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Lykke E. Andersen
Johann Caro
Robert Faris
Mauricio Medinaceli

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Lykke E. Andersen♦
Johann Caro♣
Robert Faris♥
Mauricio Medinaceli♠

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Abstract:
The high oil prices and the sharp increases in royalties mean that the natural gas boom in Bolivia has become very important for the economy. This paper uses a Computable General Equilibrium (CGE) model to assess the impacts of this boom on key macroeconomic variables as well as the distribution of incomes in the society. From a macroeconomic perspective, the natural gas boom is a blessing, adding around 1 percentage point to GDP growth rates for at least a decade, and sharply increasing government revenues available for public spending and investment. However, the poorest segments of the population (rural small-holders and urban informals) suffer actual reductions in their real incomes, compared to the counterfactual scenario without the gas boom. This means that the natural gas boom not only causes an increase in inequality but also an increase in poverty. The paper finishes with some policy recommendations on how to counteract the negative side effects of the natural gas boom.

Keywords: Natural Gas, Inequality, CGE model, Bolivia
JEL classification: Q33, Q43

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♦ Director, Institute for Advanced Development Studies, La Paz, Bolivia (landersen@inesad.edu.bo).
♣ Researcher, Institute for Advanced Development Studies, La Paz, Bolivia (jcaro@inesad.edu.bo).
♥ Researcher, Center for International Development, Harvard University, Cambridge, MA (Robert_Faris@Harvard.edu).
♠ Researcher, Institute for Socio-Economic Research, Universidad Católica Boliviana, La Paz, Bolivia (mmedinaceli@yahoo.com). Former Minister of Hydrocarbons in Bolivia.

Natural Gas and Inequality in Bolivia after Nationalization

1. Introduction

The hydrocarbon sector in Bolivia has undergone dramatic changes in the last few years. After capitalization of the state oil company in 1996 and the application of the “Ley de Hidrocarburos” (No. 1689), certified natural gas and oil reserves sky-rocketed due to increased exploration efforts. Bolivia signed a contract with Brazil to deliver 7.1 trillion cubic feet (TCF) of natural gas over 20 years, and after the completion of the pipeline in 1999, both natural gas and oil exports have increased dramatically, now accounting for almost half of the country’s exports, as compared to only 7% in 1999.

Andersen & Faris (2002) used a Computable General Equilibrium (CGE) model to simulate some of the changes that were likely to occur in the Bolivian economy due to the increased natural gas exports, focusing particularly on the changes in income distribution that were likely to arise from these economic changes. The model indicated a temporary, 3-year increase in GDP growth rates of approximately 2% per year and then a reversion to the previous level of growth. It also indicated a dramatic increase in government revenues, due to taxes and royalties received from the hydrocarbon sector, and an increase in inequality, as the government tends to spend most of its revenues on skilled workers, such as teachers, doctors, bureaucrats and consultants, while the much poorer rural small-holders are largely unaffected.

However, since that study there has been several unexpected developments in the sector. First, the price of oil did not stay at the expected level of approximately $20 per barrel, but rather jumped to more than $60 per barrel. Since the price of natural gas in the contract was linked to a basket of international oil prices, both exports and government revenues have received an enormous and unexpected boost. Second, due to the high level of prices, the hydrocarbon sector became extremely profitable, and the Bolivian government decided to increase royalties from the 18% agreed during capitalization to the 50% that the population violently demanded (Law No. 3058, May 2005). A few months later, the government added another tax increasing total government take to 82% for the two biggest natural gas fields. Finally, by May 1st, 2006, the government nationalized the hydrocarbon sector for the third time in the last 70 years.

Given that government revenues and exports from the hydrocarbon sector have proved to be many times higher than expected in 2002, this paper provides an update of the analysis provided in Andersen & Faris (2002).

The remainder of the paper is organized as follows. Section 2 provides a short history of the hydrocarbon sector in Bolivia since the first discovery of oil about a century ago till the recent nationalization in May 2006. Section 3 shows how prices, export volumes, and government revenues have evolved during the last few decades, and projects how they will evolve in the future. These are three key inputs into the CGE model, the structure of which will be explained in Section 4. Section 5 applies the model to analyze the major structural effects of an increase in Natural Gas exports. Section 6 uses the model to analyze how these structural changes will affect the distribution of income among different types of households. Finally, Section 7 concludes.

2. A short history of the Bolivian oil and gas sector[1]

Petroleum reserves were first found in Bolivia in 1896 by Manuel Cuellar, who organized the Sindicato Sucre for its extraction and commercialization. The Sindicato managed to obtain concessions totaling 74.400 hectares in 1911, but had trouble raising funds to drill wells and construct a refinery. Bolivian capitalists refused to participate, and negotiations with interested European firms were delayed by the First World War. Chilean interests, however, amassed huge petroleum concessions in Bolivia until the government of Bautista Saavedra in June of 1921 passed the “Ley Orgánica de Petróleo” limiting the size of concessions to a maximum of 100.000 hectares and setting a royalty rate of 11%.

Despite that law, Standard Oil managed to buy up more than 7 million hectares of petroleum concessions in Bolivia, and created productive wells in Bermejo (1924), Sanandita (1926), Camiri (1927) and Camatindi (1931).

The discovery of petroleum in the southern part of Bolivia provoked a war (the Chaco War of 1932-35) with neighboring Paraguay over access to these resources. More than 250.000

[1] This section is based on YPFB (1996).

Bolivians were sent to defend this inhospitable and uninhabited region, and more than 50.000 young Bolivians died, if not from bullets, then from thirst and diseases. The war was an economic disaster for both of the poor countries. Bolivia lost territory to Paraguay, but so far no oil has been found in the lost territory.

Once the war was over, Bolivian Standard Oil was accused of having smuggled oil to Argentina, evading the 11% royalties, and of not having paid the annual patents for its concessions in a time of urgent national need. Standard Oil declared itself “neutral” in the war, and refused to supply gasoline to Bolivian war planes. As a consequence of such unpatriotic behavior, the company was nationalized in March of 1937, and the state oil company, Yacimientos Petrolíferos Fiscales Bolivianos (YPFB) was created.

For several years, YPFB was struggling due to lack of capital and experienced personnel. To overcome the latter constraint, YPFB hired many foreign (mainly Argentinean) experts but also gave scholarships to Bolivian students to go abroad to study petroleum engineering, geology and chemistry.

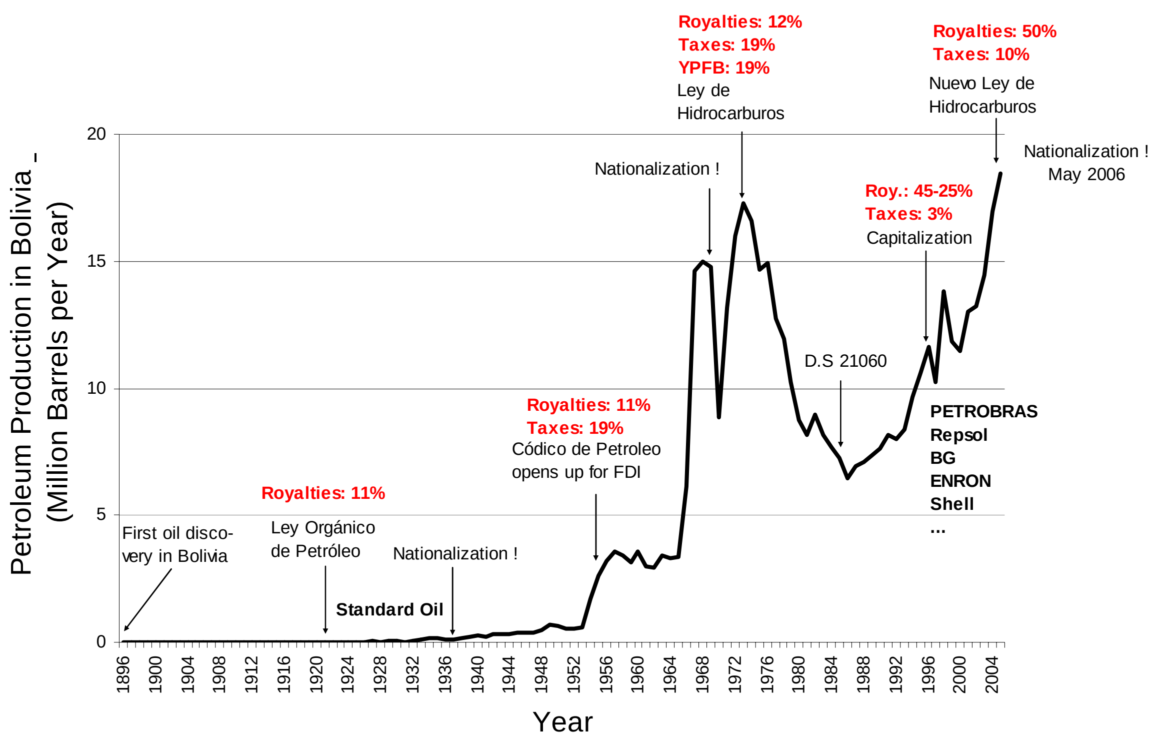
The company invested heavily in exploration activities during the 1940s and by the early 1950s production finally took off. In 1954, Bolivia achieved self-suffiency for the first time in history and changed status from petroleum importer to petroleum exporter.

Having found significant oil reserves, the country realized that it did not have the capital to rationally exploit these reserves, so in October of 1955 it passed a new law, “El Código del

Petróleo" which opened up for foreign direct investment. Apart from the royalties of 11% that already existed, this law added a tax of 19% on gross production.

Fourteen oil companies, of which Bolivian Gulf Oil was the most important, entered the country in the following years. After a period of stagnation, petroleum production five-doubled from about 3 million barrels per year during the early 60s to 15 million barrels in 1968 (see Figure 1 below).

Figure 1: Petroleum production in Bolivia, 1896 - 2005



Source: Authors' elaboration based on information from YPFB.

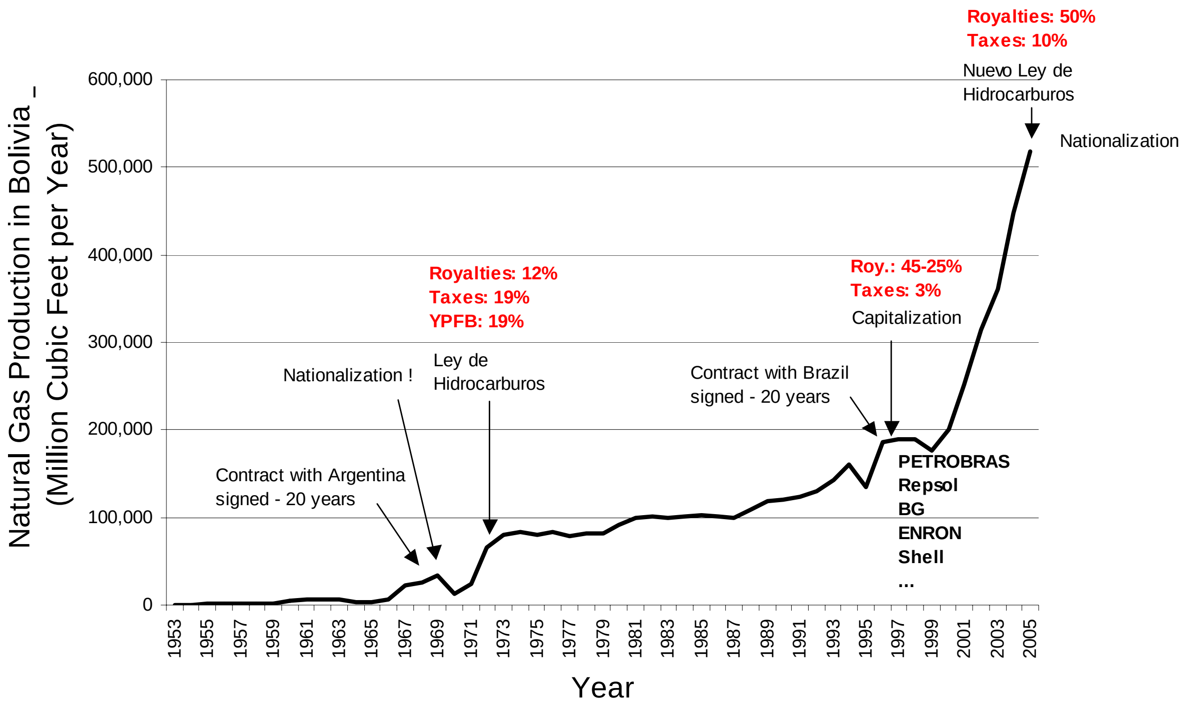
With the oil sector looking so lucrative again, the government decided to nationalize Bolivian Gulf Oil in October 1969. The company was awarded a little over $100 million in compensation, to be paid in oil from the nationalized oil fields.

The nationalization produced a temporary setback, as the World Bank suspended financing, and operational information disappeared together with Bolivian Gulf. However, already in 1972, production reached a new record of 17 million barrels.

More investment was urgently needed in order to take advantage of the extremely high oil prices in the early 1970s, so the government passed a new law “Ley General de Hidrocarburos” in 1972 which allowed for production sharing agreements between YPFB and foreign companies. Royalties were raised to 12%, the additional tax was kept at 19%, but another 19% of gross production should be paid to YPFB, which meant that the total government take was now 50%.

During the 1970s, 13 foreign companies signed contracts with YPFB and invested about $220 million dollars in the sector. Importantly, a contract was signed with Argentina to deliver natural gas by pipeline over a 20 year period starting in 1972. This marked the beginning of Bolivia’s Natural Gas boom (see Figure 2).

Figure 2: Natural Gas production in Bolivia, 1953 - 2005



Source: Authors' elaboration based on information from YPFB.

While natural gas production kept a steady pace over the next two decades in order to satisfy the contract with Argentina, oil production plummeted in the second half of the 70s in response to the falling oil prices. Both because it became non-profitable with the low prices and high taxes, but also because the country went into a general crisis during the first half of the 1980s.

Production started recovering again, together with the country, after the implementation of the Supreme Decree 21060 which put and end to hyperinflation and economic crisis with the introduction of stabilization policies and the opening up of the economy. As part of the liberalization of the economy, YPFB was capitalized (semi-privatized) in 1996, and foreign companies took over the management of the sector, while Bolivians kept an important share in the form of pension funds.

According to the "Ley de Hidrocarburos," royalties varied between 50% for already producing fields to 18% for new fields. In addition, there were various taxes on profits, but due to the large amounts of investments in the sector during the late 1990s, companies reported little profits and thus paid very little in taxes.

As companies managed to shift production from old to new fields, total government take dropped from around 50% just after the law was passed to an average around 30% six years later. In 1996, soon after the Ley de Hidrocarburos was passed, a natural gas export contract was signed with Brazil, promising the delivery of 7.1 trillion cubic feet of gas over a 20 year period. A several billion dollar pipeline was constructed to bring the gas to Sao Paolo and once completed, natural gas exports started increasing dramatically. Prices also soared, which meant that the oil and gas sector once again became extremely lucrative, and the Bolivian government decided it wanted a bigger part of the cake. It first raised royalties to 50% in 2005, and then in May 2006 it nationalized the sector for the 3rd time in 70 years.

3. The evolution of key variables

Reserves and production

This section presents more detailed information about natural gas and oil production in the period 1998-2005. Production is presented by company field operator. For example, the production of the San Alberto field is shared between three companies in the following proportions: 50% for Andina, 35% for Petrobras and 15% for Total E&F. Nevertheless, Petrobras is the company field operator, which means that these numbers have to be understood at field level, not from a company point of view.

Table 1 presents the natural gas production subject to the payment of royalties and taxes for the period 1998-2005. The important participation of the two large fields (San Alberto and Sábalo) is clearly observed. In fact, a large part of the recent natural gas production growth is due to the production from these two fields, operated by Petrobras.

Table 1: Natural gas production (Million cubic feet per day)

Operator	1998	1999	2000	2001	2002	2003	2004	2005
Andina	**100**	**80**	**108**	**126**	**164**	**135**	**179**	**168**
Río Grande	24	20	59	78	75	49	82	71
Sirari	19	17	22	23	24	13	17	20
Víbora	39	28	25	24	34	34	38	43
Others	18	16	2	1	30	39	42	34
Chaco	**79**	**73**	**77**	**108**	**103**	**104**	**116**	**114**
Bulo Bulo	-	-	14	54	69	58	33	52
Carrasco	45	39	33	11	11	15	18	19
San Roque	23	18	13	9	7	6	5	5
Vuelta Grande	11	17	17	34	13	15	28	24
Kanata	-	-	-	-	3	10	28	14
Others	-	-	-	-	0	0	5	0
Vintage	**28**	**22**	**38**	**35**	**26**	**25**	**32**	**18**
Repsol YPF	**-**	**0**	**27**	**24**	**11**	**8**	**12**	**81**
Margarita	-	-	-	-	-	-	0	65
Others	-	0	27	24	11	8	12	16
Petrobras Energia	**25**	**18**	**28**	**37**	**35**	**36**	**35**	**34**
Petrobras	**-**	**-**	**-**	**96**	**153**	**333**	**526**	**677**
San Alberto	-	-	-	96	153	200	173	304
Sábalo	-	-	-	-	-	132	352	373
Pluspetrol	**6**	**5**	**3**	**5**	**10**	**9**	**1**	**24**
Tacobo	-	-	-	-	-	-	-	23
Others	6	5	3	5	10	9	1	1
Dong Won	**0**	**-**	**-**	**-**	**-**	**-**	**0**	**-**
BG	**35**	**23**	**32**	**42**	**79**	**39**	**56**	**60**
TOTAL (MM cubic feet/day)	**273**	**222**	**312**	**473**	**582**	**688**	**957**	**1,177**
TOTAL (MM cubic meters/day)	**8**	**6**	**9**	**13**	**16**	**19**	**27**	**33**
TOTAL(1) (MM cubic meters/day)	**8**	**6**	**9**	**11**	**12**	**10**	**12**	**12**

Source: Authors' elaboration based on information from YPFB.

(1) Total without the large gas fields (San Alberto, Sábalo and Margarita).

Two facts explain the importance of these two fields in total production. The first is the production assignment of these two fields within the Gas Sales Agreement (GSA) with Brazil. According to clause 21.2 of the contract, the fields San Alberto and Sábalo have, respectively, 40.2% and 32.2% of the 30.08 MM cubic meters per day of natural gas agreed in the GSA[2]. The second fact is the large reserves in those fields.

Table 2 shows that San Alberto and Sábalo (both located in the department of Tarija) together have 46% of total natural gas reserves, as of January 2005.

Table 2: Natural Gas Reserves (TCF)

Fields	Reserves by 01.01.05	Share of reserves
San Alberto	11.7	24%
Sábalo	10.7	22%
Margarita	10.5	22%
Itau	7.8	16%
Others	8.1	17%
Total	**48.8**	**100%**

Source: Author's elaboration based on information from YPFB.

Another fact that stands out in Table 2 is the other two large fields, Margarita and Itaú, which together have 37% of the total reserves. Production from these fields is still limited due to the lack of markets. Indeed, if markets in Mexico or USA had been negotiated, these fields would have been the most important suppliers.

[2] One cubic meter corresponds to 35.3146 cubic feet.

Table 3 presents numbers for oil production, which is closely related to natural gas production, as the two are typically found together, although in varying proportions. As in the case of natural gas, San Alberto and Sábalo are the two most important fields in Bolivia. They produce almost 36% of the liquids and great part of the growth of production is due to the production of these two fields. The reserves of these two fields (Table 4) and the production of natural gas from these fields, allows such large participation in total production. However, a fact that is also worth mentioning is the quantity of exclusive oil fields with small production and reserves. These play an important function since they produce the petroleum that is used to produce diesel oil, which is in short supply in Bolivia. Although there is a large production of liquids, it is not enough to satisfy the domestic demand for diesel oil. In general the fossil fuels in Bolivia are relatively light, supplying large amounts of clean natural gas but little of the heavy, and more polluting, chemical structures needed to produce diesel oil.

Table 3: Oil Production (Barrels per day)

Operator	1998	1999	2000	2001	2002	2003	2004	2005
Andina	**10,483**	**8,874**	**9,048**	**8,563**	**8,539**	**7,744**	**6,963**	**5,583**
Río Grande	1,109	1,387	1,806	2,520	2,703	2,206	2,150	1,817
Sirari	1,677	1,463	1,531	1,142	922	701	612	458
Víbora	4,355	3,537	3,390	3,074	2,561	2,126	1,865	1,534
La Peña	765	839	1,289	1,006	1,084	1,335	880	484
Tundy	1,772	971	159	0	0	-	-	-
Others	805	677	873	821	1,269	1,376	1,456	1,290
Chaco	**11,402**	**8,659**	**7,473**	**9,189**	**9,963**	**8,856**	**9,454**	**7,824**
Bulo Bulo	-	-	640	2,572	3,551	3,383	3,128	2,966
Carrasco	4,097	2,922	2,055	633	422	347	236	192
Los Cusis	2,363	1,340	1,153	1,020	799	611	538	449
Kanata	-	-	-	-	475	1,169	2,342	1,777
Vuelta Grande	2,219	1,928	1,827	1,646	1,532	1,343	1,243	1,252
Patujusal	1,959	1,910	1,336	2,499	2,485	1,559	1,027	730
Patujusual Oeste	-	-	-	562	488	276	142	115
Others	764	559	462	257	211	168	798	343
Vintage	**673**	**434**	**676**	**597**	**465**	**386**	**446**	**220**
Repsol YPF	**13,239**	**12,934**	**11,998**	**12,435**	**10,040**	**10,042**	**9,874**	**13,731**
Monteagudo	626	1,031	830	762	657	500	402	315
Paloma	7,425	7,779	6,066	6,142	5,309	4,812	3,380	2,767
Surubí	4,508	3,547	3,929	4,266	2,409	2,587	1,977	1,922
Surubí Noroeste	-	-	-	-	-	607	3,071	2,879
Surubí BB	626	525	623	1,113	1,596	1,459	920	1,755
Margarita	-	-	501	110	-	6	67	4,046
Others	54	52	49	42	69	71	57	47
Petrobras Energía	**515**	**514**	**940**	**1,170**	**1,024**	**1,033**	**1,066**	**966**
Petrobras	**-**	**-**	**6**	**2,298**	**3,726**	**9,842**	**16,699**	**20,342**
San Alberto	-	-	6	2,298	3,693	4,932	4,442	7,443
Sábalo	-	-	-	-	33	4,910	12,257	12,899
Pluspetrol	**285**	**280**	**217**	**174**	**234**	**304**	**179**	**311**
Tacobo	-	-	-	-	-	-	-	136
Others	285	280	217	174	234	304	179	175
Dong Won	**17**	**11**	**1**	**2**	**-**	**33**	**7**	**-**
BG Bolivia	**1,128**	**680**	**1,072**	**1,220**	**2,146**	**1,193**	**1,658**	**1,680**
Escondido	739	270	671	671	1,168	822	1,121	1,049
La Vertiente	360	191	361	291	312	279	272	343
Others	29	219	40	258	666	92	265	288
Canadian	**52**	**74**	**142**	**124**	**99**	**25**	**-**	**-**
Matpetrol	**-**	**-**	**-**	**24**	**46**	**87**	**100**	**99**
Itau	**-**	**-**	**-**	**-**	**6**	**-**	**-**	**-**
TOTAL	**37,798**	**32,460**	**31,573**	**35,796**	**36,288**	**39,545**	**46,446**	**50,756**
TOTAL (1)	**37,798**	**32,460**	**31,066**	**33,388**	**32,562**	**29,697**	**29,680**	**26,368**

Source: Authors' elaboration based on information from YPFB.

(1) Total without the large gas fields (San Alberto, Sábalo, Margarita).

Table 4: Oil Reserves (Millions of Barrels)

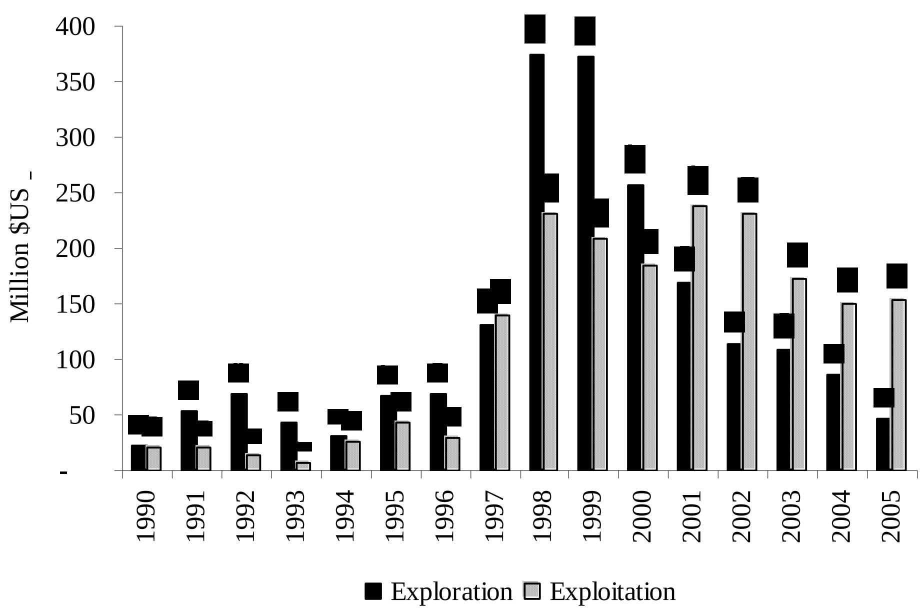
Field	Reserves by 01.01.05	%
San Alberto	160.9	19%
Sábalo	177.7	21%
Margarita	256.6	30%
Itau	114.7	13%
Others	146.7	17%
Total	**856.6**	**100%**

Source: Authors' elaboration based on information from YPFB.

Investments

One of the most interesting results of the 1996-1998 reforms in the Bolivian hydrocarbon sector was the growth of investments. Figure 3 presents the evolution of investments during the period 1990-2005, showing clearly the remarkable inflow of investments during the second half of the 90's.

Figure 3: Investment in the Bolivian upstream sector (MM $US)



However, with the application of the “Nueva Ley de Hidrocarburos” (No. 3058) in 2005, the investment perspectives in the sector are quite modest due to two reasons: 1) the application of an additional 32% tax (IDH) on the production, and b) the new structure of contracts established in the law. Regarding the first point, with the application of 50% of royalties as well as the new production tax (IDH) of 32%, there are no incentives to develop new small and medium sized fields and the large fields will be developed only under good market and price conditions. Regarding the new structure of contracts (operation, association and shared production), investments are discouraged due to the lack of clarity in commercialization aspects.

Markets

In the case of natural gas, the main share of production is dedicated to the external market, especially Brazil.[3] According to Table 5, in the year 2005, more than 87% of the sales of natural gas were dedicated to the export, while only 13% was dedicated to the internal market. Certainly this situation is different from the one observed in the years 1998 and 1999, where the export to Argentina had concluded and the volumes sent to the Brazil were rather modest.

Within the internal market, the main market is the sale to thermoelectric plants. However, an important growth in the sales of vehicular natural gas (VNG) is also observed.[4]

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[3] Medinaceli (2004).

[4] Medinaceli & Zeballos (2005).

Table 5: Bolivian Natural Gas Markets (Millions of cubic feet/day)

	1998	1999	2000	2001	2002	2003	2004	2005 (p)
External Market	**154**	**101**	**205**	**371**	**474**	**544**	**813**	**1,006**
Brazil	-	39	203	367	463	536	735	837
Argentina	154	62	2	4	11	8	77	168
Internal Market	**109**	**105**	**108**	**90**	**96**	**112**	**127**	**171**
TOTAL	**263**	**206**	**313**	**461**	**570**	**657**	**940**	**1,177**

Source: Authors' elaboration based on information from YPFB and the Hydrocarbons Superintendency.

Natural gas exports are currently destined at Brazil and Argentina only. The GSA with Brazil was signed by YPFB and Petrobras, and exports started in July 1999. The agreed sales volumes reach a maximum of 30.08 MM cubic meters per day, but actual sales have been somewhat below that level. The recent export of natural gas to Argentina is carried out through YPFB who has signed operating contracts with Petrobras and Repsol, assigning them, 2.1 and 4.4 MM cubic meters per day out of the 6.5 agreed in the sales contract. But this is only a short term contract, which expires by the end of the year 2006.

In the CGE simulations carried out in subsecuent sections of this paper, we will assume that oil and gas production, after having increased dramatically during the 1998-2005 period, will level off and even fall sligthly (see Table 6 with actual and projected production of natural gas and petroleum). The short term contract with Argentina this year is not included, and while it is possible that other export contracts will be secured in the future, this has become less likely after the nationalization.

Table 6: Actual and projected production of natural gas and petroleum in Bolivia, 1998-2019.

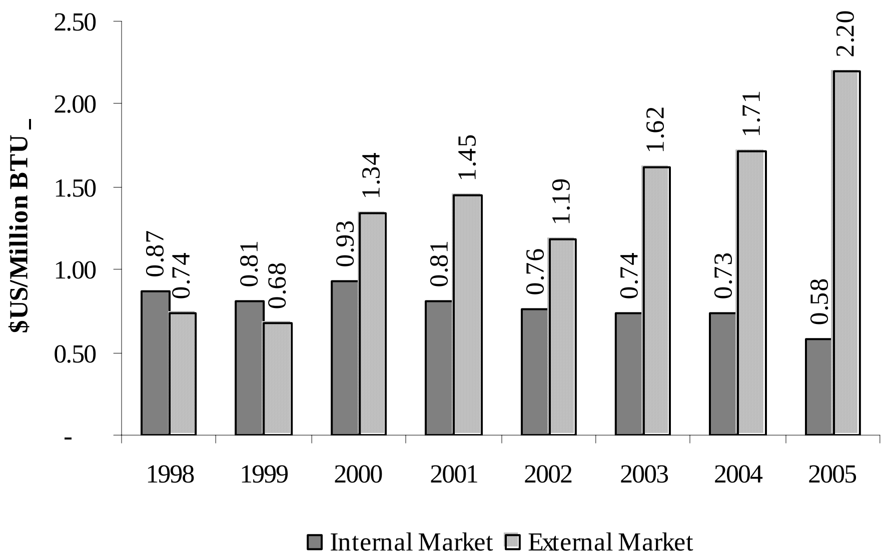
Year	**Natural Gas Production** (million cubic meters per day)	**Petroleum Production** (Barrels per day)
1998	7.72	37798.33
1999	6.28	32460.00
2000	8.85	31573.00
2001	13.40	35795.85
2002	16.48	36288.01
2003	19.48	39545.00
2004	27.10	46446.00
2005	33.32	50756.00
2006*	33.38	47208.30
2007*	33.34	44565.45
2008*	33.33	43246.77
2009*	33.22	42189.93
2010*	33.00	41236.65
2011*	32.49	39439.42
2012*	31.99	40040.39
2013*	32.22	40173.92
2014*	32.04	39457.19
2015*	31.75	38308.16
2016*	31.66	37841.35
2017*	31.62	38222.35
2018*	31.35	37871.22
2019*	30.54	37406.30

Note: * Conservative projection.

Prices

The analysis of natural gas prices is not simple, due to the wide variety of contracts in the internal market and the limited access to this information (generally private). Prices vary from contract to contract, but the Ministry of Hydrocarbons publishes a weighted average, which shows the general evolution of prices. Figure 4 presents these prices expressed in $US per million BTU for the period 1998-2005. It can be observed that the natural gas export price, mainly from the GSA, have lately been higher than the corresponding price for the internal market. The reason is that the sale price to Brazil (GSA) is a function of a basket of international fuel prices, all of which have increased dramatically during the last few years.

Figure 4: Wellhead prices ($US/ MM BTU)

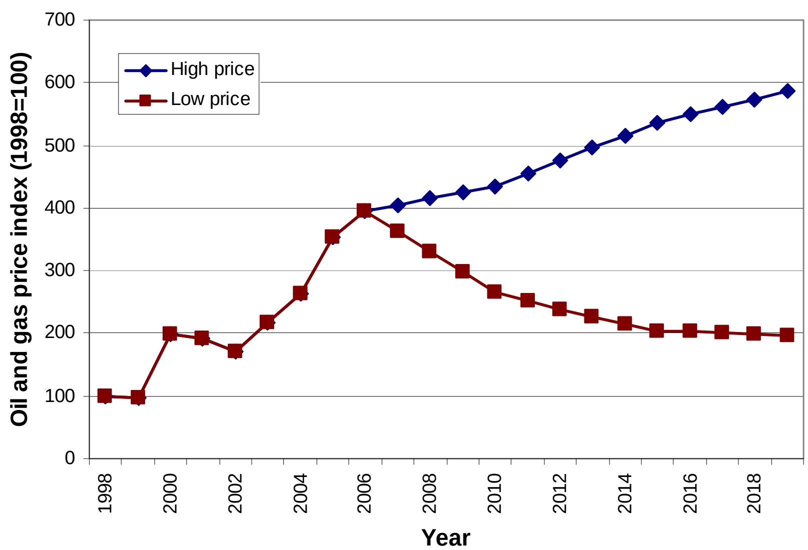


Source: Ministry of Hydrocarbons.

Oil prices are notoriously difficult to predict, so for the CGE simulations carried out in the rest of this paper we will operate with two different scenarios. Between 1998 and 2006, we will in both scenarios follow the actual development of oil and gas prices, which shows a quadrupling of prices compared to the low levels of 1998. In the “High price” scenario we assume that oil and gas prices keep increasing gradually to a level about 6 times higher than in 1998, whereas in the “Low price” scenario we assume that prices will fall back to a level only 2 times higher than in 1998 (see Figure 5).

The high price in 2019 corresponds to an oil price of about $70/barrel (in 1998 dollars) and a natural gas price of about $4.50/MM BTU. This is not impossible to imagine, especially if the demand for energy keeps increasing dramatically due to rapid growth in emerging markets such as China and India. However, consistently high oil prices tend to encourage massive investments in the oil and gas sectors, as well as in alternative energy and energy saving technology. This mechanism would tend to push prices downward again, making the "Low price" scenario equally plausible. In the "Low price" scenario, oil prices level off at around $20/barrel, roughly corresponding to the average oil price over the last 50 years, and a corresponding price of $1.66/MM BTU for natural gas exports.

Figure 5: Alternative price scenarios for CGE simulations



It should be noted that the current high level of royalties and taxes would make production unsustainable in the "Low Price" scenario, as profits would turn negative. This is not taken into account in the simulations, where companies are forced to operate despite losses.

Taxes and Royalties

Table 7 presents the results, in terms of fiscal collection, of all the royalties and taxes applied to the exploration and exploitation sector during the period 2000-2005.[5] Clearly the bulk of the contribution of the sector to the State comes in the form of royalties, however taxes are by no means negligible. Especially the recent 32% production tax (IDH) introduced by the "Nueva Ley de Hidrocarburos" in the second part of 2005 implies substantial additional revenues.

Table 7: Royalties, taxes and bonuses (Million $US)

Concept	2000	2001	2002	2003	2004	2005 (p)
Royalties	180.1	187.7	172.7	219.3	209.2	317.4
Value Added Tax	19.0	25.3	7.9	8.6	2.0	6.3
Transaction Tax	0.8	0.5	1.1	3.0	11.4	15.4
Income Tax	7.3	22.1	6.9	10.6	23.6	63.1
Bonuses	9.2	8.2	8.2	7.4	6.1	4.8
Hydrocarbons Production Tax (IDH)	-	-	-	-	-	288.5
Total	**216.3**	**243.9**	**196.8**	**248.8**	**252.3**	**695.4**

Source: Author's elaboration based on information from YPFB, Hydrocarbons Ministry and Impuestos Internos

Even more interesting numbers appears in Table 8 where the previous numbers are compared with the gross revenues at wellhead. As the table shows, the average government

[5] For a detailed discussion of the tax system see Medinaceli (2003).

take was never only 18%, as many people believed. This is mainly due the presence of "Hidrocarburos Existentes" (old hydrocarbons), which paid royalties of 50%[6] and other taxes as well. When royalties dropped almost down to 18% in 2005, due to the shift towards "New hydrocarbons", this was compensated by the introduction of the new production tax (IDH), which increased total government take to about 42% of gross production value.

Table 8: Royalties and taxes as % of the gross revenues at wellhead

Concept	2000	2001	2002	2003	2004	2005 (p)
Royalties	35%	32%	29%	27%	25%	19%
VAT, Transaction Tax and Income Tax	7%	9%	4%	4%	5%	5%
IDH	0%	0%	0%	0%	0%	18%
Total	**43%**	**41%**	**34%**	**30%**	**30%**	**42%**

Source: Author's elaboration based on information from YPFB, Hydrocarbons Ministry and Impuestos Internos

In the simulations carried out in the following sections, we assume that total government take follows the numbers presented in Table 7, increases to 50% in 2006, and stays at that level for the rest of the simulation period.

4. A CGE model of the Bolivian economy

The Computable General Equilibrium (CGE) model used for this study is a standard 12-sector recursively dynamic model. There is one capital category and five types of labor: skilled, unskilled agricultural, unskilled non-agricultural, smallholder, and urban informal.

[6] There was, with Hydrocarbons Law 1689, a good part of the production that paid 50% as royalties.

Amongst the labor classes, labor is mobile only between the two unskilled classes and between the smallholders and the informal sector. There are six household categories defined by the source of their income.

This model is constructed using a social accounting matrix (SAM) for Bolivia in 1997, developed by Thiele & Piazolo (2002). The authors of the present paper modified this SAM to estimate the sources and parameters for different fossil fuel taxes and royalties.

For the production sectors, output, prices and factor demands are all determined endogenously within the model. Production is portrayed with a multiple-stage nested function. Labor and capital are combined in a Cobb-Douglas relationship to produce value added. Value added and composite intermediate goods are pooled in a constant elasticity of substitution (CES) function. Intermediate inputs are used in fixed proportions in the creation of the aggregate intermediate factor. This formulation is constructed to reflect the flexibility in production choices for medium to long-term processes.

For the fossil fuel sector, production is fixed at the levels consistent with the contract negotiated with Brazil for Natural Gas exports. Internal demand depends on the level of activity in the economy.

The model is solved recursively over a fifteen-year time horizon. The model is run for each time period, after which the stocks of accumulated factors are updated before the model is run again for the next period. The key aspect of defining the dynamic relationship in a macroeconomic model is the treatment of savings and investment behavior. In this model, aggregate investment is determined by national savings. First, private savings are fixed as a fixed percentage of income for households and corporations according to their observed marginal propensity to save. Government savings is determined endogenously as the remainder after predetermined expenditures are subtracted from current revenues. In the absence of a solid empirical basis for estimating foreign savings levels, these are set exogenously at historic levels. Once this level of aggregate savings is determined, the allocation of investment is determined by relative profitability based upon current prices. This is an alternative formulation to fully dynamic models where consumers and producers make savings and investment decisions based upon perfect price information for all future periods, recognizing that decision-makers are imperfect predictors of the future.

The relationship between imports and domestically produced commodities, as well as the relationship between exports and domestically consumed commodities, are treated in the standard way for CGE models, using an Armington function for imports and a constant elasticity of transformation (CET) function for exports. This formulation entails the imperfect substitution between these different commodities which allows for two-way trade as in observed trade relations. The sectoral definitions of the SAM distinguish between industrial sectors that produce goods that are used primarily for consumption, intermediate production and capital investments. This permits the elasticity of substitution between imports and domestically produced goods for these different sectors to vary, and hence for scenarios to look at different taxation schemes and world price trends by import type.

The operation of labor markets follows De Santis (2000). Using the empirical observations of Blanchflower & Osward (1994) and others, a relationship between real wage rates and unemployment is specified, where higher wages coincide with lower unemployment. The empirical basis of the 'wage curve' mimics a labor supply curve when specified in a simulation model. Thus the labor markets operate on the principles of supply and demand in the model, rather than the often used simplifications of fixed wage rates or fixed labor supply curves.

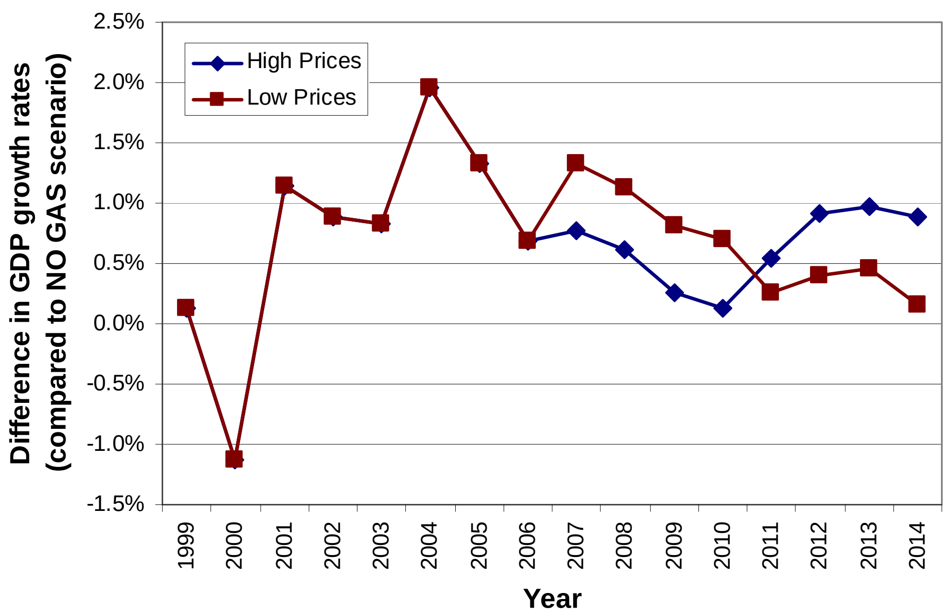
The specification of production in the fossil fuel sector differ from the other sectors of the economy, in that production is not allowed to respond to changing prices. Output of petroleum and natural gas is predetermined in the model by the currently projected exports under contract with Brazil and the associated investments in the sector (see Table 6 above).

5. Structural changes due to natural gas exports

There are three main benefits to the country of large natural gas exports: 1) It is an important source of foreign exchange which can be used to pay for imports, 2) It is an important source of savings, which can be used for carrying out investments, and 3) It is a very important source of revenue for the public sector.

There are, however, also substantial indirect impacts that will result from the large infusion of foreign exchange into the economy. In this section, we analyze the impact of natural gas exports on the Bolivian economy by comparing simulations generated by the CGE model. We operate with three different scenarios. The first is a base scenario corresponding to no gas exports to Brazil (hereafter NO GAS) where we essentially fix oil and gas production at the 1998 level. In the two other scenarios we increase gas exports (and associated oil production) according to the levels agreed in the contract with Brazil. The difference between the two latter scenarios is in the level of oil prices. In the "Low Price" scenario we assume that prices will start falling again from the currently high levels to the long term average of around $20 per barrel. In the "High Price" scenario we assume that prices will keep rising to about $70 per barrel.

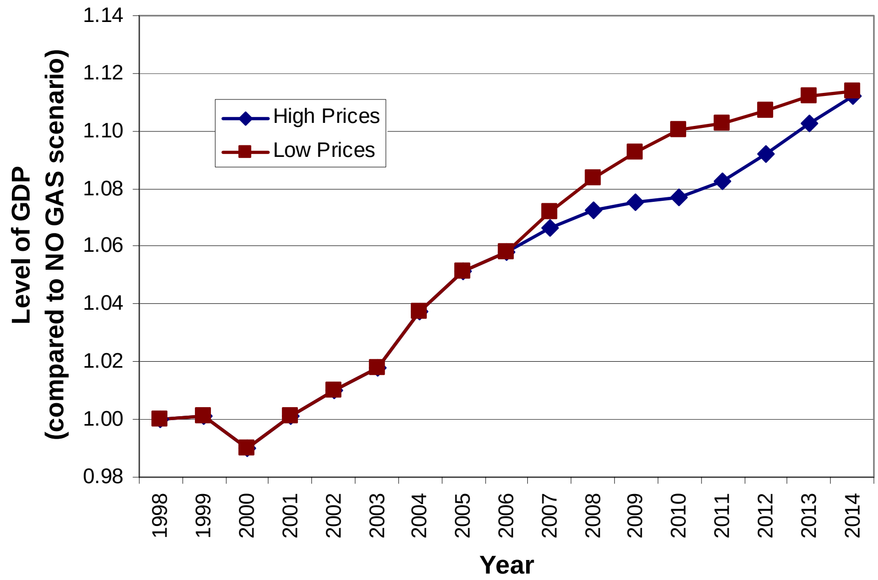
Figure 6: Increase in GDP growth rates due to natural gas exports



The apparent benefits from the increase in natural gas are substantial (See Figure 6). During the last five years, natural gas exports have added an average of 1.2 percentage points to annual GDP growth rates. In subsequent years, the additional annual growth drops to around half a percentage point more than in the NO GAS scenario, depending on the level of oil prices. It is not necessarily better for the Bolivian economy that oil prices remain high. Indeed the average GDP growth rates is approximately the same in the two scenarios, with some years showing higher growth in the high price scenarios but other years showing higher growth in the low price scenario.

The estimated benefits are persistent as the economy continues to grow upon a larger economic base. Figure 7 shows that GDP is about 11 percent higher after 16 years in either GAS scenario compared to NO GAS. This increase in growth is brought about not only by the increase in fossil fuel sales – the demand-side impact – but also by an increase in national savings as a result of the petroleum sales, which leads to higher investment and larger capital stocks – the supply-side impact. National savings and investment levels are estimated to be 35 percent higher in the Low Price scenario, and 43 percent higher in the High Price scenario, compared to the NO GAS scenario. Again, a substantial portion of this increase in national savings is drawn directly from the increase in natural gas revenues. An additional source of higher national savings is the result of cumulative growth: Higher investments lead to higher overall economic activity that brings on higher aggregate savings and investment and so on.

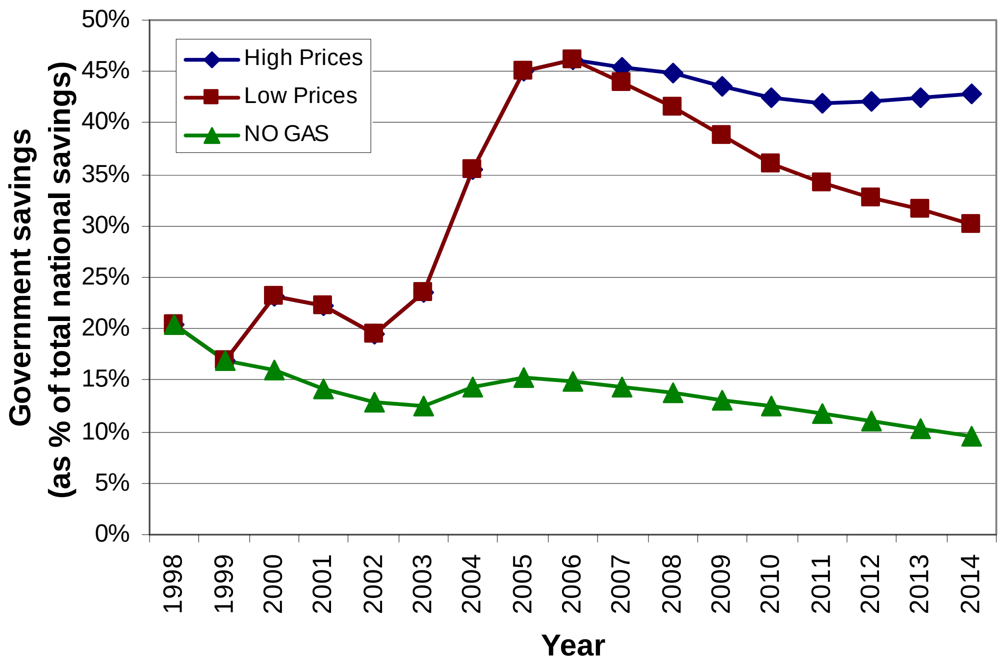
Figure 7: Increase in GDP levels due to natural gas exports



A substantial portion of the increase in the national savings rate is made up of government savings, which climbs to 45 percent of total national savings, as compared to about 15 percent in the NO GAS scenario (see Figure 8). If oil prices fall from the current high level, government savings will fall again, but still remain much higher than in the NO GAS scenario.

In the simulation model it is assumed that the government will invest all these savings in the production of public goods (such as roads), which improve the productivity of all actors. This is a very optimistic scenario with 100% efficient public investment benefitting everybody. Andersen & Faris (2002) explored what would happen if the government only invested half of the revenues in true public goods, and the rest disappeared due to corruption, failed investments, or increased spending on imported goods and services such as ministerial cars or foreign consultants. Predictably, with less public goods, the private sector would be less productive, and thus receive lower incomes. We will not repeat this exercies in the present paper, but just highlight that the simulations presented here represent a very optimistic scenario, where the government is 100% efficient in the production of productivity encancing public goods.

Figure 8: Increased importance of government savings due to natural gas exports



The increase in fossil fuel revenues accruing to the government creates an increased dependence on natural resources in the public sector. Fossil fuel's contribution to government revenues increases from about 10 percent in 1998 to about 40 percent in 2006. If oil prices remain high, the share of government revenues arising from fossil fuel exports will remain around 40 percent, whereas if prices fall the importance of fossil fuels will fall to around 25 percent, which is still considerable. This stems not only from the increase in fossil fuel taxes destined to the government but also from a reduction in tax receipts in sectors that are negatively impacted by the economic changes. The increase in revenue presents the government with many options, including a reduction of other taxes that are more distortionary, an expansion of publicly financed investment projects, or direct transfers to the population. The present simulations represent the most optimistic scenario in terms of growth, as funds are used to create productivity enhancing public goods. However, with direct transfers to the poorest part of the population, a more equal income distribution could be generated. In the present paper, it is assumed that the government maintain the same structure of spending and investment as in the base year, just on a larger scale. In a subsecuent paper, we will explore whether changes in government spending and investment might improve on the outcomes presented here.

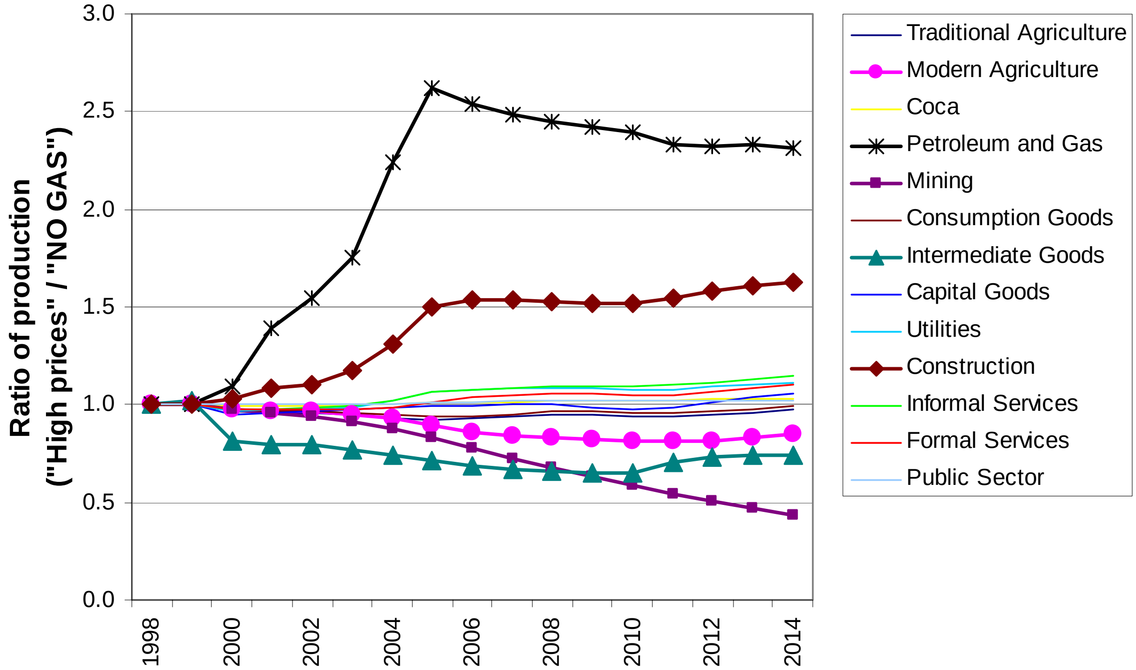
The increase in GDP growth rates is also accompanied by a substantial change in the structure of the economy. In addition to the growing fossil fuel and public sectors, the relative composition of output changes in response to the projected changes in the real exchange rate that occurs with the increased flow of foreign currency into the country. The simulations show an appreciation of the real exchange rate that reaches a level that is 35 percent stronger in the High Price scenario than in the NO GAS scenario. This constitutes a clear case of Dutch disease – imports will be cheaper and will command a larger percentage of domestic sales and the profitability and revenues for export sales in domestic currency will be lower, suppressing the non-fossil fuel export sectors.

If oil prices start falling again soon, the current appreciation will be reverted, and we will end up in 2014 with a real exchange rate that is only about 10 percent stronger than in the NO GAS scenario.

The appreciation will have the greatest impact on the sectors of the economy that have a large tradeable content as a part of their product mix. The model predicts that production in several other sectors will be substantially lower than in the NO GAS scenario, with mining, intermediate goods and modern agriculture suffering the most. Apart from the fossil fuel industry, the sectors that benefit the most from these changes are those sectors that have strong linkages with the natural gas boom and ensuing investment boom – construction above all – and those sectors with more non-tradeable content as a part of their production profile such as utilities and the service sectors.

Despite the higher levels of GDP and investment in the economy, there are three important sectors (mining, modern agriculture and intermediate goods) who suffer absolute reductions in their production levels in the long run as a direct consequence of the natural gas boom (see Figure 9). There are also other sectors which suffer initial reductions, but then recover due to the overall larger levels of GDP and investment in the economy. This is the case for consumption goods and traditional agriculture.

Figure 9: Changes in sectoral production due to natural gas exports



It should be noted that these simulations are not projections. They are simply comparing two model scenarios, where the only difference is a large increase in natural gas exports in one of the scenarios, and all variables that are not directly or indirectly affected by natural gas exports are held constant. For example, nominal prices in all other sectors have been held constant, and all other exogenous shocks are ignored, as this paper wants to separate out the effects that are a direct consecuence of increased natural gas exports.

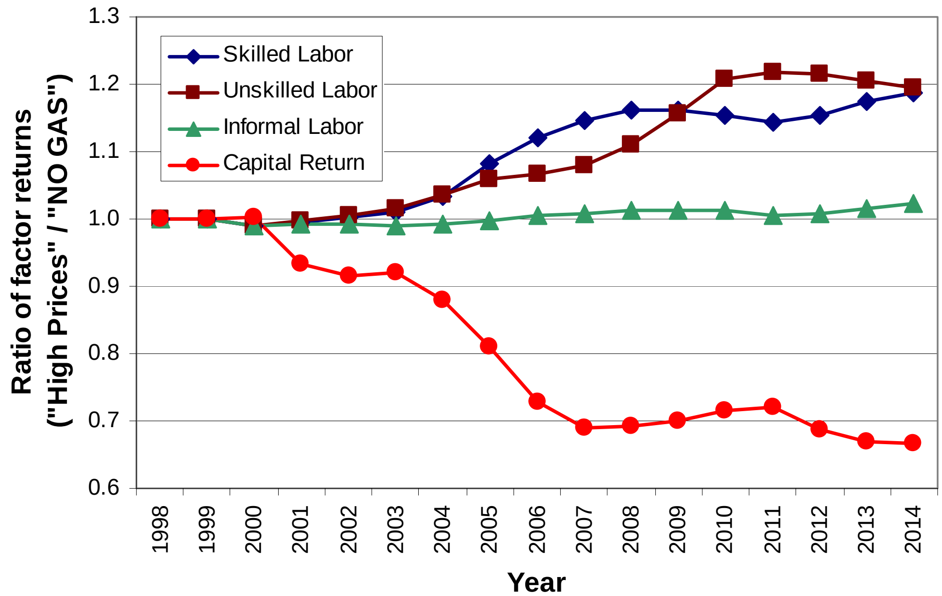
This means that even though the model indicates a negative effect on the mining sector, this sector may actually experience a boom in the coming decade, but that would be due to other exogenous shocks such as increases in the world prices of metals, large foreign investments in the sector, or new discoveries of important metal deposits in Bolivia, none of which are due to increased natural gas exports. Likewise, modern agriculture may do very well in the future, but that would be in spite of the negative effect that the natural gas boom has on this sector, and due to exogenous shocks purposely ignored in the present paper.

6. Changes in the income distribution caused by the natural gas boom

In order to assess the distributional impact of the increase in Natural Gas sales in Bolivia, we observe the predicted difference in real wage rates and returns to capital that accompanies the resource boom. We also map the difference in income accruing to six household groups.

Starting with wages, we see from Figure 10 that wages increase for both skilled and unskilled labor. Given the strong aggregate benefits of the natural gas sales presented in the previous section, this is not a surprise. Driven by higher investment, increasing capital stocks push up the marginal productivity of labor which is translated into higher wage rates. This rise in relative wage rates is counter-balanced by a drop in the average return to capital. The falling returns to capital predicted by the model are the result of the relative abundance of capital in the assumed absence of productivity gains.

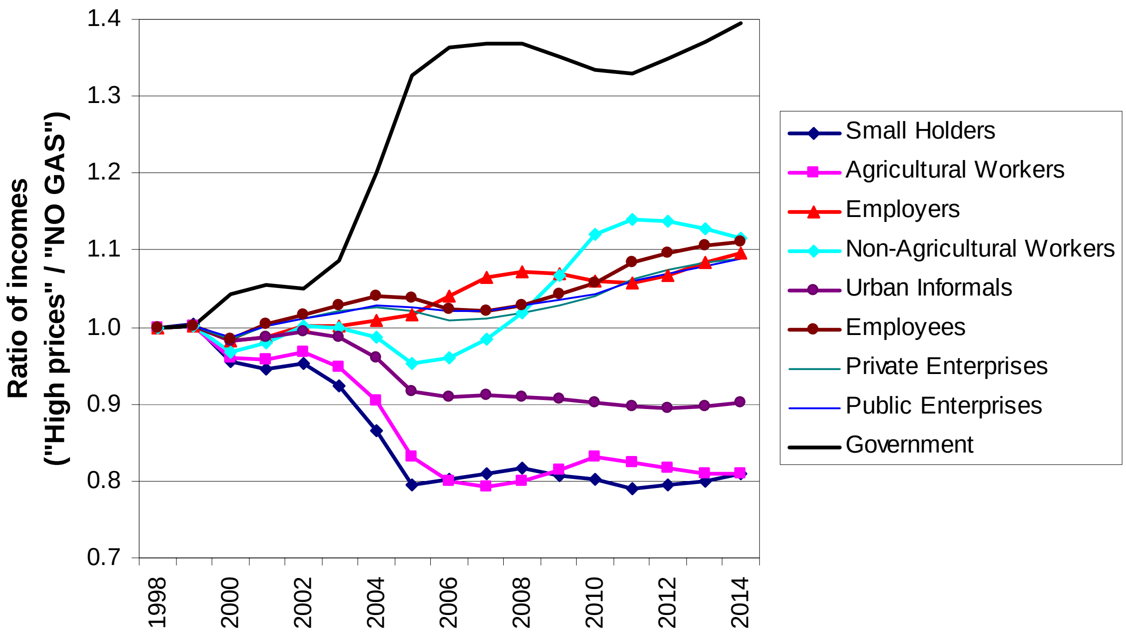
Figure 10: Changes in wages and returns to capital due to natural gas exports



Within household categories, we observe dramatic changes in real income levels. Non-agricultural workers and employees see increases of around 15 percent in both GAS scenarios compared to the NO GAS. In contrast, small-holders, urban informals and agricultural workers see decreases of 10-20 percent in the HIGH GAS scenario compared to the NO GAS scenario. This is of course linked to the relative success of the sectors from which these households derive their incomes. Non-agricultural workers and employees are mainly employed in construction and government, the two sectors that benefit most from the gas-boom (apart from the few people occupied in the gas and oil sector).

Agricultural workers suffer from the depression in modern agriculture that the sector experiences due to Dutch Disease. Small-holders and urban informals, the two big groups which include almost all of the poor in Bolivia, also see absolute reductions in their real income levels, implying that the natural gas boom not only increases inequality but also poverty. This effect is particularly strong in the high price scenario (see Figure 11).

Figure 11: Changes in real incomes due to natural gas exports



Despite the drop in average return to capital, the income accruing to capital increase as more capital is brought into production. Hence income to employers, who earn their income from capital returns, display significant increases in income. This of course implies that the return to existing capital is lower and that only those who have invested in the more profitable sectors of the new economy experience an increase in income. The owners of capital in agricultural and mining sectors will experience a drop in income in this context.

If oil prices fall again, the losses of small holders, agricultural workers and urban informals will be less pronounced. Indeed, they would almost return to the level of incomes that they would have had in the absence of the natural gas boom.

7. Conclusions

The simulations made in this paper show that the natural gas boom looks very good from the viewpoint of the government. GDP growth rates are consistently higher than in the NO GAS scenario and the government has substantially more resources available for spending and investment, implying a smaller budget deficit, less indebtedness, more public investment and better paid teachers and doctors.

However, from the viewpoint of the poor, the natural gas boom is not good news, especially not with high oil prices and high levels of royalties. Unless the government changes its spending and investment patterns to become substantially more pro-poor, the two large sectors containing most of the poor in Bolivia, small-holders and urban informals, will experience absolute reductions in real income levels compared to the NO GAS scenario. In addition, they will see an increase in inequality as the incomes of the already richer groups increase.

Modern agriculture, and other exporting sectors which might support a process of sustainable development in Bolivia, are also hurt by the natural gas boom, as they become less competitive due to the appreciation of the real exchange rate.

What can the government do to counteract these obviously negative side effects of the natural gas boom? One possibility, which the simulations above did not allow, is to increase the mobility of people from the two poor sectors (rural small holders and urban informals) to the other sectors that fare better. Essentially, the model assumed that small-holders can become urban informals if they wish, but they cannot suddenly become employees or employers in the formal sector. Agricultural workers can become non-agricultural workers, but not skilled employees. Such immobility between different levels is quite realistic in the short run. A subsistence farmer cannot suddenly start working as a teacher or a secretary, and very few of the informal family businesses grow to become formal enterprises and thus formal employers.

Achieving mobility between sectors at different levels is a long term task which requires long term policies and long term investments. While it is virtually impossible for a subsistence farmer to turn around and become a teacher or a petroleum engineer, it is not impossible for his sons or daughters to do so. The government, and the aid community, should support the movement of young people from increasingly disadvantaged rural areas to the urban formal sector which is prospering in the natural gas economy. This means better access to education, better integration of migrants from rural areas, and more formal sector jobs.

If the additional formal sector jobs are not all to be in the public sector, it is necessary to remove the obstacles that prevent informal micro-enterprises to grow into formal employers. The main obstacles to this are related to bureaucracy, taxes and labor laws, so they are not impossible to remove. Basically, a small informal family business is blessedly free of bureaucracy and pay little if any taxes. But if they should wish to turn into a formal business employing workers and paying regular salaries, they are met with a mountain of bureaucracy, labor laws which make it very expensive to get rid of un-necessary workers, and steep increases in taxes.

To make the transition smoother, and thus create more formal sector jobs, it is necessary to make labor laws more flexible. This means less job-security for those who already have formal sector jobs, but better opportunities for the poor to get a job and thus escape poverty.

It is also necessary to smooth the dramatic jump in taxes, which can be done either by raising taxes on informal businesses or reducing them for the formal businesses, or both. If it was made much simpler to register a formal business, the government could simply require all businesses to become formal, and not tolerate informal, non-contributing businesses. They could also create incentives, such as subsidized credit from sectoral development banks, which make it more attractive to become formal.

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