



**482**

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Public Expenditures and Debt at the Subnational Level:  
Evidence of Fiscal Smoothing from Argentina

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# Public expenditures and debt at the subnational level: Evidence of fiscal smoothing from Argentina\*

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## Abstract

This paper uses the particular features of the tax-sharing regime *Coparticipación Federal de Impuestos* and the fact that some provinces earn hydrocarbon royalties to investigate public expenditures and debt at the subnational level in Argentina.

We obtain that facing a one peso increase in intergovernmental transfers, provinces spend on average 36 cents in public expenditures with no changes in public debt. On the other hand, when royalties increase one peso, 59 cents are used to pay back public debt while public expenditures are not affected. These results, which are robust to many different specifications of the basic regressions, suggest a non-negligible expenditure/debt smoothing behavior of Argentine provinces.

**Keywords:** Tax sharing - Intergovernmental transfers - Oil royalties - Provincial public consumption and debt - Argentina.

**JEL codes:** C3, E62, H72 and H77.

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# 1 Introduction

In many countries, fiscal decentralization is not balanced in terms of tax and expenditure assignments. Although central governments collect most of the taxes, subnational governments are in charge of an important fraction of total public outlays. As a consequence, these countries are characterized by important vertical fiscal gaps which, most of the times, are solved through intergovernmental transfers.<sup>1</sup>

How subnational governments expend these transfers is a question that has been deeply studied in the public finance literature, both theoretically and empirically. Oates (2005) and Gamkhar and Shah (2007) identify two generations of contributions to this topic. In the earlier literature, the effects of intergovernmental grants on local fiscal policies have been analyzed in static, neoclassical models of local public finances.<sup>2</sup> In the light of the results obtained, some have warned against the fact that intergovernmental transfers are seldom exogenously determined and thus are affected, on the one hand, by fiscal competition and asymmetric information considerations and, on the other hand, by political variables or socioeconomic characteristics of the subnational units. In order to address these issues, the second-generation literature focus more on incentive problems that emerge in intergovernmental relations and emphasizes the need to improve identification issues, so as to deal with endogeneity problems prevalent in previous estimations.<sup>3</sup>

Our paper contributes to both strands of the literature. First, without departing from the neoclassical environment with a benevolent subnational government, we extend the static view of local fiscal policies and study subnational responses to changes in public revenues in a dynamic stochastic model. Adopting such a perspective enables us to analyze not only local expenditure decisions but also debt accumulation, and thus to investigate to what extent subnational governments are able to smooth public consumption when they face shocks to different sources of public revenues.

Second, we contribute to the recent empirical literature that evaluates the effects of intergovernmental transfers on local public finances by enhancing identification strategies. For that purpose, we exploit a data set that covers 24 Argentine provinces during the period from 1988 to 2009. Besides having their own revenues, Argentine provinces receive transfers from the Federal Government. The institutional arrangement of these intergovernmental transfers is a tax-sharing regime called *Coparticipación Federal de Impuestos*. Law 23,548

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<sup>1</sup>Eyraud and Lusinyan (2013) report that across OECD countries, the average share of subnational government expenditure not financed through own revenues was 40 percent between 1995 and 2005. In Belgium and Mexico these shares climb to 60 and 83 percent, respectively. Corbacho et al. (2013) document that vertical fiscal imbalances in Latin America are the highest among developing nations.

<sup>2</sup>From the empirical point of view, many contributions to this first-generation literature were concerned about the so-called “flypaper effect”. This expression illustrates the empirical regularity that subnational governments spend a fraction of a given increase in federal lump-sum transfers that exceeds by far the fraction they should have spent if private income were to increase by the same amount. For surveys on this issue see Gramlich (1977), Hines and Thaler (1985), Bailey and Connolly (1998), Gamkhar and Shah (2007) and Imman (2008).

<sup>3</sup>See, among others, Knight (2002), Gordon (2004), Dahlberg et al. (2008), Lutz (2010), Lundqvist (2015), Arvate et al. (2015) and Vegh and Vuletin (2015).

(1988) that currently regulates this regime specifies the process by which taxes collected by the Federal Government are reallocated to the provinces. In particular, the law determines, for each province, a fixed participation (or coefficient) in the common pool of taxes to be shared among all jurisdictions. Each provincial coefficient depends neither on observed characteristics nor on policies' outcomes. Also, for some provinces, another important source of public income are royalties coming from oil, gas and mineral production. This type of provincial income has been very volatile, and its main source of variation is exogenously determined by changes in international prices.

These two features of Argentine provincial public finances provide a unique setting for the empirical identification of the reaction of public expenditures and debt to changes in intergovernmental transfers and royalties, because it verifies the key identification assumption that shocks to these abovementioned sources of public revenues are truly exogenous with respect to expenditure and debt decisions.

We proceed as follows. First, we estimate econometrically the stochastic processes that characterize the evolution of Coparticipation transfers, royalties, and Gross Provincial Product (GPP). Then, we build a theoretical model of a representative provincial government that, knowing these stochastic processes, chooses public expenditures and debt to maximize its intertemporal social welfare, subject to a budget constraint. The model helps us to derive a system of equations that characterizes the optimal responses of public expenditures and debt to shocks in the different sources of exogenous, provincial, public revenues.

Next, we estimate econometrically the theoretical system of equations. The main results are the following. For each peso of increase in Coparticipation transfers, Argentine provinces raise public consumption approximately by 36 cents, while no significant effect is found on changes in public debt. Regarding royalties, the estimated response shows a significant reduction in debt: an increase in one peso in these revenues is associated with a fall of around 59 cents in public debt, while no impact is found in expenditures. These findings are robust to many different specifications, including instrumenting royalties by oil prices and considering particular provinces, so as to check for potential endogeneity of Coparticipation transfers coming from shocks affecting both transfers and provincial fiscal decisions.

These results suggest a non-negligible expenditure/debt smoothing behavior from the part of provinces in Argentina. This response is to some extent more significant with regard to increases in oil royalties, compared to Coparticipation transfers. We discuss possible reasons for these findings, among which we emphasize two explanations: the fact that oil revenues are more volatile compared with Coparticipation transfers and the non-renewable nature of oil and gas production.

## 1.1 Related literature

We are not the first to study local governments' fiscal responses to changes in public revenues in a dynamic stochastic model. Holtz-Eakin and Rosen (1991) and Holtz-Eakin et al. (1994) test empirically to what extent local government consumption decisions are determined by intertemporal considerations. Using aggregate data for US state and local governments, they perform time series estimations to investigate whether spending is determined by current or

more permanent income sources. Although their first study confirms that in small municipalities labor public demand is consistent with an intertemporal optimizing behavior under uncertainty, their second contribution asserts that local public spending is mainly determined by current resources. Dahlberg and Lindström (1998) apply the same approach to investigate the extent to which local government consumption in Swedish municipalities is determined by permanent rather than current resources, and Borge et al. (2001) extend the analysis to all Scandinavian local governments. Both papers use panel estimation techniques. While Dahlberg and Lindström (1998) find strong evidence in favor of the forward-looking optimizing behavior of Swedish municipalities, Borge et al. (2001) only confirm this assertion for Danish local governments. More recently, Vegh and Vuletin (2015) examine whether uncertainty and insurance arguments, and the resulting precautionary savings behavior, can be consistent with the “flypaper effect” phenomenon. They actually test their theory using data of federal transfers to Argentine provinces.

We extend these studies in two dimensions. First, our theoretical framework allows us to derive an empirical specification which implies that, in addition to public expenditures, we have to simultaneously look at changes in provincial assets/debt. Second, Argentine data enables us to estimate separately expenditures and debt responses to changes in two distinct exogenous sources of income: Coparticipation transfers and royalties.

Our approach can also be applied to evaluate whether subnational fiscal policies are “procyclical”. The lack of macro smoothing is a well-documented empirical fact in developing countries [see Talvi and Vegh (2005)], but relative little analysis has been undertaken on this issue at the subnational level in these economies. Our results suggest that provincial governments in Argentina have behaved much less procyclically than others have found [see, among others, Sturzenegger and Werneck (2006), Arena and Revilla (2009), Rodden and Wibbels (2010) and Vegh and Vuletin (2015)].

On the other hand, the inclusion of revenues coming from oil exploitation links our study with a recent literature that analyzes the performance of (national or subnational) governments when a significant fraction of their public revenues comes from these non-tax sources. One of the key arguments of the so-called “Natural Resource Curse” literature [see van der Ploeg (2011)] is that the nature of these type of income negatively affects both the governance and the quality of public policies, because voters face weak incentives to control the government when public revenues do not come out of their pocket. This “Rentier State Hypothesis”, first postulated by Mahdavy (1970), has been empirically studied in multicountry, cross-sectional growth regressions [see Sachs and Warner (1995)] and, more recently, using panel data estimation which allows for correcting omitted variables biases [see Aslaksen (2010) and Collier and Goderis (2012)].

A drawback of these contributions is that they often use flow indicators of exports or production, which are clearly endogenous. A relative new strand of papers, in particular Monteiro and Ferraz (2012), Caselli and Michaels (2013), Borge et al. (2015) and Martínez (2015) among others, have analyzed this “Natural Resource Curse” hypothesis in the context of local governments. On the one hand, their approach has allowed to handle potential problems of omitted variable biases as it is much more likely that basic institutional aspects

are kept constant (both across sectional units and across time) when analyzing political bodies within countries than between countries. In addition, these papers have made an effort at finding more exogenous measures of natural resource abundance.<sup>4</sup> As in Martinez (2015), we instrument changes in royalties' revenues by time variation in oil prices and cross sectional variation in initial oil production. We extend this recent literature by exploring how shocks to these natural resources-linked revenues affect not only provincial decisions regarding public consumption but also debt.

Since the seminal paper by Gelb (1988), it is a well-documented fact that oil producing countries seem to have problems at smoothing oil shocks. This procyclical behavior has been asserted by more recent papers [see Davis et al. (2003) and Erbil (2011)] that emphasize factors like the quality of institutions and the political structure as strong forces that help to determine the results. As far as we now, there is no study that analyzes smoothing-type behavior for oil producing governments at the subnational level. Our finding that oil producing provinces in Argentina have behaved, at least during the period under analysis, in a relative prudential way is somehow surprising, and calls a more cautious view as to whether the presence of these revenues is necessarily associated with big fluctuations in fiscal policies.

The remainder of the paper is organized as follows. In next section we provide a descriptive analysis of provincial public finances in Argentina. In Section 3, we describe the institutional settings that rule Coparticipation transfers and royalties. In Section 4, we develop a model that incorporates the main features of provincial public policies and inter-governmental fiscal relations prevailing in Argentina. Then, in Section 5, we formally test the main hypotheses derived from this model. These results are discussed in section 6. We conclude in section 7. All proofs are shown in the Appendix.

## 2 Sub-national public finances in Argentina

Argentina is a federal republic, consisting of twenty three provinces<sup>5</sup> and the national capital Ciudad Autónoma de Buenos Aires (C.A.B.A.).<sup>6</sup> Table 1 presents some 2001 geographic and socio-economic, provincial statistics. The first three columns display basic geographic and demographic indicators. The next two columns show the Gross Provincial Product (GPP), first expressed as a percent of the national Gross Domestic Product (GDP), and then in per

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<sup>4</sup>For example, Monteiro and Ferraz (2012) use a geographic rule that determines the share of oil revenues that accrue to different Brazilian local governments. Caselli and Michaels (2013) use municipal oil output to instrument for municipal revenue also in Brazil. Borge et al. (2015) instrument local revenue from hydropower sources in Norway using indicators of topology, average precipitation and meters of river in steep terrain. Finally, Martinez (2015) exploits time variation in the world price of oil, together with the cross sectional variation in oil intensity during a previous period in Colombian Municipalities.

<sup>5</sup>Each province is divided in municipalities. But, as their revenues and expenditures represent a very small fraction of all consolidated public revenues and expenditures in Argentina, we focus only on fiscal behavior at the provincial level.

<sup>6</sup>As the capital of the country, C.A.B.A. has some special prerogatives. Nevertheless, for all issues analyzed in this paper, C.A.B.A. can be assimilated to a province.

capita levels, in 2004 Argentine pesos (AR\$). The last column presents a provincial poverty index: the percent of households with ‘unmet basic needs’.<sup>7</sup>

**Table 1: Basic geographic and socio-economic statistics of Argentine provinces**

Province	(1) Area (Sq. km.)	(2) Population (Hab.)	(3) Density (Hab/Sq. km.)	(4) GPP/GDP	(5) Per capita GPP (2004 AR\$)	(6) Poverty index
Buenos Aires	307,751	13,827,203	44.93	35.06%	14,171	13%
C.A.B.A.	203	2,776,138	13,675.56	25.64%	51,619	7.1%
Catamarca	102,602	334,568	3.26	0.71%	11,868	18.4%
Chaco	99,633	984,446	9.88	0.96%	5,444	27.6%
Chubut	224,686	413,237	1.84	1.69%	22,852	13.4%
Córdoba	165,321	3,066,801	18.55	7.49%	13,642	11.1%
Corrientes	88,199	930,991	10.56	1.03%	6,162	24%
Entre Ríos	78,781	1,158,147	14.70	1.98%	9,545	14.7%
Formosa	72,066	486,559	6.75	0.33%	3,813	28%
Jujuy	53,219	611,888	11.50	0.59%	5,418	26.1%
La Pampa	143,440	299,294	2.09	0.89%	16,587	9.2%
La Rioja	89,680	289,983	3.23	0.72%	13,959	17.4%
Mendoza	148,827	1,579,651	10.61	2.58%	9,124	13.1%
Misiones	29,801	965,522	32.40	1.55%	8,971	23.5%
Neuquén	94,078	474,155	5.04	2.03%	23,886	15.5%
Río Negro	203,013	552,822	2.72	1.40%	14,116	16.1%
Salta	155,488	1,079,051	6.94	1.35%	7,007	27.5%
San Juan	89,651	620,023	6.92	1.00%	9,080	14.3%
San Luis	76,748	367,933	4.79	1.50%	22,810	13%
Santa Cruz	243,943	196,958	0.81	1.06%	29,998	10.1%
Santa Fe	133,007	3,000,701	22.56	7.81%	14,555	11.9%
Santiago del Estero	136,651	804,457	5.89	0.50%	3,488	26.2%
Tierra del Fuego	21,571	101,079	4.69	0.45%	25,124	15.5%
Tucumán	22,524	1,338,523	59.43	1.66%	6,954	20.5%

Sources: (1) Instituto Geográfico Militar, (2),(3) and (6) Instituto Nacional de Estadísticas y Censos, (4) and (5) Dirección Nacional de Coordinación Fiscal con las Provincias.

Provinces differ in many aspects. On the one hand, there are big ones (like C.A.B.A., Buenos Aires, Córdoba and Santa Fe) that account for more than 60 percent of Argentina’s total population, and generate almost 75 percent of its GDP. On the other hand, there are provinces that have a small population (like Catamarca, La Rioja and Santa Cruz,

<sup>7</sup>According to INDEC (1984), a household with ‘unmet basic needs’ is characterized by, at least, one of the following conditions: (i) more than three individuals per room, (ii) inconvenient house, (iii) no WC in the house, (iv) one child (six to twelve years old) that does not attend school, (v) four or more individuals per working person, where the household’s head has not completed the third year of primary school.

all with less than 1 percent of Argentina's total population) or a low participation in the national GDP (like Formosa, La Rioja and Santiago del Estero, all with less than 0.75 percent of GDP). Per capita GPP is also unequally distributed: it goes from AR\$3,488 (Santiago del Estero) to AR\$51,619 (C.A.B.A.). But this characteristic is not correlated with the participation of each provincial production in the national GDP. On the other hand, as expected, there is a strong negative correlation between per capita GPP and the provincial poverty index.

## 2.1 Provincial expenditures

The Federal Government and the provinces have different attributions and prerogatives, either on the expenditure or on the revenue side of their corresponding budget. Regarding expenditures, Defense and Foreign Affairs are the only areas where, according to the National Constitution, the Federal Government has an exclusive competence to deal with them. Then, the National Constitution defines a broad area of public services (like economic infrastructure, social insurance and poverty programs) where both levels of government share responsibilities and provide them. Finally, primary and secondary education, municipal organization and local services should be exclusively provided by provinces.

Participation of provincial public expenditures in the consolidated public sector outlays rose from 40 percent at the beginning of the eighties to nearly 55 percent in 2003. Despite the fact that there are important differences in public outlays (both in absolute and in per capita levels) between Argentine provinces, their expenditures are concentrated in public consumption (public wages, procurement of inputs and services) and transfers (mostly pensions). Table 2 shows the average percentage of public consumption and transfers in total public expenditures, by province, taking the average between 1988 and 2003.

**Table 2: Public consumption and transfers**

Province	Public consumption and transfers	Province	Public consumption and transfers
Buenos Aires	89.2	Mendoza	84.2
C.A.B.A.	88.0	Misiones	75.3
Catamarca	84.1	Neuquén	72.9
Chaco	81.5	Río Negro	81.2
Chubut	73.0	Salta	83.2
Córdoba	86.7	San Juan	78.2
Corrientes	82.3	San Luis	66.0
Entre Ríos	84.3	Santa Cruz	70.8
Formosa	76.6	Santa Fe	88.1
Jujuy	82.5	Santiago del Estero	78.1
La Pampa	73.0	Tierra del Fuego	76.7
La Rioja	82.5	Tucumán	83.7

Source: Dirección Nacional de Coordinación Fiscal con las Provincias.

For most provincial governments, these two components of public expenditures cover, on average, more than 80 percent of their total public outlays.

## 2.2 Provincial revenues

According to the National Constitution, the Federal Government has the exclusive right to tax foreign trade. Indirect taxes can be set either by the Federal Government or by provincial authorities. Finally, only provinces can directly tax their respective populations. Nevertheless, the Federal Government can constitutionally set direct taxes under “special circumstances”.

During the XIX<sup>th</sup> and the beginning of the XX<sup>th</sup> century, the Federal Government raised taxes mainly on international trade. Then, as the Great Depression caused a sudden decrease in fiscal revenues (due to the sharp decline in international trade), the Federal Government began to collect taxes that were previously assigned to the provinces, invoking the above-mentioned “special circumstances” argument. Then, provinces started to “delegate” to the Federal Government the administration of the most important taxes: personal and corporate income taxes, consumption taxes and taxes on wealth.<sup>8</sup> Due to historical reasons, this delegation has persisted until now. But it became more stringent by the end of the eighties because, according to Law 23,548 (see below), provinces cannot create new taxes.

As a consequence of this institutional process, Argentina presents a lower degree of decentralization in public revenues than of public expenditures. During 1988-2003, the Federal Government collected, on average, 77 percent of the country’s tax revenue, whereas provinces (and municipalities) only raised the remaining 23 percent. Provinces’ tax collection amounted, on average, to 2.14 percent of their GPP. As Figure 1 shows, these shares were rather constant in the period under consideration. For all provinces, the best fit line of their yearly share of provincial tax collection over GPP presents no statistically significant slope or, when it is statistically significant, its economic significance is negligible.<sup>9</sup>

What explains these low percentages? First, provincial revenues are concentrated only on few taxes. During this period, gross receipts, real state and vehicles taxes generate, on average, 81 percent of provincial fiscal revenues. In particular, the gross receipts tax explains 64 percent of these revenues. As this tax is multiphasic and cumulative, tax rates are usually relatively low (around 1.5 - 1.7 percent), and can hardly be increased. Regarding tax effort, Di Grescia (2003) applies stochastic frontier techniques and shows that, during 1960-2002, provinces were able to collect, on average, 91 percent of the potential base of this tax. Therefore, provinces face structural difficulties to increase revenues on the gross receipts tax, and a fortiori, on all taxes in general.

This gap between expenditures and tax revenues generates an important vertical fiscal imbalance, solved through a system of intergovernmental transfers and the possibility for

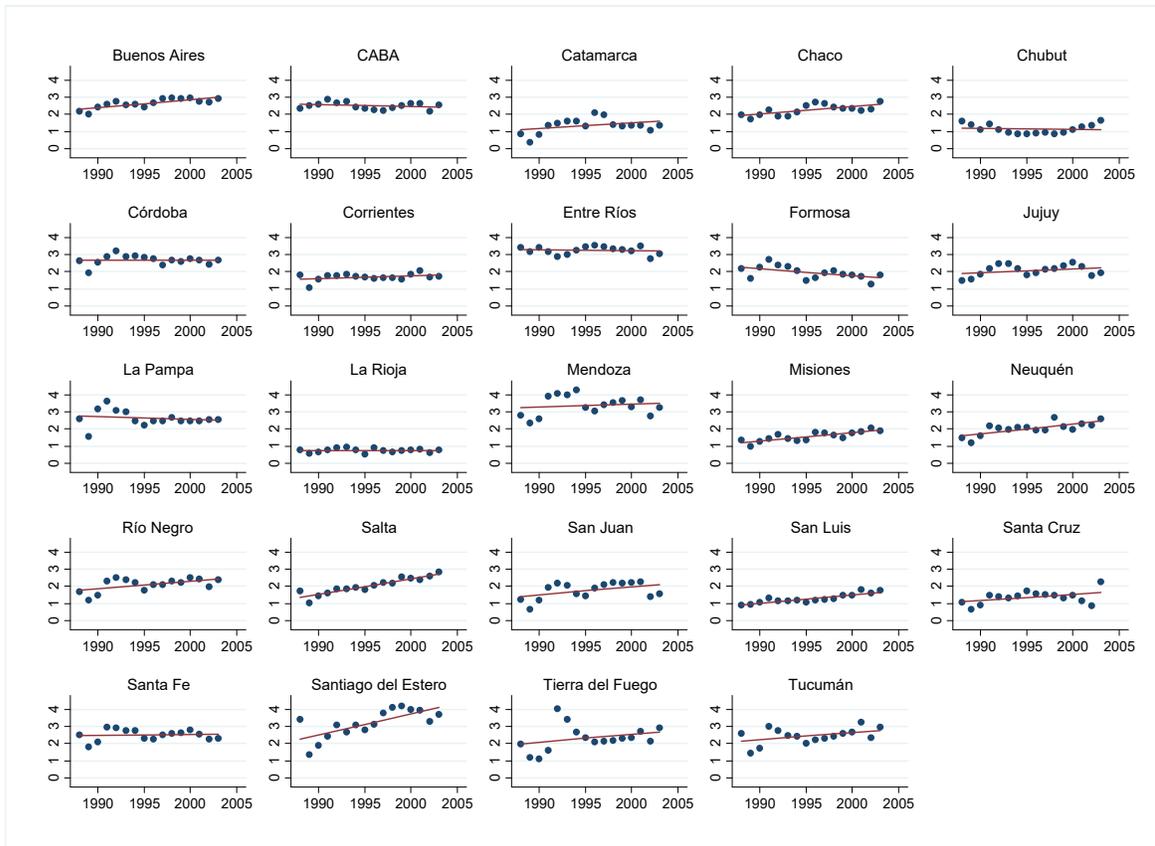
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<sup>8</sup>This delegation implied the setting of tax bases and tax rates by the National Congress, whereas tax collection and other regulatory aspects (e.g., tax enforcement) has been undertaken by agencies of the Executive branch of the Federal Government.

<sup>9</sup>In Section 5.4.2 we study in more detail the particular case of Santiago del Estero, the province whose tax receipts increase the most during the period under analysis.

provincial governments to borrow domestically and abroad.<sup>10</sup> The system of intergovernmental transfers is based on a tax-sharing regime called *Coparticipación Federal de Impuestos*.<sup>11</sup> Law 23,548 that currently regulates this tax-sharing regime has been passed in 1988. This law specifies the process by which taxes collected by the Federal Government are reallocated to the provinces.<sup>12</sup>

**Figure 1: Provincial tax collection, by province (as percent of GPP)**



Source: Dirección Nacional de Coordinación Fiscal con las Provincias

On the other hand, for some provinces, a third source of revenue comes from royalties on

<sup>10</sup>Since 1993, provincial governments have to be authorized by the (Federal) Ministry of Economy to issue debt in foreign currency. But this mandate establishes no quantitative restriction on the amount of debt that could be issued. Moreover, before 2007, no province has been denied such authorization. On the other hand, in most provinces debt has been used to finance current public expenditures until the end of the 90's, when some of them (but not all) enacted laws prohibiting such use. Therefore, this relatively freedom to borrow allowed provinces to run deficits.

<sup>11</sup>See Porto (2004) for a detailed description of the historical evolution of the Argentine tax-sharing regime.

<sup>12</sup>From now on, we denote by “Coparticipation transfers” those ruled by Law 23,548.

private sector exploitation of oil, gas and mineral resources.<sup>13</sup> The regime of royalty payments is determined by Law 17,319, enacted in 1967. This law sets up a common procedure to cash royalties, applied to all provinces. In the next section, we analyze in more detail specific features of the tax-sharing and royalties regimes.

Since the mid-eighties, Coparticipation transfers represented, on average, more than 60 percent of total provincial revenues, while provincial own taxes were about 20 percent. Royalties fluctuated around 10 percent. Thus, on average, these three sources of revenues amounted to almost 90 percent of total income.<sup>14</sup> But there are significant differences across provinces. Table 3 presents data on the revenue composition in percentage, by province, taking the average between 1988 and 2003.

**Table 3: Revenue composition**

Province	Taxes	Cop. transfers	Royalties	Province	Taxes	Cop. transfers	Royalties
Buenos Aires	46.9	44.0	0.0	Mendoza	26.5	48.6	9.3
C.A.B.A.	83.6	7.8	0.0	Misiones	14.1	72.8	1.0
Catamarca	6.2	84.5	0.2	Neuquén	13.3	30.6	40.1
Chaco	10.8	81.3	0.0	Río Negro	19.2	58.0	10.4
Chubut	12.9	52.0	23.4	Salta	13.5	66.9	5.0
Córdoba	36.1	55.3	0.0	San Juan	11.5	76.8	0.2
Corrientes	10.5	80.9	0.9	San Luis	16.1	70.7	0.0
Entre Ríos	23.6	65.9	0.9	Santa Cruz	8.4	43.1	29.1
Formosa	4.4	86.6	1.2	Santa Fe	34.9	54.1	0.0
Jujuy	8.7	69.6	0.1	Santiago del Estero	9.0	81.7	0.0
La Pampa	18.1	57.8	2.8	Tierra del Fuego	14.9	45.8	19.6
La Rioja	4.1	59.8	0.0	Tucumán	17.3	73.6	0.0

Source: Dirección Nacional de Coordinación Fiscal con las Provincias.

The capital C.A.B.A. can rely on its own taxes because its local tax base is quite large, which explains its low dependency on Coparticipation transfers. For the rest of the provinces, the average share of Coparticipation transfers is around 60 percent. But, for some small and poor provinces (e.g., Catamarca, Corrientes, Formosa and Santiago del Estero) this share rises to more than 80 percent. In the table we also observe that, for at least eight provinces, royalties represent a non negligible fraction of their fiscal revenue.<sup>15</sup> In particular, for some of them (Chubut, Santa Cruz and Tierra del Fuego), royalties are more important than their own tax revenues.

<sup>13</sup>During the period under analysis, the amounts received by provinces as mineral royalties were relatively low. Therefore, we do not consider them in the remainder of the paper.

<sup>14</sup>The remaining 10 percent of provincial revenues includes (i) transfers called *Aportes del Tesoro Nacional* (ATNs), distributed discretionarily by the (Federal) Ministry of Interior, and (ii) other transfers from the Federal Government.

<sup>15</sup>These eight provinces produced oil and gas in all these years. But this is not the case for most of the other provinces that received, on average, less royalties. Indeed, in some years, these provinces obtained no revenues from this source of public income.

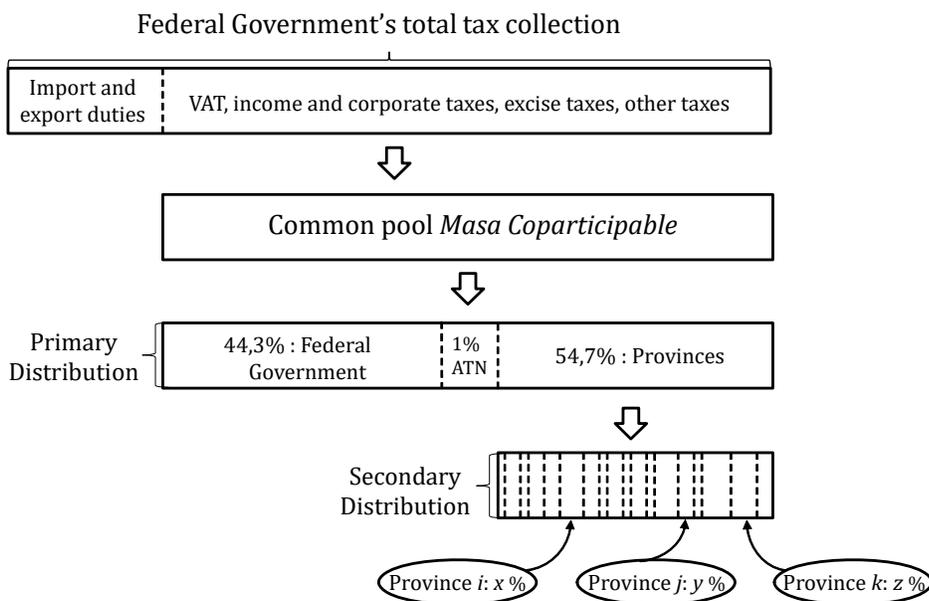
### 3 Institutional features of non-tax provincial revenues

#### 3.1 Coparticipation transfers

Law 23,548 determines that provinces cannot create new taxes and defines the process by which taxes collected by the Federal Government are apportioned to the provinces. The peculiarities of this law deserve that, in the following paragraphs, we explain them in detail.

The following figure illustrates the main features prescribed by Law 23,548.

**Figure 2: Argentina’s tax sharing regime**



First, the law stipulates that, with very few exceptions (e.g., taxes on international trade), taxes collected by the Federal Government form a common pool called *Masa Coparticipable*. Then, the law specifies a Primary Distribution of this common pool, as follows: 44.3 percent corresponds to the Federal Government, 54.7 percent is shared among all provinces, and the remaining 1 percent makes-up a fund, called *Fondo de Aportes del Tesoro Nacional*, to help provinces facing unforeseen contingencies.<sup>16</sup> Finally, the law establishes the Secondary Distribution: from the part of the common pool that is assigned to all provinces, each of them receives a fixed share. In Section 4 of the law, the coefficients (or percentages) of the

<sup>16</sup>In fact, this fund finances ATNs distribution mentioned in footnote 14.

Secondary Distribution are set, as shown in Table 4.<sup>17,18</sup>

**Table 4: Legal shares of the Secondary Distribution**

Province	Percent	Province	Percent	Province	Percent
Buenos Aires	19.93	Formosa	3.78	Río Negro	2.62
Catamarca	2.86	Jujuy	2.95	Salta	3.98
Chaco	5.18	La Pampa	1.95	San Juan	3.51
Chubut	1.38	La Rioja	2.15	San Luis	2.37
Córdoba	9.22	Mendoza	4.33	Santa Cruz	1.38
Corrientes	3.86	Misiones	3.43	Santa Fe	9.28
Entre Ríos	5.07	Neuquén	1.54	Santiago del Estero	4.29
		Tucumán	4.94		

Source: Section 4, Law 23,548.

Since 1990 several laws regulating the distribution of specific taxes to finance predetermined activities have been enacted. For example, Law 24,699 specifies that, from the total income tax collection, 440 million AR\$ should be annually deducted from the common pool *Masa Coparticipable*, to be shared among all provinces. Also, various reforms introduced new types of transfers besides the Coparticipation regime. For example, Law 24,130 stipulates that 545 million AR\$ should be taken away from the common pool *Masa Coparticipable*

<sup>17</sup>To understand how these coefficients were determined, we have to go back in time and describe the history of the tax-sharing regime before 1988. In 1973, Law 20,221 was enacted. With a stipulated duration of ten years, this law was the first to regulate the Argentine tax-sharing regime in an unified way. This law specified (Secondary Distribution) coefficients using an explicit formula that weighted provincial population (65 percent), development gap (25 percent) and population dispersion (i.e., inverse of density) (10 percent).

Although a new law should have been passed in 1983, the new democratic (Radical) government decided to extend Law 20,221's period of force. But, at the end of 1985, this law expired. As no political consensus emerged at the National Congress to pass a new law, between 1985 and 1987 provinces received national transfers that were decided at the Congress level. At the beginning of this period of legal vacuum, the pattern of these transfers across provinces was similar than the one observed under Law 20,221. But then, in particular after the legislative elections in 1987 won by the opposition (the Peronist party), negotiations at the National Congress started to reflect the new distribution of political power of the different provinces, and thus the pattern of transfers changed.

When the National Congress could finally enact Law 23,548 in January 1988, the legal coefficients that appear there crystallized the shares (of the total amount of transfers) obtained by each province during the previous months.

<sup>18</sup>For C.A.B.A. and Tierra del Fuego, the law does not specify their share of the Secondary Distribution. The reasons are the following. First, in 1996, the capital of the country became autonomous. In 2003, Decree 705 fixed C.A.B.A.'s coparticipation coefficient at 1.4 percent, taken from the Federal Government's part in the Primary Distribution. Also, in 1990, the National Territory of Tierra del Fuego, Antártida Argentina e Islas del Atlántico Sur became a province. Since then, from the Federal Government's part of the Primary Distribution, 0.388 percent has been allocated to this new province. In 1993, the Federal Government accepted to temporarily transfer to Tierra del Fuego an extra 0.312 percent, taken again from its part in the Primary Distribution. In 1999, Decree 702 fixed Tierra del Fuego's part permanently, as 0.7 percent of the common pool *Masa Coparticipable*.

to finance (i) a fund to compensate provincial financial disequilibria called *Fondo Compensador de Desequilibrios Provinciales* (85 percent), and (ii) the National Pension System (15 percent). Despite these changes, in most of the cases, the sharing of these funds among all provinces has been made according to constant and fixed coefficients, similar to those defined by Law 23,548.<sup>19</sup>

This tax-sharing regime is characterized by the following particular features. First, there is no political agreement or bargaining at the National Congress (or any other political body, like the Commonwealth Grants Commission in Australia) about the Secondary Distribution. Second, the legal coefficients have been held fixed since 1988.<sup>20</sup> Third, the coefficients are not defined by a formula, like the Canadian *Equalization Program* or the German *Laendersteuern*; so Coparticipation coefficients are related neither to observable exogenous (geographic, demographic, socioeconomic) provincial characteristics, nor to provincial expenditure plans or outcomes of provincial policies. This particular feature of the Coparticipation regime does not generate incentives within provinces to set their policies' outcomes or to manipulate socioeconomic indicators in order to obtain more resources from the Federal Government. In fact, Coparticipation transfers are closed-end, unconditional, lump-sum grants. They are closed-end because there are no limits on the absolute amount of resources that a province can receive nor on the percent of its revenues that can proceed from the Federal Government. They are also unconditional because the Federal Government cannot dictate to provinces how to use these funds. Finally, it is clear that Coparticipation transfers have neither explicitly nor implicitly matching provisions.

Clearly, among all federations, Law 23,548 defines a unique institutional context of inter-governmental relations. But, as the history of Argentina indicates, to analyze in this country a given policy it is not sufficient to look at the legal prescriptions that define it; one has to determine whether these legal prescriptions have in fact been implemented and/or enforced. We present three pieces of evidence that show that Law 23,548's prescriptions were indeed observed and enforced. Figure 3 depicts the aggregate amount of Coparticipation transfers, as the percentage of all (Coparticipation and discretionary) transfers received by provinces, between 1983 and 2012. The figure shows three distinct periods. Before 1988, the percentage changes yearly. As mentioned in Footnote 17, between 1983 and 1985 Coparticipation transfers were set according to the Law 20,221, and depended in some way upon the outcome of provincial policies.<sup>21</sup> Then, between 1985 and 1987, all Coparticipation transfers were decided by the National Congress. Thus, the allocation of these funds resulted from the outcome of political negotiations between provincial representatives with different

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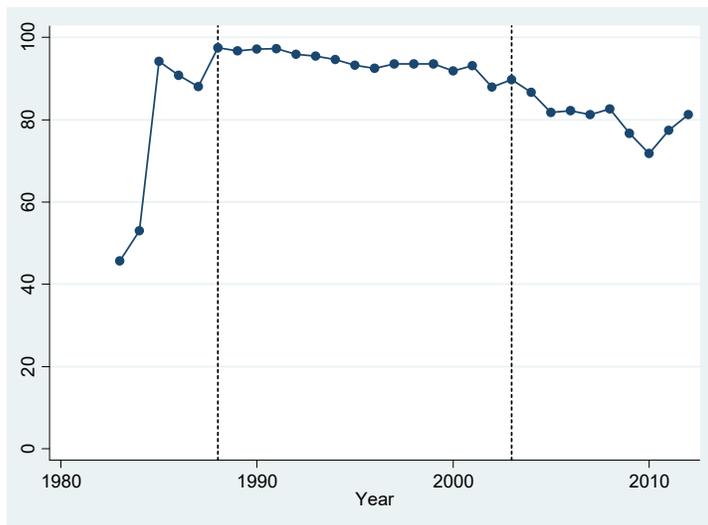
<sup>19</sup>The most important transfer whose distribution among provinces partially depends upon policies under the control of provincial governments is called *Fondo Nacional de la Vivienda* (FONAVI), a fund that helps provinces to build social housing. In 1996, FONAVI amounted to 970.1 million AR\$, only 6.7 percent of total Coparticipation transfers. Hence, at the provincial level, its impact is minor.

<sup>20</sup>The main reason is that Law 23,548 is very difficult to change. According to the National Constitution, a new law regulating intergovernmental fiscal relations in Argentina i) has to be initiated by the House of the Senate, ii) has to be approved by absolute majority of each house of the National Congress, and iii) has to be approved by all provincial Legislatures.

<sup>21</sup>Indeed, the "development gap" indicator that appeared in the formula defined in Law 20,221 was built using, as explanatory variables, "housing quality", "cars per habitant" and "degree of education".

bargaining power. Then, in 1988, Law 23,548 is enacted. Between 1988 and 2003, Coparticipation transfers represented a fairly constant and important share (on average, more than 90 percent) of all intergovernmental transfers in Argentina.

**Figure 3: Total Coparticipation transfers (as percent of all intergovernmental transfers)**



Source: Dirección Nacional de Coordinación Fiscal con las Provincias

After 2003, these shares start to decline again. Although Law 23,548 continued to rule Argentina’s intergovernmental fiscal relations, its implementation was essentially different than it was in previous years. This change was mainly due to an important increase in the distribution of Federal discretionary transfers.<sup>22</sup> According to Artana et al. (2012), the use of discretionary transfers tripled, from 0.5 percent of national GDP at the end of the 1990s, to an average of 1.7 percent of GDP in more recent years. Moreover, since 2003, discretionary transfers have been distributed neither on an equal basis, nor following the pattern of their assignment in previous years.<sup>23</sup>

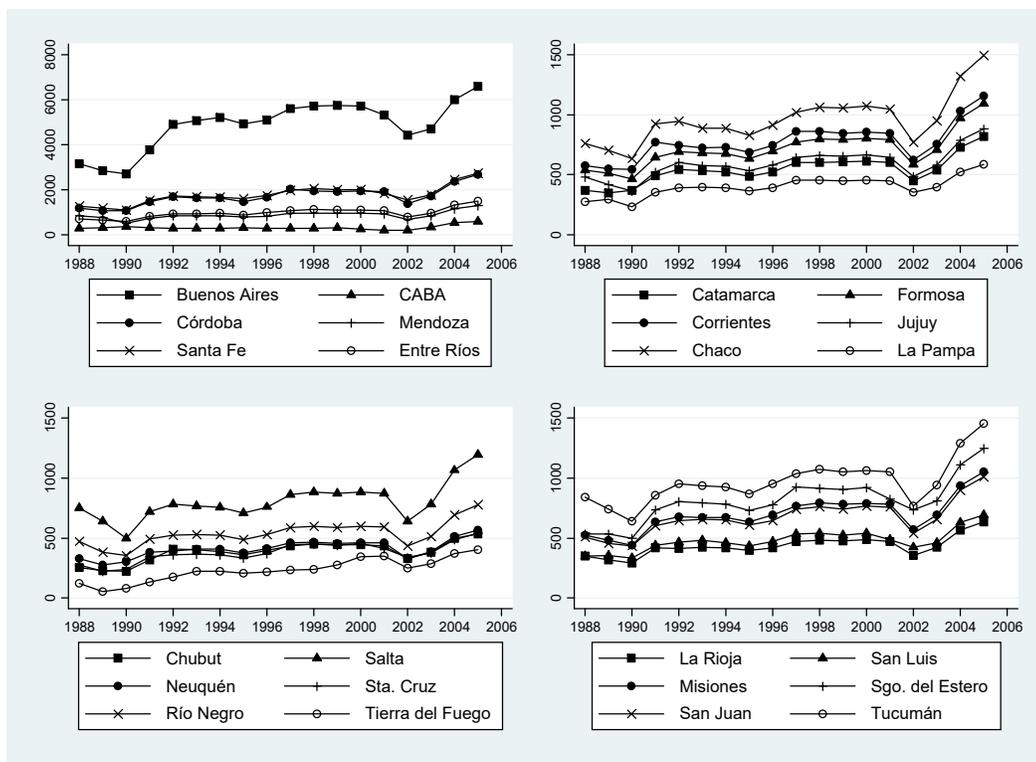
Figure 4 plots the time series of Coparticipation transfers (in millions of 2004 AR\$), for each province, between 1988 and 2005. We can observe a fairly common pattern of evolution of provincial Coparticipation transfers across time, consistent with the fact that each of these transfers is a fixed share of the common pool *Masa Coparticipable*.<sup>24</sup> Thus, their evolution reflect, in great part, shocks to the national economy.

<sup>22</sup>During the 2001-2002 macroeconomic crisis, the Federal Government introduced taxes on exports and financial transactions, whose revenues were not part of the common pool *Masa Coparticipable*. Using emergency powers that were delegated by the National Congress to the Executive branch of the Federal Government in 2002 (and renewed every year until 2010), the (Federal) Ministry of Interior was able to allocate these extra revenues at will.

<sup>23</sup>We prove this statement in Section 8.1 of the Appendix.

<sup>24</sup>This common evolution can also be perceived after 2003, confirming that Coparticipation transfers were still distributed according to the Secondary Distribution as set in Law 23,548.

Figure 4: Coparticipation transfers, by province (in millions of 2004 AR\$)

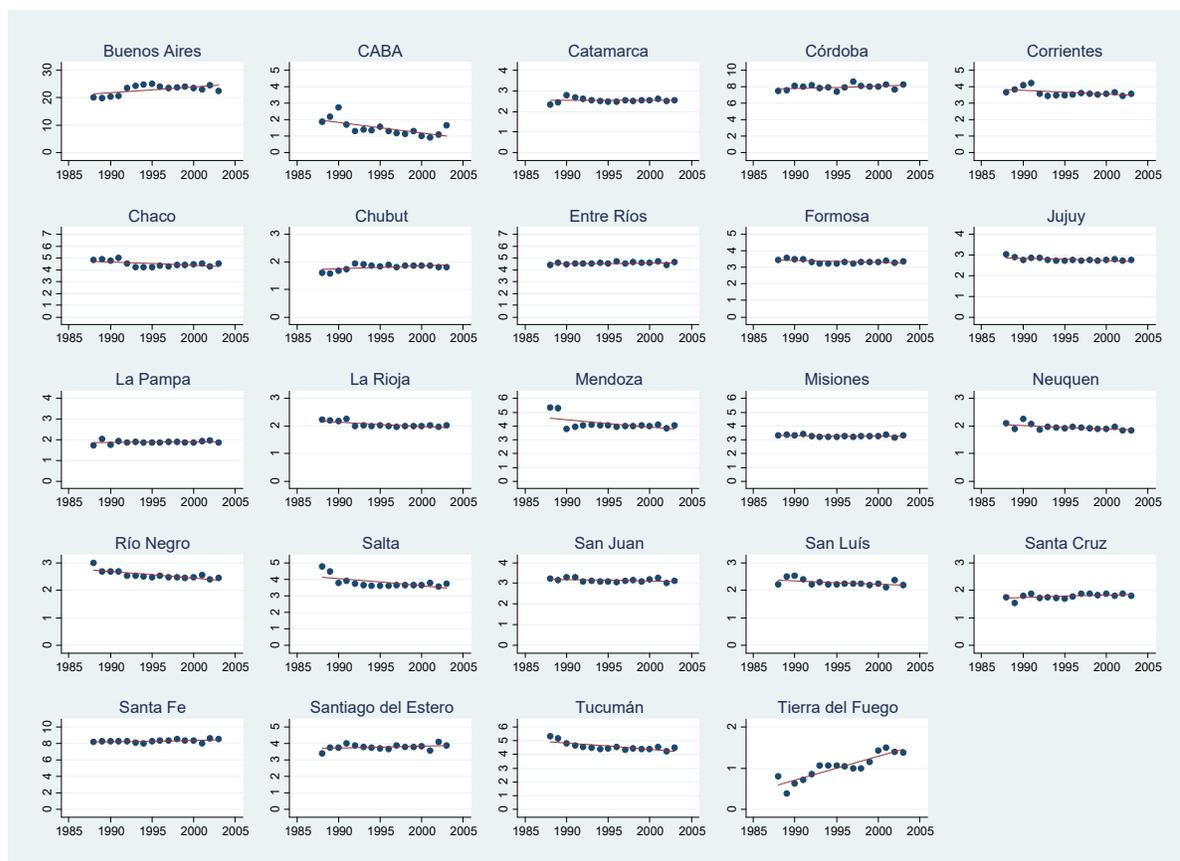


Source: Dirección Nacional de Coordinación Fiscal con las Provincias

Finally, Figure 5 depicts, for each year and for each province, the amount of its Coparticipation transfer as the percentage of total Coparticipation transfers distributed to all provinces, between 1988 and 2003. For all (except three) provinces, the best-fit line of their yearly share of the Secondary Distribution presents no statistically and economically significant slope.<sup>25</sup> These three figures prove that, between 1988 and 2003, Coparticipation transfers accounted for more than 90 percent of all intergovernmental transfers, and that they were indeed made according to the Secondary Distribution legal coefficients set in Law 23,548.

<sup>25</sup>The exceptions are Buenos Aires, C.A.B.A. and Tierra del Fuego. The best-fit line of Buenos Aires depicts an increasing trend, mainly explained by the fact that, after 1992, this province received a special transfer called *Fondo de Financiamiento de Programas Sociales en el Conurbano Bonaerense*. This transfer, whose funding comes from the common pool *Masa Coparticipable* (before its Primary Distribution), amounts to 650 millions AR\$, and has been held constant (in current terms) since 1992. Observe that, after this year, Buenos Aires corresponding percentage is fairly constant. The best-fit line of C.A.B.A. is characterized by a decreasing trend, mainly explained by changes during the 1989-1990 crisis. But, after that event, C.A.B.A.'s corresponding percentage is fairly constant. Finally, the best-fit line of Tierra del Fuego depicts an increasing trend, explained by the fact that its legal coefficient was upwardly adjusted twice. In Section 5.4 we check whether these issues affect our results.

**Figure 5: Coparticipation transfers, by province (as percent of all Coparticipation transfers)**



Source: Dirección Nacional de Coordinación Fiscal con las Provincias.

### 3.2 Royalties

As we have already mentioned, some provinces obtain important revenues from oil and gas royalties, under the regime of Law 17,319. Under this regime, royalties are collected by the Federal Government, and then transferred to the provincial governments where oil/gas production has originally taken place, according to a pure devolution criterion. Surprisingly, the regime was not modified by the 1994 constitutional amendment, that granted the property of oil, gas and mineral resources to the provinces. Though the domain of production sites has started then to be under provincial jurisdictions, the regulation and exploitation of the activity was still in 2009 under the direct oversight of the Federal Government.

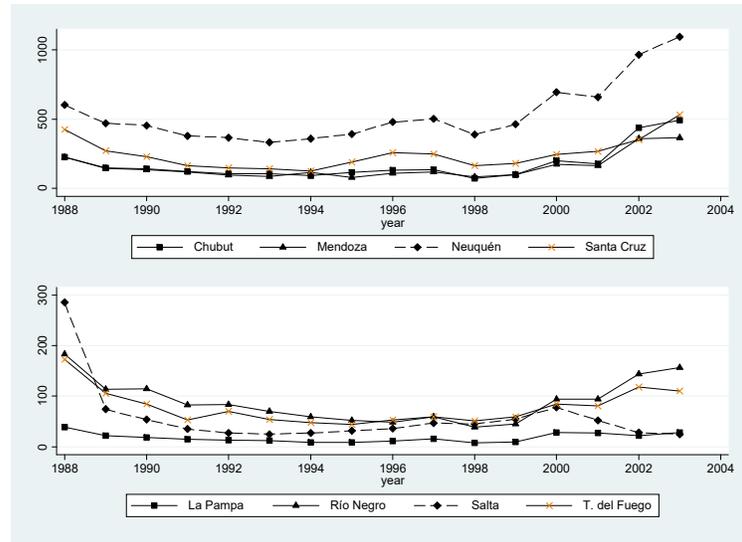
Between 1988 and 2003, the Federal Government set, for all provinces, a uniform rate of 12 percent applied to the value of oil and gas production, evaluated at international prices at the production site.<sup>26</sup> Moreover, the (Federal) Secretary of Energy was also in charge of

<sup>26</sup>Law 17,319 prohibited the Federal Government to set different rates across provinces.

auditing whether firms reported accurately their level of production.

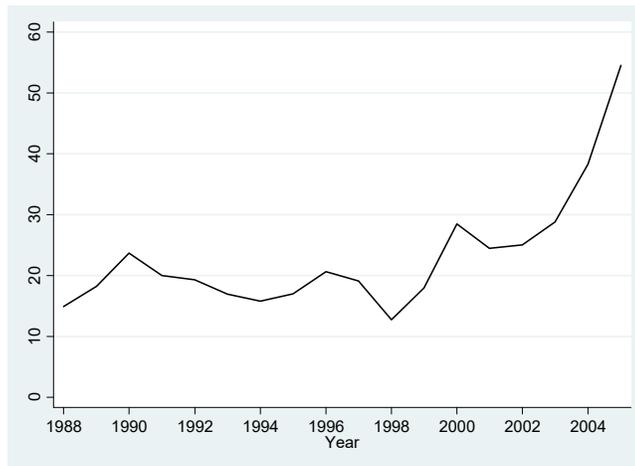
Figures 6 and 7 depict the evolution of royalties (in millions of 2004 AR\$) for the eight provinces that concentrate, on average, more than 95 percent of all royalties, and the international oil price (in current U\$D per cubic meter), between 1988 and 2003.

**Figure 6: Royalties, by province (in millions of 2004 AR\$)**



Source: Dirección Nacional de Coordinación Fiscal con las Provincias.

**Figure 7: International oil price (in current U\$D)**



Source: Instituto Argentino del Petróleo y del Gas.

Despite the fact that there are important socio-economic and geological differences among oil producer provinces, royalties fluctuate in a similar way. Moreover, their path seem to follow quite closely the evolution of the international oil price.

## 4 Theory

The goal of this section is to develop a simple model, based upon Holtz-Eakin et al. (1994) and Dahlberg and Lindström (1998), that incorporates the main features of provincial public policies and intergovernmental fiscal relations prevailing in Argentina. We analyze how provincial governments choose optimally their fiscal policies, acknowledging that their most important sources of income are exogenous and random, and evolve according different stochastic processes. The model provides a theoretical basis for the econometric specification we will use in the empirical analysis.

There is a representative province, populated by a continuum of identical residents of mass one. At the beginning of each period  $s$ , residents receive the private sector output, net of federal taxes,  $Y_s$ .

The province is ruled by a local government. In order to maximize the expected discounted value of its social welfare criterion  $W(\cdot)$ , the provincial government chooses, in each period, public expenditures  $G_s$ , subject to an intertemporal budget constraint.<sup>27</sup> On the revenue side of the budget, the provincial government receives lump-sum Coparticipation transfers  $TR_s$  from the Federal Government and royalties  $R_s$  from hydrocarbon production. We assume that the provincial government considers both sources of income as exogenous and random. The provincial government can also tax their residents and issue debt. Regarding the former, we assume that provincial tax collection is a fixed, small fraction  $\tau$  of private sector output  $Y_s$ . The provincial government considers  $Y_s$  as another exogenously determined random variable. Finally, we also assume that the province is a small open economy, with perfect capital mobility. Hence, the provincial interest rate is equal to the international interest rate  $r$ , which is constant both across time and states of nature. We denote by  $B_s$  provincial assets bought at date  $(s - 1)$ , that pay  $(1 + r)$  at date  $s$ .

The realizations of royalties, Coparticipation transfers and private sector output occur at the beginning of each period  $s$ . Thus, the provincial government can condition its control variables on these realizations. For this purpose, we define  $z^s$  as the history of all these realizations at date  $s$ , and we denote by  $F(z^s)$  its cumulative distribution function. The provincial government thus solves the following problem

$$\max_{\{G_s(z^s), T_s(z^s), B_{s+1}(z^s)\}_{s=t}^{\infty}} \mathbb{E}_t \left[ \sum_{s=t}^{\infty} \beta^{s-t} W(G_s(z^s)) \right] \quad (1)$$

s.t.

$$T_s(z^s) = \tau Y_s(z^s) \quad \forall s \geq t, \forall z^s \quad (2)$$

$$G_s(z^s) + B_{s+1}(z^s) = T_s(z^s) + TR_s(z^s) + R_s(z^s) + (1 + r)B_s(z^{s-1}) \quad \forall s \geq t, \forall z^s \quad (3)$$

---

<sup>27</sup>As Argentine provinces expend a minor share of their budget in public investment, we do not incorporate them into the model. This implies that we will not consider the provincial governments' capacity to promote GPP growth. Although this feature of the model may seem too restrictive, it indeed reflects one of the main recurrent problems that Argentine provinces have been facing for a while, as acknowledged by Porto (2004).

where (1) is the expected present value, discounted at the social rate of time preference  $\beta$ , of the stream of period-specific social welfare  $W(\cdot)$ , which only depends upon public expenditures  $G_s$ . Expression (2) defines the provincial tax collection, and (3) characterizes the provincial budget constraint. Replacing (2) in (3), we get the following aggregate resource constraint for the provincial government,

$$G_s(z^s) + B_{s+1}(z^s) = \tau Y_s(z^s) + TR_s(z^s) + R_s(z^s) + (1+r)B_s(z^{s-1}). \quad (4)$$

Using (1) and (4), the provincial government's problem boils down to

$$\max_{\{G_s(z^s), B_{s+1}(z^s), \lambda_s(z^s)\}_{s=t}^{\infty}} \mathbb{E}_t \left[ \sum_{s=t}^{\infty} \{ \beta^{s-t} W[G_s(z^s)] + \lambda_s(z^s) [\tau Y_s(z^s) + TR_s(z^s) + R_s(z^s) + (1+r)B_s(z^{s-1}) - G_s(z^s) - B_{s+1}(z^s)] \} \right] \quad (5)$$

where  $B_t$  is given, and  $\lambda_s(z^s)$  is the Lagrange multiplier associated with the intertemporal budget constraint.

The first-order conditions corresponding to problem (5) are

$$\begin{cases} \beta^{s-t} W_G(G_s) dF(z^s) = \lambda_s(z^s) & \forall s \geq t, \forall z^s \quad FOC(G) \\ -\lambda_s + \int_{z_{s+1}|z^s} [\lambda_{s+1}(z^s, z_{s+1})(1+r)] = 0 & \forall s \geq t, \forall z^s \quad FOC(B) \end{cases}$$

and the transversality condition is

$$\lim_{s \rightarrow \infty} \mathbb{E}_t \left[ \frac{B_s}{(1+r)^{s-t}} \right] = 0. \quad (6)$$

To obtain a closed-form solution, we assume that the social welfare criterion  $W(\cdot)$  is quadratic, with the following functional specification

$$W(G_s) = G_s - \frac{a}{2} G_s^2,$$

where  $a$  is a positive but a small enough number, so that welfare is strictly increasing in a neighborhood of the solution. With these assumptions, we can re-write the first-order conditions as follows<sup>28</sup>

$$a(G_s - \beta(1+r)\mathbb{E}_s[G_{s+1}]) = 1 - \beta(1+r). \quad (7)$$

Euler equation (7) describes the optimal expected change for current public expenditures. Given the assumed provincial government's objective function (where the intertemporal elasticity of substitution equals one), and depending upon the relationship between the interest rate vis-à-vis the discount rate  $\beta$ , we can have an increasing, constant or decreasing expected path of public expenditures. If  $\beta(1+r) = 1$ , (7) becomes

$$G_s = \mathbb{E}_s[G_{s+1}], \quad (8)$$

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<sup>28</sup>From now on, we omit the dependence on the history of shocks  $z^s$  to simplify notation.

which characterizes an optimal path of public expenditures that is constant in expected terms. In other words, provincial public expenditures  $G_t$  follow a martingale, a modified version of Hall's (1978) result.

Iterating on (4) and using (6), we can obtain the intertemporal resource constraint in expectations,

$$\mathbb{E}_t \left[ \sum_{s=t}^{\infty} \frac{G_s}{(1+r)^{s-t}} \right] = \mathbb{E}_t \left[ \sum_{s=t}^{\infty} \frac{(\tau Y_s + TR_s + R_s)}{(1+r)^{s-t}} \right] + (1+r)B_t. \quad (9)$$

Using the law of iterative expectations, we can rewrite the left hand side of (9) as

$$\mathbb{E}_t \left[ \sum_{s=t}^{\infty} \frac{G_s}{(1+r)^{s-t}} \right] = \frac{1+r}{r} G_t. \quad (10)$$

If we define the right-hand side of (9) as the expected level of wealth  $\Omega$ , we find the optimal level of public expenditures

$$G_t^* = \frac{r}{1+r} \Omega. \quad (11)$$

Expression (11) is the typical condition derived in intertemporal consumption models, where consumption is a function of total wealth and the propensity to consume out of wealth is closed to the real interest rate.

As we have already mentioned, one of the key assumptions of the model is that the provincial government knows the stochastic processes governing its different sources of revenues. The following expressions describe these stochastic processes:

$$\Delta TR_t = \rho_1^{TR} \Delta TR_{t-1} + \rho_2^{TR} \Delta TR_{t-2} + \xi_t \quad (12)$$

$$\Delta R_t = \rho_1^R \Delta R_{t-1} + \epsilon_t \quad (13)$$

$$\Delta Y_t = \rho_1^Y \Delta Y_{t-1} + \rho_2^Y \Delta Y_{t-2} + \omega_t, \quad (14)$$

where  $\Delta x_t \equiv x_t - x_{t-1}$ ,  $\Delta x_{t-1} \equiv x_{t-1} - x_{t-2}$  and  $\Delta x_{t-2} \equiv x_{t-2} - x_{t-3}$  denote contemporaneous, one and two-period lagged changes in the correspondig variable, and  $\xi_t$ ,  $\epsilon_t$ ,  $\omega_t$  are white noises, whose realizations occur at the begining of period  $t$ . These specifications are consistent with the evidence presented in Section 8.2 of the Appendix. There, we estimate the stochastic processes of these variables using equations in first differences, as these variables may be integrated of order one.

Finally, we can move one step further than Holtz-Eakin et al. (1994). In Section 8.3 of the Appendix, we use (11) and the stochastic processes (12), (13) and (14) to obtain explicit analytical solutions for current changes in the optimal level of public expenditures  $\Delta G_t^*$  and in the stock of public bonds  $\Delta B_{t+1}^*$ . The following proposition characterizes these changes.

**Proposition 1** *When the provincial government considers that royalties, Coparticipation transfers and private sector output evolve according to (12), (13) and (14), the contemporaneous change in the optimal level of public expenditures is*

$$\begin{aligned} \Delta G_t^* = & (1+r) \left\{ \frac{(1+r)}{J} [\Delta TR_t - \rho_1^{TR} \Delta TR_{t-1} - \rho_2^{TR} \Delta TR_{t-2}] + \frac{1}{K} [\Delta R_t - \rho_1^R \Delta R_{t-1}] \right. \\ & \left. + \frac{\tau(1+r)}{L} [\Delta Y_t - \rho_1^Y \Delta Y_{t-1} - \rho_2^Y \Delta Y_{t-2}] \right\} \end{aligned} \quad (15)$$

where  $J = (1+r)(1+r - \rho_1^{TR}) - \rho_2^{TR}$ ,  $K = 1+r - \rho_1^R$  and  $L = (1+r)(1+r - \rho_1^Y) - \rho_2^Y$ ; and the contemporaneous change in the stock of public bonds is

$$\begin{aligned} \Delta B_{t+1}^* = & -\frac{1}{J} \{ [(1+r)\rho_1^{TR} + \rho_2^{TR}] \Delta TR_t + (1+r)\rho_2^{TR} \Delta TR_{t-1} \} - \frac{1}{K} \rho_1^R \Delta R_t \\ & - \frac{\tau}{L} \{ [(1+r)\rho_1^Y + \rho_2^Y] \Delta Y_t + (1+r)\rho_2^Y \Delta Y_{t-1} \}. \end{aligned} \quad (16)$$

The model suggests that changes in public expenditures and bonds (debt) depend on past values of all sources of income, given that these variables are useful to estimate the expected wealth  $\Omega$ . Moreover, as equations (12)-(14) indicate, conditional on lagged values of these variables, changes in the contemporaneous level of Coparticipation transfers and royalties reflect the impact of shocks to these particular sources of provincial revenues. Thus, the coefficients associated with contemporaneous changes in Coparticipation transfers and royalties should be interpreted as responses to these shocks.

## 5 Empirical analysis

Using the theoretical background presented above, in this section we empirically investigate how Argentine provincial governments react to changes in their different sources of income. First, we discuss the identification strategy. Then, we describe the data employed. Finally, we present the main results and some robustness checks.

### 5.1 Identification strategy

In order to analyze the reaction of Argentine provincial governments to changes in their different income sources, we estimate the following empirical specification of the theoretical expressions (15) and (16)

$$\left\{ \begin{array}{l} \Delta G_{i,t} = \text{cons} + \alpha_0^G \Delta TR_{i,t} + \alpha_1^G \Delta TR_{i,t-1} + \alpha_2^G \Delta TR_{i,t-2} \\ \quad + \beta_0^G \Delta R_{i,t} + \beta_1^G \Delta R_{i,t-1} \\ \quad + \gamma_0^G \Delta Y_{i,t} + \gamma_1^G \Delta Y_{i,t-1} + \gamma_2^G \Delta Y_{i,t-2} + \varrho_i + d_t + \nu_{i,t} \\ \Delta D_{i,t} = \text{cons} + \alpha_0^D \Delta TR_t + \alpha_1^D \Delta TR_{t-1} + \beta_0^D \Delta R_t + \gamma_0^D \Delta Y_t + \gamma_1^D \Delta Y_{t-1} \\ \quad + \varrho_i + d_t + \mu_{i,t}. \end{array} \right. \quad (17)$$

where  $i$  represents a province and  $t$ , a year.  $\Delta G_{i,t}$  denotes the contemporaneous change in public expenditures, and  $\Delta D_{i,t}$  the corresponding change in public debt. Explanatory variables include: (i) contemporaneous, one and two-period lagged changes in Coparticipation transfers ( $\Delta TR_{i,t}$ ,  $\Delta TR_{i,t-1}$  and  $\Delta TR_{i,t-2}$ ), (ii) contemporaneous and one-period lagged changes in royalties ( $\Delta R_{i,t}$  and  $\Delta R_{i,t-1}$ ), and (iii) contemporaneous, one and two-period lagged changes in GPP ( $\Delta Y_{i,t}$ ,  $\Delta Y_{i,t-1}$  and  $\Delta Y_{i,t-2}$ ). Besides these variables, we include provincial fixed effects ( $\rho_i$ ) and time dummies ( $d_t$ ) in all regressions. The addition of provincial fixed effects allows to capture any factor that affects individual provincial fiscal decisions that remain constant across time. On the other hand, the time dummy captures shocks to (changes in) expenditures and debts that are common to all jurisdictions. Finally,  $\nu_{i,t}$  and  $\mu_{i,t}$  are error terms.

The estimation of (17) faces several potential problems, the most obvious being that Coparticipation transfers and royalties can be endogenous to political and economic factors that can potentially affect the results. Regarding the former, we follow Dahlberg et al. (2008) analysis of potential endogenous biases when estimating the effect of central government grants on local government spending, and we use the features of Law 23,548 to argue that Coparticipation transfers can be considered exogenous with respect to provinces' characteristics and their fiscal policies, validating our estimation strategy. In particular, we check the following issues:

(i) Theoretically, if the grant system is designed in negotiations between regional representatives at the National Congress, the bargaining power plus preferences for local spending affect the distribution of transfers among regions. If this were the case in our context, statistical correlations between Coparticipation transfers and public expenditures/debt may reflect the role of these unobserved characteristics, rather than the effect of these type of revenues themselves. Here, these worries are not justified because, as indicated in Section 3.1, the Secondary Distribution of Coparticipation transfers is automatically determined by fixed coefficients that have remained constant since the beginning of the regime, and during the period under analysis. In other words, since 1988 no bargain between provincial representatives at the National Congress affected the distribution of these transfers.<sup>29</sup> Hence, no political channel like the one analyzed by Knight (2002) can create an endogeneity problem here. One could also argue that some socio-economic and political, observable and non-observable, provincial characteristics that had an influence during the negotiations of the enactment of Law 23,548 in the last months of 1987 could also affect provincial public expenditures decisions later on, which could be a potential source of endogeneity that can bias the estimations. To control for this factor, assuming they were kept constant during the period we analyze, we include provincial fixed effect in the regressions.

(ii) Even in the absence of negotiations, local economic or political variables might matter because, as stated by Johansson (2003), central politicians may want to favor some specific

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<sup>29</sup>Vegh and Vuletin (2015) analyze the response of provincial expenditures to federal transfers in Argentina from 1960 to 2006. During this extended period of time, there were several changes in the federal transfers regime [see Porto (2004)], where negotiations at the National Congress played a key role. This is why these authors use changes in the index of provincial representation at the National Congress as an instrument for federal transfers. As we argue in the text, this is not necessary in our case.

regions. To achieve such a goal, they can strategically tailor the design of intergovernmental transfers to depend upon their preferred regions' particular economic or political characteristics. Therefore, regional characteristics also indirectly affect expenditure patterns, inducing an endogenous bias in the estimation. This bias is absent in our analysis because the Federal Government could not, and did not, modify the resource allocation across provinces as stated in Law 23,548. This observation rules-out the abovementioned potential concern for endogeneity.

(iii) Local, socio-economic observable characteristics may influence the way provincial expenditures are determined, and also how Coparticipation transfers are distributed. Again, this potential endogeneity bias is absent for these type of transfers because their distribution does not depend on observable provincial characteristics, as was the case with the previous Coparticipation regime defined by Law 20,221 (see footnote 17). Any provincial characteristic that, as a remaining effect of Law 20,221, could still be implicitly associated with the distribution of Coparticipation transfers (e.g., provincial density) is controlled for by the provincial fixed effect.

(iv) Unobserved characteristics and shocks, specially those that are temporal, affecting both the distribution of transfers and expenditure decisions by provinces, could consist on alternative potential causes for endogeneity. In this case, it is clear that any aggregate shock that affects all provinces at the same time (e.g., a change in the international interest rate) is controlled for by the time dummy. But we could also think about temporary shocks that, affecting the GPP of a particular province, would also have an impact on the national GDP, and thus, via the amount of taxes collected by the Federal Government, on Coparticipation transfers. For example, this may happen if the GPP of this particular province represents an important fraction of the national GDP. These shocks could have independent and direct effects on public spending in this particular, affected province, inducing a bias in the estimation. In Section 5.4.1, we deal with this potential source of endogeneity running the regressions adding a variable that captures the identity of these big provinces, and analyzing whether their reactions differ from those of less important provinces.

Regarding royalties, the legal regime in place during the period under analysis stipulated that they were computed using a common, fixed rate of 12 percent of the production value at the exploitation site, and then devolved to each producer province. On the one hand, international oil and gas prices and the exchange rate are clearly independent of provincial characteristics, or out of provincial control. On the other hand, the second determinant of royalties is oil and gas production. In principle, such variable could depend not only on the geological features of each site, but also on outcomes of provincial policies, like infrastructure and any other public good that could affect firms' decision to initiate the exploitation of a given site, or their production process. These policies define the "business climate" in a given province, and may also be correlated with public expenditures. Moreover, unobserved shocks affecting both the level of royalties and expenditure decision could also be relevant. For example, we can think of a strike by oil workers that generates social unrest which affects oil production and royalties and, at the same time, provincial expenditures (e.g., an increase

in social programs).<sup>30</sup> This could generate an spurious correlation among these variables, biasing the estimation results.

To address these concerns, we run the regressions using, as an instrument for the change in provincial royalties, the following variable

$$\Delta Z_{i,t} \equiv Q_{i,1987}^o \cdot \Delta p_t^*$$

where  $Q_{i,1987}^o$  is province  $i$ 's oil production in 1987, and  $\Delta p_t^*$  is the contemporaneous change in the international oil price. The latter is clearly orthogonal to provincial policies (including fiscal decisions). Regarding the former, we have chosen province  $i$ 's oil production in 1987 as a way to ensure that changes in oil production occurred after 1988 in this province (that could eventually depend indirectly upon governmental decisions) will not affect the evolution of royalties.

Finally, we have to allow for the possibility that the errors  $\nu_{i,t}$  and  $\mu_{i,t}$  are correlated. Indeed, this is what our theoretical model suggests, as changes in public expenditures and debt are simultaneously chosen by provincial governments, in response to the realizations of their revenues. Thus, to allow for this possibility, we estimate seemingly unrelated regressions (SUR) models.

## 5.2 Data

We use a data set that covers all Argentine provinces, from 1988 to 2009.

Concerning expenditures, we subtract the component “Interest Payments” from “Current Public Expenditures” to create a new variable denoted “Provincial Public Expenditures”.<sup>31</sup> These variables are obtained from Dirección Nacional de Coordinación Fiscal con las Provincias (DNCFP), a department of the (Federal) Ministry of Economy in charge of the fiscal relations between the Federal Government and provincial authorities. Regarding the stock of assets, equation (4) shows that changes in this variable are equal to the yearly provincial deficit (which includes interest payments). Thus, we use “Financial Result” (deficits after interest payments) to capture changes in the provincial (stock of) debt. Again, this variable is obtained from DNCFP.

The two main sources of provincial revenues are Coparticipation transfers and royalties. Data on these two variables also comes from DNCFP. Data on oil production and oil prices comes from Instituto Argentino del Petroleo y del Gas, a NGO internationally considered as having the best technical expertise in the oil and gas industries in Argentina. Finally, provincial GDP is obtained from Porto (2004).

Given the values of all these variables, we construct their contemporaneous and lagged changes. These variables are all stationary.

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<sup>30</sup>This kind of event has indeed been observed in some oil provinces, like Neuquén (1996-1997) and Salta (1997).

<sup>31</sup>Therefore, this new variable includes public consumption and transfers to the private sector, but neither public investment nor interest payments.

We express all money values in thousands of 2004 AR\$ per capita (unless otherwise stated).

Summary statistics for all variables employed in the paper are provided in Table 5.

**Table 5: Summary statistics**

Variable	Mean	Std. Dev.	Max	Min	Observations
$\Delta G_{i,t}$	-0.001	0.23	1.571	-1.164	360
$\Delta D_{i,t}$	0.139	0.285	1.46	-0.602	360
$\Delta Y_{i,t}$	0.088	1.687	8.688	-13.107	360
$\Delta Y_{i,t-1}$	0.029	1.72	8.688	-13.107	336
$\Delta Y_{i,t-2}$	0.086	1.759	8.688	-13.107	312
$\Delta TR_{i,t}$	-0.001	0.179	0.636	-1.358	360
$\Delta TR_{i,t-1}$	-0.01	0.181	0.636	-1.358	336
$\Delta TR_{i,t-2}$	0.012	0.159	0.636	-1.358	312
$\Delta R_{i,t}$	-0.006	0.143	0.821	-1.36	360
$\Delta R_{i,t-1}$	-0.009	0.14	0.585	-1.36	336
$Q_{i,1987}^o$ (in m <sup>3</sup> )	3,059,652	2,174,131.55	5,855,261	0	24
$p_t^*$ (in current USD/m <sup>3</sup> )	32.39	22.86	12.72	97.26	22

Note: All variables are in thousand 2004 AR\$ (except otherwise stated)

### 5.3 Main results

Tables 6 and 7 present the basic estimations of the paper. In Table 6, we show three different estimations of system (17). Table 7 presents the first stage for the contemporaneous and one-period lagged change in royalties.

In the first two columns of Table 6 we use the entire data set. The results show a significant and economically important positive reaction of public expenditures to the contemporaneous and to the one-lagged change in Coparticipation transfers, and a significant (but less economically important) negative reaction of debt to changes in royalties. These results cannot be taken as causal estimates of the impact of changes in these sources of income on the policy variables of the provincial governments because endogeneity issues are prevalent. In particular, as we have already mentioned, since 2003 discretionary transfers from the Federal Government started to become a very important source of income for many

**Table 6: Basic estimations**

Variables	(A) SUR (1988-2009)		(B) SUR (1988-2003)		(C) 3SLS	
	$\Delta G_{i,t}$	$\Delta D_{i,t}$	$\Delta G_{i,t}$	$\Delta D_{i,t}$	$\Delta G_{i,t}$	$\Delta D_{i,t}$
$\Delta Y_{i,t}$	0.023*** (0.007)	0.00 (0.008)	-0.005 (0.007)	-0.002 (0.009)	-0.002 (0.008)	0.00 (0.009)
$\Delta Y_{i,t-1}$	0.012 (0.007)	0.00 (0.008)	0.001 (0.007)	-0.003 (0.009)	0.00 (0.007)	-0.004 (0.009)
$\Delta Y_{i,t-2}$	-0.008 (0.007)		-0.025*** (0.007)		-0.023*** (0.007)	
$\Delta TR_{i,t}$	0.93*** (0.098)	-0.142 (0.103)	0.351*** (0.099)	-0.095 (0.116)	0.385*** (0.101)	-0.073 (0.118)
$\Delta TR_{i,t-1}$	0.311*** (0.095)	0.254** (0.1)	0.11 (0.095)	-0.057 (0.114)	0.162 (0.103)	-0.026 (0.118)
$\Delta TR_{i,t-2}$	0.082 (0.077)		-0.095 (0.079)		-0.114 (0.08)	
$\sum \Delta R_{i,t}$	-0.053 (0.061)	-0.371*** (0.065)	-0.337*** (0.098)	-0.754*** (0.118)	-0.024 (0.164)	-0.589*** (0.193)
$\Delta R_{i,t-1}$	0.102 (0.087)		0.153 (0.096)		0.082 (0.191)	
Observations	456	456	312	312	312	312
$R^2$	0.658	0.401	0.527	0.484	0.514	0.481
Hausman Test <sup>a</sup> ( <i>p</i> -value)					5.821 (0.054)	
Wald Test ( <i>p</i> -value)	887.04 (0.00)	305.52 (0.00)	347.97 (0.00)	293.12 (0.00)	323.62 (0.00)	260.02 (0.00)

Standard errors in parenthesis. All regressions include provincial and year fixed effects.

\* Significant at 10% level. \*\* Significant at 5% level. \*\*\* Significant at 1% level.

<sup>a</sup> The *p*-value of the Hausman Test is for the Wu-Hausman  $\chi^2(2)$  test.

<sup>b</sup> Angrist-Pischke multivariate *F*-test of weak instruments. <sup>c</sup> Cragg-Donald Wald *F*-statistic.

**Table 7: First stage of 3SLS**

Variables	$\Delta R_{i,t}$	$\Delta R_{i,t-1}$
$\Delta Y_{i,t}$	-0.008** (0.004)	0.009* (0.004)
$\Delta Y_{i,t-1}$	0.006* (0.004)	-0.001 (0.004)
$\Delta Y_{i,t-2}$	-0.001 (0.003)	0.01*** (0.004)
$\Delta TR_{i,t}$	-0.108** (0.05)	0.018 (0.052)
$\Delta TR_{i,t-1}$	-0.059 (0.048)	-0.137*** (0.05)
$\Delta TR_{i,t-2}$	0.05 (0.044)	0.143*** (0.046)
$\Delta Z_{i,t}$	0.004*** (0.00)	0.001*** (0.00)
$\Delta Z_{i,t-1}$	0.00 (0.00)	0.003*** (0.00)
Observations	312	312
$R^2$	0.54	0.445
Angrist-Pischke <sup>b</sup>	148.97***	89.35***
Cragg-Donald <sup>c</sup>		46.65***

provinces. Therefore, when a provincial government faces an increase in Coparticipation transfers, it may react spending a very important fraction of this increase, anticipating that, in case of a posterior reversal of this source of income, it could be rescued via discretionary transfers. A similar argument can be made to explain the low reaction of debt to an increase in royalties.

In order to deal with this issue, in (B) and (C), we restrict the data set to the 1988-2003 period, when Coparticipation transfers defined by Law 23,548 represented more than 90 percent of all intergovernmental transfers. In (B) we present the results without instrumenting royalties. We observe that the most important statistically significant estimates are economically very different from the previous specification: the reaction of public expenditures to a change in Coparticipation transfers falls by almost 60 percent, while the debt reaction to a change in royalties doubles. But we also observe a negative and significant reaction of public expenditures to an increase in royalties, which is not easy to interpret.

Finally, (C) presents the estimates derived from our preferred model specification, when we instrument royalties.<sup>32</sup> We use the Three Stage Least Square method (3SLS), as described by Zellner and Theil (1962), to simultaneously account for the endogeneity problem of royalties<sup>33</sup> and the correlation of the error term in the decision of public spending and debt of Argentine provinces.<sup>34</sup> We obtain a positive and significant estimated response of public expenditures to the contemporaneous change in Coparticipation transfers, similar to the previous estimation. On average, and other things being equal, for each AR\$ of increase in Coparticipation transfers, provincial governments increased current public expenditures by nearly 39 cents. This suggest a significant level of expenditure smoothing to shocks in this source of provincial income. Although this finding stands in sharp contrast to the result obtained by Holtz-Eakin et al. (1994) and Vegh and Vuletin (2015),<sup>35</sup> our estimated coefficients are similar to those found by Dahlberg and Lindström (1998). Also, there is no evidence of a reaction in debt to a change in Coparticipation transfers.

Now, regarding the reactions to shocks to royalties, we obtain a statistically non significant coefficient for public expenditures. But, on the other hand, public debt reacts significantly and negatively to shocks in royalties: it decreases 59 cents per AR\$ of increase in this source of revenue. Thus, provincial governments smooth shocks to royalties mostly using debt

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<sup>32</sup>Royalties also depend upon gas production and its international price. We also instrumented royalties using the provincial 1987 gas production multiplied by the change in its international price. All results were almost identical to the ones presented here, and are available upon request.

<sup>33</sup>Now, instead of  $\Delta R_{i,t}$  and  $\Delta R_{i,t-1}$ , we use the first-stage, estimated values of these changes in royalties.

<sup>34</sup>In order to test for the endogeneity of royalties, we perform a Hausman test, comparing the differences in coefficients between (B) and (C). Under the null hypothesis that SUR is an appropriate estimation technique, only efficiency should be lost by turning to 3SLS; that is, the point estimates should be qualitatively unaffected. The test statistic is distributed as  $\chi^2$  with 2 degrees of freedom (i.e., the number of regressors being tested for endogeneity). The result of the test is 5.821 with a  $p$ -value of 0.054. Therefore, we reject the null hypothesis and estimate the system using 3SLS.

<sup>35</sup>Still, we have to bear in mind that, with respect to the latter, we use different variables (public consumption instead of total expenditures, Coparticipation instead of total transfers), a shorter period of time (1988-2003 in place of 1972-2006), and a different empirical model (a system of equations rather than a single one).

management, and letting public expenditures almost unchanged (which is different from the previous estimation). If we compare these results with those obtained for Coparticipation transfers, we conclude that Argentine provinces that have access to both sources of income smooth their fiscal policy more significantly with respect to royalties as compared to Coparticipation transfers.<sup>36</sup> We discuss the intuition of this result below.

Finally, once other sources of income are controlled for, there is no response of public expenditures or debt to changes in provincial GPP, a proxy for the local tax base. This result, analogous to those obtained by Vegh and Vuletin (2015), reflects in part the already noted fact that Argentine provinces have a very limited capacity to increase their tax receipts. Given these institutional weaknesses, it is difficult to interpret the great gap between the estimated coefficient for changes in provincial private income and the corresponding for changes in Coparticipation transfers as evidence of a “flypaper effect”.

Regarding the first stage of (C), we also add as instruments of  $\Delta R_{i,t}$  and  $\Delta R_{i,t-1}$  the other exogenous variables that are included in the second stage. In Table 7, we observe that, for both instrumented variables, the coefficient of their corresponding instrument is positive (as predicted) and significant. Moreover, the null hypothesis of weak instruments is rejected at the one percent level of significance in the Angrist-Pischke multivariate  $F$ -test and in the Cragg-Donald Wald  $F$  statistic.

## 5.4 Robustness checks

We explore the robustness of these results in three different ways.

### 5.4.1 Groups of similar provinces

At the beginning of this section, we mentioned a couple of reasons to suspect that some provinces have common characteristics that may be driving the results of the basic estimation. Thus, it may be worth studying if these provinces’ public expenditures and debt reactions to changes in the independent variables are different from those of the other provinces. In order to do that, we estimate different versions of system (17), adding the interaction effect of the dummy

$$\mathbb{1}_i^J = \begin{cases} 1 & \text{if province } i \in J \\ 0 & \text{otherwise,} \end{cases}$$

where  $J$  is a set of specific provinces, with all other independent variables.

**Big provinces** We have argued that, given that provinces are relatively small compared to the national economy, each one takes the evolution of the national tax collection as given, and

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<sup>36</sup>All (but one) coefficients of the lagged changes in the explanatory variables are statistically non-significant. Despite this fact, we cannot estimate the system without these lagged changes because, as our theoretical model suggests, we could face an omitted variable problem, implying that our estimators could be inconsistent. Moreover, we have performed joint significance Wald tests, and in all cases the null hypothesis has been rejected.

thus considers Coparticipation transfers as exogenously determined. This argument is true for most provinces in Argentina, but it could be criticized for the case of Buenos Aires and C.A.B.A., with a GPP representing 35 and 25 percent of the national GDP, respectively.<sup>37</sup> To a lesser extent, the same criticism could be applied to Córdoba and Santa Fe, which are the following two largest jurisdictions. So, to see if this potential channel of endogeneity is in part driving the results of the basic estimation, we consider first that

$$J = \{\text{Buenos Aires, C.A.B.A., Córdoba, Santa Fe}\}.$$

Results are shown in Table 8, where we present the results for the 3SLS estimation.<sup>38</sup> As we can see, some coefficients of the interactions between the dummy and the changes in GPP are statistically significant. This suggests that, for example regarding their debt, these big provinces react differently than other provinces, when they face changes in the level of economic activity. One possible explanation is that, for these large jurisdictions, local tax receipts are a more relevant source of revenue than for other provinces, and thus, when this source of income changes due to shocks to GPP, it affects debt management more than for smaller provinces. However, even for these important provinces, the economic significance of all these coefficients is very low.

Interestingly, the coefficients of the interaction term between the dummy and the changes in Coparticipation transfers are not statistically significant, implying that the reactions to changes in these sources of revenue are not statistically different between these four big provinces and the other.

Finally, the remaining coefficients are very similar to those presented in the last specification in Table 6. We thus conclude that differences in provinces size is not introducing any bias that could modify the results we showed there.

**Oil provinces** Although we instrumented royalties, we can still suspect that the estimated coefficients  $\hat{\beta}_0^G$  and  $\hat{\beta}_0^D$  in Table 6 may be biased downwards because they capture the average response of all provinces in a situation where only a few of them actually receive royalties. Moreover, we can also argue that oil provinces are different from non-oil jurisdictions, in terms of their economic, social and institutional characteristics, which could imply that the response of public expenditures and debt also differ for the other sources of revenues, including Coparticipation transfers.<sup>39</sup> To evaluate this hypothesis, we now define  $J$  to be the

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<sup>37</sup>Another reason to look carefully at Buenos Aires is the following. As we have already mentioned, since 1992, this province has received an additional amount of Coparticipation transfers in the form of a special fixed fund called *Fondo de Financiamiento de Programas Sociales en el Conurbano Bonaerense*. In some years, this fund amounted to almost 25 percent of Buenos Aires' Coparticipation transfers. The establishment of this fund was the result of political negotiations that took place after Law 23,548 was enacted. Thus, these extra funds could generate an endogeneity problem.

<sup>38</sup>Results do not change in any significant way if we incorporate into the set  $J$  each of these four big provinces, one by one. These estimations are also available upon request.

<sup>39</sup>As we have mentioned in the Introduction, there is an important literature on the "Natural Resource Curse" that postulates channels through which natural resource abundance could be associated with bad policy and economic performance.

**Table 8: Big provinces**

Variables	$\Delta G_{i,t}$	$\Delta D_{i,t}$
$\Delta Y_{i,t}$	-0.004 (0.009)	-0.004 (0.01)
$\mathbb{1}_i^J \times \Delta Y_{i,t}$	0.026 (0.016)	0.04** (0.019)
$\Delta Y_{i,t-1}$	0.00 (0.008)	0.001 (0.01)
$\mathbb{1}_i^J \times \Delta Y_{i,t-1}$	-0.033* (0.019)	-0.041** (0.019)
$\Delta Y_{i,t-2}$	-0.028*** (0.008)	
$\mathbb{1}_i^J \times \Delta Y_{i,t-2}$	0.029* (0.015)	
$\Delta TR_{i,t}$	0.39*** (0.103)	-0.045 (0.121)
$\mathbb{1}_i^J \times \Delta TR_{i,t}$	-0.250 (0.439)	-0.629 (0.496)
$\Delta TR_{i,t-1}$	0.142 (0.104)	-0.036 (0.118)
$\mathbb{1}_i^J \times \Delta TR_{i,t-1}$	-0.015 (0.43)	-0.07 (0.507)
$\Delta TR_{i,t-2}$	-0.115 (0.084)	
$\mathbb{1}_i^J \times \Delta TR_{i,t-2}$	-0.042 (0.526)	
$\Delta R_{i,t}$	-0.008 (0.164)	-0.616*** (0.19)
$\Delta R_{i,t-1}$	0.06 (0.189)	
Observations	312	312
$R^2$	0.52	0.494

Standard errors in parenthesis. All regressions include provincial and year fixed effects.

\* Significant at 10% level. \*\* Significant at 5% level. \*\*\* Significant at 1% level.

The interactions  $\mathbb{1}_i^J \times \Delta R_{i,t}$  and  $\mathbb{1}_i^J \times \Delta R_{i,t-1}$  are dropped because, as the four biggest provinces receive no royalties, these interactions are equal to 0.

set of oil provinces, namely those provinces where royalties explain, on average, at least 2.5 percent of their total income during 1988-2003, as follows

$$J = \{\text{Chubut, La Pampa, Mendoza, Neuquén, Río Negro, Salta, Santa Cruz, Tierra del Fuego}\}.$$

Ideally, we should have proceeded as we did for the case of big provinces, instrumenting royalties and estimating (17) adding the interactions of the dummy with all independent variables. Unfortunately, this is not possible because we face a weak-instrument problem.<sup>40</sup>

<sup>40</sup>For provinces that received few royalties, the instruments do not explain the variability of  $\Delta R_{i,t}$  and  $\Delta R_{i,t-1}$ , and thus the coefficients related to these endogenous variables are inconsistent.

Therefore, we proceed in a different way. First, we modify the original data set, replacing the values of royalties received in all non-oil provinces by “0”. Then, we estimate (17) with this new data set, instrumenting royalties for the oil provinces. Results are shown in Table 9. There, we can observe that all coefficients are almost identical to those of the last specification in Table 6. Thus, we conclude that eliminating royalties from the non-oil provinces do not affect our results.<sup>41</sup> Next, we proceed to estimate the same specification as before, but adding the interaction effect of the dummy that characterizes “oil provinces”.<sup>42</sup> Results are shown in Table 10.

Regarding Coparticipation transfers, we observe no significant different behavior between these oil producer provinces and the others.<sup>43</sup> As before (see Table 6), oil producer provinces show a strong negative reaction in public debt when royalties increase. Finally, the only noticeable difference with respect to the non oil provinces is that both public consumption and debt react to contemporaneous and lagged shocks to GPP. But again, the economic significance of these coefficients is low.

### 5.4.2 Specific provinces

Here we examine whether some provinces, with particular characteristics, may bias the results obtained in Table 6. We proceed to estimate the last specification of this table, but eliminating these particular provinces from the data, one by one. The results are shown in Table 11.

As we have already mentioned, Argentine provinces face structural difficulties to increase their own tax receipts. Indeed, during the period under analysis, Figure 1 shows that most provinces raised a fairly constant share of their GPP in own taxes. But some of them were able to increase this share. In particular, Santiago del Estero almost doubled it. As this may bias our estimations, in columns (A) we eliminate this province from the data. All coefficients are almost identical to those obtained in the last specification in Table 6. Thus, excluding this province has no impact on the results.

In Section 2, we explained that 1 percent of the common pool *Masa Coparticipable* was used to finance the provision of ATNs, discretionary transfers distributed by the (Federal) Ministry of Interior. For most provinces, these transfers represented a negligible source of revenue during the period 1988-2003. But this was not the case for all of them. During 1989-1999, La Rioja received, on average, 32 percent of all ATNs (Cetrángolo and Jiménez, 2003). In particular, during some years, La Rioja received the same amount of ATNs than of Coparticipation transfers.<sup>44</sup> As there is a clear concern for endogeneity with this source

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<sup>41</sup>This is not surprising, given the fact that, in most of the years, royalties received by oil provinces represented more than 97 percent of all royalties.

<sup>42</sup>Proceeding in this way eliminates the abovementioned weak-instrument problem because we do not need to instrument royalties in non-oil provinces.

<sup>43</sup>The only difference emerges in the reaction of public expenditures to a two-period lagged change in Coparticipation transfers. But the coefficient is only significant at the ten percent level of significance.

<sup>44</sup>This exceptional situation can be explained by the fact that President Menem (1989-1999) was originary from this poor province.

of revenues, in columns (B) we exclude La Rioja.

**Table 9: Eliminating royalties from non-oil provinces**

Variables	$\Delta G_{i,t}$	$\Delta D_{i,t}$
$\Delta Y_{i,t}$	-0.002 (0.008)	0.00 (0.009)
$\Delta Y_{i,t-1}$	0.00 (0.007)	-0.004 (0.009)
$\Delta Y_{i,t-2}$	-0.023*** (0.007)	
$\Delta TR_{i,t}$	0.385*** (0.101)	-0.074 (0.118)
$\Delta TR_{i,t-1}$	0.162 (0.102)	-0.023 (0.118)
$\Delta TR_{i,t-2}$	-0.114 (0.08)	
$\Delta R_{i,t}$	-0.024 (0.164)	-0.588*** (0.192)
$\Delta R_{i,t-1}$	0.082 (0.191)	
Observations	312	312
$R^2$	0.514	0.48

**Table 10: Oil provinces**

Variables	$\Delta G_{i,t}$	$\Delta D_{i,t}$
$\Delta Y_{i,t}$	0.022* (0.013)	0.031** (0.015)
$\mathbb{1}_i^J \times \Delta Y_{i,t}$	-0.021 (0.014)	-0.035** (0.017)
$\Delta Y_{i,t-1}$	-0.037** (0.015)	-0.041*** (0.015)
$\mathbb{1}_i^J \times \Delta Y_{i,t-1}$	0.042*** (0.017)	0.046*** (0.017)
$\Delta Y_{i,t-2}$	0.009 (0.013)	
$\mathbb{1}_i^J \times \Delta Y_{i,t-2}$	-0.037*** (0.014)	
$\Delta TR_{i,t}$	0.298** (0.15)	-0.182 (0.17)
$\mathbb{1}_i^J \times \Delta TR_{i,t}$	0.153 (0.143)	0.209 (0.161)
$\Delta TR_{i,t-1}$	0.145 (0.141)	0.025 (0.164)
$\mathbb{1}_i^J \times \Delta TR_{i,t-1}$	0.021 (0.151)	-0.095 (0.158)
$\Delta TR_{i,t-2}$	0.136 (0.15)	
$\mathbb{1}_i^J \times \Delta TR_{i,t-2}$	-0.267* (0.148)	
$\Delta R_{i,t}$	-0.091 (0.181)	-0.582*** (0.211)
$\Delta R_{i,t-1}$	-0.017 (0.199)	
Observations	312	312
$R^2$	0.523	0.499

Standard errors in parenthesis. All regressions include provincial and year fixed effects.

\* Significant at 10% level. \*\* Significant at 5% level. \*\*\* Significant at 1% level.

In Table 10, the interactions  $\mathbb{1}_i^J \times \Delta R_{i,t}$  and  $\mathbb{1}_i^J \times \Delta R_{i,t-1}$  are dropped because they are colinear with  $\Delta R_{i,t}$  and  $\Delta R_{i,t-1}$ .

Again, all coefficients are almost identical to those obtained in the last specification of Table 6, implying that La Rioja does not seem to introduce any particular bias in the estimation.

The next two regressions exclude the provinces whose Coparticipation coefficients were defined after Law 23,548 was enacted in 1988. Columns (C) show the results without C.A.B.A.. We observe no impact on the results, except for the (significant at the 10 percent level) coefficient of the reaction of public expenditures to the lagged change in Coparticipation transfers. Finally, columns (D) present the results excluding Tierra del Fuego. Most

Table 11: Eliminating specific provinces

Variables	(A)			(B)			(C)			(D)		
	$\Delta G_{i,t}$	$\Delta D_{i,t}$	$\Delta G_{i,t}$	$\Delta G_{i,t}$	$\Delta D_{i,t}$	$\Delta G_{i,t}$	$\Delta D_{i,t}$	$\Delta G_{i,t}$	$\Delta D_{i,t}$	$\Delta G_{i,t}$	$\Delta D_{i,t}$	
$\Delta Y_{i,t}$	-0.002 (0.008)	0.001 (0.009)	-0.002 (0.008)	-0.002 (0.009)	-0.004 (0.009)	-0.006 (0.009)	-0.006 (0.01)	0.00 (0.009)	0.013 (0.011)			
$\Delta Y_{i,t-1}$	-0.001 (0.007)	-0.003 (0.009)	-0.001 (0.007)	-0.007 (0.008)	-0.007 (0.008)	-0.002 (0.008)	-0.003 (0.01)	-0.007 (0.009)	-0.009 (0.011)			
$\Delta Y_{i,t-2}$	-0.024*** (0.007)		-0.023*** (0.007)			-0.027*** (0.008)		0.006 (0.008)				
$\Delta TR_{i,t}$	0.365*** (0.104)	-0.077 (0.121)	0.372*** (0.105)	-0.141 (0.116)	-0.141 (0.116)	0.393*** (0.105)	-0.067 (0.124)	0.423*** (0.12)	0.114 (0.161)			
$\Delta TR_{i,t-1}$	0.171 (0.105)	-0.021 (0.121)	0.146 (0.107)	-0.048 (0.116)	-0.048 (0.116)	0.187* (0.107)	-0.004 (0.122)	0.12 (0.128)	0.014 (0.17)			
$\Delta TR_{i,t-2}$	-0.125 (0.082)		-0.116 (0.082)			-0.122 (0.085)		0.309*** (0.115)				
$\Delta R_{i,t}$	-0.024 (0.168)	-0.608*** (0.197)	-0.021 (0.167)	-0.609*** (0.186)	-0.609*** (0.186)	0.008 (0.167)	-0.598*** (0.195)	0.212 (0.147)	-0.297 (0.195)			
$\Delta R_{i,t-1}$	0.087 (0.196)		0.026 (0.191)			0.066 (0.192)		0.279 (0.194)				
Observations	299	299	299	299	299	299	299	299	299			
$R^2$	0.514	0.476	0.505	0.511	0.511	0.519	0.489	0.524	0.477			

Standard errors in parenthesis. All regressions include provincial and year fixed effects.  
\* Significant at 10% level. \*\* Significant at 5% level. \*\*\* Significant at 1% level.

coefficients remain almost unchanged, in particular the one that characterizes changes in public consumption to the contemporaneous shock in Coparticipation transfers. But, regarding the coefficient of the debt reaction to changes in royalties, both its statistic and economic significance fall. This can be explained by the fact that this province exhibits a high variability between debt and royalties. Despite this fact, we still obtain a marginally significant result that provinces with royalties use a one AR\$ increase in this source of income to reduce debt by nearly 30 cents.<sup>45</sup>

## 6 Discussion

We have provided consistent evidence on the behavior of Argentine provinces regarding their reaction in public consumption and debt to changes in their two major sources of income. First, an increase (decrease) in Coparticipation transfers in one AR\$ induces an increase (decrease) of provincial public consumption expenditures of about a third of that amount. Thus, provinces seem to smooth, in an important manner, their public consumption with respect to shocks to these transfers. This result is very robust to applying IV techniques to instrument royalty revenues, to control for potential different behavior of some group of provinces, and even when we exclude from the data some specific provinces.

Regarding changes in royalties, we observe that oil provinces' reactions are sharper: facing an increase (decrease) in one AR\$ in this source of revenue, oil producing provinces do not significantly increase (decrease) public consumption; instead much of the adjustment goes to a decrease (increase) in debt. Importantly, the sign and even the magnitude of the debt reaction is roughly maintained when we instrument royalties and consider particular provinces, except when we exclude Tierra del Fuego. Why do oil provinces save (via a reduction in their public debt) an important fraction of additional royalties, while this is much less so when they face an increase in Coparticipation transfers?

One reason that can be brought in is the fact that provincial governments may have perceptions that changes in royalties are more volatile than those corresponding to Coparticipation transfers (for a given level of correlation between them). If this were the case, a precautionary savings argument, as pointed out by Vegh and Vuletin (2015), could be made to explain these different behaviors. Indeed, royalties are more volatile than Coparticipation transfers, as it is shown in Table 12 in the Appendix. There, the estimated coefficient of variation of the error term in the autoregressive equations is higher for royalties than for Coparticipation transfers.

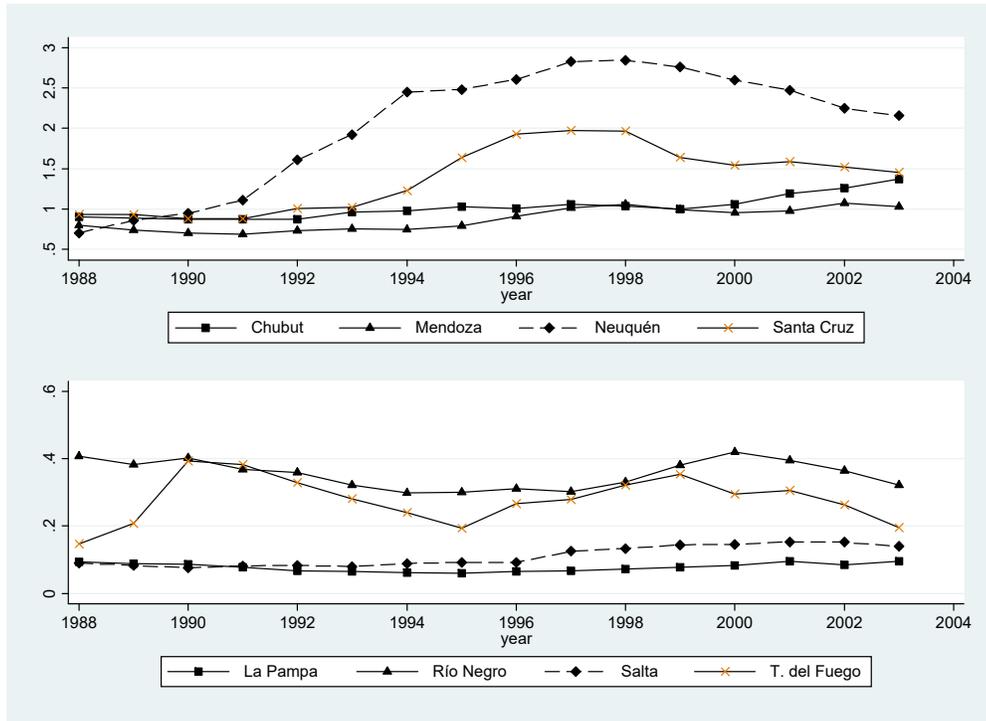
An alternative answer to the abovementioned question could be related to the non-renewable nature of oil production. Our estimation of the autoregressive coefficients in the equation of royalties (see Table 12 in the Appendix) was based on a short period sample, and thus may only include the stochastic process of the oil price. However, royalties combine rates, prices and quantities. Since oil is a non-renewable commodity, the optimal smoothing strategy should take into account not only the fluctuations of the oil price but also the evolution of its production. As explained in Barnett and Ossowski (2003), in the context of

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<sup>45</sup>The  $p$ -value of this coefficient is 0.12.

oil producing units the best known strategy is a fiscal policy that preserves the government oil and non-oil wealth, which implies that, in each period, public consumption should be limited to permanent income, an argument familiar from the tax smoothing literature (Barro, 1979).<sup>46</sup> As shown in Figure 8, oil production's performance varied across oil provinces during the period under analysis. Therefore, these provinces might be at different stages of their long-run savings strategy, and our estimation may be capturing that.

**Figure 8: Oil production, by province (in millions of cubic meters)**



Source: Instituto Argentino del Petróleo y del Gas.

## 7 Conclusions

Studying the impact of changes in public revenues on subnational public expenditures is not easy. From a theoretical perspective, it has been shown that one needs to depart from a simple static model, and incorporate dynamic and stochastic features to capture the very nature of local governments decisions. Empirically, researchers face potential concerns for the endogeneity of local public (tax and non-tax) revenues. Indeed, in many developed

<sup>46</sup>Moreover, even in richer models that include other policy options such as private capital accumulation and public infrastructure construction, [e.g. van der Ploeg and Venables (2011)], the optimal use of government revenues is not to increase public consumption.

and developing countries, intergovernmental transfers are usually allocated as a function of observed provincial characteristics or policies' outcomes; in other cases, an important fraction of these transfers is discretionally assigned by yearly budget decisions that reflect political negotiations at Congresses or directly between the central government and the subnational authorities.

This paper has adressed these two issues. We have presented a dynamic stochastic model that incorporates many aspects of subnational public finances in Argentina. There, besides having their own source of revenues, the most important type of transfer that provinces receive from the Federal Government comes from the tax sharing regime *Coparticipación Federal de Impuestos*. Each province's transfer is predetermined by a legal, fixed coefficient that depends neither on its characteristics nor on its policies' outcomes. In addition to Coparticipation transfers, oil royalties are an important source of income for some jurisdictions. This type of provincial income has been very volatile, and its main source of variation is mostly determined by changes in international prices. These two features of the Argentine data provide a unique setting for empirically identifying the impact of shocks to these sources of income on provincial public expenditures and debt, without major concerns for endogeneity issues. Moreover, we examine whether there has been public expenditures smoothing at the subnational level.

The main econometric results suggest a relative important provincial expenditure smoothing in Argentina. This response is more significant with regard to shock in royalties, compared to Coparticipation transfers. Within the possible explanations for these different provincial reactions, we emphasize the higher volatility of royalties (with respect to Coparticipation transfers) and the exhaustible nature of these revenues.

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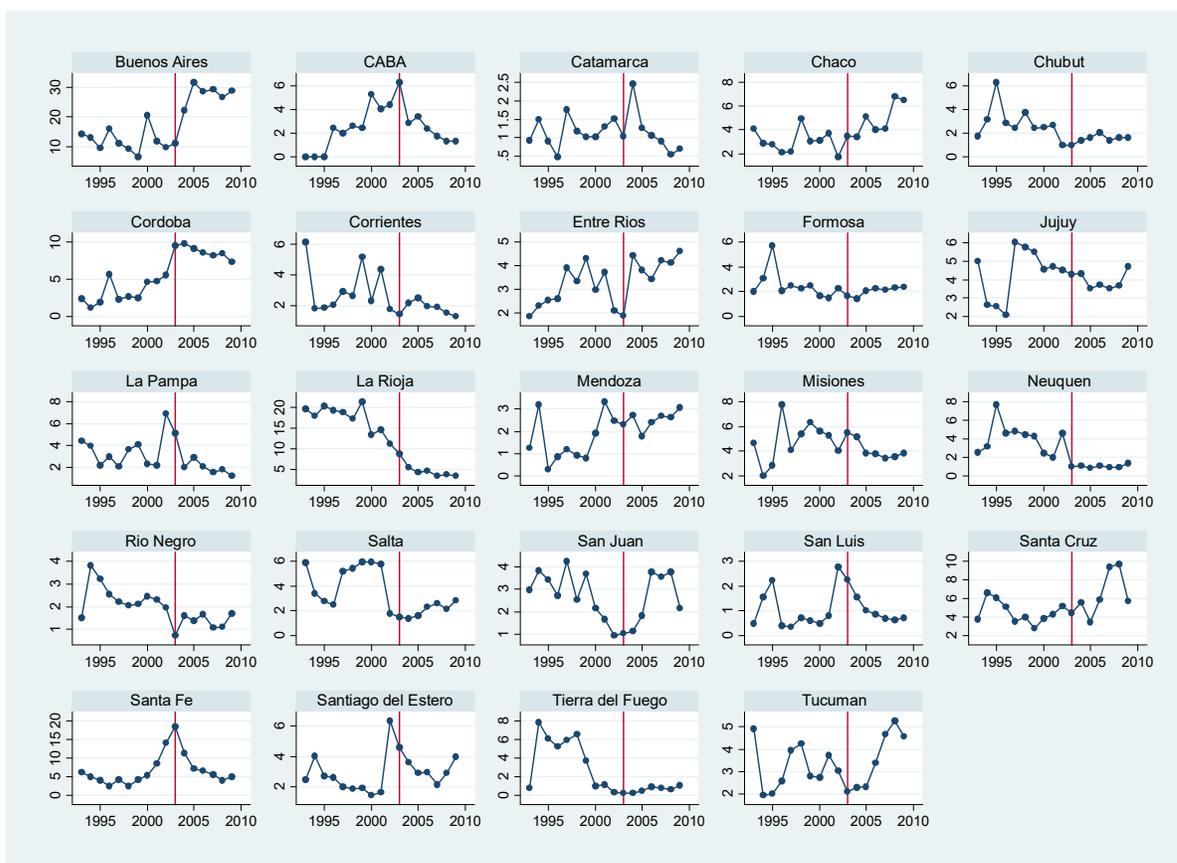
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## 8 Appendix

### 8.1 The use of discretionary transfers

After 2003, discretionary transfers distributed by the Federal Government represented a higher fraction of provincial incomes than under previous years. But this does not necessarily imply that the allocation of these transfers suffer from endogeneity problems. One could argue that their distribution may have replicated the assignment of Coparticipation transfers. The following figure proves that this was not the case. Figure 9 depicts, for each province, the percent of discretionary transfers received (out of the total amount of discretionary transfers allocated to all provinces), for the period 1993-2009.

**Figure 9: Discretionary transfers, by province (as percent of all discretionary transfers)**



Source: Artana et al. (2012)

The figure shows that discretionary transfers were distributed neither on an equal basis, nor according to the Secondary Distribution coefficients of Law 23,548. Moreover, after

2003, the allocation of discretionary transfers did not follow previous-years patterns: some provinces received an increasing fraction of all these transfers, while others saw their part decrease.

## 8.2 The stochastic processes of royalties, Coparticipation transfers and GPP.

Instead of solving the theoretical model presented in Section 4 by assuming specific stochastic processes for royalties, Coparticipation transfers, and private sector output (which determines provincial taxes), we empirically estimate them. We use annual data for the period 1988 - 2003, aggregating (or averaging out) across all provinces. We postulate that these variables evolve according to  $AR(p)$  processes in first differences to avoid spurious regression results. For each type of revenue,<sup>47</sup> we estimate specifications with one, two and three lags, and we compute the  $p$ -value of the Breusch-Godfrey statistic B-G, corresponding to the highest lag considered. For all specifications, we finally compute the Akaike (AIC) and the Bayesian (BIC) statistics. Table 12 presents the results.

The first three columns present the results for royalties. According to the AIC and BIC statistics, the specification with one lag should be preferred. Moreover, the  $p$ -value of the B-G statistic shows no serial correlation of errors in all specifications. Given that the coefficient for the first lag is lower than one, changes in royalties follow a mean reverting process. This is consistent with what has been found for oil prices.<sup>48</sup>

The next three columns show the results for Coparticipation transfers. Based on the information conveyed by the AIC and BIC statistics, the specification with two lags should be preferred. No specification shows serial correlation of errors. The two-lag specification implies that changes in these fiscal resources are subject to cyclical fluctuations, as shown by the change in sign between the coefficients of the first and the second lag. This is consistent with the fact that these transfers follow the evolution of the federal tax collection, which, in turn, depends on the national GDP. Clearly, the latter is subject to cyclical fluctuations.

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<sup>47</sup>These estimations were undertaken separately. One may wonder whether previous lags of some variable could influence the contemporaneous lag of other variable. In order to verify if this is indeed the case, we estimate a VAR model with first differences in royalties, Coparticipation transfers, and GPP. The results, which are available upon request, show that estimating the three autoregressive equations separately is without any loss of generality.

<sup>48</sup>The fact that oil prices follow an autoregressive process has been accepted in most of the empirical literature on the issue. Pindyck (1999) argues that nonstructural models for energy prices should incorporate mean reversion to a stochastically fluctuating trend line. In particular, these type of models performed well with oil prices. Even in recent literature, where oil prices are modeled as endogenous to supply and demand shocks, the autoregressive behavior of oil prices is further reaffirmed. Casassus et al. (2005) model equilibrium spot and futures oil prices in a general equilibrium production economy. They estimate the model using the Simulated Method of Moments for futures prices and macroeconomic data, and found that the resulting equilibrium oil price exhibits mean-reversion and heteroscedasticity. In a more empirical exercise, Killian (2009) proposes a structural VAR model of the global crude oil market that jointly addresses reverse causality from macro aggregates to oil prices and the fact that the oil price is driven by different demand and supply shocks. He shows that both oil supply and demand shocks are mean reverting.

Table 12: Estimation of autoregressive equations in first differences for royalties, Coparticipation transfers and GPP

	Royalties			Coparticipation transfers			GPP		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Constant	0.029 (0.027)	0.038 (0.029)	0.058* (0.031)	0.032 (0.038)	0.036 (0.035)	0.021 (0.035)	0.147 (0.187)	0.161 (0.181)	0.12 (0.203)
1 lag	0.334* (0.169)	0.133 (0.270)	-0.008 (0.289)	0.188 (0.254)	0.222 (0.234)	0.163 (0.290)	0.55** (0.212)	0.806*** (0.247)	0.782** (0.311)
2 lags		0.288 (0.189)	0.032 (0.270)		-0.637** (0.26)	-0.510* (0.262)		-0.491* (0.24)	-0.388 (0.363)
3 lags			0.255 (0.207)			-0.208 (0.328)			-0.086 (0.306)
AIC <sup>a</sup>	-23.784	-21.748	-19.716	-13.167	-15.519	-14.714	37.73	33.879	34.213
BIC <sup>b</sup>	-22.239	-19.624	-17.159	-11.622	-13.395	-12.158	39.276	36.003	36.77
B-G <sup>c</sup>	0.3025	0.2372	0.7139	0.512	0.875	0.194	0.093*	0.858	0.497
CV <sup>d</sup>	2.171				2.086			2.212	

Standard errors in parenthesis. \* Significant at 10% level. \*\* Significant at 5% level. \*\*\* Significant at 1% level.  
<sup>a</sup> Akaike Information Criterion statistic. <sup>b</sup> Bayes Information Criterion statistic. <sup>c</sup> Breusch-Godfrey statistic for the highest lag.  
<sup>d</sup> Coefficient of variation of error term.

Finally, the last three columns present the estimation for private sector output (using data on GPP). Again, based on the information conveyed by the AIC and BIC statistics, the specification with two lags, with no serial correlation of errors, should be preferred. As expected, this specification shows that changes in GPP obey a dynamic process subject to cyclical movements (again, there is a change in sign between the coefficient of the first and the second lag).

### 8.3 Optimal changes in current public expenditures and debt

From the first-order conditions of problem (5) and assuming that  $\beta(1+r) = 1$ , we obtained

$$G_s = \mathbb{E}_s[G_{s+1}].$$

Then, we worked with the intertemporal provincial resource constraint to find the optimal level of public expenditures

$$G_t^* = \frac{r}{1+r}\Omega.$$

In order to get an expression for  $G_t^*$  that can be easily implemented in the empirical analysis, it will be convenient to expand the expected wealth term  $\Omega$ . We start with royalties. From (12), we get

$$\mathbb{E}_t[\Delta R_{t+s}] = (\rho_1^R)^s \Delta R_t. \quad (19)$$

Using (19) and the fact that  $\mathbb{E}_t[\Delta R_{t+s}]$  can be expressed as

$$\mathbb{E}_t[\Delta R_{t+s}] = R_{t-1} + \sum_{i=t}^s \mathbb{E}_t[\Delta R_i],$$

we obtain

$$\sum_{s=0}^{\infty} \frac{\mathbb{E}_t[R_{t+s}]}{(1+r)^s} = R_{t-1} \frac{(1+r)}{r} + \Delta R_t \frac{(1+r)}{r} \frac{(1+r)}{(1+r-\rho_1^R)}. \quad (20)$$

Given that the stochastic process followed by Coparticipation transfers is given by

$$\Delta TR_s = \rho_1^{TR} \Delta TR_{s-1} + \rho_2^{TR} \Delta TR_{s-2} + \xi_s, \quad (21)$$

obtaining an expression like (20) is not immediate. We proceed as follows. Let's define

$$\zeta_s = \begin{bmatrix} \Delta TR_s \\ \Delta TR_{s-1} \end{bmatrix},$$

$$M = \begin{bmatrix} \rho_1^{TR} & \rho_2^{TR} \\ 1 & 0 \end{bmatrix},$$

and

$$v_s = \begin{bmatrix} \zeta_s \\ 0 \end{bmatrix}.$$

With these definitions, we can write the stochastic process of transfers as the following first-order vector difference equation

$$\zeta_{s+1} = M \cdot \zeta_s + v_{s+1}. \quad (22)$$

Then, we can obtain  $\mathbb{E}_0 [\Delta TR_t]$  calculating the following inner product

$$\mathbb{E}_t [\Delta TR_{t+s}] = \begin{bmatrix} 1 & 0 \end{bmatrix} \cdot \mathbb{E}_t [\zeta_{t+s}] = \begin{bmatrix} 1 & 0 \end{bmatrix} \cdot M^s \cdot \zeta_t. \quad (23)$$

Using (23),

$$\mathbb{E}_t [TR_{t+s}] = TR_{t-1} + \sum_{i=0}^s \mathbb{E}_t [\Delta TR_{t+i}],$$

and

$$\sum_{i=0}^s M^i = [I - M^{s+1}] \cdot [I - M]^{-1}$$

where  $I$  is the identity matrix, we get

$$\mathbb{E}_t [TR_{t+s}] = TR_{t-1} + \begin{bmatrix} 1 & 0 \end{bmatrix} \cdot [I - M^{s+1}] \cdot [I - M]^{-1} \cdot \zeta_t. \quad (24)$$

Using (24), the expected discount sum of Coparticipation transfers can be expressed as

$$\sum_{s=0}^{\infty} \frac{\mathbb{E}_t [TR_{t+s}]}{(1+r)^s} = TR_{t-1} \frac{(1+r)}{r} + \begin{bmatrix} 1 & 0 \end{bmatrix} \cdot \left[ \frac{(1+r)}{r} I - \left[ \sum_{s=0}^{\infty} \frac{M^s}{(1+r)^s} \right] \cdot M \right] \cdot [I - M]^{-1} \cdot \zeta_t. \quad (25)$$

Assuming that all eigenvalues of matrix  $M$  verify  $|\lambda_i| < 1+r$ ,<sup>49</sup> we have that:

$$\sum_{s=0}^{\infty} \frac{M^s}{(1+r)^s} = \left[ I - \frac{M}{(1+r)} \right]^{-1} = \begin{bmatrix} \frac{(1+r)^2}{(1+r-\rho_1^{TR})(1+r)-\rho_2^{TR}} & \frac{\rho_2^{TR}(1+r)}{(1+r-\rho_1^{TR})(1+r)-\rho_2^{TR}} \\ \frac{(1+r)}{(1+r-\rho_1^{TR})(1+r)-\rho_2^{TR}} & \frac{(1+r-\rho_1^{TR})(1+r)}{(1+r-\rho_1^{TR})(1+r)-\rho_2^{TR}} \end{bmatrix}.$$

Using expression (25), we obtain

$$\begin{aligned} \sum_{s=0}^{\infty} \frac{\mathbb{E}_t [TR_{t+s}]}{(1+r)^s} &= TR_{t-1} \frac{(1+r)}{r} + \frac{(1+r)}{r} \frac{(1+r)^2 \Delta TR_t}{(1+r-\rho_1^{TR})(1+r)-\rho_2^{TR}} \\ &+ \frac{(1+r)}{r} \frac{\rho_2^{TR}(1+r) \Delta TR_{t-1}}{(1+r-\rho_1^{TR})(1+r)-\rho_2^{TR}}. \end{aligned} \quad (26)$$

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<sup>49</sup>This is true if the system is covariance stationary.

Regarding GPP, as its stochastic process has the same autoregressive form than the corresponding process of Coparticipation transfers, we obtain

$$\begin{aligned} \sum_{s=0}^{\infty} \frac{\mathbb{E}_t[\tau Y_{t+s}]}{(1+r)^s} &= \tau Y_{t-1} \frac{(1+r)}{r} + \frac{(1+r)}{r} \frac{(1+r)^2 \tau \Delta Y_t}{(1+r-\rho_1^Y)(1+r)-\rho_2^Y} \\ &+ \frac{(1+r)}{r} \frac{\rho_2^Y (1+r) \tau \Delta Y_{t-1}}{(1+r-\rho_1^Y)(1+r)-\rho_2^Y}. \end{aligned} \quad (27)$$

Plugging (20), (26) and (27) in (11), we get

$$G_t^* = A_t + rB_t, \quad (28)$$

where

$$\begin{aligned} A_t &= R_{t-1} + \frac{(1+r)\Delta R_t}{1+r-\rho_1^R} \\ &+ TR_{t-1} + \frac{(1+r)^2 \Delta TR_t}{(1+r-\rho_1^{TR})(1+r)-\rho_2^{TR}} + \frac{\rho_2^{TR}(1+r) \Delta TR_{t-1}}{(1+r-\rho_1^{TR})(1+r)-\rho_2^{TR}} \\ &+ \tau Y_{t-1} + \frac{(1+r)^2 \tau \Delta Y_t}{(1+r-\rho_1^Y)(1+r)-\rho_2^Y} + \frac{\rho_2^Y (1+r) \tau \Delta Y_{t-1}}{(1+r-\rho_1^Y)(1+r)-\rho_2^Y}. \end{aligned}$$

Replacing (28) in time  $t$  government's budget constraint, we also obtain the optimal value

$$B_{t+1}^* = \tau Y_t + TR_t + R_t + B_t - A_t,$$

implying that

$$\Delta B_{t+1}^* = \tau Y_t + TR_t + R_t - A_t. \quad (29)$$

Advancing (28) one period and subtracting the result from (28), we obtain

$$\Delta G_{t+1}^* = A_{t+1} - A_t + r\Delta B_{t+1}^*. \quad (30)$$

Plugging (29) in (30), we find

$$\Delta G_{t+1}^* = A_{t+1} - (1+r)A_t + r[\tau Y_t + TR_t + R_t]. \quad (31)$$

Lagging the above expression one period, we get

$$\Delta G_t^* = A_t - (1+r)A_{t-1} + r[\tau Y_{t-1} + TR_{t-1} + R_{t-1}]. \quad (32)$$

Replacing  $A_t$  and  $A_{t-1}$  in (32) and computing, we finally obtain the expression for the contemporaneous change in the optimal level of public expenditures

$$\begin{aligned} \Delta G_t^* &= (1+r) \left\{ \frac{(1+r)}{J} [\Delta TR_t - \rho_1^{TR} \Delta TR_{t-1} - \rho_2^{TR} \Delta TR_{t-2}] + \frac{1}{K} [\Delta R_t - \rho_1^R \Delta R_{t-1}] \right. \\ &\left. + \frac{\tau(1+r)}{L} [\Delta Y_t - \rho_1^Y \Delta Y_{t-1} - \rho_2^Y \Delta Y_{t-2}] \right\}, \end{aligned}$$

where  $J = (1 + r) (1 + r - \rho_1^{TR}) - \rho_2^{TR}$ ,  $K = 1 + r - \rho_1^R$  and  $L = (1 + r) (1 + r - \rho_1^Y) - \rho_2^Y$ . Regarding the contemporaneous change in the optimal stock of public bonds  $\Delta B_{t+1}^*$ , we develop (29) and obtain

$$\begin{aligned} \Delta B_{t+1}^* = & -\frac{1}{J} \{[(1 + r)\rho_1^{TR} + \rho_2^{TR}]\Delta TR_t + (1 + r)\rho_2^{TR}\Delta TR_{t-1}\} - \frac{1}{K}\rho_1^R\Delta R_t \\ & -\frac{\tau}{L} \{[(1 + r)\rho_1^Y + \rho_2^Y]\Delta Y_t + (1 + r)\rho_2^Y\Delta Y_{t-1}\}. \blacksquare \end{aligned}$$