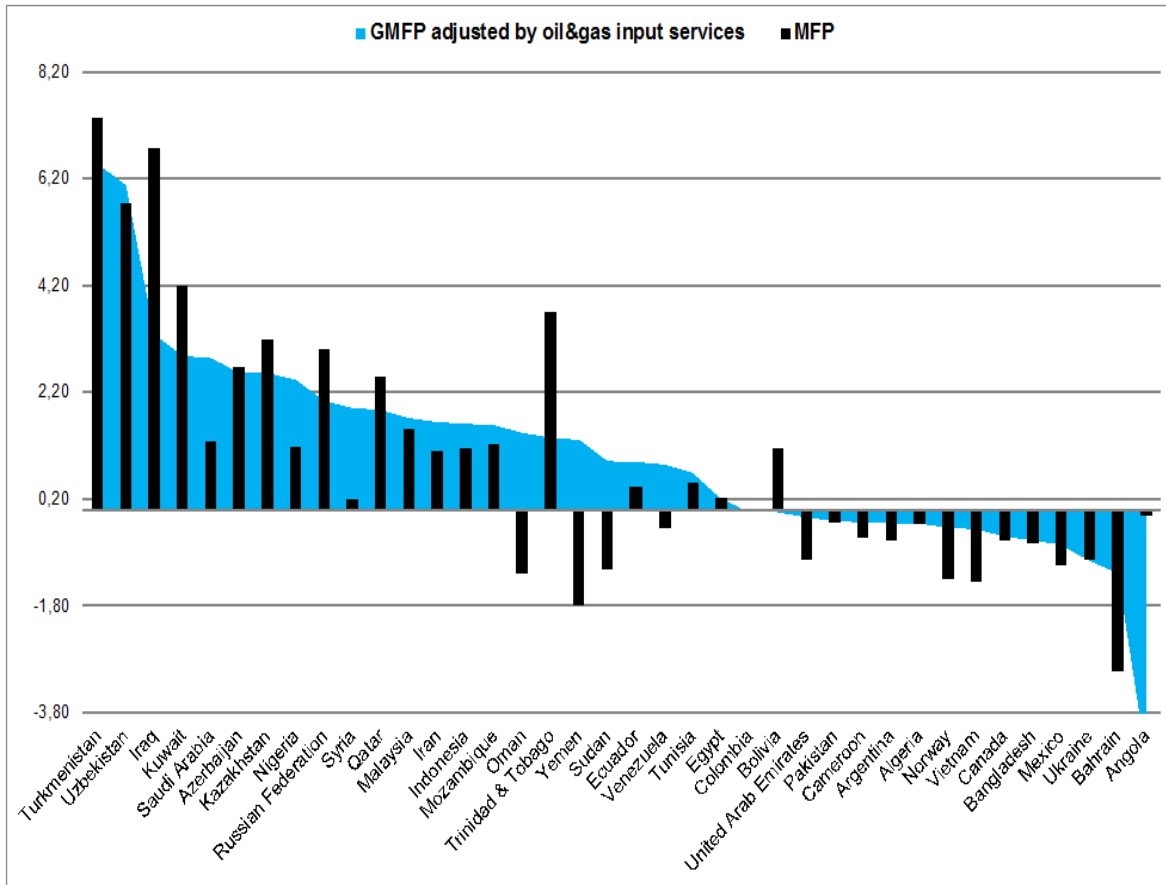
Figure 19: GFMP and MFP annual growth in oil and gas dependent country (+China and USA) 1990-2012

Not all countries with GMFP positive trend have the same growth profile. Some countries adjust to the oil and gas prices boom increasing their fuel extraction at a dynamics above their nonICT capital growth, so they belong to case I (GMFP < MFP): Turkmenistan, Iraq, Kuwait, Azerbaijan, Kazakhstan, Russian Federation, Qatar, Trinidad & Tobago and Egypt.

Countries with a high share of oil and gas world output or world GDP have a GMFP with positive trend, showing slower extraction rate of fuels reserves, less than their net investment in nonICT capital (case II): Uzbekistan, Saudi Arabia, Nigeria, Syria, Malaysia, Iran, Indonesia, Mozambique, Oman, Yemen, Sudan, Ecuador, Venezuela and Tunisia. Moreover, Oman, Sudan, Venezuela and Yemen change the sign from negative MFP growth to positive GMFP thanks of the adjustment. Lastly, a group of countries that showed a negative GMFP trend belongs to case I: Colombia, Bolivia, Ukraine and Angola. Another group belongs to case II, reversing their measured MFP negative trend thanks of slow pace of oil and gas service input contribution as United Arab Emirates, Algeria, Norway, Canada, Mexico, Bahrain. Furthermore, Bolivia changed their measured MFP positive trend towards a negative GMFP trend.

5. SUMMARY AND CONCLUSIONS

Natural and Human Capital are one of the main engines behind Growth, Competitiveness and Wealth Performance of Nations. Moreover, Natural and Human Capital are key drivers of welfare and environmental sustainability, as Stiglitz, Sen, Fittousi (2009) report pointed out. Recent commodities prices boom era, which apparently has reached an end, update the old debate about growth profile of natural resource dependent economies in terms of Resource Curse and Dutch Disease.

Despite the outburst of economic literature that measures natural and human capital, not all those metrics are consistent among them and with the rest of wealth components. Furthermore, not all economic research treat those types of assets as service inputs in growth accounting in a compatible way with System of National Accounts 2008 (SNA08).

SNA08 focus on assets boundary based exclusively on ownership principle. This approach excludes several assets that are important for welfare and growth sustainability analysis: human capital and several natural assets that are not subject to property rights (unproved mineral deposits, shale oil and gas unproved resources, natural forest, non-cultivated wild fish, etc.).

This research proposes to enlarge SNA asset boundary to include broad natural and human capital thanks to the adoption of Hulten definition of investment "every expense in order to increase future consumption" and the symmetric principle analogy with produced capital. Thanks to this new welfare and growth sustainability asset boundary (KLEMS+N), non-economic natural and human capital but also other intangible assets (brand name, organizational capital and other marketing assets) that explains the market value of firms and the Welfare, Wealth, Competitiveness and Growth Performance of Nations could be included.

This research links and adjusts several canonical metrics of natural and human capital (Hamilton World Bank natural capital, Jorgenson Fraumeni Human Capital, Jorgenson-BLS labor service input) in a unique consistent metrics that we called "KLEMS+N" to measure broad natural and human capital as wealth as service inputs compatible with SNA08 and OECD Productivity and Capital manuals focused on produced capital.

The methodology could be applied to analyze natural capital dependent growth profile during a commodities boom to test Resource Curse and Dutch Disease. Some indicators are, between each other: drop of domestic savings, domestic currency appreciation, deindustrialization and productivity slowdown. We test the proposed KLEMS+N methodology to oil and gas dependent countries. This paper showed that some of this signals of growth unsustainability for oil and gas dependent countries are mixed.

Oil and gas wealth explains most of the change of national wealth of oil and gas dependent countries. During commodities prices boom, wealth/revaluation effects -not

savings- explains almost the total change of wealth of oil and gas dependent countries. Oil and gas were the most dynamics assets that contribute to the change of national wealth the group.

Despite a hike of gross savings of the group during the boom from 23% (1990-1998) to 30% (2002-2008) of gross national income (10% to 18% of net savings); most of the increase of gross savings during booming years was offset by energy depletion (and depreciation of produced assets). Hence, genuine savings remained around 7% during 1990-2008 independent of the oil and gas price cycle. Natural Rents generated during the oil and gas prices boom after 2002 were exhausted. Furthermore, most of big players at oil and gas world markets showed a lower or inclusive negative genuine savings during the last commodities prices boom, endangering their future growth sustainability.

GDP growth of oil and gas dependent economies accelerates during the booming years thanks to productivity acceleration. Natural capital services adjustment of traditional growth accounting based on traditional inputs (produced capital and labor input) is outstanding. Traditional MFP was negative biased due to oil and gas services grew less than non ICT capital. Generalized Multifactorial Productivity (GMFP) growth contributes with an important share of oil and gas nations' growth performance. However, GMFP growth performance of oil and gas countries group, moreover during commodity prices boom, were heterogeneous.

According to the methodology proposed and main findings of this paper, this research would allow including natural and human capital in the core of SNA responding concerns of Stiglitz-Sen-Fitoussi about overconsumption and development sustainability.

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