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The Effects of Rent Assignment on Long-Lived Public Goods in Exhaustible Resource Economies

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The effects of rent assignment on long-lived public goods in exhaustible resource economies

By

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Abstract

Exhaustible resource rents are an important taxable base in many countries, with revenue sharing often part of the scheme. In some cases large shares are retained for the central government. Generally, the discussions of exhaustible resource taxation consider assignment of resource rent tax base and revenue sharing from the limited perspectives of efficiency and stability. Tax assignment and sharing arrangements are assumed to have a neutral effect on investment of resource rents in long-lived public goods. We attempt to demonstrate that this may not be the case, specifically looking at the question of whether rent assignment is neutral to effects on investment of rents in long-lived public goods, a normative policy objective, and under what conditions it occurs. We test the theoretical propositions with data from the Russian Federation to derive empirical results. The results from the Russian Federation point toward an important dimension of rent tax assignment in a federation. They results show that ceteris paribus, higher share of rent for the federation may lead to lower investment in long-lived public goods and may be constrained by stability. Another argument has been made for reconsidering rent tax assignment using assertive ethnic identity as a manifestation strong ownership claims. Communities with strongly valued identities value ownership over land and exhaustible resource endowments in their areas. This may be the case especially if ethnic identity is important to the resource owning community. The empirical results show that a decrease in the regional share of rent resulted in a fall in investments in the republics and regions with strong ethnic identity. Republics among the producing regions have historical claims to a distinct identity and may have a preference for preserving their identity. This preference is manifested as higher levels of rent investment. Following this line of argument, it can be concluded that rent assignment, through rent tax or revenue assignment, should favor producing regions within the range of stability in a federation, if the objective is achieving higher investment in long-lived public goods.

Chapter 1 Introduction

Research question and contribution to the literature

Exhaustible resource rents are an important taxable base in many countries, with revenue sharing often part of the scheme. In some cases large shares are retained for the central government. Generally, the discussions of exhaustible resource taxation consider assignment of resource rent tax base and revenue sharing from the limited perspectives of efficiency and stability. Tax assignment and sharing arrangements are assumed to have a neutral effect on investment of resource rents in long-lived public goods.[1] In the discussion we are presenting in the following chapters, we attempt to demonstrate that this may not be the case. This research specifically looks at the question of whether rent assignment is neutral to effects on investment of rents in long-lived public goods, a normative policy objective, and under what conditions it occurs. We test the theoretical propositions with data from the Russian Federation to derive empirical results.

This research adds to the literature of exhaustible resource rent assignment by demonstrating that assignment and revenue sharing arrangements may not be neutral with respect to investment of exhaustible resource rent in long-lived public goods. It presents a case for

[1] Most discussions do not mention if there would be any effects of assignment of rent taxation on investment choices of exhaustible resource rents. For example some of the important discussions of rent taxation make this common omission: Dasgupta, Heal and Stiglitz (1981) show taxation affects inter-temporal allocation of exhaustible resource through effects on the pace of extraction; McLure and Mieszkowski (1983), present different issues concerning efficiency, equity and allocation of rents, treating them only as revenues in the general pool without connecting them with assignment of rent taxation; this particular treatment is the main discussion in Boadway and Flatters (1983) in the same volume and remains the standard approach; McKenzie (2006) is a discussion of arguments for centralization due to efficiency effects of rent revenues; Daubanes (2009) traces the effects of exhaustible resource extraction and import on gross domestic product and Boadway and Keen (2010) focus on tax policy, design and discussion of tax instruments.

enhancing the scope of rent assignment discussions and bringing in rent investment considerations into revenue sharing decisions. In this sense, it adds the allocation dimension to the earlier assignment question that generally concerns itself with distribution and stability concerns. A theoretical model developed in Chapter 2 shows that under commonly faced policy choices, rent assignment (and revenue sharing) affect(s) investment of exhaustible resource rent in long-lived public goods. The following two chapters, using data on the Regions of Russia provide some validation to the theoretical propositions. We show that assignment of rent taxes or changes in rent shares may have effects on investment in long-lived public goods—a finding that has importance for development policy.

For good economic reasons, exhaustible resource rents serve as a tax base for efficient taxation.[2] Resource rent revenues lead to different expenditure choices regarding current and capital spending. For both tax and expenditure efficiency, a framework will be required that links both the revenue and expenditure sides of policy choices. Within this framework, rent tax assignment and revenue sharing will be considered and different options may be linked to certain expenditure choices. In the following chapters, a case is laid out in a federal setting where assignment of tax on exhaustible resource rents and revenue sharing are made in such a framework, and under certain circumstances, have effects on investment choices. A majority of discussions about resource rent taxation have concerned themselves with macroeconomic stabilization and redistribution objectives.[3] This discussion attempts to add to the literature on the subject by focusing on the allocation effects of rent taxation as it distills the effects of assignment and sharing arrangements on public investment. In this sense, the discussion builds a case for the

[2] These reasons, for example, are laid out in McKenzie (2006).
[3] Musgrave's trilogy of government functions is a used as a baseline consideration for tax assignment also. See for instance McLure and Martinez-Vazquez (2001). The discussion presented in the following chapters mostly takes up the resource allocation arguments.

pursuit of development policy[4] through an analysis of assignment of exhaustible resource rent tax and revenue sharing.

In this introductory chapter, we have dealt with a description of key basic assumptions and concepts that are used later on. At the same time we have attempted to provide definitional clarity for some terms. More specifically, the concept of rent is recounted along with various types of resource rent taxes. The assignment question and its various arguments are briefly discussed. Then the importance of investment of exhaustible resource rents is highlighted before priming the discussion for the theoretical and empirical considerations.

Resource rent and resource rent taxes

Exhaustible resource rent is an important fiscal item in many federations. Rent collection and sharing therefore commonly crop up as important issues in intergovernmental relations. Argentina, Australia, Brazil, Canada, India, Iraq, Mexico, Nigeria, Pakistan, Russia, United Arab Emirates, United States and Venezuela are among the major federations of the world. All of them produce oil, gas and other minerals in quantities that are significant quantities. For example, oil extraction is an important sector in the gross domestic product in a number of federations.[5] Reserves are endowed in some regions only. As a result, rent tax collection and revenue sharing are important considerations for the national or subnational fiscal policy.

Among the federations, Iraq has a major dependence on oil production as it contributes 54 percent of GDP. Nigeria, another major federation, gets nearly 40 percent of GDP from oil. In the United Arab Emirates, the contribution of oil to GDP is greater than 20 percent of GDP. In

[4] For a detailed discussion of this concept, see Bahl (1999).

[5] The percentages listed here were calculated by first computing the value of oil and gas produced by multiplying production with average weighted world price of crude oil and gas; the monthly production of oil and gas and monthly world weighted prices from *Oil and Gas Journal* database were used. GDP at current US$ from WDI 2008 as reported for each country were used for the calculations.

case of Venezuela, oil accounts for 20 percent of GDP closely followed by the Russian Federation with around 17 percent of contribution to GDP coming from the oil sector. For Mexico, another important federation, the contribution to GDP from oil and gas is around 5 percent.[6] A more precise measure of the significance of the petroleum sector to government is the share of rent tax revenue as a percentage of total revenue. Again, in a number of federal countries[7] oil and gas rent tax revenues appear as important items in the tally for total revenue. In Australia, at 2.9 percent of total government revenue, it is noticeable. In Pakistan, at 8.4 percent of total tax revenue, it is significant enough to create long drawn out political conflict between producing provinces and federal government. In the United Arab Emirates, with nearly 75 percent of total revenue, petroleum becomes the mainstay of the fiscal regime. To a lesser degree, in Venezuela with half of government revenue coming from this sector, it again becomes the main source of revenue. In the largest federation, Russia, it accounts for 36.7 percent of total revenue signifying that rent taxes make a major contribution to government operations.

Before entering upon the discussion of neutrality or otherwise of assignment of rent tax and revenue sharing arrangements, it is important to clarify a few connected concepts. The two foremost issues are what a resource rent is and what taxes could be classified as resource rent taxes. Exhaustible resource rent is defined as the sum of sales revenue and extraction costs, computed over a unit of the extracted resource (Dasgupta & Heal, 1979). It can be understood as partly a Ricardian rent and partly a Hotelling rent.[8] Whereas the first component of this rent is a

[6] Calculated from Government of Mexico's Sistema de Cuentas Nacionales de México. Cuentas de bienes y servicios 2005-2009. Año base 2003. Primera version, Table 51,page 117.
[7] The percentages are based on the sources listed under Table 4.3 in Chapter 4.
[8] The term is due to the seminal work on exhaustible resources by Hotelling (1931). The efficient extraction path is delineated according to Hotelling's rule where the price of the extracted resource grows at a rate equal to that of rate of interest (Devarajan & Fischer, 1981).

fairly well established concept,[9] Hotelling rent is a term used to refer to the fact that extraction of a finite stock is only rational if the value of extracted amount is higher than the net present value of the same amount if left unextracted.[10] Resource rents taxes attempt to reach this base and siphon it away for the general use of the society.

If economic rent can be computed for a unit of extracted resource, for the purposes of taxation this represents a base upon which an efficient tax could be levied. Since the rent is an economic profit, it accrues due to scarcity of the resource. Rent signifies the willingness of the production process to pay for the use of the extracted resource. The resource is used up in the process and is lost forever. Rent is the one-time value paid for this single use to the owner. A tax rate that equals the amount of rent remains efficient.[11] A resource rent tax levied at an efficient level will have no influence on investment, types of investment, labor-capital ratio, choice of technology, pace of extraction, mine closure and final disposition of extracted stocks.[12] In practice, neither the price of extracted resource nor the costs remain stable over time. When combined with the complexity of mining operations spread over several mines, each with differential costs, it means that rents may vary between mines and over time. The conceptual clarity of rents is not equally replicable in its practical calculations.

Although not central to the analysis presented in the following chapters, reiteration of the tax efficiency and whether it would be affected by the assignment decision is important as a benchmark of reference. Assuming that there is no information asymmetry, government can design and collect an efficient resource rent tax. It is not necessary that a single instrument

[9] Economic rent is typically defined as the excess proceeds in a production process given to a factor, above the amount required to draw the factor into the process or to sustain the use of the factor (Shepherd, 1970).
[10] Otto et al. (2006) present a discussion of economic rent accruing to mineral extraction.
[11] Theoretical discussions of neutrality and some design issues of resource rent tax are represented in Garnaut and Ross (1979) and Fraser (1993).
[12] Gamponia and Mendelsohn (1985) show the incidence of different taxes on the owners.

should be employed to siphon away rents. Different levels of government can share the base. As long as the multiple instruments collect all the economic rent that is there and there are no administrative costs associated with multiplicity of instruments, taxation will remain efficient. For the most part in my discussion, we maintain these assumptions that resource rent taxes being modeled in the analytical framework are efficient.[13] The same assumption extends to the case of multiple tax instruments, all delving into the same base. Later in the analysis, for the sake of expositional simplicity a single tax is employed in the model.

In practice, a number of taxes are used to tax exhaustible resource rents. A World Bank study enumerates these taxes under two categories (Otto et al., 2006). The first category comprises the *in rem* taxes and includes unit based royalty, ad valorem royalty, sales and excise tax, property tax, export duty, withholding on remitted loan interest, withholding on imported services, value added tax, registration fee, rent or usage fee and stamp duty.[14] The second category is made up by *in personam* taxes. Corporate income tax, capital gains tax (levied only in developing countries), additional profits tax (rarely used), net profits royalty or net value royalty and withholding on remitted profits or dividends. The *in rem* taxes do not clearly aim for the economic rents accruing to extracted resources. Only where tax systems lack adequate capacity, unit based or ad valorem royalty could be arguably a crude means of siphoning parts of rent to the government.[15] On the other hand, *in personam* taxes are levied on profits and they are adequate to siphon away economic rents. Corporate income tax, levied at a higher than normal rate, siphons away economic profits from mining operations to the government. In general royalty is paid regardless of the profits of the operation. In some cases, a mineral tax may be

[13] In practice, if an operational measure cannot be found, the tax may not be efficient.
[14] The lists of the two categories of taxes are derived from Otto et al. (2006), Table 2.2, p.32.
[15] For a description of this case see Hogan and Goldsworthy (2010), p.140.

named differently but in essence it is a net profits royalty.[16] These are two examples of pure rent taxes. Disregarding the complexity of computing rent or pure economic profits for mining operations that may be spread over several jurisdictions or countries, corporate income tax is used to tax rents. If the rate is the same across all sectors, then it does not become a rent tax. But in countries where the tax code legislates special (often higher) tax rates for the mineral sector, it becomes partly a rent tax. For example, in Malaysia and Venezuela the corporate income tax for the oil sector is higher than other sectors. Other commonly used instruments are license fees (Brazil), bonus bids (Canada) and export levies (Argentina, the Russian Federation). Local governments may levy a special rate property tax. The special component of the rate allows them to retrieve some of the rent whereas the general component of the rate is designed as the normal property tax payment for use of local services, following the benefits principle.

Without going into further details of tax instruments and their relative merits, we want to focus on the effects of base assignment and revenue sharing arrangements on investment in long-lived public goods—the topic of my analytic endeavor. Therefore, for the remaining discussion, we abstract from reference to individual tax instruments unless specifically required. Instead we use the term resource rent tax which embodies the taxes levied to siphon away economic rents accruing to extraction of exhaustible resources. This term is also useful as it captures an essential feature of exhaustible resources namely, the finite stocks and one time rents that can accrue to producing jurisdictions. Before leaving the discussion of individual tax instruments, we present a short aside on royalties to clarify the extent to which they could be counted under a resource rent tax.

Royalties are a common tax instrument levied in most countries with significant mining operations. It is a tax specific to natural resources. Two aspects of natural resource royalty can be

[16] The Mineral Extraction Tax in the Russian Federation is a royalty which is levied on a notional net value.

brought up to clarify the nature of this levy. The first one relates to the nature of the levy. It is defined as a payment for resource ownership. In this sense royalty has a legal status not necessarily very significant for fiscal policy.[17] It can be charged only by the owners and payment recognizes resource ownership. Royalty is paid in lieu of transfer of property rights of the mineral from the endowment owner to the firm carrying out the mining operation. The second aspect of royalty is not equally clear. It is levied on the base, the resource rent, but in some cases without specifically claiming the levy to be a resource rent tax.[18] The general practice of setting royalty rates is also a manifestation of this approach. In many cases, an arbitrary rate is set which remains fixed over long periods of time.[19] The rate is sufficiently low to keep it below the upper bound of rent assessment. Resource rents vary with production methods, commodity prices and cost of mining. Royalty collects a known fraction of the value of production without the necessity of calculating resource rents for individual mining operations.[20] Beyond this feature of royalty it is but another instrument for collection of part of the resource rents.[21] In some cases, no explicit royalty is collected but another tax assumes the same role. A good example of this kind of tax is the Mineral Extraction Tax in the Russian Federation. It is levied at a uniform rate across all mines with varying exemptions and depreciation allowances.

[17] Sometimes a distinction for royalty has been made as an interest free of production expense; see for example Maxwell (1954, 1995) with reference to the United States. A recent account of mineral royalties with international cases has been provided in Otto et al. (2006).

[18] Otto et al. (2006), p.50, provide a detailed definition of royalty as '[a] royalty is any tax that exhibits one or more of the following attributes: the law creating the tax calls that tax a royalty; the intent of the tax is to make a payment to the owner of the mineral as compensation for transferring to the taxpayer the ownership of the mineral or the right to sell that mineral; the intent of the tax is to charge the producer of the mineral for the right to mine the mineral produced; the tax is special to mines and is not imposed on other industries.'

[19] South Africa has recently introduced a variable royalty regime, changeable with commodity prices that will be levied on the base of sales revenue (Cawood, 2010).

[20] This would be true for unit based and ad valorem type royalties only if they are the only instruments collecting a notional value of rent which is not clearly defined.

[21] Where a royalty is a gross receipt tax, it resembles a general sales tax and appears to be royalty in name only.

Assignment of resource rent tax and revenue sharing

The general question of assignment of rent tax base and revenue sharing is relevant under any tax assignment scheme.[22] The clearest case of assignment of resource rents would be through assignment of resource rent as a tax base to a certain level of government. In other cases, it could take place through a sharing of the tax base, where different levels of government levy their own taxes. Revenue sharing on derivation basis may also be part of the assignment scheme. Assuming that resource rent taxes are levied at an efficient level and the same shares apply, base and revenue sharing may achieve the same outcomes for the producing regions because both schemes will result in the same amount of revenue with the producing regions. In practice, the shares of exhaustible resource rent provided under revenue sharing, belonging to producing regions and the rest of the country, may or may not be the same as base sharing. Tax assignment may give a higher share to the centre but impose a derivation based high share in revenues for the producing regions. On the other hand, if the country has not legislated revenue sharing arrangements, shares in the base will determine the revenue shares of different levels of government. In this case, the rent assignment will take place through base sharing. If there is efficient central taxation, the only efficiency important at the subnational level is on the expenditure side. Therefore, the discussion in the following chapters posits the rent tax assignment question allowing for different types of tax and revenue sharing arrangements to operate under it. For the purposes of the following chapters, 'rent assignment' means the final shares of producing regions against the rest of the country, derived from base sharing and/or revenue sharing arrangements.

[22] McLure (2003), p.205, provides five alternatives as 'forms of revenue assignment' for oil tax revenues.

Main arguments in favor of central assignment of rent taxes and revenue shares

The non-neutrality of rent assignment, if authenticated, implicitly raises a question about the balance of arguments in favor of centralization. Therefore, it will be useful to briefly recount these arguments here. Efficiency of rent collection arrangements is an important consideration in tax policy. It allows governments to avoid creating deleterious effects of taxation on investment decisions, pace of extraction, type of methods used to extract resources, processing choices and final usage. Rent tax assignment choices are considered under the efficiency framework. A considerable quantum of research has been devoted to elaborating conditions under which tax efficiency operates.[23] This literature deals with the difficulties of computing rent and variations in rent amounts over time.[24] International commodity prices are known to fluctuate. At the same time, production processes undergo technological changes, in turn affecting production costs. All this makes computing rents complex requiring high levels of capacity at various levels of government. Generally, it is assumed, sometimes with weak justifications, that central levels of government have higher capacity. This argument alone sways the assignment question, when it comes to exhaustible resource rents, in favor of centralization although even here we may get inefficient taxes. The need to employ efficient taxation in this way leads to arguments for centralization of rent taxes.

[23] For example, see Boadway and Flatters (1993), Daniel, Keen and McPherson (2010).

[24] Most countries use various methods to arrive at a plausible and agreed amount of rent that is to be siphoned away for the common good of the society. Recent dispute over mineral rent tax rate in Australia is a manifestation of the difficulty of setting the exact size of the base even in developed economies (Novak, 2010). In developing nations, the size of the rent in mining operations is often difficult to work out due to specific conditions of the mining operations (Hossain, 2003). Concessions may be offered to attract investment (Otto, 2000). Generally, once the base is known there is little argument for setting a rate that is less than hundred percent[24].

Without necessarily deprecating the merits of these arguments, it is easy to say that such argumentation could only justify administrative centralization, without overshadowing the domain of revenue sharing. The producing regions could still receive derivation based shares from centrally administered resource rent taxes. Even if there are incontrovertible arguments in favor of centrally administered resource rent taxes, they by no means can preclude subnational sharing of revenues. The discussion in the following chapters therefore eschews these arguments entirely and focuses on the effects of rent assignment on a less studied area, namely public investment of resource rents.

Another set of three issues commonly raised in connection with rent taxation pertains to the potential effects of rent revenue on the economy. First issue is the injection of revenues derived from resource rents gathered in the producing regions that lower the tax price of public services provided in their jurisdictions. The tax price change induces labor migration due to differences in net fiscal benefits between producing and non-producing regions. It is argued that this is an inefficient outcome. To prevent such labor migration, exhaustible resource rents should be spread over a country as much as possible, it is argued. This argument seemingly combines allocation and distribution choices. Another related issue works at all levels of government. Resource rents may cause exchange rate effects and crowding out of other sectors in the economy. Macroeconomic effects may require stabilization, which lies in the functional purview of the central government. Thirdly, fluctuations in commodity prices create unpredictability in rent revenues.[25] Rent based revenues are pro-cyclical exposing subnational governments to fiscal pressures during economic downturns. Subnational governments, when they have a legally

[25] Boadway and Keen (2010), Figure 2.1, have documented fluctuations in real prices of crude oil, copper and uranium between 1966 and 2007, showing large swings without any pattern.

constrained access to credit markets, have a lower capacity than central governments to absorb the effects of revenue fluctuations (Norregaard, 1997).

All three issues, it is argued, point toward centralization of rent. These arguments are stronger than the efficiency considerations because their effects go beyond tax administration. In addition to assignment of rent taxes to the center, on the basis of these arguments, producing regions can be deprived of high shares in revenue also. While recognizing these arguments, it suffices to say here that none of them makes a water tight case for complete centralization of exhaustible resource rents. Arrangements at subnational levels, such as savings funds, endowment facilities or fiscal rules, may provide answers that are possible at the central level.[26] The following chapters do not attempt to address these options in order to focus on a relatively less studied issue in rent assignment, namely the effects of rent assignment on public investment.

Resource rent and concern for long run productivity

Exhaustible natural resources present some unique issues for policy formulation. They are further rendered interesting when viewed in a federal context. Theory argues for a wider sharing of rents in a society (Dasgupta & Heal, 1979; McKenzie, 2006), but it does not clearly spell out whether this sharing should be at the regional level or at the national level. The ownership question assumes significance when it comes to sharing of resource rents. This is partly due to the nature of the resource rents. Exhaustible resources are irreplaceable engendering strong ownership claims. They cannot be regenerated in timescales relevant to human planning cycles. With an exhaustible resource, 'the intertemporal sum of the services provided by a given stock of the resource is finite' (Dasgupta, 1984, p. 153). Exhaustible natural resources are

[26] In the United States for example, five states have large savings funds (Richardson, 1999).

generally endowed unequally to certain regions.[27] Many times their ownership is claimed by the society as a whole. Economic theory presents arguments in favor of this treatment arguing that since exhaustible resources generate rents and the tax cannot be shifted,[28] their community ownership is more efficient over individual ownership. The efficiency argument is based on the distortionary effects of rent on economic agents. It will be inefficient to leave these rents to be exploited by private individuals. Taxation of rents to the point of their exhaustion and then utilization of revenue for the general community weal is a practical mechanism for community ownership.

This provides a measure of equity within society, at the same time ensuring that economic distortion is minimized. However, what is not clear is what constitutes a community for the purposes of sharing of resources. In practice this question is not clearly answered. Community could arbitrarily comprise individuals living within the geographic confines of country or a subnational region. It could be all individuals of such a set currently alive or also include any number of future generations. A cursory observation of the way nations are carved up shows that communities for the purpose of sharing of exhaustible resource rents varies very much in size, nature, constitution and timeliness. Economic theory for the purposes of rent assignment does not attempt to create another definition but takes politically constituted communities as given.

Rent assignment discussions therefore do not address community ownership of rents and its effects on expenditure choices. Even if efficient taxation is employed and macroeconomic instability is addressed through fiscal rules, expenditure choices for accumulating resource rents are important to development and growth in the economy. As discussed below, unlike other

[27] The same may hold for renewable natural resources.
[28] For a classical account of the arguments, see Kitrell (1957). For a recent discussion see Rothman (2000).

forms of taxation, rent tax combined with appropriate expenditure choices, can be an instrument for development and long term sustainability of productivity. Implicitly, rent assignment based on the arguments recounted above, assumes that expenditure preferences are the same across jurisdictions in a country. More specifically, it assumes that producing regions and communities asserting ownership to exhaustible resource endowments have the same rent investment preferences as other communities in a nation. These assumptions are not plausible. The discussion in the following chapters addresses this discrepancy in the rent assignment question. It connects rent assignment with expenditure choices, employing a policy framework, and allows for differences in preferences for rent investment among regions.

An argument for linking rent assignment to expenditure choices is made from the perspective of development and growth. Finite resources extracted from endowments are used as inputs in the current production processes. They sustain current levels of consumption. Resource rent is collected by government and can be invested or consumed. Once the stocks decline or are exhausted, the productivity of the economy will be adversely affected. Decline of stocks can mean declining levels of consumption and welfare in this situation. If rent is consumed, the productivity and consumption level become low as stocks approach zero. However, if rent is invested in producible capital, it will sustain current levels of production.[29] This policy choice is referred to as the Hartwick Rule (Hartwick, 1977). More specifically, all the rent from exhaustible resource should be invested in producible capital to preserve current levels of productivity and consumption. This principle is the normative outcome for policy choices in most of the following discussion.

[29] This is different from other taxes as the base for such taxes is not exhaustible. Taxes may distort economic behavior but they can be harvested in perpetuity as long as the transactions or incomes are there.

A related concept, genuine savings or genuine growth, attempts to take exhaustible resource decline and environmental damages into consideration. In this discussion, the issue of rent assignment is being analyzed assuming that the notions of the Hartwick Rule and genuine national savings indicate an interest in seeking optimal rent investment namely a level of investment that sustains productivity of the economy. Exhaustible natural resources are an endowment but by their nature the stocks deplete regularly with extraction. This means that their extraction is carried on over a finite period of time. Extraction does two things: it makes an input available to the production of goods and services within the economy and it also deprives future generations of an input in the production process. It also reduces the opportunity to collect rents in the future. If the rent is consumed by the current generation, it enhances their welfare measured in consumption terms, but it potentially reduces the welfare of the future generations. The Hartwick Rule is a theoretical concept which describes that under certain conditions intergenerational equity can be guaranteed even when exhaustible natural resources are extracted. These conditions include constant returns to scale production, stable population and no technological progress. It states that if rents from exhaustible natural resources are invested in long term replaceable capital, then there is no change in the intergenerational welfare (Hartwick 1977). According to the Hartwick Rule

$$\Delta k = - y(t)$$

Where Δk is the change in capital in time t and y(t) is the amount of resource extracted in the same time period. The rule means that the all the resource rent should be invested in producing new physical capital. If this condition is met then consumption remains unchanged over all time periods.

The intergenerational distribution of benefits within the federal arrangement of government is complex. Relying on the Hartwick Rule, we would argue that the intergenerational assignment of benefits is a function of extraction rate, distribution of ownership and the type of investments or consumption generated by the rental income. Exhaustible natural resource is available, by definition, in some time periods only. Its availability to production immediately creates an intergenerational equity question. If it is available to individuals living in the prior time period only, then it is their endowment and has a wealth and income effect during it. The consumption level of the individuals in the prior time period will be significantly improved, depending upon the size of the endowment and cost of extraction. Going by a utilitarian perspective, the intergenerational equity question is not significant. In the later time period, when the resource has been exhausted, individuals will not have any endowment to rely on. There should be a negative of the income and wealth effects in operation, reducing their consumption levels. As long the sum of generational welfare has increased, which generation benefited the most is unimportant. But applying Rawls principle, if we assume that no individual before the start of time knows if he will belong to the prior generation or the later one, then he will only choose an intertemporal distribution of the endowment such that his consumption stays the same in either time period. To achieve a no envy result, some distribution principle is required.

Hartwick (1977) suggests that this can be achieved if the royalty from the exhaustible natural resource is invested in reproducible capital. In the first time period when the resource is extracted all the rents should be invested in production of reproducible capital which leads to a higher level of consumption for the individuals in that time period. In the second time period, only a higher stock of reproducible capital is available. This becomes an endowment for the

second generation and ensures that their consumption level, measured in present value terms, does not change below that of individuals in the preceding time period. The same principle has been endorsed by Solow (1986) when he suggests that as a rule, efficiency and equity both can be achieved if the rents from exhaustible natural resources are invested in capital formation. A nice implication of the Hartwick Rule and Solow's discussion is that equity does not need to be considered separately. As long as efficiency is achieved and the Hartwick Rules is followed, equity follows. In other words, an exhaustible resource is also part of the capital available for production. As long the capital available for all time periods is the same, given no increase in population or change in technology, it does not matter whether a natural resource or reproducible capital forms the stock of capital in a certain time period.

Intergenerational equity is a one way concept, where the earlier generation can take actions to improve the later generation's welfare. But the other way round is not possible due to one way flow of actions (Rawls, 1971). There are various views of maximizing intergenerational equity, ranging from the utilitarian to the Rawlsian. The Rawlsian max-min social welfare function would ensure that the welfare of the poorest generation is maximized (Solow, 1974). There are apparent problems with both the views. But Hartwick Rule by comparison offers a simpler criterion. An simple analysis of rent sharing and welfare consequences is presented in Appendix A.1.

The following chapters

In the following three chapters, this simple framework is expanded to take into account differences in preferences, tax base endowments and sharing of exhaustible resource tax base. Chapter 2 begins with a discussion of the value of long-lived public goods to economic

development and growth. This is later used as a policy device to set up the theoretical model for rent tax assignment in a federal country. The theoretical model presents a general case in a two-region federation where regions vary in tax base endowments and preferences for long-lived public goods. After the discussion of the general case, additional cases are presented to discuss intergovernmental grants, differences in tax base endowments (general measures of regional wealth) and other subnational taxes. The results yield hypotheses that can be empirically tested. The government while allocating fiscal resources makes a fundamental choice, how much to allocate to investment in public capital out of the total expenditure. The ratio between investment and total expenditure is kept a certain level as governments seek to provide higher current expenditures to their populations. The increase in long-lived public goods is another objective that the governments pursue while attempting to keep current expenditures at a certain desirable level. The theoretical model attempts to explain the effect of reduction in subnational share of resource rents in this context. After presenting the model we then use six cases to characterize different situations in the world federations.

In Chapter 3 an empirical model is developed to test the implications of the theoretical model. The hypothesis in Chapter 2 predicts that an increase in the federal share of rent at the expense of producing regions leads to a decline in investment in long-lived public goods. Such a policy change namely an increase in federal share of rent, has been mapped in the Russian Federation from 2002 to 2007. This experience offers a quasi natural experiment for empirical evaluation of the effects of the policy change on investment in long-lived public goods. A panel data of regions of Russia from 2000 to 2008 is used to test the theoretical results from the first paper. The summary statistics presented are normalized to assess application of program evaluation methods. The empirical models are discussed in the paper to lay out the assumptions

maintained on the model. Before testing for the effect of changes in resource rent revenue shares of regions, we have identified some determinants of new investment in fixed public capital in the regions of Russia. The variables that have a significant effect on new investment in fixed public capital in the regions of Russia are used as controls for the subsequent estimations. Using program evaluation methods, we employ two types of difference-in-differences estimators to study the effect of changes in the regional share of rent revenue on new investment in fixed public capital. The first set of estimators estimates the effect on new investment in fixed public capital separately for each post treatment year. The second type of estimator estimates the effect on new investment in fixed public capital for all the entire post treatment time period. The robustness of the results from the difference-in-differences estimators are then checked using two additional methods. First we estimate the effects using bias corrected matching estimator. The results corroborate the general findings obtained from the difference-in-differences estimation. Then, we use a propensity score matching to test the validity of the estimated effects. Again we find that the results are generally the same as obtained from difference-in-differences estimation.

Chapter 4 offers some world examples of rent assignment and provides evidence that identity based ownership of resource rents may not be neutral to rent assignment. There we provide a brief review of the resource rent tax assignment in the major federations. The variations in the treatment are discussed. We also provide examples on rent tax instruments employed in these countries at different levels and conclude that resource rent tax assignment should not be left to the general assignment problem but should be given a special consideration. Using data from the Russian Federation we use a difference-in-difference-in-differences estimator to find out the differential effects of increases in the federal share of resource rent at the expense of regions. The differential effect is mapped out for producing regions and

producing republics. The results show that the new investment in public capital in the republics with claims to ethnic identity declines more than it does in the other producing regions. Using the percentage of ethnic Russian population in the total population we find that a higher percentage of ethnic Russians in the population increases the investment in new fixed public capital. The conclusion makes a case for enhancing the scope of issues that should be considered for rent assignment.

Chapter 5 is a brief narration of the most important results obtained and it concludes the discussion. It argues for widening the scope of rent assignment discussions and recounts some of the reasons from earlier chapters in favor of subnational rights in exhaustible resource rents.

Chapter 2 A Theoretical Model for Exhaustible Resource Rent Assignment

Introduction

In this chapter we are presenting a model to analyze the effects of assignment of rent tax levied on an exhaustible resource and revenue sharing on investment in long-lived public goods. It is predicated on the main argument that rent tax assignment and rent revenue sharing are not neutral in terms of effects on investment in long-lived public goods. Producing regions may differ from non-producing jurisdictions in their preference for public infrastructure and other long-lived public goods. Such differences, if present among the two types of regions, render rent assignment non-neutral to rent allocation. In general such differences are not studied. The model that is laid out later in this chapter attempts to take differences in preferences into account and maps them out on rent allocation. The rent assignment is characterized by a change in the shares between federal and subnational governments. Tax base and revenue sharing are assumed to be equivalent to simplify the model. The theoretical discussion presents first a general case, modeling a federation with differential tax base endowments. Then it sets out variations on the general model by bringing in the role of intergovernmental transfers and differences in regional level preferences for long-lived public goods. The differences in preferences are allowed but not necessarily invoked as assumptions. They become relevant to some results.

The assignment of rent tax in multi-tiered government has not been discussed from this perspective. In order to focus on the effects of assignment on investment in public goods, we abstract away from the tax design issues and present an approach that integrates tax assignment

and expenditure allocation. To lay out this approach the following narrative alludes to several issues that are germane to the discussion, focusing on a normative connection between exhaustible resource rent and investment in long-lived public goods, efficiency and equity as relates to use of exhaustible resources and the world federations endowed with asymmetric exhaustible resource endowments. These allusions at the outset allow me to characterize the model with its attendant arguments.

Rent tax in general is an instrument for siphoning away economic rents from exhaustible resource extraction to the general benefit of the economy, endorsed in theory for the efficiency gains it provides to the society.[30] As long as the tax instrument scoops up all of it, neither leaving any economic rent in the hands of mineral extracting private companies nor expropriating more than can be counted as the actual rent, it is efficient, providing a rare tool to policy makers. Discussions aiming to hone tax instruments that meet this surgical precision have been recorded from the points of view of feasibility of administration.[31] Some other concerns are computation of profits with fluctuating commodity prices (Bahl & Bird, 2008). We do not pursue these discussions any further here, assuming that design and implementation of such taxation is feasible.[32] Instead we are focusing on the outcomes of rent taxation in a federal setting.[33] In doing so we are attempting to answer a question, as laid out above, that is important both from efficiency and equity perspectives: even if a rent tax is efficiently levied and administered, the

[30] Boadway and Flatters (1993) reiterate the generally held views that resource rent taxes are non-distortionary and allow a distribution of rents over all members of a society; Dasgupta, Heal and Stiglitz (1980) present a discussion of tax instruments with reference to their effects on depletion rates; Bergstrom (1982) argued that an excise tax on oil rents can efficiently capture rents. Similarly, Otto (2000) reiterates the theoretical certitude and in addition provides a description of rent tax instruments in developing countries.

[31] Land (1995) gives a detailed treatment of progressive profit taxation of mineral resources. A discussion of tax instruments and their assignment in federal settings is presented in McKenzie (2006). Table 9.1 shows, using examples from 23 countries, that various types of taxes have been assigned among three tiers of government.

[32] For a discussion of mining tax decentralization in a multi-tiered government, see Otto (2001).

[33] I do not distinguish between royalties and natural resource taxes in my characterization of rent tax as essentially both are effectively taxing economic rent; Watkins (2001) presents a discussion of natural resource royalties, their justifications and usage distinguishing their legal application from natural resource taxes.

level of assignment in a federation has an effect on outcomes, and in turn an effect on efficiency (and equity, as laid out in the Hartwick rule). This examination broadens the scope of efficiency to include expenditure outcomes in addition to the traditional concern with tax efficiency, balancing the focus with regard to the use of rent tax revenue. If efficiency is achieved in this enlarged scope, it ensures equity by sustaining the level of productivity inter-temporally. The question is examined by positing the assignment of rent tax and expenditure questions in a general multi-tiered government framework. The implicit argument is that it is not only taxation alone but expenditures also that determine the efficient (and equitable) outcomes. Unless discussed together, efficiency is at best a partial achievement. This integrated approach of rent tax and capital expenditures adduces a wider scope of efficiency.

The chapter is structured as five sections. Two important building blocks are crafted in the first two sections before the model is discussed. The place of public infrastructure, a type of long-lived public good, in development is the first one. Following a narration of this notion we present a brief description of an important exhaustible resource, petroleum, in federations and in particular the type of revenue and base sharing arrangements that are used. Hence, Section 1 recounts the importance of long-lived public goods and explores their connection with rent taxation from a normative policy perspective. The inclusion of this description is necessary to concretize the notion of efficiency of outcomes. The section sets the stage for the following theoretical framework. It also introduces the enlarged scope of efficiency for policy consideration. The discussion culminates by introducing the tradeoff in expenditure choices between long-lived and consumable public goods in development. Section 2 takes a slight but relevant detour to briefly visit world cases of federations and large countries where the discussion of rent tax assignment could be important. We are referring to these cases to identify

some basic parameters of rent tax assignment in federal countries to make use of them in setting out problems discussed under the theoretical model. The types of tax and base sharing in 10 federations, *inter alia*, are presented. Here my position is that the sheer size of mineral extraction and related revenues, even whilst ignoring the political issues, dictates a relevance of tax and expenditure assignments that could only be ignored at the peril of loss of efficiency. Various types of instruments used for rent tax collection and sharing ratios are summarized.

Section 3 presents a theoretical model for exhaustible rent assignment in a federation and constitutes the core of this discussion. The model builds a general case where long-lived public goods are pursued as the first objective of development. This pursuit is arguably made under the Hartwhick rule, genuine savings approach or simply infrastructure for growth approach. The provision of consumable public goods, competing for fiscal resources, form the second objective of development policy. In the general case, federal taxation on the general tax base and the natural resource rent operate as distinct policy variables. We allow for a differential social valuation of the two types of public goods across subnational jurisdictions, allowing policy choices which can emphasize one over the other. The choices are made in the subnational domain. The general case presents a model for investments in the stock of long-lived goods in a federation with subnational governments operating under the tutelage of the center. This case applies to most established federations as well as large unitary countries under certain assumptions. The model is, however, sufficiently flexible to analyze the effects of some other policy variables.

Section 4 contains a discussion of relaxing some of the strict assumptions of the general case. We allow for additional scenarios to be depicted through variations in the model. First of all, federal level investment in long-lived public goods is brought into the model. This provides

insights into the impact of federal rent taxation on the development of long-lived public goods. The case allows for direct investment in long-lived public goods through a straightforward budgetary allocation, in the shape of vertical programs or establishing a savings fund. Developing the model further, we bring in the role of explicit transfers. The general case has implicit transfers built in the model. Equalization transfers in the model show that the results will vary with additional parameters when considered. In another iteration of the model, the regional fiscal resource is shown as a function of the subnational tax policy and administration. Whether changes in subnational taxation, given the federal taxes on general tax base and natural resource rent, would affect increase in long-lived public goods or not. The discussion of each case is validated by reference to cases from the federations around the world. Finally, in many cases, resource rich regions are poor and under-populated compared with the rest of the country. The question of whether these facts change the results of the earlier analysis or not, is also modeled. For the purposes of this analysis we bring in changes in distribution of the fiscal resource, which is a proxy for regions' wealth.

Section 5 concludes the discussion of the theoretical model. The contribution of the model to the assignment question in federations is highlighted. The policy preference for long-lived public goods (or lack thereof) varies across regions. Where there is a higher preference for sustainable improvements in welfare, as would be expected in regions with high resource ownership, resource rent tax (or revenue) assignment is not neutral to new investments in long-lived public goods. The expectation for higher preference in regions endowed with exhaustible resources is based on its connection with ownership. But there may be cases where such preference is not found.

Role of Long-lived Public Goods in Development

Exhaustible resources are often key inputs in production processes sustaining the current level of social welfare in a country. For example, production processes with presently available technology are dependent on exhaustible resources, in turn generating a similar dependence of household consumption on them.[34] At the same time, allocation of rent to production of consumable goods or new investment in long-lived goods is a choice that partially determines the stock of capital over time. If rents together with the exhaustible resource are consumed, then the outcome ceteris paribus, leads to lower productivity and consumption over time. If however, long-lived public goods are generated in addition to consumption, productivity is sustainable inter-temporally. If public infrastructure is one of the expenditures choices for accumulating rent revenue, it is pertinent to see if it is relevance and importance to development.

Public good provision is central to pursuit of development. Governments pursue development through taxation, expenditure and regulation, but largely through public expenditure.[35] As a result of this expenditure various types of public goods are provided. These public goods in various ways have a positive effect on human welfare (Anand & Ravillion, 1993)[36] and most public goods are known to have a positive income elasticity of demand.[37] Commonly recognized public goods like childhood vaccination, public health, urban planning,

[34] The production processes use both exhaustible and renewable resources as inputs. Here, and later in this section, only one type of resources is specifically mentioned because of the focus of this paper on exhaustible resource rents.
[35] This assertion is made to focus on public expenditure made out of rent tax revenue but is by no means unsupported by evidence. Taxation, despite its redistributive effect is best treated as a revenue raising measure. The effects of taxation on economic development have been discussed as incentives to development (Wasylenko, 1999 provides a survey of literature on taxation and economic development); regulation has its effects on welfare but is limited in scope.
[36] As an indirect effect, Cellini, Ferreira and Rothstein (2010) set out empirical evidence showing there is increase in housing values as a result of school investments; Brandts and Rivas (2009) present experimental evidence demonstrating that institutional environment with a higher punishment possibilities results in higher well being controlling for income and other relevant variables; Sandler and Arce (2007) note the emphasis on public goods as means to development in international financial assistance to developing countries.
[37] For example Hewitt (2007) presents empirical estimates of national public goods where the demand for such goods increases concavely with income;

education and road have well recognized effects for social welfare and a higher level of consumption of public goods in some ways indicates that they are synonymous with development. Not only that but centralized versus decentralized mandates of providing public goods in multi-tiered government have an effect on public investment expenditures.[38] However, both development and public goods are understood very differently by individuals and development has been recognized as a set of choices that emerges out of a number of variables including but not limited to economic growth.[39] The definitional spread results in changing relative emphasis on the type of public goods but a large fraction of public expenditure in long-lived public goods is never absent from government decisions. In fact, large scale investments in long-lived public goods have been the hallmark of many government policies.[40]

Discerning government policy distinguishes between types of public goods. When government chooses levels of public goods and the type of public goods that are to be provided, there exists a basic tradeoff between consumable public goods and new investment in long-lived public goods.[41] Repair and maintenance expenditures would also be a complementary part of the choice. Public expenditure directed toward provision of security, system of courts, air traffic control, regulation and monetary policy are consumed in the present. Benefits are enjoyed in the current time period. In contrast to this type of expenditure new capital investment in buildings,

[38] Kochar, Singh, and Singh (2009) using data from Indian Punjab show that central mandates overlaying decentralized public good provision mandates have a positive effect on creating intra-village equality in public expenditure. Using data from 2400 Chinese villages Luo, Zhang, Huang and Rozelle (2007) present evidence for the effect of direct village head election on increased investment in public goods.

[39] A number of insightful discussions have been carried out to expand the scope of development. The classical version of development as synonymous with economic growth was replaced by the UNDP's adoption of Human Development Index as a measure of development, thus enhancing the scope of the term. For instance Pope (2009) uses measures of morbidity and mortality in addition to income; Collier (2009) discussed security and accountability as public goods for development;

[40] For discussions of importance given to development of public infrastructure as a cardinal component of state's development policy see for China (Bai & Qian, 2009), India (Lall, 2007; Banarjee & Somanathan, 2007; Patel and Bhattacharya, 2009), Spain (Salinas-Jiménez, 2004), Canada (Harchaoui, Tarkhani & Warren, 2004), Singapore (Phang, 2002), and United States (Cain, 1997).

[41] Adam and Bevan (2006) argue that public infrastructure has a positive effect on the non-tradable production by generating a productivity bias in favor of places where it is created.

roads, bridges and even research and development produces capital that contributes to higher welfare through technological change, growth and development, guaranteeing the same or higher consumption in the following time periods as well as lifting productivity in the present.[42] Expenditures on teachers and doctors are consumed in the present but have longer term consequences. As a result they would be difficult to classify.

The contribution of public expenditure on long-lived public goods or public infrastructure to growth has been debated and empirically studied. The empirical results have shown the contribution of public expenditure can be positive, negative or may have no effect.[43] But if public expenditure on infrastructure is separated out, it has been shown to have a positive effect on growth. It is due to the perceived or real effects of public infrastructure on growth that nearly all nations pursue an increase in the stock of public infrastructure by making new investments in public capital. Although not very clear, but public infrastructure contributed to development in several ways. Rural infrastructure is recognized to have a positive impact on agricultural productivity and rural economic development.[44] Rural roads have been the touchstone of rural development in developing countries for their known benefits on agriculture productivity, rural

[42] The increase is growth rate is temporary and after sometime the growth rate to its earlier level; the increase in output is however permanent.

[43] Arguments have been made in favor of the positive effect of public infrastructure on growth (Aschauer, 1989; Hulten & Schwab, 1991; Duffy-Deno & Eberts, 1991; Mankiw, Romer & Weil, 1992; Garcia-Mila & McGuire, 1992; Tanzi & Zee, 1997; Eberts & McMillen, 1999; Chandra & Thompson, 2000; Esfahani & Rameriz, 2003; Bronzini & Piselli, 2009; Federke & Bogetic, 2009) and in some empirical studies on metropolitan economies only (Crifield & Panggabean, 1995); In some other studies the effects have been questioned on the basis of estimation techniques (Hotz-Eakin, 1994) or shown to be small (Holtz-Eakin & Schwartz, 1995; Garcia-Mila, McGuire and Porter, 1996). Alesina et al., 2002, find negative effects of public spending on private investment but use wage expenditures. Others have argued the positive effect to be through maintenance of existing stocks (Rioja, 2003). In case of Mexico, using general equilibrium analysis Feltenstein and Ha (1999) show the effect to be negative. Calderon and Serven (2004) present empirical analysis using panel data of 100 countries and show that infrastructure stocks have a positive effect on growth and reduction in income inequality. A recent discussion of an abstract model is contained in Gupta and Barman (2009).

[44] Shenggen and Zhang (2004) present empirical evidence in support of the effect of infrastructure on rural development in China. Bond (1999) discusses the positive effects on public infrastructure on the poor communities. Gibson and Olivia (2009) provide empirical evidence of the positive effect of non-farm infrastructure on employment and incomes in rural Indonesia.

economy and poverty reduction. Development of regions is a result of government provision of infrastructure and other public goods.[45] Development when seen as a wider pursuit, including but not limited to growth, places an even higher value on public infrastructure. Some types of infrastructure are almost a necessary condition for provision of different types of public goods that in turn have positive outcomes for development.[46] For instance, school buildings and health facilities are built to provide public education and health. In other cases, it is both an intermediary good as well as a final consumption good (Eisner, 1991). Through private cost-savings public infrastructure increases productivity.[47] In all these practices of development, public infrastructure is given so much importance that budgetary classification separately lists out capital expenditures from recurrent public expenditures.[48] The role of public infrastructure investment in attracting private investment is considered important, even if the empirical evidence is not watertight.

Assignment of rent tax revenue in a federation assumes significance from another perspective also. Sustainable development as a policy objective is a potential replacement for the traditional economic development. A future decline in welfare is a valid concern for individuals who can enjoy their current consumption if they are relatively free of anxiety about the future. They also care about the welfare of subsequent generations, as their utility is a sum of their current consumption and discounted utility of future generations. Decay of current capital, decline in exhaustible resource stock and stagnation in technological change cause a decline in

[45] The case of three states of India has been presented in Wanmali and Islam (1995).
[46] For instance see (Fay et al., 2005) for a discussion of the effects of access to basic infrastructure services on child-health outcomes in the context of Millennium Development Goals with evidence from cross-country regressions. Huillery (2009) shows that early investments in education during colonial era has a persistent positive effect on educational outcomes in French West Africa.
[47] Using state level data for the United States for the time period 1982-1996, Cohen and Paul (2004) find that public infrastructure results in increases in magnitude and significance of private cost-savings.
[48] Operation and maintenance expenditure and other expenditures like teacher salaries or expenditure on purchase of essential drugs are closely linked with development. They are classified under recurrent expenditures.

consumption per capita (Cheviakov & Hartwick, 2009). In general sustainable development means that social welfare, discounted by the pure rate of pure time preference, should not decline over time. To achieve this end, capital formation attains not only a high significance but meets another challenge. The productive base of a nation, if declining over time, would lead to lower productivity and consumption in the consequent time periods, resulting in a decline in social welfare.

The productive base includes capital in its various forms like manufactured capital, human capital and natural resources. In addition technology, in turn comprising of knowledge and institutions, complete a nation's productive base (Arrow et al., 2004). Maintaining a non-decreasing productive base, at least at its current level and in the measurable domain, is largely a policy that ensures sustaining the achieved levels of capital, depicted by the unchanging sum of all three types of capital. The nature of development itself creates a challenge, namely use of exhaustible resources diminishes the stock of existing capital. Use of exhaustible resource may be a necessary input in the production function of goods in an economy and attain the current potential level of welfare. By definition, the stock of exhaustible resources is finite (Dasgupta & Heal, 1979). Even when exhaustible resource is used up in production of consumable goods and contributes to gains in social welfare, it may lead to decline in the stock of capital. From the point of view of sustainability, use of exhaustible resources in production raises important questions for development. Forgoing usage altogether may neither be desirable and practicable nor necessary under the available technology. But a recognition of the fact is required that such usage leads to a decline in the productive base. If usage of exhaustible resources is off the accounting matrices, it may shore up an incomplete picture of development. On the other hand

the recognition of depletion, even when accounted with new explorations, creates a platform for working out choices that can sustain a nation's productive base.

The current level of capital stock can be sustained over time if exhaustible resource rents are invested in manufactured capital (Solow 1974; Dixit et al. 1980; Solow 1986). Investment of rents in manufactured capital increases its stock over time. It has been argued that all the rents from exhaustible natural resources if invested in manufactured capital, would sustain current productivity (Hartwick, 1977).[49] The policy condition set up in this manner could insure both efficiency and equity considerations (Buchholz et al., 2005). The outcomes are based on the notion of substitutability between natural and manufactured capitals and to some extent, between material and knowledge stocks (Solow, 1993). Despite the normative clarity of these assertions it is not clear under what circumstances this is achievable. More poignantly, it is pertinent to pursue this inquiry to find out under what set of circumstances it is more likely achievable in a federation. From resource exploitation[50] to rent collection and investment, a range of issues pertain to ownership rights and how they are assigned to different levels of government.

Responding to the need for recognizing resource depletion in development measures, the concept of genuine savings has been worked out.[51] So far the work has established that genuine savings provides an accounting docket which can periodically portray changes in a nation's productive base (Dasgupta & Maler, 2000). Various calculations, using some proxies for

[49] Use of exhaustible resource, with rents invested in manufactured capital can provide constant level of consumption over time, under certain conditions (Hartwick, 1978). Dixit et al. (1980) show in a general model of accumulation with heterogeneous capital goods that if valuation of net investment is constant over time, then it would result in intertemporal equity. The change in genuine savings relative to changes in interest rate determine the effects on consumption as rising, declining or remaining stable (Hamiltion & Hartwick, 2005)

[50] Bohn and Deacon (2000) have shown that ownership risk has significant effects on the pace of exploitation.

[51] 'Genuine savings' (Hamilton & Clemens, 1999) and 'genuine investment' (Arrow et al., 2004) are measures that account for resource depletion and adjust standard measures of investment or change in capital with this change. Hamilton, Atkinson and Pearce (1997) clarify the notion of genuine savings using questions of measurement, substitutability, depreciation of manufactured capital, exogenous versus endogenous technological change and preferences for natural assets.

exhaustible resource use, have been made (Arrow et al., 2003). Genuine savings measures, despite the need for further development and data, show that traditional measures of growth and development are majorly over-assessed. When use of exhaustible natural resources (or renewable resources, for that matter) are accounted for, the level of growth achieved by various countries diminishes. In case of oil producing nations it has been shown that growth rate falls in the negative range.[52]

Given the importance of the normative policy prescription, it is important to note that there is often a mismatch between tax and expenditure decisions in this particular domain in federal countries. In federal countries it is the subnational levels that are mostly responsible for public infrastructure. As argued above, rent taxation is often centralized. Natural resource rent taxes are mostly levied by federal government. In some cases, subnational governments are allowed to levy some taxes on the same base or receive parts of the tax through revenue sharing.[53] In federations, only some categories of infrastructure are kept with the federal government; airports, ports, railway tracks, dams, national highways may be built and maintained by federal government due to their trans-jurisdictional externalities. In most cases roads, urban infrastructure, irrigation networks and public buildings for service delivery would be built, operated and maintained by the subnational governments. Creation of public infrastructure by multiple levels of government becomes a complex pursuit.[54] Add to this

[52] Arrow et al. (2004) show, using data for about three decades from 1976 to 2001, that genuine investment defined as a change in genuine wealth is negative for Middle East and North Africa (Table 1). For China, India and Pakistan it is positive but much less than the reported levels of investment as ordinarily defined.

[53] Even in general, allocation of resources between different levels of government can have an impact on economic development. The evidence for China has been presented in Zhang and Zou (1998).

[54] A discussion of infrastructure development in a federal structure can be found in Hulten and Schwab (1997). Presenting data for United States from the Congressional Budget Office for 1956-1989 for eight categories of infrastructure namely highways, mass transit, rail, aviation, water transport, water resources, water supply and sewage treatment, they demonstrate that most of the spending is by state and local governments. Out of the total expenditure on public infrastructure direct federal expenditures was 14 percent, federal grants accounted for another 18 and state and local expenditures made up the remaining 68 percent.

financing from exhaustible resource rent taxation and the arrangement would demand a further careful consideration. In addition to the nearly ubiquitous political concerns regarding distribution of rent tax revenue, a key question is concerns creation of public infrastructure for development, whether it by or the federal government. What types of rent tax assignment or rent revenue sharing would be conducive to investment in public infrastructure is discussed here in this context.

Pursuing development and increase in public infrastructure in a federal country where exhaustible resource revenue is an important component of public finance highlights the importance of rent tax assignment and rent revenue sharing within the consideration of investment in infrastructure. Development policy is a balancing act. The demand of consumable public goods has a high claim on public budgets. Growth in infrastructure stock has a tradeoff with current expenditures on education, health, agriculture extension, offices and regulation. While pursuing investment in long-lived public goods, governments attempt to provide public goods for current consumption. Equity demands a wider sharing of the resource. Stability concerns may warrant return of a major share of revenue on derivation basis. At the same time, pursuit of development would entail additional choices in revenue assignment from exhaustible resource rents. The theoretical model attempts to incorporate such choices and to provide results that would still be relevant to pursuit of development.

Federations with Asymmetric Resource Endowments

The federations allow either one or both levels of government to siphon away economic rents of exhaustible resources. A number of tax instruments are available. Each option has its merits and some demerits. A brief review of rent tax assignment in federal countries shows the

wide variations in practice. Out of the 24 federal countries in the world, at least 12 have petroleum mining as an important component of the gross domestic product. The rent tax or revenue assignment is by no means a question exclusively relevant to the federations. There are a number of large sized countries with multi-tiered governments that are not formally federal but have petroleum mining as an important activity in their economy[55] and distribution of rent amongst jurisdictions carries an importance for policy consideration resembling the assignment question in the federations. The model discusses the formal case of federations but could provide analogous analysis for this set of countries. But for the present, we continue to describe the question for federal countries for the most part. Over the last 20 years, petroleum mining and upstream revenue have been increasing in 12 of these federal countries.[56] When the known reserves are included, 12 federal and large multi-tiered countries possess 52 percent of the total known world reserves of oil and gas.[57] For some federal countries, the contribution from petroleum to GDP is almost or higher than one-fifth of the GDP. For example in Russia it is 16.61 percent and in Venezuela it is 21 percent. In United Arab Emirates it is 34 percent,[58] in Nigeria 39.59 percent and in Iraq 53.87 percent of GDP. Here we have used oil and gas as an example. Rent tax assignment pertaining to gold, diamonds and other minerals would be analogous to this discussion.

Federal countries face a particular challenge in assigning rent tax revenue because of several reasons. First, the resource ownership is a contested territory. There is no universal

[55] Generally recognized federations are: Argentina, Australia, Austria, Belgium, Bosnia and Herzegovina, Brazil, Canada, Comoros, Ethiopia, Germany, India, Malaysia, Mexico, Micronesia, Nigeria, Pakistan, Russia, St. Kitts and Nevis, South Africa, Spain, Switzerland, United Arab Emirates, United States of America and Venezuela are recognized as federations of regions, provinces or states. Iraq, Nepal and Sudan are evolving federations. Other large countries with important subnational regional entities are not formal federations but rent tax assignment issues pertaining to federations are validly applicable to their cases also. In this group would be countries like China, Indonesia, Kazakhstan and .

[56] Based on calculations from the *Oil and Gas Journal* Energy Database.

[57] Calculated from the *Oil and Gas Journal* data base.

[58] Calculated from Table 1, IMF (2009).

principle to settle contending ownership claims of petroleum or mineral reserves in federations. The property rights to natural resources can be distinguished into several levels of ownership including ownership, management rights, development rights, revenue collection and regulation.[59] Several shades of property right assignment can be seen among federal countries. Australia and Canada, for example, have settled the question of property rights in favor of subnational governments but Brazil and Venezuela have invested them in the federation. Pakistan and Russia allow joint ownership by subnational and federal governments. In case of offshore reserves, contrary to expectation, subnational jurisdictions have staked successful claims in Brazil and Australia. In Canada, despite the constitutional cases decided in favor of Canada, Nova Scotia and Newfoundland have gained access to control, regulation and revenue from offshore oil and gas reserves (MacDonald & Thompson, 1986; Jennifer, 2008).[60] In countries where the federal level has vested the property rights in subnational levels of government, it often retains some measure of influence through environmental legislation and export tax provisions.

In some other cases, the clarity of rights is subservient to functional definitions and some policy considerations. For example, arguments made for sharing of petroleum revenue for Iraq substitute a synthetic concept of social surplus, a sum of rents and economic development, for property right (Bishop & Shah, 2008). Second, development of exhaustible resources may impose costs and benefits differentially across regions and measures for mitigating environmental costs that are not located in regions of benefits may also require supra-territorial intervention. This is particularly relevant to offshore mining. Third, natural resource endowments

[59] Schlager and Ostrom (1992) present a taxonomy of property rights over natural resources and lay out the distinctions that stipulate rights to access, exclusion and alienation.
[60] The Atlantic Accord was updated in 2005 as an agreement between Canada and the provinces of Nova Scotia and Newfoundland and Labrador.

translate into fiscal capacity for regions where they are located.[61] Even if the revenues were left to the producing subnational jurisdictions, the arrangement creates demands on the federal government for equalization from the non-producing regions.[62] The fourth issue concerns the macroeconomic effects of commodity exports. These effects visit on the manufacturing sectors due to exchange rate appreciation. Additionally, reallocation of factors of production may result in increase in wages and may be even cost of capital in the non-producing regions.[63] Fifth is a related concern that rent tax revenue concentrated in some regions will induce migration of labor and capital leading to inefficient outcomes (McLure, 2003). This concern of course is constructed in a particular setting where the present allocation of factors is taken to be efficient and any change brought about by exhaustible resource mining, both upstream and downstream, would be considered to be a departure from the equilibrium.

On the other hand decentralization of rent taxation, with or without natural resource management, is a meritorious option as it creates a higher level of political stability when strong demands for ownership rights are assuaged.[64] The existence of royalties on mineral resources is an express recognition of ownership rights of communities, provinces or states or, as the case may be, of the nation. Due to their strong nexus with resource ownership and consequent political basis, they are often ensconced in law.[65] Such ownership rights are recognized politically, consequently translating into begrudging fiscal regimes. Ownership per se is not

[61] In Australia, the rent tax revenues are counted toward a state or territory's fiscal capacity for calculation of relativities.
[62] In Canada, the equalization scheme came under pressure when the revenues in Alberta and Saskatchewan increased as a result of oil and gas mining in their territories. A solution was found in the form of restricting the calculation of the equalization standard to 10 provinces, leaving out Alberta and Saskatchewan.
[63] Boadway (2006) provides a description of such effects in a federal country
[64] This position is certainly exemplified in cases of Australia, Brazil and Canada as the federal authorities have conceded some or all components of exhaustible resource management and shared major shares of rent tax revenue with the subnational entities. More recently, in Pakistan the constitutional amendments have recognized the ownership rights of the provinces over natural resources. Another viewpoint has been presented by McLure (1994) arguing that centralization of rent taxation would stabilize the Russian Federation.
[65] Otto et al. (2006) present an analysis of the mineral royalty regimes for a select number of countries and find that they often defined and elaborated in the legal framework.

discussed as a reason for awarding rent taxation to a subnational jurisdiction primarily due to the concerns highlighted above. If rents are considered a patrimony and frittered away, conditions described as the 'Dutch disease' or the so called 'resource curse' would not be unexpected outcomes. It is however a valid question that would communities with strong ownership bias be more predisposed to frittering away rents by indulging in easy consumption or would they be more likely inclined toward making the optimal use of the finite rent. The model in this paper leaves the option of considering that communities with strong ownership rights may be inclined toward generating producible capital. Beyond arguments in support of the connection between ownership claims and preference for rent investment, this remains an empirical question.

A number of imposts are used to siphon away rents by different tiers of government. Ranging from royalties to differential corporate income tax, the purpose of these imposts is to collect the exhaustible resource rents and place them in the general coffers for production of public goods. The theoretical clarity of rent tax efficiency is only matched by the operational difficulties of its administration. The rents, defined as the sum of sales revenues and extraction costs, are not easy to calculate with fluctuating world commodity prices, changeable technological solutions and information asymmetries abounding between mining companies and government entities. The governments attempt to scoop up rents by levying a number of taxes.[66] The instruments are not only multiple but they vary across nations and over time. Despite the medley of tax instruments, the effective tax base remains the economic rent in each case as long as the rate is chosen appropriately. For the purposes of the discussion in this paper, all the federal taxes are recognized as one effective tax. Similarly, all subnational taxes are defined as one effective subnational tax.

[66] Sometimes, the revenue from mineral resources is classified as non-tax item as in case of India (Noronha & Srivastava, 2010). Accounting classification however would not change the basic nature of the levies.

In addition to allowing subnational regions levy their own taxes on the shared base, federations in some cases share revenues with the regions. If the federation recognizes the property rights of the regions, then revenue sharing has higher sharing ratios in the formula in favor of subnational governments and sharing is on derivation basis. This is the most common case as exemplified by Australia, Brazil and Pakistan. In case the federation asserts its property rights on the resources, as is most commonly the case with offshore petroleum reserves, the revenues either form part of the general equalization pool or stay separately with the federation. Canada provides an example of the former treatment where the federal share forms part of the general distributable pool. On the other hand in India, upstream petroleum levies are not part of the distributable pool for the National Finance Commission Award. The model presented in this chapter does not distinguish between tax rates and revenue shares and treats them as equivalent. This is because, it is assumed that when rent taxes are levied at an efficient level, base sharing and revenue sharing will results in the same amount of revenue for the producing regions.

Equalization, an ongoing policy concern in federations, aims at bringing horizontal imbalances in subnational fiscal resources, the potential government revenues, within some acceptable range by instituting intergovernmental transfers. Treatment of natural resource rent revenues varies among different federations. In Australia, the Commonwealth Grants Commission includes rent tax revenues in the state's fiscal capacity for determining relativities (CGC, 2008). As a result if a state has a smaller than average share of general tax base excluding natural resource rents but the total tax base share is above average, it is not eligible for federal transfers. Its hemispheric opposite, Canada has revised its equalization scheme to exclude Alberta and Saskatchewan from the calculation of the standard fiscal capacity with the effect that the size of the federal distributable pool does not rise with an increase in oil prices, laying a

relatively smaller burden on the federal budget. At the same time, the rent tax revenue of Newfoundland and Nova Scotia is not included in the calculation of their fiscal capacity, allowing them to remain eligible for federal transfers. In general 50 percent of natural resource revenue is excluded from fiscal capacity calculation (Pourde, 2010). Pakistan's federal transfers treat rent tax revenues as a separate stream. In case of India, oil and gas royalties are channeled into the producing states' non-tax revenue excluding it from revenue sharing considerations (Noronha & Srivastava, 2010). The Russian equalization system uses oil and gas revenues for general transfers but allows revenue sharing from income tax on derivation basis (Kurlyandskaya, 2007). In Indonesia, the natural resource revenues are contested and an argument was made that they should be kept separate from the general equalization pool because they are shared as a compensatory measure for environmental costs (Bahl & Tumenassan, 2002).

Various investment instruments are also in vogue. The best known are the stabilization and saving fund schemes. The effect on funds on public infrastructure depends upon the transparency and predictable rules. In Russia a fund was created in 2004. Since 2009 it has been replaced by a Investment Fund. In Canada, a fund exists at the provincial level named as Alberta Heritage Fund. The stabilization fund in Venezuela did not produce the results envisaged at the design stage. The funds despite their mixed experience remain an instrument of choice. Some more discussion is adduced under the model. For the purposes of the model, they may mean the same thing as investment depending upon the allowable expenditures.

A Model for Exhaustible Resource Rent Assignment

The federation comprises of two regions A and B and is denoted by two types of taxes and a pure public good that is non-rival and non-excludible in both regions. The federation has precedence over regions that is manifested in the shape of primary decisions on the level of taxes and the regions subsequently deciding in the residual policy space.[67] Two types of fiscal resources are available, *Y* and *M*. *Y* is a general fiscal resource[68] that is distributed in the two regions with $Y_A + Y_B = Y$, where Y_i is the resource located in region *i*, *i* = A, B. While defining the fiscal resource the social planner decides what is to be allocated to private goods.[69]

Out of the total fiscal resource, pY, $p \in (0,1)$, is located in Region A. In addition to this, an exhaustible natural resource endowment is placed in Region A. Mining of this resource results in an extracted value *M*, part of which is an ascertainable economic rent τM. The federation shares the rent as a tax base with Region A while enjoying precedence in setting its tax rate. The rent tax is only administered at an efficient level. The efficiency condition means that $\tau = \alpha + \beta$, where α is the federal rent tax and β is the regional rent tax applied by Region A only.[70] To

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[67] Most federations function in accordance with this principle.

[68] The fiscal resource is defined as the outcome of tax policy and administration as:
$Y = m(I).\boldsymbol{\Omega}$
Where $m(.)$ is a function of total income and $\boldsymbol{\Omega}$ is a vector of income brackets. The function $m(.)$ defines the tax base on total income $\boldsymbol{I}$ by laying down definitions of tax base (income, consumption or wealth), imposing exemptions and deductions and awarding credits. It is obvious that $\boldsymbol{I} - \vartheta Y$ is the after tax income and that remains decentralized to private individuals and is thus allocated to private goods. Tax policy, comprising of $m(.)$ and $\boldsymbol{\Omega}$ remains unchanged for the most part, in the discussion here. Therefore, for expositional simplification, I let Y be the taxable base.

[69] Further to the explanation in the last footnote hereinbefore: this is plausible to see as a result of the tax policy. Choosing a definition of a tax base itself involves applying exemptions and deductions, to state two possible ways, which in turn allow the social planner to allocate resources to private goods. The social planner in this case can make this decision because the subnational governments are not allowed to have an independent tax policy. In a case discussed as Problem 6, the regions can choose their own tax rates and this will constrain how much can the social planner allocate to private goods.

[70] In practice a number of tax instruments are used to siphon away economic rents. The list includes royalty, excise duty, corporate income tax, severance tax. α denotes the effective tax rate. If there is only one tax on economic rent, then α will denote tax rate.

concretize the notion of α here it would be appropriate to clarify that it is the fraction of rent collected by the federal tax policy. It corresponds to all the levies enforced by the federal government. In other words it is the effective tax rate on economic rent. The federal precedence and efficiency condition together ensure that choosing α also constrains Region A in setting β. The federation levies a tax on the general tax base also in way that ϑY is taken up by the federation, using it for the national pure public good *G* that is consumed all over the nation. To focus on the issue of rent tax assignment and its effect on long-lived public goods, we assume that there are no externalities of taxation at either level in the federation.[71] As a result of the federal tax on the general base, only $(1-\vartheta).pY$ is available as fiscal resource for regional expenditures in Region A and $(1-\vartheta)(1-p)Y$ in Region B. Rent revenue may be a substitute for a higher overall tax burden. While considering a linkage between rent assignment and expenditure choices, we assume that this substitution works for only the current consumption of rent and does not affect investment preferences.

Each region provides regional public goods that are locally non-rival and non-excludable. The residents of the other region are excluded from local public goods. Budgetary decisions allocate the available fiscal resource in a region to two composite public goods X_i and some C_i. In each region, $X_i$is a long-lived public good and C_i is a consumable public good that once provided can only be consumed instantaneously. The political process of exercising citizen choices results in allocation of fairly stable shares of the fiscal resource to each type of public goods in each region such that π_i is the share of the total fiscal resource available in region *i* to long-lived public goods. Using the preferences in each region for long-lived public goods, $q.(1-\vartheta)Y$, $q \in [0,1]$, of the total resource is spent on building long-lived public goods, where

[71] The case for federal tax influencing subnational decisions and subnational jurisdictions producing horizontal tax externalities is discussed in Goodspeed (2000). The paper also provides empirical estimation of the size of effects.

$q = \pi_A.p + \pi_B(1-p)$. Choosing q leaves $(1-q)(1-\vartheta)Y$ for consumable regional public goods, C_i. It is also clear that $q = \pi_A.p + \pi_B(1-p)$ embodies the results of the preference for long-lived public goods in each region.[72] We assume that $\pi_A \geq \pi_B$ to sketch out the results concretely. This assumption is relaxed for some of the analysis later on in the discussion. By this formulation, the omniscient legislative process by choosing q allocates $(1-q)$ of the fiscal resource to provision of consumable public goods in the regions.[73]

To focus on the relevant question of rent assignment and its effects on long-lived public goods, we assume that balanced budgets are a constitutional requirement at all levels. This ensures that available fiscal resource is equivalent to expenditures at each level of government and in every jurisdiction.[74] For completeness, we assume that the expenditure on public goods is completely enshrined in the public expenditure and if there is any private production of public goods that is fully financed by the governments.

The social planner seeking development optimizes an objective function that embodies the simultaneous choice between long-lived public goods and consumable public goods at the national and regional levels of government.[75] In the first instance, the social planner seeks to

[72] Clearly q is not a choice variable for the policy maker with two cases of exception. The distribution of the general national fiscal resource Y and preference for long-lived goods π_i are exogenous. The first case of exception can be readily understood and occurs when the definition of the fiscal resource can be altered through tax policy. The second case of exception is possible when the central planner overrides π_i in the region by creating specific purpose grants for capital development.

[73] The private goods C_i drop out of the model.

[74] Some allocation of Y to X_i may mean transfer of benefits to future consumers. Since costs could also be shifted in this way, I assume the net effect is zero.

[75] Government's objective function has been discussed in the literature as a device to model policy choices. In some cases, it uses policy rules other than the traditional Bergman-Samuelson social welfare function. An early discussion was presented by Behrman and Craig (1987) where regional inequality and output, with a mutual tradeoff, are placed in the objective function. In Grossman and Helpman (1994) government's objective function is the weighted sum of campaign contributions and net of contributions welfare. Kee, Olarreaga and Silva (2007) use a linear government objective function that is a sum of a matrix of foreign contribution to gain market access and a welfare measure that is in turn a sum of tariff revenue, consumer and producer surplus and foreign contributions made to gain market access. More recently Qiao, Martinez-Vazquez and Xu (2008) use the approach to specify a choice between growth and decentralization. Another formulation (Castells & Sole-Olle,2005) uses a variation of Behrman

increase public infrastructure or long-lived public goods. The first policy objective is represented by a function *h* such that

$$h = \pi_A . X_A + \pi_B . X_B \qquad (2.1)$$

where X_i are the changes in the stock of long-lived public goods in region *i*. The change in stock is weighted by the preference for long-lived public goods in each region.[76] to take into account differential subjective valuation of long-lived public goods across regions. Through a choice of ϑ and α, the central planner seeks to influence the level of public goods in the nation. Assuming that the national public good *G* has an effect on the level of investment in long-lived goods in the regions, X_i is a function of ϑ, α, income, sectoral composition of regional product, urbanization and existing stocks of private and public infrastructure.[77] In addition to these variables, government revenue will also affect X_i. Out of these variables, only ϑ and α are the variables amenable to policy choices. Government revenue will have two components and only one of

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and Craig (1987), incorporating a choice between output and regional inequality in the government's objective function. In Collie and Vandenbussche (2006) the government in the home country chooses its tariff to maximize an objective function, which is given by the weighted sum of consumer surplus, profits of domestic firms and tariff revenue. Breuillé and Gary-Bobo (2007) set up local government and central government objective functions. The arguments in the former are social value of public good, disutility of tax, cost of collection effort and landlords' rents. The latter has social utility of national public good, deficit and expected transfers to local governments and weighted local jurisdictions' utility specified in the former.

[76] The function *h* is analytically equivalent to but more tractable than a traditional social welfare function. To see this, let the social welfare function be defined as:

$W = f(U_A(X_A), U_B(X_B))$

Where U_i is the utility gained by a representative agent in region *i* by consuming the benefits of long-lived public good X_i. Maximization by choosing ϑ gives

$$\frac{\partial W}{\partial \vartheta} = \frac{\partial h}{\partial U_A} \cdot \frac{\partial U_A}{\partial X_A} \cdot \frac{\partial X_A}{\partial \vartheta} + \frac{\partial h}{\partial U_A} \cdot \frac{\partial U_B}{\partial X_B} \cdot \frac{\partial X_B}{\partial \vartheta} = w_A \frac{\partial X_A}{\partial \vartheta} + w_B \frac{\partial X_B}{\partial \vartheta}$$

which is same as the result from maximizing *h* with respect to ϑ, with w_i as the weights in place of π_i. Equivalent results would be obtained with maximization with respect to α.

[77] The demand of public infrastructure or long-lived public goods has been studied by Burkhead and Miner (1971), Fay (2001) and Sturm (2001, 2003). These studies classify per capita income, sectoral distribution of GDP, urbanization, farmland and a number of political variables to influence demand for investment in public infrastructure.

these will be affected by the two choice variables. Government revenue determined by intergovernmental transfers will be exogenous.[78]

The second policy objective is captured by R, a negative of the ratio of the fiscal resource allocated to long-lived public goods in both regions to total fiscal resource in the nation. The negative sign ensures that reduction of this ratio is the policy objective that is pursued. The negative of the ratio embodies the political consideration where a certain level of current consumption of public goods is deemed important from the voter perspective. A reduction in R is defined as an increase in public expenditure on consumable public goods having an immediate positive effect on welfare.[79] Following the preferences of the electorate, the government delivers consumable public goods contributing directly to gains in welfare.

The policy question the governments are continually resolving, namely the allocation of the fiscal resource to long-lived goods and consumable public goods, is represented by an objective function defined as:[80]

$$c.h + R \qquad (2.2)$$

Where *h*, the increase in public infrastructure or long-lived public goods and R signifies the negative of the ratio of allocation to long-lived public goods to total fiscal resource available in the nation.[81] The ratio[82] is given as

[78] An exception to this statement is the case of conditional capital transfers. This case is discussed in Problem 2.
[79] The two way effects of public infrastructure and private production for economic development have been discussed in Wang (2002) with empirical evidence from seven East Asian economies.
[80] The objective function here uses a structure that is similar to the objective function portrayed in Qiao, Martinez-Vazquez and Xu (2008) whilst using different arguments. They set up an objective function that moderates a choice between growth and decentralization. Other discussions have focused on the choice between consumption and investment of rents. The choice between upfront spending rents on consumption and investment has been discussed in Takizawa, Gardner and Ueda (2004) where they argue that if the economy is on a stable growth path the choice has no effect on long run growth but has adverse outcomes if the initial capital stock is low. Agenor (2009) presents a theoretical model of production of infrastructure and consumable public good tracing effects of infrastructure on long run growth.

$$R = -\left[\frac{\pi_A(p.(1-\vartheta).Y + (\tau-\alpha)M) + \pi_B.(1-p).(1-\vartheta).Y}{Y+\tau.M}\right] \quad (2.3)$$

The ratio is equivalent to the sum of expenditures on long-lived public goods in region *i* divided by the total public expenditure in the nation. This is so because total expenditure equals total fiscal resource in the nation by the balanced budget assumption.

The two types of public goods and their effects on development are important to the policy makers.[83] This signifies the composition of the public expenditure in the federation. *c* is the weight the planner attaches to long-lived goods and $c \in [0, \infty)$. As *c* approaches infinity, the preference for long-lived public goods reaches a level where the state has negligible concern for current welfare levels.[84] Conversely, as *c* approaches zero, the preference for current consumption overtakes investment in long-lived public goods.[85]

The federal tax rate α denotes a key policy choice. The federal government enjoying its precedence can siphon away ever higher levels of rent from Region A but it would be constrained by the political instability it may generate in the federation. A very low α would

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[81] The discussion on consumption against investment in the context of future production possibilities in well narrated in Arrow et al. (2004). Their paper while presenting the general problem also shows that for government policy it remains an important tradeoff.

[82] For notational simplification, this can be rewritten as:
Where $R = -\left[\frac{\pi_A(p.(1-\vartheta).Y+(\tau-\alpha)M)+\pi_B.(1-p).(1-\vartheta).Y}{Y+\tau.M}\right] = -\left[\frac{(1-\vartheta).Y(p.\pi_A+(1-p).\pi_B)+\pi_A(\tau-\alpha).M}{Y+\tau.M}\right]$
Or simply as $R = -\frac{q(1-\vartheta).Y+\pi_A(\tau-\alpha).M}{E} = -\frac{E_A+E_B}{E}$
Where E_i is the expenditure in region *i* and E is the total national public expenditure.

[83] Gupta et al. (2005), using data from 39 low-income countries demonstrate that the effect of capital expenditures on growth is positive whereas that of wage related expenditures is not. Devarajan, Swaroop and Zhou (1996) using data from 43 developing countries for 20 years show that given the initial levels of public infrastructure, the effect of current expenditure (consumable public goods in this model) is positive while at the same time the effect of capital expenditure in negative when their dependent variable is growth in per capita incomes. Alesina et al. (2002) find for OECD countries that there is a negative effect of wage related government spending on business investment.

[84] It can be argued that the developmental states like South Korea, Taiwan, Singapore and lately Vietnam during the phase of massive investments in public infrastructure through forced savings depicted a high value of parameter *c*. For a review of the 'developmental state' see Woo-Cummings (1999).

[85] Major subsidy programs like interfering with commodity prices are a manifestation of a low value of parameter *c*. Among the resource rich nations subsidized commodity prices have a major stake in the budgets. For example see (Myers and Kent, 2000) for subsidies on both exhaustible and renewable natural resources.

unusually favor Region A leading to consequences for other regions.[86] On the other hand, a very high value of α may become unsustainable politically leading to political instability in the federation.[87] For a politically stable federation, the federal share should be constrained between the minimum efficient threshold and the maximum political stability level. We constrain the value of α to lie between two bounds as described below:

$$0 \leq \frac{(1-\vartheta)p.Y - (1-\vartheta)(1-p).Y}{(1-\vartheta).Y} \leq \frac{\alpha M}{\tau M} \leq \frac{(1-\vartheta).qY}{\tau M} \cdot B \leq 1 \qquad (2.4)$$

Where

$$\frac{(1-\vartheta)p.Y - (1-\vartheta)(1-p).Y}{(1-\vartheta).Y}$$

$$= \begin{cases} \frac{(1-\vartheta)p.Y - (1-\vartheta)(1-p).Y}{(1-\vartheta).Y} \ if \ \ (1-\vartheta)p.Y - (1-\vartheta)(1-p).Y \geq 0 \\ 0 \ otherwise \end{cases}$$

$$\frac{(1-\vartheta).qY}{\tau M} \cdot B = \begin{cases} \frac{(1-\vartheta).qY}{\tau M} \cdot B \ \ if \ < 1 \\ 1 \ \ otherwise \end{cases}$$

If the numerator in the first inequality is less than zero, than the inequality is replaced by an equality equal to zero. If the right hand side term of the second inequality is greater than 1, then it assumes the value equal to 1.

The first inequality means that the share of federal rent tax revenue out of the total economic rent is no less than the difference in the fiscal resources of the two regions as a fraction of the total fiscal resource in the nation, when the general tax base in the producing region is higher than the non-producing region. Since the lower bound is at zero, it means that the non-

[86] Boadway (2006) is a discussion of the effects of higher fiscal benefits of oil production in Alberta on the rest of the provinces in Canada. The case for a federal role is argued in this paper. However, the effects of equalization may in themselves be distortionary to factor mobility (for example see Petchey, 2009). Similarly, in special settings, equalization may have a depressive effect on natural resource taxes (Smart, 1998).

[87] A number of conflicts in several countries pertain to disputes over siphoning of economic rent of exhaustible resources to the benefit of the entire country at the expense of the producing region.

producing regions would not object to very low values of α if they have more of the general base than the producing region. The left hand side in the first inequality is a measure of minimum fairness. The second inequality ensures that the share of federal rent tax revenue out of the total economic rent accruing from the exhaustible resource in Region A is not greater than the expenditure on long-lived public goods in the nation as a fraction of the economic rent. The inequalities can be simplified as:

$$2p - 1 \leq \frac{\alpha}{\tau} \leq \frac{(1-\vartheta).qY}{\tau M} \cdot B \qquad (2.5)$$

Or

$$(2p-1).\tau \leq \alpha \leq \frac{(1-\vartheta).qY}{M} \cdot B \qquad (2.6)$$

It would be appropriate to highlight the meanings of these inequalities further. When α is chosen between the two bounds and constraints are met with inequalities, the federation is politically stable. The operative interval between the two bounds represents the region of political stability where the resource region is not wary of siphoning of its rent into areas it does not value. For all values circumscribed within the two bounds, α denotes a working quid pro quo between the producing region and the rest of the federation, with the net gain to the region as positive but not necessarily strictly positive. These gains may accrue through consumption of the federal public good or in the form of other intangible benefits received by the region by association with the rest of the federation. At the lower bound the non-producing regions are indifferent to the producing region's inclusion in the federation. At the upper bound, the producing region is indifferent to participating in the federation. Hence both bounds spell political instability for the federation constraining the federal government to choosing a value of α that lies strictly within the interval.

These benefits could be exemplified by reduced cost of regional security due to internalization of some parts of a border, high value of diversity, access to a larger market or gain in size as a country on the international stage increasing importance in global fora. If such benefits to the region are highly valued compared to the total rent of the exhaustible resource (and the sum of the national investment in public infrastructure is greater than the accruing rent, creating a stronger template for national economic development that in turn will be shared by the resource region), then the upper bound for α may not lie within the unit interval and will not be binding.[88] The upper bound is given by the ratio of the total investment in public infrastructure to total contribution to national income by exhaustible resource mining deflated by the preference of long-lived public goods in the resource region.[89] The denominator includes the returns to labor and capital in addition to the economic rent. This case will denote the situation where the non-producing region's investment in the public infrastructure is also large. In this case, the benefits of association outweigh the diminished share of rent. In cases where the upper bound equals α, the federation approaches political instability. The value of α is the maximum the producing region is willing to agree to. As α approaches the upper bound, the situation characterizes heightened political awareness in the producing region, ready to question the cost of association in relation to the benefits.

[88] This situation would arise when the exhaustible resource mining revenues of all sorts are not a major economic activity in the country. Understandably, in such cases the value of the exhaustible resource rent to the resource region will not be a major factor in its relationship with the center. In case of Pakistan, this situation is demonstrated by Punjab's relationship with the center. In India Gujarat, Assam, Tamil Nadu, Rajasthan and Andhra Pradesh are the five states that have oil mining (Noronha & Srivastava, 2010) but compared with the investment in national public infrastructure, the oil revenues are not very large.

[89] The deflationary factor ensures that there is a higher impact of high preference for long-lived goods on the upper bound of α.

When α is equal to the lower bound, it symbolizes a federation approaching instability.[90] The lower bound is the minimum the federation is willing to get from the resource region and continue to bestow the benefits of association.[91] In this case the locus of instability is outside the resource region. To avoid political instability, the federal tax share is chosen as $\alpha \in (0,1)$. A detailed description of this argument is given in Appendix B.2.

With efficient rent taxation in place, fiscal resources completely measured and multi-tiered government in existence, the social planner solves the following problems:

Problem 1. The federation levies a tax α on the exhaustible resource rent, leaving the remaining to the resource region; it also taxes the general base in both the regions at the same rate. Since the federal tax on the general base levied on the existing bases in the regions, it takes a higher amount of revenue from the richer region (which is the resource region also), but provides an equal amount of national public good to both regions delineating an implicit transfer to the poor region. The subnational taxes in this case are allowed to be equal to the remainder of the general base. The resource region, therefore, in addition to the regional tax on the general base, by this principle levies a tax on the rent that completely siphons away all the remaining exhaustible resource rent. When the overall level of fiscal resource is determined in each region, the allocation to private goods is determined.[92] The social planner maximizes a development function that allows a tradeoff between long-lived public goods and consumable public goods with a potentially higher social and planning valuation of the former.

More concretely, the social planner maximizes the following objective function

[90] A good discussion of this situation is contained in McLure (1994) with reference to the Russian Federation. At the point in time producing oblasts retained most of the rent.
[91] Using a game theoretic analysis, Treisman (1999) argues that outcomes of redistribution in federations depend on heterogeneity of population and degree of initial decentralization. The analysis establishes stability of federation as a function of heterogeneity and benefits acquired by regions, with the former determining the characteristics of public goods that are generated.
[92] This treatment is similar to Qiao, Martinez-Vazquez and Xu (2008).

$$Max_{\{\vartheta,\alpha\}} c.h + R_1$$

Subject to the constraints

$$(2p-1).\tau \leq \alpha \leq \frac{(1-\vartheta)qY}{\pi_A M} \cdot B$$

The results of this maximization problem are summarized in the following proposition:

Proposition 1. *Let* $\{\vartheta, \alpha\}$ *be the solution to Problem 1. Given that* $c \in (0, \infty)$, *at the optimum*

(i) Tthe effect of ϑ *and* α*, the federal share of fiscal resource from the general base and exhaustible resource rents respectively, on long-lived public goods is determined as* $\frac{\partial h}{\partial \vartheta} < 0$ *and* $\frac{\partial h}{\partial \alpha} < 0$*, when* $(2p-1).\tau < \alpha < \frac{(1-\vartheta)qY}{\pi_A M} \cdot B$

(ii) If the share of federal share in rents is fixed at the least desirable level, or $(2p-1).\tau = \alpha$*, then* $\frac{\partial h}{\partial \vartheta} < 0$ *and* $\frac{\partial h}{\partial \alpha} = 0$. *If* $\alpha = \left[\frac{(1-\vartheta)qY}{\pi_A M} \cdot B\right]$*, or the maximum acceptable to the producing region,* $\frac{\partial h}{\partial \alpha} = 0$*, indicating that there is no further effect on producing region's investment in long-lived public goods.*

A property of the solution to Proposition 1 is given below:

Property. *Given that* c *is a policy variable and indicates preference for investment of fiscal resource in long-lived public goods in the federation,* $\frac{\partial \vartheta}{\partial c} < 0$ *and more poignantly* $\frac{\partial \alpha}{\partial c} < 0$. *In case of inequalities,the effect of* c *on* ϑ *and* α *is zero.*

The latter result is intuitively appealing indicating that at this level of the federal share of rent, the producing region does not alter investment in long-lived public goods. At this level of α, $\frac{\partial \vartheta}{\partial c} < 0$ and $\frac{\partial \alpha}{\partial c} = 0$. If $\alpha = \left[\frac{(1-\vartheta)qY}{\pi_A . M}\right]$ or the maximum acceptable to the producing region, $\frac{\partial h}{\partial \alpha} = 0$,

indicating that there is no further effect on producing region's investment in long-lived public goods.

This proposition delineates the most general case. In most cases, the choice of α will be plausibly maintained as an interior point of the interval. In this stark case, the effect of α on long-lived public goods is such that a higher preference for long-lived public goods like public infrastructure would entail a lower level of α and higher level of the regional share in the economic rent. Proposition 1 shows that subnational discretion in expenditure allocation, manifested through the choice of investment of available fiscal resource in long-lived public goods, plays out differently in response to federal choices. It emphasizes in relation to α that a policy choice aiming to build a higher stock of manufactured capital would integrate a decrease in α in its portfolio under certain conditions. In turn the conditions are given by the range of α within the federal agreement interval. When α is not constrained as an interior point of the interval but fixed at either of the bounds, the policy choice becomes free of the effects of federal rent tax on investments in long-lived public goods. In case where α equals the lower bound, the regional investment in response to changes in α having peaked no longer demonstrate a further response. On the other side, when α is set as equal to the upper bound of the federal agreement interval, the negative response to the federal tax is exhausted with no further decrease in the regional investment in long-lived public goods.

Additional Cases Of Rent Assignment

The general case is based on a stark model. To increase the scope of the model, certain assumptions are relaxed. The following problems set out the cases where earlier assumptions are relaxed and in some cases, new factors are brought into consideration.

Problem 2. In this case the federal level creates a heritage savings fund to visibly direct its tax revenue from the exhaustible resource rent into a para-budgetary facility that may in turn allocate funds to investment in long-lived public goods.[93] The same depiction would denote the case where the federation formally assigns a fraction of its rent tax revenue to vertical programs for investment in long-lived public goods without creating a heritage sort of fund.[94] One way to achieve this would be to set up a circumscribed capital grant. The social planner maximizes an objective function that still seeks to increase the size of long-lived public goods whilst at the same time offering a certain level of consumable public goods.

The problem is given by the following maximization:

$$Max_{\{\vartheta,\alpha\}} c.h + R_2$$

Subject to the constraints

$$(2p-1).\tau \leq \alpha \leq \frac{(1-\vartheta)qY}{\pi_A M} \cdot B$$

Where $R_2 = -\left[\frac{(1-\vartheta)qY+\pi_A(\tau-\alpha)M+\pi_C.\alpha M}{Y+\tau M}\right]$

And $\pi_G.\alpha M$ is the size of the heritage fund facility or the vertical program of capital investment and π_G is the federal preference for long-lived public goods denoted by the share of

[93] Heritage sort of funds are operating in many countries with the more recognized ones in Norway, United Kingdom, Netherlands in Europe and Azerbaijan and Kazakhstan in Central Asia (Kalyuzhnova, 2006). In case of federal countries important ones operate in the Russian Federation, Venezuela and at the provincial level in Alberta, Canada. The Russian Federation set up a Stabilization Fund in 2004 to hold down excess liquidity in the economy (Tabata, 2007). In 2008 it was replaced by an 'oil and gas transfer' in the federal budget which was defined as a percentage of anticipated GDP, as 6.1 percent in 2008, 5.5 percent in 2009, 4.5 percent in 2010 and 3.7 percent from 2010 for the subsequent years. The remaining Mineral Extraction Tax and export duty revenues are channeled into the Reserve Fund till it exceeds 10 percent of GDP. Any additional amounts accruing toward it would then be placed in the National Wealth Fund. The Reserve Fund is a facility to compensate for revenue volatility in the federal budget arising out of commodity price fluctuations and the National Wealth Fund is designated as a resource for the pension system. The Stabilization Fund has been criticized as an option with low returns on investment compared with investment in infrastructure (For critiques of the fund see Popova, 2008).

[94] A savings fund can be simply used to stager the public expenditure over time, absorbing the inflationary impact of natural resource revenue, without necessarily directing it to investments (see Davis et al., 2001a). In such a case it is a tool of fiscal policy aiming to smooth expenditures over time (Davis et al., 2001b) The treatment in Problem 2 is a simplification of the purposes of the fund, aiming to focus on the issue at hand.

the federal rent tax revenue directed to the fund facility. This is also equivalent to the size of the capital grants in comparison to the total federal rent tax revenue.

The results of the maximization problem after setting up a heritage savings fund sort of facility at the federal level are given in the following proposition.

Proposition 2. *If* $\{\vartheta, \alpha\}$ *be the solution to Problem 2, given that a special savings fund directs a fraction of its total amount into long-lived public goods and the federal offset of exhaustible resource rent is chosen as an interior point in the interval* $\left[(2p-1).\tau, \frac{(1-\vartheta)qY}{\pi_A M} \cdot B\right]$,

(i) the effect of the federal share of rent on investment in long-lived public goods is negative, provided that the preference for long-lived public goods in the producing region is greater than the preference for such goods at the federal level. If the preference is reversed, such that $\pi_A < \pi_C$, *then effect is also reversed or* $\frac{\partial h}{\partial \alpha} > 0$. *However, if there is no difference in the preferences in the producing region and that at the federal level, ceteris paribus,* $\frac{\partial h}{\partial \alpha} = 0$.

(ii) if α *is chosen to match either the lower or upper bound of the interval then,* $\frac{\partial h}{\partial \alpha} = 0$.

The Proposition shows that that the effect of the federal share from the exhaustible resource rent α, is governed by the ascendency of preference for long-lived public goods in the producing region.A property of the proposition is given below:

Property. *The effect of* c *on* α, *is not only negative but independent of the relative preferences for long-lived public goods. showing that in these cases it does not have an effect on the investment in long-lived public goods.*

If the preferences for investment in long-lived public goods are the same in the producing region and at the federal level, then the change in α has no effect on investment in long-lived public goods. In such a situation, rent tax assignment would also be neutral to change in the stock of long-lived public goods. This result however, is subject to a stringent requirements. In addition to the equivalence of preferences, it will require the fund facility to be transparent, predictably managed and buttressed against perverse usage. The real life examples of natural resource savings funds do not provide many examples which could meet these conditions. Intuitively, Proposition 2 indicates that fixing α at the highest possible level would have no substitution effect on long-lived goods; any reduction in the fiscal resource in Region A would be adjusted in consumable public goods. The key point in this case is the decision to hypothecate a known fraction of the savings fund to investment in public infrastructure. In practice this may not happen as easily. In case of Norway, which is not a federation, the fund mechanism has made a transparent allocation to savings over current expenditures. On the other hand other experiences have not been always sanguine, current expenditures taking precedence over investment and discretionary policy holding sway over rules. Venezuela is characterized by centralization of oil revenue as well as failure to successfully operate a fund with transparency and predictability guaranteed by rules (Fasano, 2000).

Problem 3. As before, two regions A and B, comprise a federation with exhaustible resource located in Region A only. An equalization transfer is made from the federal government to the poor region.[95] For simplicity of exposition we assume that the transfer achieves complete

[95] The incentive effects of transfers in creation of infrastructure and locational efficiency are valid issues. For discussion see Petchey (2009). In the discussion here I am abstracting from this issue to focus on the effects of rent tax assignment.

equalization.[96] The social planner maximizes an objective function under the same constraints as in the general case and the transfer is incorporated in the objective function.

The problem can be written as:

$$Max_{\{\vartheta,\alpha\}} c.h + R_3$$

Subject to the constraints

$$(2p-1).\tau \leq \alpha \leq \frac{(1-\vartheta)q'Y}{\pi_A.M} \cdot B$$

Where $R_3 = -\left[\frac{(1-\vartheta)q'Y+\pi_A(\tau-\alpha)M}{Y+\tau M}\right]$ and $q' = p.(\pi_A + \pi_B)$

The results of the maximization problems are given below in the proposition.

Proposition 3. *Let $\{\vartheta, \alpha\}$ be the solution to Problem 3. At the optimum,*

(i) if the federal share of exhaustible resource rent is such that it is an interior point in the interval $\left[(2p-1).\tau, \frac{(1-\vartheta)qY}{\pi_A M} \cdot B\right]$, then $\frac{\partial h}{\partial \alpha} < 0$

(ii) if the federal offset share of exhaustible resource rent is chosen equal to either the lower bound or the upper bound of the interval, then $\frac{\partial h}{\partial \alpha} = 0$ and $\frac{\partial \alpha}{\partial c} = 0$.

From the proposition, it is evident that the effects of change in the policy variable c is manifestly characterized by $\frac{\partial \vartheta}{\partial c} < 0$ and $\frac{\partial \alpha}{\partial c} < 0$.

This shows that a general equalization transfer does not have any effect on the level of investment in long-lived public goods that is determined by the general model. In this formulation, the general equalization transfer is equivalent to the implicit transfer in the general model specified in Problem 1 as they result in the same effects on investment in long-lived public goods. An increase in the federal offset of the resource rent will still have a negative effect

[96] This is admittedly a strong assumption but it describes the highest impact of transfers on the variables of interest.

on investment in long-lived public goods. A general equalization scheme may serve some important purpose in a federation, but it does not take away the effect of federal offset from investment in public infrastructure. Given that there would be differences in regional preferences for long-lived public goods, equalization transfer per se does not have an impact on spending decisions in the non-producing region. The result shown in Proposition 3 however differs in one respect from that in Proposition 1. The negative effect of an increase in α will be smaller in this case compared with the case with implicit transfer.[97]

Problem 4. The federation sets up an equalization transfer out of the rent tax pool generated through the federal rent tax α. Region A does not receive any transfer but only Region B is entitled due to its relatively weak general tax base.[98] For simplicity of exposition, we assume that in this case, the federal government does not set up a heritage sort of savings fund facility.

The social planner in this case maximizes an objective function that incorporates this type of transfer but is subject to the same constraints. It is given by:

$$Max_{\{\vartheta,\alpha\}} c.h + R_4$$

Subject to the constraints

$$(2p-1).\tau \leq \alpha \leq \frac{(1-\vartheta)qY}{\pi_A.M} \cdot B$$

Where $R_4 = -\left[\frac{(1-\vartheta)qY-(\pi_A-\pi_B.\varphi).\alpha M+\pi_B.\tau M}{Y+\tau M}\right]$ and $\varphi \in [0,1]$ is the share of the federal rent tax revenue set aside for the transfer pool, taking a value equal to zero if no transfers are

[97] Comparing equations (1.6) and (3.4) in the Appendix, it is evident that the denominator in (3.4) is greater than the denominator in (1.6). This is because $E_B' \geq E_B$, as the former includes the equalization transfer.

[98] This problem is a simplified version of the case of the Russian Federation from 2004 onward. The equalization transfers in Russia are not made explicitly from a fund financed by oil and gas revenues. However, the size of the total federal transfers to regions compares as half of the total oil and gas revenue accumulating to the federal budget (Kurlyandskaya, Pokatovich & Subbotin, 2010). Considering the fungibility of the funds in the federal budget, it is easy to argue that a fraction of the equalization transfer pool is financed by the oil and gas rent tax revenue.

made from the rent tax revenue of the federal government and equal to one when the entire amount of the federal rent tax is designated as the transfer pool.

The results obtained from this maximization are summarized in the following proposition and the proof is recorded in the Appendix B.1.

Proposition 4. *Let's say* $\{\vartheta, \alpha\}$ *is the solution to the maximization set up in Problem 4. At the optimum,*

(i) given that the federal rent tax α *is chosen from the interior of the interval* $\left[(2p-1).\tau, \frac{(1-\vartheta)qY}{\pi_A M} \cdot B\right]$, *the effect of change in* α *is such that* $\frac{\partial h}{\partial \alpha} < 0$ *if* π_A *is greater than* π_B *deflated by* φ, *the share of the federal rent tax set aside for the transfer pool.*

(ii) If α *is set equal to either of the bounds, then* $\frac{\partial \alpha}{\partial c} = 0$.

A property of Proposition 4(i) is that: *the effect of the policy variable is on the federal rent tax is given by* $\frac{\partial \alpha}{\partial c} < 0$.

This important result demonstrates that both the preference for long-lived public goods in the non-producing regions and the share of the federal rent tax revenue designated for the transfer pool will influence the effect on investment in long-lived public goods. Since $\pi_A > \pi_B$ by assumption and the upper bound of the value of φ is no greater than 1, the transfer scheme is still a weaker arrangement compared with decentralization of rent taxation. There would be however, no difference between derivation based sharing and decentralization of rent tax. As long as the producing region has a higher preference for long-lived public goods, the transfers financed by the federal rent tax revenue do not provide a more efficient mechanism to increase investments in the stock of national infrastructure. The limits of the potential of this policy choice are further clarified if the assumption on preferences is relaxed. If $\pi_A < \pi_B$, showing a

reversal of preferences, the results do not immediately change to a positive effect on long-lived public goods. Since the direction of effect is still controlled by the product $\pi_B.\varphi$, the only straightforward case with the change to a positive effect is when $\varphi = 1$. However, if $\varphi < 1$ then despite $\pi_A < \pi_B$, the effect of an increase in the federal rent tax may not be positive. The minimum condition for reversal of the effect of α on h of course would be $\pi_A \leq \pi_B.\varphi$.

Problem 5. In this case, the resource region is the poorer region with only a small fraction of the general tax base located in its jurisdictional confines.[99] Assuming there is a federal grant set up to provide resources to Region A, the impact will be the same as the case set out in Problem 3 with the exception that the choice of the transfer will be from the rent tax pool. In this case, the claim on economic rent of the exhaustible resource becomes even more significant with a higher local political appeal. These aspects are incorporated in the model by primarily redefining the first inequality in Equation (6). Since $Y_A < Y_B$, it implies that $p < 1 - p$ and the lower bound of α is negative.[100] This means that only if α is not strictly positive and $\pi_A > \pi_B$, the desired high expenditure on long-lived public assets in Region A will be sustained.[101] The maximization problem is:

$$Max_{\{\vartheta,\alpha\}} c.h + R_5$$

Subject to the constraints

$$(2p-1).\tau \leq \alpha \leq \frac{(1-\vartheta)qY}{\pi_A.M} \cdot B$$

Where $R_5 = -\left[\frac{(1-\vartheta)q''Y+\pi_A(\tau-\alpha)M}{Y+\tau M}\right]$ and $q'' = (1-p).(\pi_A + \pi_B)$

[99] This is not atypical of many exhaustible resource mining regions in the world.
[100] In fact the lower bound of α is not strictly positive, if $p \leq .5$, indicating relative poverty of the producing region in terms of the general tax base.
[101] Since α is a tax rate or effective tax rate, it can be easily understood as non-negative. The negative range can be understood as a case for explicit federal transfer as a stability condition.

The results of this problem are summarized in the following proposition and the sketch of a proof is given in the Appendix B.1.

Proposition 5. *Let $\{\vartheta, \alpha\}$ be the solution to the maximization set up in Problem 5.*

(i) Then if α is chosen as an interior point of the interval $\left[(2p-1).\tau\ , \frac{(1-\vartheta)qY}{\pi_A.M} \cdot B\right]$ such that $\alpha \geq 0$, then the effect of a change in the federal tax rate on the exhaustible resource rent is given as $\frac{\partial h}{\partial \alpha} < 0$. If α is chosen as equal to the lower or upper bound, there is no effect on the investment on long-lived public goods, same as discussed under earlier propositions. The same results will apply if $\alpha < 0$, except that it is better understood as a transfer.

A property of Proposition 5(i) is that: *A policy with increasing consideration for long-lived public goods would see* $\frac{\partial \alpha}{\partial c} < 0$.

In some cases the producing regions are poorer than the rest of the country. This is probably the case in most developing countries. Problem 5 shows that in this situation the producing region's claim on the economic rent of its exhaustible resource is even stronger. Even when the main results as summarized in Proposition 5 are no different from the general case, it is the low range of the federal rent tax that is noteworthy. The low values of α denote the higher tolerance for low federal taxes in the federation. The stability condition at the lower bound may be $\alpha \leq 0$, indicating a recognition of the region's low general tax base. If the stability condition is in this range, it is not binding. In other words, very low α will be acceptable to the federation and there is no strictly positive value of the federal rent tax that will be considered too low to affect the stability of the federation.

Problem 6. Federal government may have instituted a reasonable degree of tax decentralization. This notion can be captured in two ways. First, by simply ensuring that $\vartheta < 1 - \vartheta$, the tax decentralization on the general base can be spelt out. In this case the analysis presented under Problems 1 to 5 will apply except that the marginal impact of increases in ϑ and α would be smaller than in those cases. The results would extend to $\frac{\partial \vartheta}{\partial c}$ and $\frac{\partial \alpha}{\partial c}$. The second way of explicitly allowing for differential tax choices in the regions offers more interesting analysis, depicting specific ranges of local tax policy choices. To allow for this, the available fiscal resource in the regions is itself considered a function of local tax policy after the federal government has made its tax known. Hence $Y_A = f(\gamma, p, Y)$ and $Y_B = f(\delta, 1 - p, Y)$, where γ and δ are the regional tax levels defined as $\gamma, \delta \in (0,1]$, such that if either γ or δ is chosen equal to 1, then the region chooses its tax at the maximum level in their respective regions. It would be useful to clarify that γ and δ are repositories of tax policy and administration. Higher tax rates and effective administration will be denoted by higher values getting closer to 1.[102] Y_i is the level of tax capacity in each region.[103] Given, these details, the social planner in this case solves the following problem.[104]

$$Max_{\{\vartheta,\alpha\}} c.h + R_6$$

Subject to the constraints

[102] It is easy to argue, following (Bahl & Linn, 1992) that local tax policy and administration together constitute the tax effort :

$$\frac{t}{I} = \frac{t}{D}.\frac{D}{j}.\frac{j}{K}.\frac{K}{I} = t^r.d^e.j^r.y^e$$

Where $t =$ tax revenue, $D =$ demand or calculated revenue, $j =$assessed value, $K =$ tax base as defined under the policy and $I =$ total income; $t^r =$ collection efficiency, $d^e =$ administration effect, $j^r =$ assessment ratio and $y^e =$ base effect. Here $\gamma, \delta = f\left[\frac{t}{Y}\right]_i \xrightarrow{yields} (0,1]$, for region *i*.

[103] If $\gamma = \delta$ and the regional tax is levied at the maximum feasible level so as to collect all the available revenue, the problem reduces to the general model.

[104] The regional taxes are not choice variables for the central social planner.

$$(2p-1).\tau \leq \alpha \leq \frac{(1-\vartheta)qY}{\pi_A.M} \cdot B$$

The results of the maximization problems are given in the following propositions.

Proposition 6. *Let $\{\vartheta, \alpha\}$ solve the maximization set out in Problem 6.*

(i) If Region A lowers its tax after the federal government has levied α on the economic rent from the exhaustible resource, the effect on long-lived public goods investment is given by $\frac{\partial h}{\partial \gamma} > 0$.

(ii) In Region B the effect of change in the applicable regional tax is given by $\frac{\partial h}{\partial \delta} > 0$.

The results here show that the effects of local taxes on infrastructure investment are independent of the federal rent tax. For the general model and its various variations, we assumed local taxes to be at the efficient level to focus on the effects of federal rent tax on public infrastructure. When the local taxes are allowed to vary, they indicate an income effect on investment in long-lived public goods that is independent of the difference in preference for long-lived public goods in each region.

In all the cases presented above, the preference for long-lived goods π_i is treated as a constant. However, it is plausible to say that it may change over long range due to immigration and urbanization. In both cases but in the latter eventuality in particular, π_i may increase due to the type of infrastructure that is required.[105] Using the general model for simplicity of exposition we allow for changes in π_A. The results of this analysis are presented in the following property of Proposition 1 and sketch of a proof is provided in the Appendix B.1.

[105] In case of India, Pradhan (2007) argues that infrastructure has contributed to the degree of urbanization in the states.

Proposition 7. *When Problem 1 is solved by* $\{\vartheta, \alpha\}$, *then at the optimum, a change in the preference for long-lived public goods over consumable public goods is given by* π_A *and* $\frac{\partial h}{\partial \pi_A} > 0$.

This proposition lays out an important policy consideration: if a community owning an exhaustible resource is initially inclined toward meeting higher levels of consumption of public goods due to historically lower standards of public goods, it is quite conceivable that this may not be a long term preference. Once the threshold is crossed and a higher preference for long-lived public goods in manifested, the effect on investment in long-lived public goods will become positive. Secondarily, if government follows a policy of urbanization, the preference for long-lived public goods may change in an erstwhile rural producing region and it will have implications for the federal rent tax.

Increase in economic rent is possible if world commodity prices increase while the costs of inputs do not change majorly.[106] Using the general model, the maximization problem remaining the same but the impact of changes in revenue from the exhaustible resource on investment in long-lived goods can evaluated. The results are summarized in the following property of Proposition 1 with the sketch of a proof in the Appendix B.1.

Proposition 8. *Let* $\{\vartheta, \alpha\}$ *solve the maximization problem set out in Problem 1 as before. Then a change in* M *can be modeled as* $\frac{\partial h}{\partial M} > 0$ *and the effect of federal tax on long-lived public goods as before will be* $\frac{\partial h}{\partial \alpha} < 0$.

[106] The increase in oil prices Between 2005 and 2007 provide ready examples of increase in rent tax revenue in Russia and Canada.

Property of Proposition 8. *The two effects work in opposite directions and depend on the size of general tax base relative to natural resource revenues accruing to the economy. The effect of α, dominates even for small ratios of $\frac{M}{E(E_A+E_B)}$ or the size of the natural resource revenue relative to a product of public expenditures and investments on long-lived public goods. The dominance is an increasing function of preference of long-lived public good investments in Region A, π_A. The higher the α the lower will be the ratio of M to the product of total public expenditure and investment on long-lived public goods.*

This result provides an important insight. If the total revenue from exhaustible resource extraction increases due to a change in world prices, the overall effect on investment in long-lived public goods will be positive, an income effect. At the same time, an increase in the federal rent tax, will depress such investments, going counter to the income effect. Surprisingly, a larger M compared with the general tax base ensure that the effect of change in α dominates the income effect.

Conclusion

The theoretical model presented in this chapter attempts to link rent assignment with expenditure choices. It does not compulsorily constrain the producing regions to have a higher preference for investment in long-lived public goods. The model only posits that it may be plausible that producing regions do have higher preferences for investment of rents. Examples are there where subnational jurisdictions or countries have created facilities for retention of rent proceeds. The model contributes an analytic device which incorporates a number of variables toward building a theory of rent assignment: (a) it links rent assignment decisions to expenditure outcomes; (b) differences in preferences for investment in long-lived public goods among

regions are explicitly allowed; (c) difference in tax base or general income levels is allowed and its impact on rent assignment outcomes are laid out; (d) the benefits derived from being in a federation, as opposed to an autonomous existence, are used as a constraint for describing the choices faced by producing regions; (e) the policy choice of rent shares are described by using a constraint which balances producing region's benefits of association against rent revenues; (f) the effect of changes in federal share at the expense of producing regions on investment in long-lived public goods are shown to be non-neutral.

The model provides a framework for observing the effect of rent sharing choices between producing regions and the rest of the country within the ambit of development policy. Policy preference may be different than resident preference. Governments may deem investment in long-lived public goods as a higher or lower public good, depending upon whether they are facing elections, embarking on a nation building exercise or attempting to attract private investment and businesses in a competitive international market.

While rent revenues are important from a stabilization point of view, they have a place in development policy from the investment perspective. The subnational governments pursue their own investment (and expenditure) choices within the federal confines. One way to constrain such choices is to create conditional grants for pursuing federal objectives. While these may be necessary in some cases, they are not an instrument of choice for federal policy priorities in general. Investment in infrastructure can be financed by federal grants but due to substitution effects they may not achieve a sufficiently high investment in public infrastructure at the regional level. On the other hand, if producing regions exhibit a higher preference for investment in long-lived public goods, federal policy may interfere with it by collecting higher percentages of rent at the federal level. The higher preference for long-lived public goods and higher emphasis of

federal policy on investment in infrastructure would together best be harnessed by allowing higher shares of rent revenue to the producing regions. The higher shares of course do not mean they should necessarily ignore the macroeconomic concerns. Such issues should be explicitly addressed through adoption of appropriate fiscal rules instead of the crude vehicle of rent assignment. Higher federal rent retention may help mitigate macroeconomic concerns but may also result in lower investment of rents.

The model shows that rent assignment or sharing between federal government and producing regions may have effects on investment in long-lived public goods or public infrastructure. A development policy laying a strong emphasis on increase in the stock of public infrastructure or investment in public infrastructure may under certain circumstances plausibly reduce the federal share of rent revenues and allow them to flow to the producing regions. This result shows that some additional thought must be given to regional claims on rent revenue. In addition to assuaging political demands, it may well have a rational justification in the form of higher investment in public infrastructure.

Chapter 3 The Effects of Rent Share Changes on Public Investment in the Regions of Russia

Introduction

A decrease in the share of resource rent tax revenues may lead to a reduction in subnational government current and capital expenditures. Whether the decrease affects both current and capital expenditures or not depends on a number of factors, including the demand elasticity of expenditures by subnational governments, taxing powers of the subnational governments, and the existence of other types of transfers. An important but less emphasized factor is the ownership of exhaustible resources and under its influence expenditure choices made for the rent revenue. To study this question, an empirical analysis of the case of the Russian Federation is presented in this chapter. For this analysis the implicit assumption is that the producing regions have a higher sense of ownership than the federal government, having consequences for expenditure choices. This assumption is further elaborated in Chapter 4.

Propositions 1 and 2 presented in Chapter 2 show that an increase in the federal share of rent will have a negative effect on investment in public infrastructure. Proposition 2 differs from Proposition 1 in that it includes explicit federal transfers to regions. The transfers are unconditional allowing regions to follow their own expenditure choices. This key theoretical result yields three testable questions: whether change in federal share at the expense of producing regions has an effect on investment in the regions, whether this effect is negative, and what is the quantum of this effect. Derived from these, following are the specific empirical questions studied

here: (a) what is the effect of a decrease in the share of resource rent tax revenues on investment in fixed public goods in the regions of Russia; and (b) what is the effect of rent tax share reduction on total expenditure when investments and total expenditures are simultaneous choices. Both questions use two different definitions of subnational investment in fixed public capital as explained later. The decrease in regional shares of rent tax may be compensated by an increase in federal (and in turn regional to local) transfers.[107] To account for this, transfers and total subnational revenue are used as explanatory variables in addition to other controls. The three questions are part of the broader discussion of the effects of tax assignment on subnational public goods.

The changes in the regional shares of rent tax revenue accruing from taxation of oil and gas extraction in recent years offers a quasi natural experiment to study the questions. The Russian Federation reduced the regional share of rent tax revenue generated from oil and gas mining from 60 percent of total revenue that the regions received till 2002 to 20 percent from 2002 onward. The regional share of rent tax revenue was further reduced to 15 percent in the following year. In case of gas revenue, the share was reduced to zero from 2004 onward whereas from oil mineral extraction tax, it was further reduced to 5 percent of the collections. The regional shares were calculated on derivation basis. A regional share of zero from all resource rent tax revenue will apply from 2010 onward. The progressive changes in the regional shares of resource rent tax have directly affected 37 producing regions only, while the remaining 46 regions remain unaffected. This chapter uses three program evaluation methods to estimate the effect of rent tax revenue share reduction on subnational investment in fixed public capital. Different measures of investment in fixed public capital are annually reported and they serve as measurable additions to the stock of long-lived public goods. The terms long-lived public goods

[107] Unless the context implies otherwise, regional refers to regions and local governments in that region.

and fixed public capital are used interchangeably throughout the discussion although the former has a wider meaning.

The empirical questions discussed in this chapter arise from the propositions of the theoretical model in the chapter above. The theoretical model for rent tax assignment in a federation was framed using the policy choice between investment in long-lived public goods and maintaining a certain level of current public expenditures. Given the assumed differential preferences for investment in long-lived goods across regions in a federation, the theoretical propositions show that a reduction in the subnational share of rent tax revenue will in general have a negative effect on subnational investment in long-lived public goods and this will be scaled by the differences in preference between current expenditure and investment. The increase in the federal share of resource rent taxes, at the expense of regions in Russia, is a real life occurrence that closely resembles the theoretical model. The second precept in the model assumes a certain inertia in current public expenditures and a higher preference of long lived public goods in the producing regions. These are testable questions. If these assumptions hold there will be a decline in investments in long-lived public goods in the producing regions.

The theoretical model also showed that there will be a decrease in the overall investment in long-lived public goods across all regions if the central government preference for long-lived goods is less than the producing region. Another important result was that federal to subnational transfers do not compensate for the increase in the federal share and the decline in investments in long-lived public goods will continue despite the transfers. The only exception to this result was the case of a conditional federal transfer for capital investment in the subnational jurisdictions. The quasi natural experiment of rent tax share reduction in Russia affords an opportunity for employing an empirical test of these theoretical propositions. In accordance with the theoretical

propositions, the effect on investment in long lived public goods is estimated using controls that comprise fiscal parameters, structural variables, demand variables and measures of economic activity. Three program evaluation methods are used although only the results from the first one are discussed in this chapter. The other two are presented in Appendix C.3. Using the first method, we have estimated the effect of rent share reduction using difference-in-differences estimators. The results of the matching estimator and propensity score estimation are given in Appendix C.3 as robustness checks. To provide an appropriate context to estimation of the policy change on investment in long lived public goods, we have also attempted to establish a set of determinants of public capital investment. Using some of the earlier studies, we have identified variables that have been found to significantly affect investment in long lived public goods in other countries. We have also added a set of additional controls drawing from structural, demographic, demand and economic variables that could intuitively influence public investment.

The chapter is organized in five sections. Section 1 lays out the empirical models with a discussion of control variables and assumptions maintained on the data for identification of average treatment effects. Section 2 provides a description of the data. The variables of interest have been described along with source of data. Section 3 is an overview of descriptive statistics. They have been presented by treatment status to set the stage for the following analysis. Additional statistics suited to program evaluation methods have also been listed. Following this discussion, in Section 4 presents a summary of important results from different estimations. Section 5 concludes the paper.

Empirical models

Multiple treatments and groups of regions

Mineral Exrtaction Tax, levied under the Tax Code of the Russian Federation is the main rent tax collection instrument since the tax reform. At the beginning of the decade, in 2000 the producing regions were still awarded 60 percent of the revenue from resource rent taxes on derivation basis. The initial high shares were a continuing result of the successful bargaining of the resource rich regions with the center in the mid 1990s (Bahl and Martinez-Vazquez, 2006). These taxes were levied as license fees, royalty, excise duty and other instruments. For the period of this dataset 2000 to 2007, Mineral Extraction Tax levied as a production excise remained the predominant resource rent tax.[108] It has been levied at a uniform rate on all types of oil and gas mines[109] not discriminating on the basis of differences in quality, cost of production or time of operation.[110] The regional share of revenue collected under oil and gas taxes was 60 percent of the total in 2000 and 2001. As part of the ongoing recentralization of assignments, the regional share of rent revenue was reduced to 20 percent of collections in 2002. The reduction applied to both oil and gas taxes. In 2004 the region's share in oil tax revenue was reduced to 15 percent and that on gas to zero. From 2005 onward the share from oil revenue was further reduced to 5 percent while it remained at zero for the revenue from gas. The reductions of the two tax shares, those of rent taxes on oil and gas, are identified as multiple treatments. For the

[108] The Strategies and Measures to Improve the Tax System submitted to the Duma proposed simplification of taxes (Martinez-Vazquez, Rider & Wallace, 2008). The tax reform brought about by adoption of a new tax code in 2001 simplified mineral taxation by eliminating most minor taxes and created a unified Mineral Extraction Tax by combining subsurface mineral tax and excise duty on minerals (Chua, 2003).

[109] The gross revenue of the oil sector increased from $53.1 billion in 2000 to around $200 billion in 2006; the tax revenue during this time period reached 125.2 billion from an initial collection of $14.8 billion (Yuriy Bobylev "Reformu nado prodolzhat' (Reform Should Be Continued)," *Neft' Rossii*, 1:72–77, 2008) quoted in Alexeev and Conrad, 2009, p.98).

[110] Of late some exceptions to the rule have been made (Kurlyandskaya et al, 2010). But these do not apply to the time period included in the data in general having application to new projects in three regions in the far east commencing from January 2007.

models, the treatments are specified as reduction in oil tax revenue share, gas tax revenue share and oil and gas taxes revenue share. There are three reductions in oil tax revenue shares, two in gas revenue share and three for oil and gas tax taken together. In all there are eight treatments but each applies only to a group of regions and not others.

The regions fall in two broad categories of producing and non-producing regions. The latter are the control group for the policy change treatment. Out of the 83 subjects of the Russian Federation, either oil or gas or both have been mined in 38 regions during the time period between 2000 and 2007. Out of these regions 36 produce oil. From 2000 to 2007, oil was produced in varying quantities in all of the 36 producing regions although for some years there are missing observations. No production is indicated in case of 8 regions for two years or less. This indicates no production or no reporting. Similarly, gas is mined in 32 regions. No production is however reported in 6 of these regions for two years or less indicating no production or no reporting. In one case, Chukotka Autonmous District, mining was reported for 2006 only. Out of these regions, both oil and gas are mined in 30 regions. Only oil production in this time period has been reported in 9 regions and only gas mining in 5 regions. The cases of missing values, where neither oil or gas production value is reported in an otherwise producing region, are 6 regions. We have classified the 37 regions where both oil and gas or either of the two commodities have been mined from 2000 to 2007 as the producing regions. They are further subdivided as oil only regions, 9 cases, gas only regions, 5 observations during the time period, and oil and gas regions, 30 observations over the years. The remaining 45 regions are the non-producing regions which are spread across the territory of Russia. To avoid overlaps between the two groups, we do not reclassify producing regions out of this group even if no production is reported for a certain year. As indicated above, such years are not many except for one region,

Chukotka Autonomous Okrug. This region is kept in the non-producing category and dropped from estimation because of other missing values. On this basis, 37 regions are classified as producing regions. All of them are in the general treatment group. The remaining 46 regions constitute the control group. All the oil and gas producing regions have been included in this analysis. Some earlier discussions of mining regions and their effect on fiscal policy have focused on the rich oil producing regions only.

The variation in the number of regions where oil and gas has been produced during 2000 to 2007 presents certain problems as well as certain opportunities for analysis. The variation within the producing regions allows creation of more than one treated groups. This has been exploited as the multiple treatments. However, the fact that certain regions have missing values for some years creates an issue for their placement in the treated group in that particular year. To identify treatment effects no overlap can be allowed between the treated and control groups. To ensure that this requirement is fulfilled the membership of the two groups is defined as constant, with no year to year changes between them. This is plausible because a producing region's revenue shares apply have future expectations as well. The investment or expenditure decisions are influenced by the annual revenue shares as well as future expectation of revenue. Therefore even if production does not take place in a certain year, investment decisions will still be influenced by long term revenue expectations and remaining stocks of petroleum.

Specification

The variation in treatments and the variation in producing regions is valuable and is exploited by the following models. The first model is based on the multiple treatment models presented in Gruber (1994), Waldfogel (1999) and Baum (2003). The model uses multiple

groups and multiple treatments to make full use of the variations in application of treatments that have changed over time. The model can be written as:

$$y_{it} = \beta_0 + \beta_j g_m + \beta_l r_q + \beta_k g_m r_q + \gamma_p X_p + \gamma_r region_i + \gamma_t year_t + \varepsilon_{it} \qquad (3.1)$$

Where y_{it} is a measure of investment in fixed public capital or acquisition of new capital by subnational government on account of debt financing or private sector donations, g_m is a treatment group, $m = 1,2,3,$ r_q is treatment, $q = 1, \dots, 8$, X_p is a vector of control variables, $region_i$, $i = 1, \dots, 83$, is a vector of dummy variables for the regions and $year_t$, $t = 1, \dots, 8$, is a vector of year dummies.[111] β_js signify the difference between the mean values of the outcome in the groups in the pretreatment period. β_ls indicate the effect of treatment q and β_k is the difference-in-difference (DD) estimator. Inclusion of controls is important to ensure that factors affecting investment are included in the estimations.

X_p is a vector of variables having a bearing on investment in public capital and includes fiscal variables, structural variables, measures of economic activity and demand factors (discussed in detail in the following sub-section). The inclusion of control variables creates an analytic framework where the effects on the outcome from other variables are allowed.

The region and time dummies are included to pick up time-invariant region specific effects and time varying effects. The inclusion of year dummies provides sufficient regularity in estimating effects of specific time period effects. Time trend on the other hand captures the overall growth in investment due to time. . In this case, the following version is estimated with fixed effects:

$$y_{it} = \beta_0 + \beta_j g_m + \beta_l r_q + \beta_k g_m r_q + \gamma_p X_p + \gamma_t year_t + \varepsilon_{it} \qquad (3.2)$$

[111] In some estimations, year dummies are replaced by a time trend to manage collinearity between treatment periods and years.

The second model uses approximation in treatments to estimate yearly effects. All the producing regions in this case are placed in a single treatment group and the remaining regions serve as the control group. There is therefore only one treatment group dummy variable, $g1$, which equals 1 if the region is a producing region, 0 otherwise. Each year after 2002 is specified with a separate dummy variable, $post_q$, $q = 2002, \dots, 2007$. The argument for annualized effects of treatment is plausible due to the fact that investments may be decided with a certain time lag and would manifest through annual budgetary allocations. This model attempts to capture the well known fact that there is a time lag in planning and implementation of capital investments. Using the same control variables as employed in the first model, the following equation is used for estimation:

$$y_{it} = \beta_0 + \beta_j g_1 + \beta_l post_q + \beta_k g_1 post_q + \gamma_p X_p + \gamma_r region_i + \gamma_t year_t + \varepsilon_{it} \quad (3.3)$$

Where β_k is a difference in differences estimator giving the effect of policy change on investment in the producing regions. Another version of the model is employed using fixed effects:

$$y_{it} = \beta_0 + \beta_j g_1 + \beta_l post_q + \beta_k g_1 post_q + \gamma_p X_p + \gamma_t year_t + \varepsilon_{it} \quad (3.4)$$

In order to jointly estimate the effect of policy change on the entire post-treatment period, another version of the model is estimated:

$$y_{it} = \beta_0 + \beta_j g_1 + \beta_l postx + \beta_k g_1 px + \gamma_p X_p + \gamma_r region_i + \gamma_t year_t + \varepsilon_{it} \quad (3.5)$$

Where $postx$ is a dummy variable taking a value of 1 if the year is from 2002 to 2007, 0 otherwise. β_k, $k = 1$, in this case is a difference in differences estimator capturing the effect of

rent tax share reduction on investment in infrastructure. The model is also estimated using fixed effects.

Lastly, to estimate the treatment effects for both investments in public capital and current public expenditures, the choices are treated as simultaneous. The theoretical model laid out in Chapter 2 also incorporates a simultaneous choice between long lived public goods and total expenditure in its second term. The empirical model arising out of the theoretical model is a set of seemingly unrelated equations as below:

$$y_{it} = \beta_0 + \beta_j g_m + \beta_l r_q + \beta_k g_m r_q + \gamma_p X_p + \gamma_r region_i + \gamma_t year_t + \varepsilon_{it} \quad (3.6)$$

$$m_{it} = \delta_0 + \delta_j g_m + \delta_l r_q + \delta_k g_m r_q + \theta_q Z_q + \theta_r region_i + \theta_t year_t + \omega_{it} \quad (3.7)$$

Where the first equation is the same as equation (1) and in the second equation m_{it} is the current expenditure in region *i* in year *t* and Z_q is vectors of variables having an effect on total expenditures. All other variables in equation (7) are the same as defined above.

The estimations in most cases employ panel data with fixed effect, heteroskedasticity robust models. Ignoring the treatment in the shape of tax share reductions, the investment in fixed public capital is a function of explanatory variables

$$y_{it} = f(X_{it}, \varepsilon_{it})$$

where Y_{it} is a type of investment in fixed public capital in region *i* in year *t*, $i = 1, \dots, 83$ and $t = 2000, \dots, 2008$. X_{it} is a m-dimensional vector of explanatory variables and ε_{it} is the unobserved heterogeneity. To capture all the features of the regional level data, the structure of the error term includes both region and time variant heterogeneity and region specific components. In other words,

$$\varepsilon_{it} = a_i + \vartheta_t + u_{it}$$

where a_i is the region specific, time invariant unobserved effect, ϑ_t is the time effect that is the same to all regions and u_{it} varies for both regions and time periods.

There are two measures of the dependent variable in equations (3.1) to (3.6). The first measure, investment in fixed public goods is a real value of investment financed from subnational government budgets. This measure captures only the formal budgetary choices. Although it does not capture the entire range of infrastructure investment by subnational governments, it does provide a clear indication of how much of the available fiscal resource is allocated to investment. In other words, rent revenues included in the fiscal resource are part of this variable and it indicates how much of the rent or other revenue is invested. The second measure is included to capture the peculiarity of lingering effects of the Soviet system of financing infrastructure. Subnational governments get developed infrastructure facilities from private sector and commercial state enterprises. This could be counted as a form of hypothecated taxation. Some infrastructure is financed by debt. The second measure of investment, labeled as acquisition of fixed public investment, comprises of budgetary investment, donated infrastructure and debt financing of fixed public capital.

The empirical model uses changes in revenue shares as treatments. It could be argued that despite changes in shares, the actual revenues may change differently due to changes in extraction and world oil and gas prices. The model uses share changes to signify treatment for three reasons; (a) the implicit argument here, and explicitly included in the theoretical model in Chapter 2, is that the change in investment preference is linked to resource ownership perceptions manifested through higher shares for producing regions. It is this mechanism which creates a higher preferences for investment of exhaustible resource rents in the producing regions. (b) the revenue effects may not be distinguishable from other income effects and

therefore it would add little value to model them separately let's say from real GRP or general measures of real subnational revenue. (c) The changes in oil and gas prices are collinear with time. The extracted amounts are reported on annual basis. Inclusion of time trend and year dummies would be able to pick any effects due to changes in oil and gas revenues over and above changes in rent shares. However, to insure that these are plausible reasons for not including the revenues flows from oil and gas mining in the producing regions, equations were re-estimated with inclusion of measures of oil and gas values. The discussion in Section 4 refers to these issues.

It is also important to note that oil and gas are not the only exhaustible resources in the regions of Russia. Other precious minerals and coal mining also takes place in some regions. During the time period for which data have been included in this analysis, changes in revenue shares of other resource taxes were not made. Therefore, any effects should not overlay the effects of changes in the share of revenues flowing from oil and gas taxes. Assuming that rent revenues are diverted to long-lived public goods, it can be said that the results would be biased downward due to omission of any variable signifying other mineral stories in the model.

Control variables.

A vector of control variables, X_p, is included in all the models. Estimation of policy change embedded in a structural model has advantages as discussed by Heckman (2010). The fiscal variables include gross regional product per capita (as a measure of the general tax base), revenue per capita, value of transfers per capita and total expenditure per capita. All the fiscal variables are computed as real values. As indicated in the correlation matrix (in a following section), revenue and expenditure have a high correlation through the balanced budget constraint,

so only one of them is used in alternative specifications. The structural variables include log of population, population density, urbanization, stock of fixed capital and farmland. Population below working age, public enrolment, number of outpatient visits fixed by available infrastructure, volume of transported goods, bus passengers and car ownership are the demand factors. The selection of controls is based partially on earlier work on establishing determinants of investment in public infrastructure. Additionally, controls that affect demand for public infrastructure have been added.

Much guidance could not be found on determinants of public investment in long-lived public goods. The selection of independent variables for the model has relied on two methods. The first method uses variables discussed in other studies that have attempted to identify determinants of public investment. The second method uses theoretical considerations of demand for public goods. The first set of variables uses the few studies on the subject that are available. One such study is by Sturm (2001). The study has identified a number of variables as determinants of investment in public infrastructure and presented empirical estimates for 123 non-OECD countries.[112] In another study, using data on 22 OECD countries, Sturm (2003) finds that political and institutional variables account for much of the public spending on capital goods. The analysis uses cross country data and therefore controls for differences in macroeconomic situations have been also included. Similar results are found in the European Union context by Pitlik (2010).[113] For the estimation of determinants of public infrastructure in the regions of Russia we have only included gross domestic product (real gross regional product)

[112] The study uses three sets of determinants: (a) structural variables: degree of urbanization, population growth; (b) economic variables: real economic growth, government budget deficits, interest payments, private investment, foreign aid, openness, foreign direct investment; (c) political and institutional variables: ideology, electoral cycles, coalition variables, economic and political freedom, political instability. It presents evidence of significance for urbanization pct., increasing deficits, private investment (as substitute), foreign aid, openness and political variables.
[113] Others have tested for fiscal rules and structural factors; for example see Stančík and Välilä (2009).

and population growth rate from the list in Sturm (2001). We do not have data on subnational political composition of regional legislatures. The other reason for not including the political variables is that the Russian case is different than European countries included in the Sturm samples. Other variables included from the Strum studies are a measure of agriculture, urbanization and population growth rate.[114]

The second set of variables included in the model is based on theoretical considerations for demand of long-lived public goods. These variables are of four types: fiscal parameters, structural variables, demand variables and measures of economic activity. Revenue per capita would plausibly have an income effect on investments. On the other hand real value of federal transfers to regions should also have a differential impact than total revenue.[115] The conditions on transfers and inframarginal nature of most transfers may channel them toward existing regional priorities. Some transfers may carry conditions such as capital investment only. This will lead to an unclear effect of transfers on investments in public capital. We have therefore included the overall real revenue per capita and real value per capita of federal transfers to regions.[116] The second subset comprising structural variables[117] includes demographic variants also. The variables in this group are a measure of farmland, level of urbanization percentage, population growth rate, population density, log of population and existing stock of fixed capital.[118]

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[114] The variables have been extracted from the model used by Fay (2001) and Fay et al. (2003) for ascertaining the demand for national public goods.
[115] The discussion refers to federal to region transfers only because there are no direct transfers to local governments from the federal government.
[116] The role of transfers has been discussed by Gramlich (1994) among others.
[117] The structural variables allow the estimation equations to include demand for infrastructure investments to provide services in subnational functions of expenditure assignments subject like oblast roads, housing, drinking water, sewage, education and health facilities. The assignment of functions listed here were taken from Table 2.1, Martinez-Vazquez and Boex (2001).
[118] These variables are extrapolations from the discussion of determinants of public capital formation presented in Burkhead and Miner (1971), pp.305-306.

The third subset of variables attempts to capture the differential demand for public investment arising out of demand for public goods. Since 2000, the federal government has increased controls over the regions diminishing the authority of subnational legislatures. After 2002 all regional governors have been appointed by the federal government. It is plausible that the subnational level investment decisions continue to respond to other factors specific to each region. Demand for public goods like education, health and economic infrastructure needs public infrastructure.[119] Non-working age population, enrolment in schools, hospital beds per 10,000 population may be plausibly influencing investment in public infrastructure. This may occur in response to expansion of public infrastructure to cater to higher demand for public goods. The fourth set of variables allows the model to include economic conditions for investment in infrastructure. A number of economic flows indicate the level of economic activity. Important ones are the volume of good transported by rail, volume transported by road, passengers traveling by public buses, number of car ownership defined over population per 1000 population, product of number of passengers of public buses and kilometers of travel and industrial production index by volume. To see if the investment is anti-cyclical or otherwise, we have included consumer price index and unemployment rate.

The fiscal variables like size of the tax base, revenue and transfers for instance would have an income effect on investments. This should result in a positive sign on these variables unless privatization is preferred. A higher need for infrastructure in captured by log of population, shown by a positive sign on the coefficient. At the same time, if population density is

[119] Martinez-Vazquez and Boex (1999), Table 11, reported real gross regional product, cost of living index, population not in working age bracket, population percentage below poverty level, transfers per capita and tax effort as significant determinants of public expenditure in the regions. These variables have been added in the estimation equations. The list has been updated using Tables 4.2 and 4.3 in Martinez-Vazquez and Timofeev (2006). These tables report higher shares of local government expenditures in housing and utilities, education and health up to 66 percent in case of rural and 72 percent in case of urbanization percentagean local government.

high the demand for infrastructure should have a negative coefficient. Urbanization has been seen to have a negative effect on investment in infrastructure (Strum 2001). A higher fraction of farmland in total area requires more public infrastructure and should have a positive effect on investments. Hence the expected sign on urbanization is negative while that on farmland is positive. The existing stock of fixed capital may have an effect on investment but it is not easy to establish the direction of this effect. For example, if there is a high fraction of public infrastructure in the existing stock it may lead to a slowdown in investments and have a convergence effect among regions. On the other hand, high value of stock may also mean relatively new infrastructure requiring less replacement investments. A low value of infrastructure could mean depreciated stock or lag in development. The first situation may lead to high investment but the second could mean low investment as investment may be attracted to developed areas. The sign on existing stock of capital could be negative if convergence in there.

Population below working age would mean a higher demand for education and other public services resulting in a positive effect on investment. This will be indicated by a positive sign on the coefficient. Public enrolment could mean either a higher demand for public education or higher percentage of school going children in population. In either case it should have a positive sign. Various measures of burden of disease also similarly signify demand for public goods that in turn require a higher investment in infrastructure, resulting in a positive sign on the coefficient. Car ownership, bus passengers and measures of volume of goods transportation will have a positive effect on demand for investment in infrastructure and this will be manifested in the shape of positive signs on their coefficients.

The data come from observational study instead of a randomized experiment. That is quite in the nature of many economic inquiries. The fact that data are not random introduces a

concern about the identification of the estimates. We employ three estimation methods to invoke assumptions on the data to identify the treatment effects.

The results of estimations for determinants of investments in fixed public capital and determinants of new acquisition of fixed public capital in the regions of Russia are provided in Appendix C.2.

Data description

Russia is a two-tiered federation with the local governments in most cases constrained by regional tutelage on budgetary matters.[120] Below the federal government there are 83 regions or 'Subjects' of Russia.[121] Not all the subjects are alike. Out of them 21 are republics, 46 are oblasts, one is an autonomous oblast, there are 9 krais, 4 are autonomous okrugs or federal districts and 2 federal cities. The current number of subjects has emerged after mergers in the last decade. Although all the subjects are recognized at the same level, the autonomous districts are parts of the oblasts in which they are situated. Data are sometime reported separately for them. In other cases, they are included in the oblasts. For the analysis in this paper, three autonomous okrugs are important. They are Nenets Autonomous Okrug situated inside Arkhangelsk Oblast and Khanty-Mansi Autonomous Okrug and Yamal-Nenets Autonomous Okrug located in Tyumen Oblast. Mostly statistics are reported separately for these districts but they are at the same time included in the regional statistics. We have compiled data for all the subjects, including the autonomous districts. However, in most of estimations, the okrugs are dropped due

[120] This is the constitutional position as described by De Silva et al. (2009). Progressive recentralization has curtailed the regional level autonomy as well. Freinkman and Plekhanov (2009) argue that regions dependence on federal transfers and resource rents have strengthened subnational centralization.
[121] In 2000 there were 89 regions. Due to mergers the number has come down to 83 in 2009.

to their special status whereby they do not control the same control over expenditures. Most of the main service delivery expenditures are controlled by the region. Revenues collected in the okrug also go to the oblast, except where there is a special agreement to override this arrangement.[122]

The dataset of regional level variables used for analysis presented in this chapter was created using three sources. Annual data are reported by the Federal Statistics Service in the form of Regions of Russia, Socio-economic Indicators. The variables included in the data are primarily from the 2009 edition and most of the variables are drawn from this publication's online version. The Regions of Russia, Socio-economic Indicators 2009 reports data from 2000 to 2009 for most variables. These time series have been used as they are unbroken and updated. However, for some time series some earlier years are absent in this edition. For these variables we have used the nine earlier editions namely the 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007 and 2008 editions of Regions of Russia, Socio-economic Indicators. Out of these, only for a limited number of variables the data relies on the Regions of Russia, Socio-economic Indicators, 2000. The details of the variables in the dataset are provided in Appendix C.1. The last population census in the Russian Federation was conducted in 2002. The data from the population census on national composition of regional population has been used from this source. The national compositions given in Table 3.2 of the population census online version have been used. For duration of stay, Table 6.1 from the same source has been used. The area of each region is reported by Regions of Russia, Socio-economic Indicators 2009. We have used the regional areas from this source.

[122] This asymmetric arrangement for this class of subjects was instituted since 2005 as earlier asymmetries were done away with; see De Silva et al. (2009); p.53.

There are 112 regional variables in the dataset, in most cases as a time series of 8 years. For some variables, the time series stretches a bit longer and includes observations for year 1999 also. We have dropped observations for 1990 and 1995 due to their weaker reliability and discontinuity. In addition to these variables we have created variables for treatment status and time period. For 2009, the region wise production of oil and gas is not reported. Only Federal District level mining data are available. Due to this discrepancy, year 2009 is also not included in the data. The changes in the status of some regions offer an obvious difficulty in getting comparable observations over this time period. The 89 regions of 2000 have become 83 subjects in 2009. However, this difficulty is mostly circumvented in the 2009 edition where the observations pertaining to earlier years have been updated and the reported data are only for the latest number of regions. It has been achieved by reporting data that are for the new region. In case of variables where we had to use the earlier versions of the Regions of Russia, Socio-economic Indicators, the data are reported separately for each entity. In case of the variables where the data for the region includes the autonomous districts below it, we have dropped the observations pertaining to the sub-regional autonomous districts and only used the regional level observations. For example, the 2003 edition lists data for Chita Oblast and below it for the autonomous district of Aginsk-Buryat. The observation for Chita Oblast includes data for the district as well as the remaining region. We have used the regional observations in all such cases to complete the time series. In case of expenditure data, the autonomous districts data is reported separately. The regional observation includes the expenditures of the autonomous districts. The autonomous district total expenditures for years 2000, 2002, 2003, 2004 and 2005 are included in the regional observation and the time series are comparable. The fact that that autonomous okrugs are not included introduces a specification error. The preferences of the autonomous

okrug population may differ from those of the remaining oblast. They may identify strongly with the resource while the rest of the oblast may not. Due to this reason, the results need to be interpreted with the caveat that there may be a downward bias in the estimators.

The expenditure data presents another issue. The classification is not uniform over the years. The total expenditure for regions is comparable across all the years but disaggregated expenditures are reported under different classifications that change over the years. Therefore, only total expenditures are used. The revenue tables, including transfers, were constructed using different years. The subnational tax revenue was not reported for all years in the data. Some other subclassifications of revenue were not continuous over time. Non-tax revenue is not reported for all the years. To avoid these issues, we have used total revenue and total expenditure data. By subtracting the budgetary investment from total expenditures, we have obtained current expenditures for each year.

The data are reported for fixed capital investments on an annual basis for all regions. In the Regions of Russia, Socioeconomic Indicators 2009, Table 24.1 reports data on fixed capital investments in total in current prices for each region. The classification for investment by source of funds was used to derive investment in fixed public capital financed from subnational budgets. The nominal values of fixed capital investment by the public sector under ‘state’, ‘municipal’ and ‘mixed Russian’ categories ownerships was calculated using the percentage scores on public and private investment reported in Table 24.5 (and comparable tables in earlier editions) The methodological notes at the end of Chapter 23 explain that the state category pertains to regional level investment and municipal to local governments. The mixed Russian category (as translated) is financed by both subnational and federal governments. These calculations generate variables

for public sector investment by ownership of level of government. The regional and municipal investments were added to generate subnational acquisition of fixed capital assets.

The gross regional product is reported in the Regions of Russia, Socio-economic Indicators 2009 and earlier editions but the series was incomplete. It did not have data for 2008. Instead we used the time series for gross regional product reported in the National Accounts of Russia (online version). Using the regional populations given in the Regions of Russia, Socio-economic Indicators 2009, the real gross regional product per capita was generated. The observations for the three producing autonomous okrugs are missing. These regions are therefore not included separately in the estimations. Instead they appear as part of their oblasts.

More than one types of measures of investment in long lived public goods are included in the data. We have calculated real investment in fixed public capital by subnational governments in each region, real investment in fixed public capital directly financed by subnational budgets (regional and municipal) and real investment in fixed capital financed by federal budgets. We are considering all of these measures of increase in the stock of long-lived public goods. This term is used interchangeably in the paper with these measures when a general meaning is implied.

The international oil price from the Oil and Gas Journal data was also included in the data. The oil production data are reported in thousand tons while the prices are reported per barrel. We have used oil industry conversion table taking 1 ton crude oil to be equivalent to 7.3 barrels, assuming a specific gravity of 33 API. For gas prices we have used the time series indicated in Figure 3.1 in Tsygankova (2009). We have used the average gas prices for industry in Russia.

Descriptive statistics

Summary statistics

Table 3.1 presents summary statistics by treatment status. The left hand side five columns are for the producing regions. The right hand side five columns list the statistics for the control group, the regions where oil and gas mining has not taken place during the time period under consideration. The two sides of the table show that despite mining on average the two groups are not very different. For example the mean real expenditure per capita in the producing regions in 19,000 rubles compared with 16,000 for the control group. The real value of fixed assets on average is higher in the producing regions compared with the control regions at 324 thousand rubles per capita against 187 thousand rubles per capita. The mean real revenue per capita coincides with the real expenditure per capita, although minima and maxima are different. Predictably, the control group regions receive more transfers in real terms on average, 5,000 rubles per capita compared with 3,000 rubles per capita in the producing regions. The negative minimum value for producing region indicates mutual settlements between federal government and the regions in these years. Some non-producing regions also have negative transfers but the minimum value at 35 thousand rubles per capita for the producing group of regions is higher than 17 thousand rubles per capita for the control group. The producing regions on average employ a higher number of people than the non-producing regions. The real gross regional product is higher for the producing regions at 75,028 rubles per capita. The mean value for the control regions is 64,610 rubles per capita. The minimum value on the hand for the producing regions is only 4,844 rubles per capita compared with 8,536 rubles per capita for the control regions. This shows that not all the producing regions are equally rich nor are all the control regions all poor. In fact the percentage of population living below subsistence level on average is only 2

percentage point higher for the latter. The maximum value of 94 percent indicates that there are some very poor regions in the producing group with some very rich regions. The mean real wages are higher in the producing regions as would be expected due to the mining operations and higher demand for labor.

Normalized differences in means of treated and control observations

The normalized differences in average values of the variables by treatment status were computed. The normalization assumes the variables in the two groups, treated and control to be normally distributed with a joint normal difference distribution. The normalized statistics are a ratio between the mean and standard deviation of the normal difference distribution. The statistics are computed in this manner to establish the validity of the linear estimation models incorporating DD estimators. These statistics are reported in Table 3.2. The normalized differences in most cases lie below one-quarter. Only in case of enrolment in public sector schools, real investment in fixed capital by municipalities, goods transported by road, accidents, railway density, hospital beds by population, farmland, population growth rate and population below working age the difference are more than a quarter. Table 3.2 shows, as explained later, that the normalized differences are in a range where linear estimation models for differences-in-differences can be used as plausible estimation equations. Secondly, in these cases, it is important to note that most of the differences in the average value of intuitively point toward a higher need for investment in long-lived public goods in the producing regions. For example, the average volume of goods transported by road is higher in the producing regions with a normalized difference of 0.35 but road density is lower with a normalized difference in average values of -0.18. The differences in paved roads as a percentage of total roads are also negative. In another sector of service delivery, the difference in hospital beds per 10,000 population is also

negative showing a lower average value of the variable in the producing regions. Farmland difference is positive which means again a higher need for public infrastructure. The difference in population below working age is positive with a value of 0.45 showing a high need for public services like education. The population growth rate difference is also positive with a value of 0.31 and the migration rate difference is 0.08. It may mean that a larger number of people are migrating into producing regions.

Figure 3.1 shows the changes in the unconditional mean real values of two key variables, by treatment status, namely the real revenue per capita and real transfers per capita. It is important to note that real revenue in both cases increases without any dips, although the increase slows down before accelerating in case of the treated group. The revenue per capita in the treated group lies above the revenue per capita in the control group on average for all the years in the sample. The transfer paint a different picture. The real transfers per capita in the control group lie above the real transfers per capita to the treated group. They also show a small decrease for a year during 2003 in the treated group. Figure 3.2 graphs the unconditional means of three variables. Investment in fixed capital by subnational governments, acquisition of fixed capital and and total subnational public expenditure, all three in real ruble terms and evaluated per capita are shown in the figure by producing and control group as mean values over time. There is an increase in public expenditure and the rate of change picks up after 2006. The expenditure in the treated group lies always above that in the control group. The unconditional mean of real investment in fixed capital in the treated group increases over time, lies above the unconditional mean of the control group except from 2003 to 2004 and becomes close to it again in 2007. For the acquisition of fixed capital, the graph for the treated group lies above the graph for the control group except during 2003 and 2004 when the position is reversed. The graphs

show that the increase in the unconditional means of expenditures for both groups is denoted by a higher positive slope compared with a flatter curve for real investment. The trends, especially the almost close and sometimes parallel graphs of real investment in the two groups, provide some justification for employing the difference-in-differences estimator described later. The assumption that the outcomes in the two groups may have continued parallel to each other in the absence of the treatment can be supported by the parallel part of the two graphs from 2002 to 2003. Based on these years, the mean real investments in fixed public capital and mean real value of acquisition of capital by subnational government may be continued on parallel paths over time in the absence of treatment.

Key variables

The key variables of interest include the real values of investment in fixed public capital by subnational governments, investment acquisition of fixed public capital by subnational governments, investment financed directly by federal budget, the real value of fixed capital (stock), real gross regional product, real transfers and real revenue. The mean value of investment in fixed public capital by subnational governments ranges from 23 to 30 percent of total revenue during 2000 to 2007. In the same time period investment financed by subnational budgets was between 11 and 13 percent of total revenue, over a smaller spread. The real value of investment by subnational government increased progressively over time from 1.72 thousand rubles per capita in 2000 to 10.20 thousand rubles per capita in 2007. During this time period, investment financed by subnational budgets increased from 690 rubles per capita in 2001 to 4.11 thousand rubles per capita in 2007.

The intergovernmental fiscal arrangement in Russia comprises of expenditure and revenue assignment. The 1993 constitution lays down exclusive federal responsibilities alongside

joint federal and regional responsibilities.[123] Important sectors from the point of view of infrastructure development were given to the regions. Education, health, water facilities and housing fall in the subnational jurisdiction. Social protection and free public transport for some kinds of citizens were also given to the regions.[124] The new assignment of functions became settled 2005 onward. A year later, the local responsibilities were also settled. Some of the regional functions are performed through municipal governments. For example, preschool, primary, secondary and afterschool education is provided by municipalities while vocational education is managed by the regions themselves. Important infrastructure responsibilities at the subnational level include construction and maintenance of roads, inter-settlement and intra-settlement roads, intercity transportation, libraries, museums and housing for low income households. Regions and municipalities invest in fixed public capital to fulfill responsibilities in the areas of water supply, waste disposal, health and education. Other than the case of autonomous okrugs, the asymmetric federal relations have been replaced by symmetric arrangements. In case of autonomous okrugs important functions including education, health and social welfare are performed by the respective oblasts. The tax shares are therefore assigned to the oblast even when collected in the territorial jurisdiction of the autonomous okrug (De Silva et al., 2009).

Total revenue comprises of shared taxes, own tax revenue, non-tax revenue and federal transfers. Subnational taxes in Russia are levied under the Tax Code which specifies the base and

[123] According to article 72 of the Constitution of the Russian Federation, ratified on December 12, 1993, education, health, social welfare and management of mineral resources are some of the important joint responsibilities, The article provides for subnational legislation in addition to federal statutes to regulate and implement these expenditure responsibilities. The details of the expenditure assignment are given in the Law on the General Principles of the Organization of Government in Subjects of the Federation adopted in 1999.

[124] The functions were assigned by the Federal Law No.84-FZ General Principles of the Organization of Governments in the Subjects of the Federation and amendments to various statutes approved by the State Duma in 2004. See Table 3.1 in De Silva et al. (2009). The local government responsibilities were delineated through the Federal Law No.131-FZ on General Principles of the Organization of Local Self-Government.

the range of rates. Collection is by the central tax administration and regions and local governments have the authorities to vary the rates for their assigned taxes. This is constrained by the fact that there are rate ceilings for taxes. Enterprise property tax, transport tax and tax on gambling business are regional taxes and all the revenues is retained in the region of collection. Personal property tax and land tax are pure local taxes with local governments getting all the revenue collected in their jurisdiction. Regions and local governments also receive shares of revenue in some federal taxes including enterprise profit tax, personal income tax, excise taxes on alcohol and beverages, gasoline and beer, mineral resources extraction tax on common mineral and other minerals (not including oil and gas), simplified tax on small businesses, single tax on imputed income and single tax on agricultural enterprises.[125] In addition to tax revenue, subnational government have access to non-tax revenue items that include income from use of property, paid services and funds accruing from civil, administrative and criminal penalties.[126] The mean value of real subnational revenue per capita was 6.11 thousand rubles in 2000 and it progressively increased to 32.23 thousand rubles in 2007. In the meantime the mean value of real transfers per capita increased from 1.18 thousand rubles to 9.80 rubles. As Figure 3.1 shows, the increase in transfers has not been as smooth as the increase in revenue. This could be attributed to discretionary transfers as well as arbitrary changes in the transfer pool on an annual basis.

Intergovernmental transfers are an important component of the federation's fiscal architecture in Russia. On average, the sample data shows that transfers as a percentage of total subnational revenue remained between 24 and 32 with the maximum dependence on federal

[125] Based on Tax Code of the Russian Federation, Part Two No.117-FZ of August 5, 2000 amended in December 2003. The shares of mineral resource extraction tax on oil and gas were reduced from 2000 to 2005 as described elsewhere.

[126] This description is based on the definition of non-tax revenues provided in the methodological notes in Chapter 23, Finance, Regions of Russia, Socioeconomic Indicators, 2009.

transfers as high as above 90 percent of total revenue for most of the years.[127] A closer look at the data reveals that the higher amounts of transfers have gone to regions where there was conflict or mergers and regions with high political significance. The federal transfers comprise formula based equalization grants (37 percent of total transfers), gap filling subsidies (since 2004, 9 percent of total), compensation for federal mandates (subsidized rent entitlements to some categories of federal beneficiaries, blood donors and cost of civil registration offices; 13 percent), cofinancing for social expenditures established by federal or (and later on) by regional laws (5 percent), capital transfers under federally targeted or regional development programs (20 percent), subnational finance reform grants (0.2 percent), ad hoc subsidies (0.4 percent), operating transfers to special territories and transfers to restricted-access cities (3 percent) and other grants (13 percent).[128] The first two types are general purpose transfers while the others are conditional grants. Initially up to 2005, the gap filling subsidies were also meant for compensation to regions for loss of revenue on account of centralization of oil and gas rent tax revenues. Except for the first three types all the remaining transfers have been consolidated under the Fund for Cofinancing of Expenditures since 2007.

Correlation matrix

The key parameters of interest in the estimations are those on the difference-in-differences estimators. The inclusion of fiscal variables and other controls in the empirical models laid out in Section 1 was tested using pairwise correlations. The results of their

[127] Transfers as a percent of total regional revenue were equal to or greater than 90 percent in case of Kursk Oblast (1 year), Ingushetia (2), Karachay-Cherkessia (1), Chechnya (4), Republic of Mari El (1) and Saratov Oblast (1). The real transfers were negative for Moscow (6 years), Nenets AO (1), St. Petersburg (1), Samara Oblast (1), Sverdlovsk Oblast (1), Tyumen Oblast (1) and Khanty-Mansi AO (3). In case of Ingushetia and Chechnya the federal transfers were as high as more than 50 percent and upto 120 percent of real gross regional product in certain years.

[128] The percentages represent a three year average from 2005 to 2007 calculated from the data reported in Table 3.6 in De Silva et al. (2009). The data for 2007 were based on budgeted figures.

correlations are given in correlation matrices reflected as Table 3.3 and Table 3.4. The first number in each box is the correlation coefficient, below it is the number of observations. Only coefficients significant at 10 percent level or below are reflected in the matrix. The Correlation Matrix 1 (Table 3.3) shows that among the fiscal variables there is a high correlation between two tax base indicators namely, real gross regional product per capita and real value of fixed capital per capita. Only one of these two variables is included in the estimation equations. The correlation coefficient of real transfers per capita and real gross regional product per capita is 0.24. Both variables are retained as controls because of the low correlation coefficient and the fact that neither is used for inference based on the model. The real transfers do not exhibit a high correlation with real value of subnational taxes (correlation coefficient is 0.21). The correlation between transfers and gross regional product and between transfers and subnational taxes at this level may not be materially affecting the key results because the model estimates a difference-in-differences estimator which is not the coefficient on either of the two variables. The strong correlation between local taxes and total revenue (0.88) again shows that only one of the two needs be in the estimation equations. Total revenue is used due to the availability of the longer time series of this variable. The transfers have high correlations with real expenditures per capita (0.61) and real revenue per capita (0.61). In some estimations only one of the two variables, expenditures or revenues, is included. On the other hand, real subnational revenue per capita has comparatively weaker correlations with real value of fixed capital (0.58) and real gross regional product (0.57). Since the empirical models do not provide inference on individual coefficients on the three variables, they are included in various estimation equations with the caveat that individual coefficients on them, when any two of them are included, may not be individually unbiased.

The Correlation Matrix 2 given in Table 3.4 presents the entire range of pairwise correlations between fiscal variables and all other variables. The three variables built on estimated population of a region, population density, log of population and population growth rate have weak correlations or one that is not statistically significant. Among the remaining variables included as controls in the models none of the correlation coefficients is remarkably high.

Results

Multiple treatment models

Subnational investment in fixed public capital

The estimations reported here are attempting to pick up the effects of revenue share changes on investments in fixed public capital in the regions. The null hypothesis is

$$\partial fix_{it} / \partial S_{it} < 0,$$

or the change in investments in fixed public capital in region i and time period t with a change in the share of region i is negative. The coefficient on the difference-in-difference estimators employed in the equations estimates this change.[129]

The first estimation uses the multiple treatment model with three treatment groups and seven different policy changes as treatments. The treatment groups are oil only regions (5), gas only regions (2) and oil and gas regions (30). All the non-producing regions form the control group (47). The treatments include changes in oil tax revenue share, gas tax revenue share and the two changes combined together. Each treatment represents a reduction in oil and gas tax

[129] The determinants of public investment in the regions were estimated using instrumental variables and seemingly unrelated equations models. The results have been placed in Appendix C.2.

share of the regions or reduction in one of the tax shares. The dependent variable is the investment in fixed public capital financed from subnational budgets, measures in real rubles per capita. The results in Table 3.5 are presented in three columns. The first column has a time trend while the second column includes a full range of year dummies. The first two columns estimate a fixed effect model presented in equation (2) in Section 1.2 above, using small sample correction for error variance[130] with robust standard errors. The third column estimates the model using a full range of region dummies and robust standard errors as presented in equation (1). The year dummies and region dummies are not shown in the table.

The results show that the effect on all three treatment groups is negative but not significant. The effect of individual tax share changes is also statistically not significant. Each DD or difference-in-differences estimator is specific for a treatment and a treated group, estimating the differential effect of each treatment on a treated group. The DD estimators for oil only and gas only regions are not significant except for the first treatment and oil only interaction where the coefficient is positive and significant at 10 percent level. For the gas only treatment, the DD estimator is almost always negative but statistically not significant. For the oil and gas regions, the DD estimators are always negative and statistically significant at 10 percent level in the first two columns. In the third column, they are statistically significant at 5 percent level. However, after the third treatment, the last change in the oil and gas tax shares, the DD estimator although still negative is not statistically significant. The negative sign on the estimators is in accordance with the theoretical propositions presented in Chapter 2. The DD estimators show that when rent revenue share are brought low as a result of federal policy the producing regions

[130] This correction provides small sample variance and covariance matrices, replacing $\hat{u}'\hat{u}/n$ with $\hat{u}'\hat{u}/(n-K)$, correcting the results (Baum, et al., 2003) for the Hansen J statistic in this case.

scale down their investments. The effects are disproportionately absorbed in public investment. As we can see, there is no compensatory investment from the transfers.

The coefficient on real per capita transfers is negative and significant at 1 percent level showing that with a real ruble increase in transfers per capita there is a decrease in investment in fixed public assets. For a thousand ruble per capita transferred to the region, there is a decrease in investment in fixed public capital amounting to 148-149 rubles. It is clear from the table, that the inclusion of full range of year dummies and estimation by a simple instrumental variables model with a complete range of region dummies do not change the results. However, the pooled model estimates the effects of tax changes better. In the oil and gas regions the average treatment effect was reduction of 215-216 real rubles per capita after the first treatment and increased to a reduction of 485-486 real rubles per capita.

The coefficients on other variables have signs as expected in accordance with theory or earlier studies with some exceptions. The investment in fixed public capital increases with increase in revenue but decreases with real gross regional product. The coefficients on both variables are significant at 1 percent level. The positive coefficient on real revenue shows that for a 1000 ruble per capita increase in revenue, there is only 133-134 rubles invested in fixed public capital. This is in accordance with expectations. At the same time, a one real ruble increase in gross regional product per capita is associated with a small decrease in investment in fixed public capital, amounting to less than $1/1000^{th}$ of a ruble. The negative sign is an important result but diminished by the size of the coefficient. The decrease with increase in real gross regional product is not easy to explain. A one percentage point increase in population below working age decreases investment by 146-147 rubles indicated by the coefficient which is significant at 10 percent level. This is contrary to expectation as a higher percentage of population below working

age would need a higher stock of public facilities for education and primary health. Similarly, the coefficient on population density is negative and significant at 10 percent level (5 percent in the third column). This means that thinly spread population requires a greater stock of public capital. The positive coefficient on log of population is statistically significant at 1 percent level showing that a 1 percent increase in population leads to a 10,210-10,560 rubles increase in investment in fixed public capital. Regions with large population invest more in new public capital to address congestion costs accruing on existing facilities. The sign on farmland, volume of goods transported by rail and urbanization are positive and except urbanization significant at 1 percent level. For urbanization, the coefficient is significant at 10 percent (5 percent in the third column) level. The positive sign on farmland and volume of goods transported by rail show that as expected there is a higher investment in new public capital associated with the higher needs of farmland and transportation. Contrary to other studies, the positive sign of the coefficient on urbanization shows that higher investment went into urban areas across regions of Russia. The coefficients on other controls are not statistically significant.

The estimation included real gross regional product and real revenue as endogenous variables. The excluded instruments (also called instrumental variables) were paved roads as a percentage of total length of roads in a region, real value of paid services per capita and volume of waste water generated per capita. The first stage F-test statistics for joint significance of excluded instruments have been reported in the table. Using the Staiger-Stock (1997) method, since the F-test values are greater than or close to 10, it can be accepted that the instruments are strong. The value of Craig-Donald statistic computed for the equations, as reported in the table, is higher than the minimum threshold for the size of 10 percent bias. Choosing a significance level of 0.1, the values reported in the table are higher than the critical values of the statistic

reported in Table 2 of Stock and Yogo (2004). This corroborates the result that the instruments are not weak. To test for orthogonality of each of the excluded instruments, C-statistic[131] was computed. The p-values for the first two columns are 0.308 and 0.275. The null hypothesis that the instruments in each case were orthogonal to the error term could not be rejected. The p-value for the Hansen-J statistic, as reported in the table, also show that the null hypothesis that the equations are not overidentified cannot be rejected.

The equation was re-estimated with inclusion of oil and gas values computed as a product of extracted quantities and average annual prices. The results remained qualitatively the same without major changes in the size of coefficients. These repetitions were performed for all the models with similar results.

These results provide some support to the theoretical predictions. An increase in the federal share of rent at the expense of producing regions results in a decline in investment in long-lived public goods. The regions make expenditure choice while keeping the ratio of current to total expenditures constant or even attempting to increase as a political objective, as portrayed in the theoretical model. The results emphasize that centralization of exhaustible resource rent, while arguably attractive from other objectives, may have consequences for investment in long-lived public goods at the subnational level.

Subnational investment in fixed public capital (with stock of fixed capital)

In Table 3.6 the results appear from the estimation of a model which uses real value of fixed capital stock per capita as a control variable. Due to the strong correlation between real

[131] Baum, Schaffer and Stillman (2002) have described the C-statistic obtained in instrumental variable estimations that provides a test for validity of instruments.

value of fixed capital and real gross regional product, only the former is included in this model. Both are measured as per capita values. In this estimation, the real value of investment in fixed public capital from the subnational budgets remains the dependent variable. This model, a variant of the one reported in Table 3.5, allows controlling for the effect of existing stock of fixed capital on investments in fixed public capital. The equations for the first two columns were estimated as fixed effects models to account for time invariant region specific unobserved heterogeneity. Robust standard errors and small sample correction for error variance have been used. The third column reports results from an instrumental variable estimation using a full range of region dummies. The results are qualitatively the same as those reported for the model using real gross regional product per capita in place of real value of fixed capital per capita in the region. In this case however, the DD estimators for the gas only regions in addition to the estimator for oil and gas regions for the second treatment are negative and statistically significant. The estimator for the oil and gas regions with the second treatment is significant at 5 percent level (1 percent in the third column). The coefficient on transfers is still negative and significant at 1 percent level. Similarly, the coefficient on revenue per capita is positive and significant at 1 percent level. The real value of fixed capital per capita has a negative coefficient which is significant at 1 percent level. This is similar to the coefficient on real gross regional product per capita in the earlier model. Among the other variables, only the coefficients on farmland, volume of goods transported via rail and urbanization are significant. They retain the signs from estimation of the previous model.

The real revenue per capita and real value of fixed capital per capita are endogenous in the model. Four variables, paved roads as a percentage of total roads, real value of paid services per capita, waste water generated per capita and residential area per capita, were used as

excluded instruments. The F-test statistics for joint significance of excluded instruments are large. Using the Staiger-Stock (1997) method, since the F-test values are always greater than 10, it can be accepted that the instruments are reasonably strong. The value of Craig-Donald statistic computed for the equations, as reported in the table, is higher than the minimum threshold for the size of 10 percent bias. Choosing a significance level of 0.1, the values reported in the table are higher than the critical values reported in Table 2 of Stock and Yogo (2004). This corroborates the conclusion based on Staiger-Stock method that the instruments are reasonably strong. To test for orthogonality of each of the excluded instruments, C-statistic was computed. The p-values ranged from 0.656 and 0.514. The null hypothesis that the instruments in each case were orthogonal to the error term could not be rejected. The p-value for the Hansen-J statistic, as reported in the table, also show that the null hypothesis that the equations are not overidentified cannot be rejected.

The results show that the DD estimators are robust to inclusion of real value of fixed capital in the regions in place of real gross regional product. The signs and levels of significance provide qualitatively the same results. They again portray a decline in investment associated with decrease in regional share of rents from oil and gas mining.

Subnational gross investment in fixed public capital

The subnational governments acquire fixed capital sometimes that is financed by other sources. Following the practice prevalent during Soviet times private enterprise may invest in infrastructure that is now publically managed. Some of these projects could assume the form of negotiated taxation. The regional level data report new fixed public capital by ownership and this measure takes into account infrastructure investments owned by the public sector financed by

budgets, debt or private sector. The null hypothesis remains the same for this variable. The multiple treatment models are then estimated substituting the dependent variable, acquisition of fixed capital by ownership in place of investments measured by source of funds. Table 3.7 reports the results of the multiple treatment models with new public capital owned by subnational governments as the dependent variable. The models in the first two columns were estimated employing fixed effects. A full range of year dummies was also included in the estimation reported in the second column. Robust standard errors and small sample correction for error variance have been used. The third column shows the results when the model is estimated with a complete range of region dummies as a pooled regression. Robust standard errors have been used. The year and region dummies are not reported in the table.

The treatment group dummies have negative coefficients that are statistically not significant except for oil only regions in the first and third column. In the first and third columns the coefficient on the oil only group is negative and significant at 5 percent level. On the other hand the tax on oil treatment dummies have negative coefficients that are significant at 5 percent and 1 percent levels in the first column and significant at 1 percent level in the second and third columns. The coefficients on other treatment dummies are not significant. The DD estimators on oil only regions and gas only regions are statistically not significant. The DD estimators on oil and gas regions have negative signs as expected in accordance with the theory model laid out in Chapter 2. For the first two treatments they are statistically significant at 10 percent level but for the third treatment they become significant at 5 percent level. As is clear from the table, the inclusion of full range of year dummies and estimation by a pooled instrumental variables model, with a complete range of region dummies, do not change the results. These results show that a reduction in rent tax shares resulted in a decrease in gross investment in new public capital in the

oil and gas regions. The effect increased with the third treatment. After the first treatment the average treatment effect in the oil and gas regions was a reduction in investment ranging from 687 to 700 real rubles per capita. This increased to 929-943 real rubles per capita after the second treatment and 1,369 to 1,377 real rubles per capita after the third treatment.

The control variables have the signs as expected according to theory and other studies with some exceptions. The coefficients on real gross regional product per capita and real revenue per capita are not significant. The coefficient on real transfers per capita is negative and statistically significant at 1 percent level indicating that with a 1000 ruble increase in transfers among the regions, there is a decrease in gross investment in new public capital amount to 332-328 real rubles. The coefficient on volume of goods transported by rail is positive and significant at 10 percent level (5 percent in the third column). The coefficients on car ownership and hospital beds per 10,000 population are negative but only significant in the third column. In this column the coefficient on car ownership is significant at 10 percent level while the coefficient on hospital beds becomes significant at 1 percent level. The coefficients on other variables are not significant. The time trend is positive and significant at 10 percent level in the first column and becomes significant at 1 percent level when the full range of year dummies is included. The estimation was also done with world price as an independent variable. The coefficient was positive and significant as it substituted the time trend due to the continual increase in oil price during the time period.

All three estimations in Table 3.7 have real gross regional product per capita and real revenue per capita as endogenous variables. Three variables, paved roads as a percentage of total length of roads in a region, real value of paid services per capita and number of doctors per 10,000 population were used as excluded instruments. The first stage F-test statistics for joint

significance of excluded instruments have been reported in the table. Using the Staiger-Stock (1997) method, we can accept the instruments as reasonably strong. The Craig-Donald statistic on the other hand has a low value. The p-value for the Hansen-J statistic, also reported in the table, does not allow me to reject the null hypothesis that the equations are not overidentified. The C-statistic was computed for each excluded instrument and the p-values allowed me in each case to reject the null hypothesis that the instrument is not orthogonal to the error term.

The results reported in Table 3.7 are important as they corroborate the earlier results and at the same time re-emphasize the effect of declining shares on a wider measure of investment. the dependent variable not only includes investments in fixed capital from regional budgets but also those made under the government influence by commercial and private enterprises and debt financing of infrastructure. The decline in this measure of investment indicates that regions carry out investment decisions under an inter-temporal revenue constraint and the future loss of rent may have effects on all means of financing investment in long-lived public goods.

Subnational gross investment in new fixed public capital with stock of real fixed capital

Table 3.8 presents results of estimating a model with subnational acquisition of new fixed public capital per capita as the dependent variable. The model is the same as in Table 3.7 except that real value per capita of the fixed capital is substituted in place of real gross regional product per capita. Due to the strong correlation, both variables are not included. The results are qualitatively the same. The DD estimator after the third treatment for oil only group is however positive and significant at 10 percent level in the first column. The DD estimators for the oil and gas group are still negative but significant at 10 percent level after the first and third treatments.

Annualized effects models

Single treatment with annualized effects

The estimations reported in this sub-section pertain to the empirical model laid out in equations (3) and (4) in Section 1.3. The treatment effects are defined as results of annualized application of share reduction, respecting the budgetary process.

The models in equations (3) and (4) were estimated. The results are presented in Table 3.9. The dependent variable is investment in fixed public capital financed by subnational budgets. The first column shows the results of a fixed effects estimation using time trend. The second column adds a full range of year dummies. Both estimations employ robust standard errors and small sample correction for error variance. The third column shows the results when a pooled model is estimated as instrumental variables specification with a full range of region dummies. Robust standard errors were used. The coefficient on the dummy variable for the treated group, including all oil and gas regions as well as oil only and gas only regions, is negative and significant at 1 percent level as shown in the third column. In the first two estimations the group dummies are dropped on account of collinearity. The interaction terms, *p1g1, p2g1, p3g1, p4g1, p5g1 and p6g1,* are the DD estimators for the annualized effects. The DD estimators in this case pick up annualized effects of the reduction in rent tax revenue share of the producing regions. They pick up lagged effects of earlier reductions in rent tax revenue shares as well as effects of tax share changes taking effect in the year. The estimators always have a negative sign except for year four. They are only significant at 10 percent level in the third year after the treatment began where the estimated average treatment effect is a reduction of 358 real rubles in the treated regions. The coefficient lies between the coefficients for the first

and second treatment in Table 3.5. The coefficients on post treatment years, each depicting an annual application of treatment as a budgetary phenomenon, are negative but not significant. As in the multiple treatment cases above, the coefficient on real value of transfers per capita is negative and statistically significant at 1 percent level showing that for a 1000 real ruble increase in transfers, there is a decrease of 150 real rubles per capita in investment in fixed public capital.

Among the other variables, the coefficient on farmland is positive and significant at 5 percent level and the coefficient on volume of goods transported via rail is positive and significant at 1 percent level. Population density has a negative coefficient that is significant at 10 percent level showing that for a thousand individuals per square kilometer increase in density, there is a reduction of 84.5 rubles in new public investment. On the other hand, urbanization has a positive coefficient that is significant at 10 percent level also. This shows that when population density is taken into account, urbanization is associated with an increase in investments. Again the size of the coefficient is small indicating a 69 ruble increase in investment as degree of urbanization among the regions increases by one percentage point of population. At the same time, a one percent increase in population leads to a higher investment in fixed public capital to the tune of 11 thousand rubles per capita. The size of the coefficient is quite close to the one estimated in the multiple treatment model. All other variables are not statistically significant.

The model used real gross regional product per capita and real revenue per capita as endogenous variables. In this case, three variables, paved roads as percentage of total length of roads, real value of paid services per capita and air pollutions generated per capita in the region, were the excluded instruments. Testing for the validity of instruments, the first stage F-test statistics for the joint significance of excluded instruments have been reported in the table. The values are higher than the threshold of 10 proposed by Staiger-Stock (1997), indicating that the

instruments are reasonably strong. The Craig-Donald statistic at 25.19 is higher than the critical value of 13.43 computed for a significance level of 0.1 by Stock and Yogo (2004). The result corroborates the conclusion that the instruments are reasonably strong. The C-statistic was computed individually for the excluded instruments. The p-values allowed me to reject the null hypothesis in each case that the excluded instruments are not orthogonal to the error term. Finally, the p-value associated with the Hansen-J statistic comes to 0.514 indicating that the equations are appropriately specified as the null hypothesis that the equations are not overidentified cannot be rejected.

The results again corroborate the findings from the multiple treatment model estimations reported in Section 4.1. They show that the decline in investment takes place in certain years after the regional rent shares decrease. These results capture the delayed effect which is expected given the nature of time lag in public investment decisions.

Subnational gross investment in fixed public capital

Single treatment model with annualized treatment effects was then estimated with subnational acquisition of new fixed public capital. Table 3.10 reports the results from the estimations. The first column was estimated with fixed effects and time trend. The second column shows results when a full range of year dummies is included. Both estimations used robust standard errors and small sample correction for error variance. The results in the third column are for a pooled instrumental variable estimation with a complete set of region dummies. The DD estimators picking up the annualized effects of exposure to the treatment are negative for years 2 and 3 after treatment and statistically significant at 10 percent level in column 3. The only annual treatment estimator that is statistically significant (at 5 percent level) is for year 2

post treatment and is reported in the third column. The coefficients on other variables are qualitatively the same as reported for the multiple treatment model.

Seemingly unrelated equations estimation with multiple treatments

With investment in fixed public capital financed from regional budgets

To rule out the possibility of an income effect with no substitution effect, the multiple treatment model was estimated as a seemingly unrelated equations model with investment in fixed public capital and total public expenditures as the dependent variables. Table 3.11 reports the results of the estimation. The estimators are employed for both investments in fixed public capital and total public expenditure. The first column represents the result when investment in fixed public capital financed by subnational government budgets is the dependent variable and the second column has current expenditure as the dependent variable. A complete set of region dummies and time trend are included in both equations but they are not recorded in the table. The year dummies are not included due to their high collinearity with the treatments. The coefficients on treated group dummies are negative for all the three groups in the first column but statistically significant at 1 percent level for the oil only group. At the same time, the coefficient is negative and statistically significant at 5 percent level for the oil only group in the first column. The coefficients for the gas only and oil and gas groups are negative for investment and positive for total expenditure. In both cases they are not statistically significant. These results indicate that the direction of effect of reduction in rent tax shares on investments is negative but not so for the current expenditure. The coefficients on individual tax revenue share changes are not significant.

The DD estimators show that the average treatment effects for investment and current expenditures have opposite signs in most cases. The DD estimators for oil only group are

positive and significant for both the new investments and for current expenditureafter the first treatment or reduction in shares. In the oil only regions, the effect is positive on both investment in fixed public capital as well as current expenditures. It is statistically significant at 5 percent level. It also shows that the current expenditures increased by about six times the increase in investments in fixed public capital. The estimator for current expenditures in the oil only group after the second treatment is positive and significant at 5 percent level and that for post third treatment is positive and significant at 5 percent level. In case of gas only regions, only the DD estimators after the second gas treatment is positive but not statistically significant.

For the oil and gas group, the DD estimator for investment is negative for all three treatment applications but statistically significant at 10 percent level after the first treatment and at 1 percent level after the second and third treatment. At the same time, the coefficients for total expenditures for the group are not statistically significant even though they are positive for the second treatment application. The results indicate that the reduction in rent tax shares mainly affected investments in fixed public capital while having no effect and sometimes a positive effect on total expenditure. The magnitude of effect on investments picked up in this model by the DD estimators, a reduction of 182 real rubles after the first oil and gas treatment, 485 real rubles after the second oil and gas treatment and 327 real rubles after the third oil and gas treatment, is again close to the treatment effects estimated in the multiple treatment model of Table 3.5 and annualized effect model of Table 3.9.

The coefficient on real value per capita of transfers to regions is negative for investments while being statistically significant at 1 percent level and positive but not statistically significant for current expenditures.. The real revenue per capita is positive and significant at 1 percent level for both investments and current expenditure. In this case the size of the coefficient under the

investment equation is 1.7 times the coefficient under the current expenditure equation. The coefficient on real gross regional product per capita is negative and significant at 1 percent level showing that it has a negative association with investment in fixed public capital. As in the earlier estimations, the size of the coefficient is very small amounting to a less than $1/1000^{th}$ of a ruble decrease in investment with a one ruble increase in real gross regional product per capita. In the investment estimation, the signs on population below working age, volume of goods transported via rail, population density, log of population, urbanization and farmland are the same as estimated in the multiple treatment and annualized treatment effects models.

With gross investment in fixed public capital financed from regional budgets

The second model given in equations (6) and (7) was estimated as seemingly unrelated equations. The results have been reported in Table 3.12. The estimators were deployed to pick up changes in both new subnational acquisition of fixed public capital and total expenditure. The first column reports the results when new subnational acquisition of fixed public capital is the dependent variable with total expenditure as the dependent variable in the second column. A complete set of region dummies and time trend were included in both equations without representation in the table. The coefficients on treatment dummies are negative for all the three groups in the first column but statistically significant at 1 percent level and 10 percent level for the oil only group and oil and gas group, respectively. At the same time, the coefficient is negative but statistically significant at 5 percent level for the oil only group in the second column. The size of the coefficient in the first column is about 2.2 times the coefficient in the second column. This means that for the oil only group the reduction in new subnational acquisition of fixed public capital is 2.2 times the reduction in total expenditures. The

coefficients are negative and statistically not significant for the gas only and oil and gas groups. These results indicate that the direction of effect on investments is negative but the effect on the total expenditure is smaller than the effect on new subnational acquisition of fixed public capital. The coefficients on individual tax revenue share changes are not significant except for three cases. For the oil tax share change from 20 to 15 percent for the regions, the coefficient under current expenditures equation is positive and significant at 10 percent level. The gas tax share from 15 percent to zero change in the new acquisition of public capital equation has a negative coefficient that is significant at 5 percent level.

The DD estimators for oil only group are positive but statistically significant for the current expenditures are positive and statistically significant at 1 percent levels for the second and third treatment and 5 percent for the first treatment or tax share change. This shows that the total expenditure in the oil only regions increased with tax share reductions. The coefficients for gas only group for total expenditure are positive but negative for investment in fixed public capital. They are statistically not significant in either case. For the oil and gas group, the DD estimators for investment are negative for all three treatment applications but statistically significant at 10 percent level after the first and second treatment, at at 1 percent level after the third treatment. At the same time, the coefficients for total expenditures for the group are negative but not statistically significant. The results indicate that the reduction in rent tax shares mainly affected subnational acquisition of fixed public capital while having no effect and sometimes a positive effect on current expenditure.

The coefficient on real value per capita of transfers to regions is negative for investments and positive for current expenditures. In the first case it is statistically significant at 1 percent level and in the second case at 5 percent level. The real revenue per capita is positive and

significant at 1 percent level for current expenditure. The coefficient on real gross regional product per capita is statistically not significant.. In the investment estimation, the signs on population below working age and volume of goods transported via rail and farmland are the same as estimated in the multiple treatment and annualized treatment effects models but only significant in case of the latter. Population growth rate on the other hand is a significant determinant of current expenditures while other variables are not statistically significant.

The multiple treatment model was estimated replacing subnational investment in fixed public capital by federally financed investment in fixed public capital. The DD estimators show that the coefficients are negative but not significant. So it suggests that there is no evidence that the increase in federal share of rent taxation increased federal investment in new public capital.

The alternative methods for estimating average treatment effects were also used. Average treatment effects using matching estimators as defined earlier were used. The results have been summarized in Appendix C.3. The results corroborate the estimates presented here when acquisition of fixed capital is the dependent variable. Results for investments from regional budgets could not be corroborated with method. In the end, a model using propensity scores was estimated. The results are also given in the Appendix C.3. Again, the results for acquisition of fixed capital were corroborated by this method. For investment from regional budgets they could not be. Both alternative methods show that the average treatment effect on the treated was negative in case of acquisition of fixed capital by subnational governments. In some cases, the average treatment effect is also negative but the average treatment effect on the treated is of a higher magnitude.

Conclusion

This chapter has attempted to test two theoretical propositions from Chapter 2. Specifically, the empirical questions explored the effect of decrease in the share of resource rent revenues on investment in fixed public goods in the regions of Russia and the effects of the investment and current components of total public expenditure as simultaneous choices. The estimation equations used two different definitions of subnational investment in fixed public capital. The empirical models were developed to create estimators that could specifically provide answers to these questions. The models exploited a quasi natural experiment in the Russian Federation, namely the reductions in rent shares of producing regions between 2004 and 2006. The three reductions and three types of producing regions that formed the quasi natural experiment, provided a set of variations that were all used in the model to bring out the effects of each type of policy change and its variegated application. The chapter employs a program evaluation method embedded in a structural model of determination of public investment. In doing so, it attempts to make a methodological contribution.

The theory model presented in Chapter 2 lays out an analytic framework for rent tax assignment. Given the priority of keeping current public expenditure, or consumption, at a certain level, a gain in federal share of rent tax revenue at the expense of regional share of the revenue needs to be viewed from the perspective of its effect on investment in new public capital. This chapter shows the real life changes in rent tax revenue shares in the Russian Federation took place in a context that was similar to the parameters defining the theory model. The estimations have been carried out using determinants of public capital investment in the regions of Russia. Using both an instrumental variables method and a seemingly unrelated

equations estimation, a set of variables was identified that have an effect on investment in public capital investment.

Investment in in fixed public capital has been used as a measure of increase in long-lived public goods. The measure is defined in two ways, investment in fixed public capital from subnational budgets and acquisition of fixed capital by subnational government. The estimation results have shown that rent tax revenue assignment is not neutral to investments in public capital. Important as it may be to development policy, this finding holds implication for the discussion of rent tax assignment. The DD estimators employed in all the three models provide some evidence in favor of the theoretical propositions that an increase in the federal share of rent results in a decline in public investment. Inclusion of a longer time series for both pre-treatment and post-treatment time periods enhances the sample size and also allows for picking up specific time effects. The main results are consistent across the the three models. The multiple treatment method exploits the entire range of variations in treatment application and in addition to its methodological relevance, shows moderately strong evidence of decline in public investment. The annualized treatment method provides another analytic variation by allowing lagged effects of the policy change to appear over the subsequent years. This method in particular recognizes the nature of the budgetary process where any effects on capital investment programs would appear with some time lag due to their medium term planning horizons. The seemingly unrelated equations method is particularly of interest because it closely demonstrates the simultaneity in the choice of new capital investment and setting the overall size of public expenditure. It is also able to provide an empirical estimation method that very closely aligns the objective function elaborated for the theoretical model in the previous chapter. All three methods recognize gross

regional product, value of fixed capital and subnational revenue as endogenous variables in the choice model.

The estimation equations have been specified to separate out the effect of policy change from revenue effects and the effects of other variables. In addition to the results connected to the DD estimators, the findings show that real gross regional product per capita and measures of economic activity increase investment in fixed public capital in subnational jurisdictions, while controlling for other factors. Some structural variables like farmland and population density were significant but others like road density were not statistically significant. All these results except that on gross regional product are in accordance with expectations based on theory and earlier studies. The coefficient on the existing stock of fixed capital is negative but only significant in a few estimations. This result provides weak evidence that there may be convergence in the stocks of fixed capital across the regions of Russia. Demand variables like population below working age, public school enrolment and hospital beds per 10,000 population are significant only in some cases. The signs on their coefficients are not always easy to interpret. After demonstrating the effect of determinants on public investment, we have employed three program evaluation methods and the results provide insights into the effect of policy change on investment in long-lived public goods.

The tax sharing policy change has an effect on investment which is a component of development policy. Therefore, from a policy perspective the findings have an implication. The results show that the main brunt of reduction in subnational share of rent tax revenue was borne by investment in public capital.[132] In terms of income effect, most of the response came on the recurrent expenditure side as the total revenue coefficient in 0.13 for the capital expenditure and 0.85 for current expenditure. For oil and gas regions, however, there was also a price effect

[132] This is in line with the earlier findings of Oxley and Martin (1991) in case of other OECD countries.

exclusively for capital expenditure. There is some evidence that total public expenditures inclusive of social expenditures were protected compared with investment spending.[133] The decline in infrastructure expenditure is noteworthy because it cannot be explained by convergence as was the case in the United States and some other OECD countries.[134] The decrease in investment is not compensated by any upward trend in federally financed investment. This indicates that the increase in federal revenues is channeled into other areas. Transfers do not substitute shared revenues in this case. Mostly transfers are used for other types of expenditures. This result could be attributed to the particular nature of transfers in Russia where existing facilities account for measures of fiscal need.

Investment in long-lived public goods is a variable that is amenable to direct and indirect policy effects. The theoretical model in Chapter 2 shows that a higher value of increase in long-lived public goods should result in lower federal share of rent revenues. It is difficult to say if the results could be interpreted in this way to say that there is a low value attached to increase in long-lived public goods. If the government in Russia deliberately planned to siphon resources away from investment toward consumption, the effect of the changes in rent tax shares may not be a matter of concern. On the other hand, if the policy seeks to carry out nation building and includes investment in long lived public goods, the effect of changes in tax shares is not neutral to investment in fixed public capital. In either case, it supports the view that rent tax assignment should be viewed from the perspective of investment outcomes and not necessarily treated as a matter of administrative advantages or macroeconomic concerns.

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[133] A similar finding was reported by Sanz and Velazquez (2003) but contrarily to their findings productive investments decline.

[134] A discussion of these issues has been presented in Munnell (1993) for United States and other European countries.

The empirical evidence presented in this chapter supports the hypothesis that an increase in federal share of rent revenue at the expense of subnational governments will decrease investment in long-lived public goods. Whether this effect is due to differences in preference for long-lived public goods or due to inertia in existing current expenditure allocations can be further investigated. In the next chapter, we present some discussion addressing the first question.

Chapter 4 Resource rent sharing reconsidered in the context of regional identity

Introduction

Resource rent sharing between producing regions and rest of the country, through base or revenue sharing, are employed as conflict management tools in some countries. This is understandable due to the preponderance of conflicts arising from exhaustible resource benefit sharing. In this chapter, we present additional evidence that leaving more rent with the producing regions, where such regions have strong community identity, may stimulate investment in long-lived public goods. In this context, the rent sharing question could be considered anew from a development policy point of view. The effect of rent tax assignment on expenditure choices, as demonstrated in the Chapter 3, is not neutral but often it is not studied from this perspective.

In this chapter some additional arguments are made for reconsidering the role and effects of rent tax assignment. Importance of rent to development, connection of rent sharing with political stability of a federation and politically finalized sharing arrangements in some federal countries are presented to highlight the political significance rent sharing in several countries. These issues provide a background to the empirical results presented later in the chapter. The chapter begins with a discussion of rent related issues in federal countries, different types of ownership associated with it and also evidence on various ways in which federations deal with the issue of rent sharing. The importance of rent to development and its connection with political stability are recounted to provide a context to review the nexus of regional identity and claims of exhaustible resource rents. Federations are finely balanced institutional arrangements where

resource rent often is a contested issue. Due to strong community ownership claims on rent are made and pursued. A federal arrangement that bestows higher shares of rents where there is a higher sense of ownership is not only a political consideration as commonly understood. A valid question is if resource ownership claims intertwined with identity lead to expenditure choices that are different than those made by the federal government or other regions. Within the context of examples of rent sharing from different federations, an empirical test is applied to the case of the Russian Federation to find out if regional identity plays a role in preferences for investment of rents.

We have seen that the case of the Russian Federation which comprises of producing regions where some are republics and regions with strong ethnic identity. Republics among the producing regions have historical claims to a distinct identity and may have a preference for preserving their identity. The evidence in the previous chapter showed that change in rent shares had an adverse effect on investment in long-lived public goods. In this chapter using the case of producing republic an attempt is made to find if there is any evidence that identity based community ownership of exhaustible resource endowments matters to investment choices and it should be included in the assignment question. Following this line of argument, it can be discussed if rent assignment, through rent tax or revenue assignment, should favor producing regions within the range of stability in a federation.

Where investment of rent is a priority, rent assignment should be considered as a special case under the assignment question. If there is evidence that subnational entities have a differential preference for investment in long-lived public goods, then centralization of rent shares will not be neutral to investment. In such cases, rent tax assignment should favor producing regions if they have a higher preference for long-lived public goods. Development

policy goals often include increasing the stock of public infrastructure as well as reducing the possibility of conflict generated by unrequited claims to resource ownership. Assignment of rent revenue or taxes to producing regions will be conducive to development policy goals. Centralization on the other hand may run counter to the goal of increasing investment in long-lived public goods. The macroeconomic considerations will still remain relevant. They should be addressed by setting clear fiscal rules that provide a limited set of allocation choices to producing regions, without necessarily burdening the assignment question with these objectives.

Despite the well known association of resource riches and a mixture of conflict and opportunity for growth and development, there is not much guidance on rent tax assignment in the general tax assignment literature from these perspectives. The current thinking arises out of the general revenue assignment principles and does not provide a special treatment to taxes levied on exhaustible resource rents. The basic precept remains an agreed principle that the rent should be all picked up by some tax instrument and used for the general benefit of the society. Beyond this to whose benefit should it be applied is not clearly spelt out. There has been a considerable amount of concern in the literature about the macroeconomic effects and labor market efficiency.[135] Community claims on rent are generally treated as almost an unwelcome aberration. The macroeconomic concerns and difficulties of administering a resource rent tax dominate the considerations.[136] Due to these concerns, centralization of rent tax collection and revenue is favored as an assignment solution. Tax efficiency has been another area of interest that has been studied in some detail.[137] The arguments for centralization are only qualified by the

[135] For example see Boadway (2006), and for a classical treatment of the subject see Dasgupta, Heal and Stiglitz (1980), Bergstrom, Cross and Porter (1981) and Bergstrom (1982). Otto (2000) and McKenzie (2006) have a similar emphasis. For a recent discussion see Boadway and Keen (2010).
[136] For example see Boadway (2006), Tordo (2007) and Boadway and Keen (2010).
[137] For example see Gamponia and Mendelsohn (1985);

need to pay for subnational services and political reasons.[138] All these are important considerations. But given the close link of rent tax revenue and long-term growth, it can be argued that rent tax assignment is neither best treated as a general tax assignment not merely a function of political compromise. And if so, is there a model of rent tax assignment in a multi-tiered jurisdiction.

The theoretical model in Chapter 2 assumes that investment preferences may vary across regions. Proposition 2 shows that an increase in federal share of rent will result in a decrease in investment of rent in long-lived public goods if preferences are distributed likewise. The adverse effects in the regions will vary according to the extent that preferences for rent investment vary across regions. Could this be related to exhaustible resource endowments is a question that can be asked in the context of rent assignment. This proposition provides the theoretical context for the empirical model used in this chapter.

Exhaustible resource rent is a finite asset often identified with strong community ownership. Two features of resource rents are noteworthy from a policy perspective. They are a strong claim to ownership by communities and an associated higher preference for investment of rents over consumption. The latter is by no means a ubiquitous practice but there are examples to show that communities prefer investment over immediate consumption.[139] A number of world examples show that communities have chosen to allocate exhaustible resource rents to long-lived assets. A preference for long-lived assets over immediate consumption is an important behavior norm from a policy perspective.

[138] McKenzie provides these two cases as exceptions to the arguments for centralization of resource rent taxes.
[139] Fasano (2000) presents a review of oil savings funds in Norway, Chile, Venezuela, Alaska, Kuwait and Oman.

The world experience shows that claims to rent are made by communities who can assert ownership of land. At times, such claims are intertwined with identity politics.[140] The exhaustible nature of rents makes them a patrimony to which outside claims can be thwarted. On the positive side, the ownership rights may lead to efficient rent allocation, namely investment in long-lived assets. Exhaustible resource rent has demonstrably influenced allocation decisions. When producing regions are seen as distinct from other regions, rent sharing is not a straightforward option to be addressed in an equalization scheme. These distinguishing features of resource rent mean that it should merit a special treatment under the revenue assignment question, where assignment principles specific to exhaustible resource rents are adopted. Given these two features of resource rents, it can be asserted that rent assignment, tax base or revenue sharing, merits a special treatment under the general assignment question, catering to the distinct nature of this tax base.

The central argument in this chapter is that exhaustible resource rent assignment should be given a special consideration under the revenue assignment question, using a rational framework distinctly different from the general arguments applicable to other sources of revenue. The importance of this question is shown with a discussion of the case of federal countries. We have argued in the earlier chapters that rent tax (or revenue) assignment, keeping in view the efficient use of the rent, should be an important consideration within the general tax and expenditure assignment frameworks. In doing so, we have attempted to demonstrate that resource rent revenue assignment is not neutral to outcomes like new investment in long-lived public goods. In addition to efficient tax instruments, revenue assignment decisions, which

[140] For example, see Akapalu and Parks (2007) in case of Nigeria; Billon (2001) for a more general discussion of the issue.

include rent tax base and revenue sharing, also matter to development policy when investment in long-lived goods is a policy choice.

The two preceding chapters have shown that with some assumptions on differential preferences of long-lived public goods in a country and a political stability constraint, it is possible to construct a model for rent tax assignment within the context of development policy. The empirical evidence lends support to non-neutrality of rent sharing and assignment for investment in long-lived public goods. In this concluding chapter we refer to different world federations alongside a discussion of rent tax assignment. The differences is rent sharing across federations could be due to different settlements of political stability arrived at between the federation and the producing regions. The discussion in this chapter is organized in five sections. In the beginning, Section 1 briefly lays out the importance of resource rent sharing in relation to conflicts in world federations. Section 2 presents a discussion of complexity introduced by different patterns of resource ownership. It explains that ownership could be constitutional or legal but not necessary leading to control over revenues. Section 3 presents evidence from world federations and suggests that no uniform practice of rent sharing exists. Section 4 revisits the assumption made in the theoretical model of Chapter 2 that producing regions may have a higher preference for investment of rents in long-lived public goods. The argument for special consideration of exhaustible resource rent in this section uses empirical results from the Russian Federation to show that community identification with land and exhaustible resource endowment may influence rent investment choices. Based on these arguments, Section 5 concludes that a rational framework will be useful in analyzing rent assignment and may possibly help create efficient arrangements for use of rent in fiscal choices. The conclusion, based on this discussion, does not unambiguously support the commonly made centralization argument for resource rents.

Resource rent issues in a federation

The extent to which public investment of resource rents is important to a federation depends upon its development policy. The effects of rent tax base and revenue sharing influence on public investment are being discussed here with reference to ethnic diversity in a federation. A fiscal approach that employs efficient taxation and allocates rent revenue to creation of long lived public capital suits development objectives. The so called Hartwick rule suggests that all rents should be invested in long-lived goods to keep productivity from falling below current levels (Hartwick, 1977; 1978; Solow, 1986). This notion is also supportively captured by the discussions of genuine national savings and genuine national product (Hamilton & Clemens, 1998). The fiscal approach on the whole needs to meet all three standards namely, efficient taxation, efficient levels of rent investment and mitigation of conflicts. Even when largely ignored in the revenue assignment question, it is apparent from world experience that while aiming at efficient taxation and levels of public investment, it is critical that the fiscal approach keeps the federation with minimum conflict and politically stable.

In this context, design of taxes and arrangements for sharing of benefits from exhaustible resource exploitation are consequential issues for development outcomes. The constitutional and political status of subnational entities in a federation adds an additional dimension of importance to the treatment of resource rents in the fiscal architecture. In federal countries, the subnational entities have (mostly) clearly recognized political status and using this legal position they can stake claims on resource rents against the federation and against other subnational entities. This constitutional situation makes the claims on resource ownership and arrangements for sharing of benefits more intricate and complex under a federal arrangement, as they become intertwined

with the constitutional scheme and identity politics. The fact that subnational entities in a federation have a recognized constitutional *locus standi* allows them to make claims and raise issues with rent sharing arrangements within the pales of law, with stronger legitimacy and higher political acceptability. Unlike a unitary state, a federation may become politically unstable if these issues are not resolved.[141] Therefore, settlement of resource related rights and sharing of benefits receive (and should receive) added attention in a federal country.

Natural resources are important to development policy and its outcomes. They are associated with conflict as well as a number of development opportunities in the producing countries. For countries with a lower capital labor ratio, natural resource endowments attract investment and if managed and harvested properly, natural resources provide financing for development. Many countries, despite these advantages, have been unable to gainfully employ their natural resource to their advantage and follow a path leading to higher development. In fact in some contexts, a negative relationship between natural resource abundance and growth has been found to operate (Sachs & Warner, 2001). The well known notion of the 'Dutch disease' has been developed to explain this relationship. According to this concept, preponderance of natural resource in the economy crowds out other sectors. The related 'resource curse' hypothesis, explains the relationship through weak institutions and rent seeking behavior. Studies have also established the relationship between natural resources and conflict under certain circumstances (Collier & Hoeffler, 1998; Le Billon, 2001; Olsson, 2007).

At the same time, it is also recognized that the negative outcomes are not inexorable consequences of resource endowments in a country. Strong institutions may prevent conflict and

[141] I do not imply that such conflict cannot occur in a unitary state. In fact Aceh in Indonesia and the interregional distribution of canon revenues in Peru (Ahmad & García-Escribano, 2006) are examples from unitary state. In the federations due to already defined positions of subnational entities, the conflicts are more tangible and intermixed with identity politics. The discussion here for federations may also be generalized to unitary states.

lead to positive outcomes. The putatively negative resource-growth relationship is therefore more a consequence of missed opportunities than an immutable curse. It can be deduced from these discussions that it is the absence of appropriate incentives, rules and systems to siphon rents to the general public weal that leads to adverse effects on growth and development (Sala-i-Martin & Subramanian, 2003). However, despite this recognition, no clear guidance is available on building up the framework for rent collection and allocation. Clearly, rent assignment will be an important component of what could be called an optimal institutional scheme to guarantee positive outcomes from exhaustible resource exploitation. The effect of rent tax assignment on expenditure choices, as demonstrated in the last chapter, is not neutral but often it is not studied from this perspective. An appropriately designed tax system in a resource rich economy can efficiently pick up rents from resource mining and channel them to pursuit of welfare maximization. But it is only optimally chosen expenditures that can provide long term productive sustainability. A tax and expenditure system that is efficient for extracting economic rent as well as channeling it to optimal investments will be required for pursuit of development objectives. When both the tax and expenditure choices can be influenced by rent assignment arrangements, the case for centralization of rent revenue as a general dispensation under the assignment question becomes considerably weakened.

It will be pertinent to refer to some conflicts that arise out of benefit sharing on account of natural resources in various countries and recognize that resource rent-sharing arrangements are often a cause for concern in the federal policy context. In Canada for example, Alberta and other producing provinces have asserted their right to petroleum rent (James, 1993). Depending upon the international price of oil, the arrangement may be questioned vigorously or less strenuously. Nigeria has an ongoing conflict in the Niger delta where three of the nine producing

states are located (Iledare & Suberu, 2010). The conflict over resource rights rises and ebbs when faced with different settlements. The latter in this case are nothing but revenue sharing arrangements. The Russian Federation during the 1990s saw producing regions claiming major share of the rent from oil and gas production.[142] The quantum of stability in the Russian Federation has varied over time. From a fragile federation in the 1990s it has emerged as a country with a strong and assertive center (Mitin, 2008). At a subliminal policy plank, the resource rent sharing has changed over time as well. Pakistan only recently attempted to gain stability after conceding joint ownership of both onshore and offshore natural resources formally to the provinces through a constitutional amendment.[143] Recently, in Iraq negotiations on resource rights were held as part of the constitution making exercise. The constitution making had to navigate between regional and national claims on petroleum reserves and mining operations. The question was so basic to the country and difficult to resolve that its constitutional resolution in favor of the 'people' remains open ended, leaving room for interpretation and a long drawn out settlement. Nepal agreed in 2007 in a referendum to switch to a federal governmental structure after more than a decade long insurgency. Part of the strong demand for federalism comes from regional and community assertion of resource ownership. In Nigeria, the 1999 constitution settled the ownership of petroleum in favor of the federation but allowing for asymmetric distribution of revenue to producing states. The fact that such conflicts have afflicted both rich and poor countries means that there is some evidence that rent tax assignment should lie in the interior of the stability constraint as we have argued in the first chapter. In other words, rent shares should neither tilt too aggressively toward the center nor completely ostracize non-producing regions. Otherwise political instability and conflict may ensue.

[142] A detailed discussion in the first post-Soviet decade in presented in Alexeev, 1999.
[143] Article 172 (3) of the Constitution of Pakistan after the Eighteenth Constitutional Amendment.

Recognizing the importance of resource ownership related conflicts many countries have attempted to address the question at the constitutional or statutory level. The older federal constitutions did not avidly address resource ownership and sharing. In the later constitutions that have been written after experiencing conflict and arriving at new national consensus, natural resources have received more attention (Haysom & Kane, 2009). Various ways have been attempted to settle the ownership question and sharing of benefits. Rent tax assignment may or may not align with the ownership titles. Most rent tax assignments are at best compromises and not necessarily made under a rational framework.[144] As long as they work politically, there is not much reason to reopen the question in any particular country. However, settlements are not constant over time. Changes in fiscal fortunes or political stability may call them into question. Therefore, there is a need for a rational framework to assign rent tax revenues to serve as guidance to assignment decisions in multi-tiered countries.

The ownership question and political stability

Resource ownership matters to claims on rent and ownership question affects sharing arrangements. In many cases, claims lead to political action that results in changes in sharing arrangements. Therefore, the discussion in this section clarifies the concept of ownership, what it entails and how it relates to political stability. Together these issues provide a context in which rent assignment can be discussed.

Resource ownership can be explained as three types of rights namely ownership as having a property title, management rights and as revenue share. Ownership and management, the first two, do not necessarily affect rent revenue assignment. But the latter is carried out within the confines of ownership rights. Resource ownership is only important because it may

[144] For example see Table 4.1 for Canada, Nigeria, Pakistan and the United States.

allow regions (or the federation) to stake a claim to a higher share of rent. In other words, for rent assignment, ownership and management rights may or may not be relevant. If ownership is legally vested in the center, it does not bar subnational entities from staking a claim to rent. The assignment question, it seems, does not settle with constitutional and legal settlements but may additionally require responding to claims on rent by subnational entities in open political process. Rent belongs to the community, the usual refrain, manifests in different shares between producing regions and the federation across countries. The differences can be easily noted to conclude that no universal practice exists. It is also noteworthy that different sharing rules cannot be completely explained by political bargaining. The stability constraint, discussed in the last section, provides an analytical device to explain variations in rent sharing across countries, especially federations.

Despite the importance of exhaustible resources to many economies, there is no universal practice of assigning resource ownership and management rights. In a federation there are a number of issues concerning use of exhaustible resources that require settlement. Some of these are long term institutional issues like ownership while others, unique to the nature of the problem like efficient rate of resource mining, rent collection, sharing and allocation, require continual work to address changes in the international capital and commodity markets. The first set of issues pertains to settlement of ownership and management. It would be difficult to argue that a normative prescription exists for conferring ownership of an exhaustible resource on a community, local jurisdiction, state or federation. In this regard, the general principle often repeated in discussions that rents should be collected and spent on the general welfare of the community has little practical use. The definition of community may be settled on the federation, a constituent state or a local community. The practice varies so much that is appears almost

arbitrary and any attempt to evolve a rational framework trivial. In practice, therefore, centralization or decentralization of rent revenue both will measure up to the principle under different definitions of community. It can also be said that federations are not uniform in the way they define common benefits. In some cases, the subnational interests and benefits are subordinate to national interest as defined by the center.[145]

Table 4.1 shows the number of producing regions in case of federal countries where exhaustible natural resources are important to the economy and briefly lists how they have settled the ownership of such natural resources. The practice in the existing federations shows that wide variations exist in settlement of property rights. Argentina allows provinces to own onshore as well offshore reserves up to 12 miles. Australia has worked out a similar dispensation but with onshore reserves belonging to the states and offshore to the commonwealth government. In Brazil, ownership is vested in the union but subnational governments are guaranteed revenues through legal provisions. In Iraq, the constitution has vested ownership in the people under provisions that are open to interpretation in the future. India allows ownership to subnational

[145] In federations the national interest can be defined as a sum of subnational benefits plus additional benefits provided by the federal arrangements and it is this sum that is maximized.

$$Max\ W_{\{C_i\}} = \alpha_1[B(C_i) - C_1(C_i)] + \alpha_i(R_i - C_i)$$

subject to $B - C_1 \geq 0$ and $B - C_1 \geq \sum_i -(R_i - C_i)$

where B is a measure of total benefits that the federation generates, a function of C_i, and are consumed in every region in the federation[145] and C_1 is the cost of maintaining the federation and is an increasing function of $\sum_i -(R_i - C_i)$, R_i is the measure of local benefits that can be generated in region i, state or province on its own and C_i is the cost that region i pays in joining a federation. The cost can be characterized as the fiscal resource taken away from the region by the federal government. $\alpha_j, j = 1,2, \ldots, i+1$, are the weights attached by a social planner to the federal benefits and net regional benefits. The first constraint is the basic foundational condition for a federation whereas the second is the stability constraints based on a compensation criterion. C_1 increases with political conflict. The more the conflict endures, the higher is the cost of maintaining the federation. Any negative net benefits will increase the cost of maintaining the federation whereas positive net benefits reduce it. It is clearly possible to have a negative net benefit in a region as long as $B \gg R_i - C_i$ or when $\alpha_1 \gg \alpha_i$. In federations, where the first condition is met, regions may be willing to give up ownership of exhaustible resource endowments. Where the second condition is met, with or without the first condition, a political choice for nation building may be a dominant concern leading to federal ownership of resources. Indonesia settled the Aceh demands for ownership of oil mining in the form of an asymmetric sharing of 70 percent of revenue with the province. If the weights are some measures of social values of federal versus regional benefits in the population then the maximization allows the planner to choose a higher cost, in this case a higher level of federal share in the rents. Since such values vary across nations, it is expected that the level of federal share in the rent revenue will vary across countries.

governments but keeps management rights for the federal government. In Russia, onshore resources are jointly owned but in practice the regions do not have management role. Pakistan has worked out a joint ownership regime keeping management with the federal government. Venezuela keeps both ownership and management for the federal government.

The assignment of ownership and benefits is not always with the same level of government. In Nigeria and India, ownership of onshore exhaustible resources vests in the federation. The countries that have given a clear ownership title to subnational governments are Canada, United Arab Emirates and Australia. The Russian Federation and Pakistan have declared a joint ownership of exhaustible resources between the federal government and the producing region or province. In the United States, there are two types of ownership regimes. Mining on private lands is privately owned whereas on state land, around 30 percent of the total area of the country, it is nominally vested in the federal government with sharing of management and revenue rights with the states (Mieszkowski & Soligo, 2010). In case of offshore mining, nearly all federations including Russia, Canada, the United States and Venezuela assign some level of ownership to the federal government.

Once the ownership has been settled, management and regulation rights are largely, but not always, decided according to efficiency and scale considerations. Subnational governments may not have the technical capacity to design and implement resource mining contracts. Policing implementation and the requisite capacity for doing so would be another issue. The balance of the argument in such cases is mostly in favor of the higher levels of government with one exception. Local costs in the form of environmental damage can best be assessed at the local level. There is a higher motivation to act on such issues at the subnational level. When resource rich jurisdictions are landlocked, mining may require transportation across other jurisdictions. In

case of Russia, natural gas pipelines from Caucasus and other Russian oblasts cross several non-producing regions before they reach markets in Europe. A similar situation applies to producing regions in Sudan.[146] Such transboundary issues can best be internalized with a federal role in management (Silva et al., 2009). In practice federations have adopted increasingly a dual approach. The formal statutory management of mining is with the federal government. This may extend to regulation of exports, as in case of Australia. Local jurisdictions are given role in mitigating environmental costs. In many cases, mining firms deal directly with local communities in addition to regulatory compliance with the federal standards. The pace at which mining is carried out may have implications for macroeconomic stability. Federal governments may want to step in to regulate management for this objective also.[147]

Revenue sharing in federal countries—some examples

Revenue sharing is perhaps even more important than the ownership question in federal countries. Exhaustible resource rent embodies the largest share of benefits. Other benefits like employment generation, power at negotiation tables and political strength are of lesser significance at the regional level. The importance of the rent revenue sharing question is a function of the size of rent tax revenue as a fraction of total government revenue. Federations have base sharing or revenue sharing arrangements essentially to deal with the remaining claims after settling the ownership question. In Canada and Australia the provinces and states tax the base with the federal government collecting some part of the rent through corporate income tax. The United States allows local jurisdictions to levy a severance tax while the royalty is collected

[146] Similar issues have been seen in centralized China.
[147] Corruption is a major issue and siphoning away rents for private purposes is a major concern in many countries. To focus my attention on the specific questions being discussed in this chapter, I have not included corruption in the scope of my discussion.

by the federal government and then shared with the states. The Russian Federation collects almost all the rent through the Mineral Extraction Tax since 2001 and shares part of the revenue with the producing regions. From 2010 it will retain all the revenue. Brazil, India, Nigeria and Pakistan collect all the revenue at the federal level and then share it with the producing jurisdictions. In India the transfers are recognized as non-tax income of the producing states and it is not an important issue in the general revenue assignment. Nigeria transfers the revenue in accordance with a formula to all the states, with some preferential allocation to producing states, and it is one of the most contested questions in the Nigerian federalism.

Among the major federations, Argentina, Australia, Brazil, Canada, India, Iraq, Mexico, Nigeria, Pakistan, Russia, United Arab Emirates, United States and Venezuela produce oil and gas in significant quantities and rent tax revenue is an important consideration for the national or subnational fiscal policy. Table 4.2 shows that oil alone is an important sector in the gross domestic product in several federations. Iraq depends on oil production with around 54 percent of GDP coming from this sector alone. In case of Nigeria, nearly 40 percent of GDP comes from oil. In the United Arab Emirates, it is more than 20 percent of GDP. This is closely followed by Venezuela where oil accounts for 20 percent of GDP and the Russian Federation with around 17 percent of oil sector in GDP. A more precise measure of the significance of oil and gas sectors to government is the share of rent tax revenue collected to total revenue. Table 4.3 shows that in a number of federal countries, oil and gas rent tax revenues account for a major share of total revenue. In Australia, at 2.9 percent of total government revenue, it is noticeable. In Pakistan, at 8.4 percent of total tax revenue, it is significant enough to create long drawn out political conflict between producing provinces and federal government. In the United Arab Emirates, with nearly 75 percent of total revenue, petroleum becomes the mainstay of the fiscal regime. To a lesser

degree, in Venezuela with half of government revenue coming from this sector, it again becomes the main source of revenue. In the largest federation, Russia, it accounts for 36.7 percent of total revenue signifying that rent taxes make a major contribution to government operations.

There are primarily two ways in which federations assign resource rent tax revenue. The first method is by tax assignment. Under this method, the rent is declared as the shared base among different levels of government. The right to levy a tax on the base defined as the economic rent of an exhaustible resource is either given to the federal government or to a subnational level or vested in multiple levels of government. This method has some advantages. It allows each level of government to set its own rate and carry out its own collection.[148] Mines differ from each other in the quality of their deposits reflected in the differential costs of extraction. Subnational governments can choose different rates to ensure that the rent is siphoned away efficiently.[149] This method also vests a higher degree of ownership in the subnational governments. When ownership of mineral endowments is politically sensitive, this method has the advantage of assuaging local community claims and providing political stability. On the other hand this method leads to some practical difficulties. Multiple instruments increase compliance costs. There is a higher administrative cost of the system due to coordination requirements.

The second method is sharing. In this case the federal government sets the rate and collects the revenue. It is then shared according to some sharing rule with the producing jurisdiction. The rule, among other things, in general allows favorable shares on the derivation principle. The advantage of centralized tax policy and administration lies in its administrative efficiency. At the same time, it may lead to claims by subnational jurisdictions against federal

[148] Perhaps due to capacity concerns, no developing country allows complete tax discretion to subnational governments except in case of minor minerals.

[149] Elected officials with a short elected life, signifying a high discount rate, may want to expedite the pace of extraction. This could be dealt with by higher transparency and accountability.

government. Where there is a strong identity attached to producing jurisdictions, it may lead to conflict seeing federal tax on resources as unfair. Another undesirable effect, which is often ignored, could be a lower investment in long-lived public goods.

Table 4.4 demonstrates that there is no universal scheme of sharing arrangements and they vary by country. In Canada, for example, the provinces primarily tax exhaustible resource rents. The federal government levies corporate income tax only. Australia allows the states to retain rents but adjusts them completely in the equalization scheme. The United States collects rents on federal lands but passes almost 90 percent of the royalties to the states (Mieszkowski & Soligo, 2010). Looking at the petroleum sector, Table 4.4 shows that there is no universal practice of tax or revenue assignment in the world federations. If there is a norm it is that a combination of tax instruments are allowed to capture exhaustible resource rents. Several reasons could explain the multiple instruments in use. Assessment of rents is difficult. When governments aim to siphon away all the rent multiple instruments have a better chance at meeting that aim. With a few exceptions, all the tax instruments collect from the same base. The payments are either in monetary units or in kind. The latter option is also kept in the tax regime to ensure that supernormal profits that may accrue due to unusual world commodity prices may also be captured by the government.

This type of variation in selection of tax revenue shares and instruments shows that the effective rent shares of producing regions lie on a wide interval. This outcome can be explained by using the idea of a stability constraint as mentioned in Section 2. A region joins a federation trading off some of the benefits of independence with those derived from association. Association comes at a cost, which in this case it is the federal share of the rent revenue. Only if the net benefits of association are larger than the benefits of independence the producing region

joins or remains in the federation. In this simple characterization, assume no costs of dissociation. The benefits of association arise out of common identity, shares national defense, higher position in international fora, larger market and diversity. Since most of these variables have at least partially a subjective valuation, it is easy to see that different federations provide different benefits of association. As a general principle, where there are higher benefits of association, the federal share of rents will be higher. In cases where subnational identity is different than national identity the benefits may be valued considerably lower leading to instability and even exit. In such situations the federal share of rent will be smaller.

Using data on fractionalization measures of ethnicity and linguistic diversity from Alesina et al. (2003) we calculated the correlation between federal share of rent and the fractionalization measures. We found that the correlation between federal share of rent and ethnicity fractionalization is -0.6732 and between federal share of rent and linguistic diversity in a federation it is -0.4909. The federations with clear assignment and rent shares were only used. The correlations indicate that where there is higher fractionalization it is associated with a lower federal share of rent.

Once the rent is defined, the federal systems have a wide range of complex instruments to reach the base. Out of these, the Russian Federation after 2001 levies a simple tax regime. The Mineral Extraction Tax is levied at a uniform rate on the base of the value of extracted mineral not allowing any cost differentials across mines. The tax is administered by federal authorities. In India the tax is collected on sales and extraction and comprises of dead rent, royalty, sales tax and profit oil and gas. Similarly, in other federations rent tax is often a combination of various tax instruments not necessarily levied by the same level of government. Rent assignment seems

to respond to political characteristics of federations. This is an important issue for a rational framework of rent assignment.

The case of Russia's regions

Subnational identity is a strong motivation for decentralization. If the producing regions assert a subnational identity that is different from the federal nation state, then exhaustible resource rents assume a special importance. Regions with a strong sense of a distinct identity are very likely to see exhaustible resource rents belonging to the region (Green, 2010). If this is the case, will it influence how rent is allocated in the region? This being an empirical question, we have used data from regions of Russia to see if investment decisions vary between producing regions with a strong claim to a distinct identity versus those producing regions which are not distinguishable other than as Russian geographic unit. Out of the 36 producing regions of Russia, 22 do not have an ethnic identity that is distinct from Russian. The remaining 14 however assert themselves as republics or regions with a strong claim to an ethnic identity. In case of republics, the status is a result of history and past assertions at establishing a separate identity. Some republics date back to the times prior to the October 1917 revolution. The 2002 population census provides estimates of subnationalities in each region. In the republics there are large groups which are ethnically distinct and in many cases lend their name to the republic. Tatarstan, Bashkortostan and Sakha Republic are some examples.[150] The census data also shows that regions vary by percentage of population resident in the region by birth, indicating another measure of community ownership of land and resources. Using these variations among the

[150] The regions with a strong preference for subnational identity are: Nenets Autonomous Okrug, Adgygea, Dagestan, Ingushetia, Kabardino-Balkar Republic, Kalmykia, North Ossetia-Alania, Chechnya, Bashkortostan, Tatarstan, Udmurtia, Khanty-Mansi Okrug, Yamalo-Nenets Okrug and Sakha Republic.

producing regions and control group regions, we have estimated a difference-in-difference-in-differences estimator to see if reduction in rent tax share of regions has a differential effect on both types of regions. The null hypothesis is that regions with an ethnic identity have a higher preference for investment of resource rents. The tax share changes, the reductions in regional shares of oil and gas taxes, made in 2002, 2004 and 2005 offer a quasi natural experiment to study the question.

The data were used to estimate an empirical model:

$$y_{it} = \beta_0 + \beta_j g_j + \beta_l postx + \beta_k g_j postx + \gamma_p X_p + \gamma_r region_i + \gamma_t year_t + \varepsilon_{it} \quad (4.1)$$

Where y_{it} is a measure of new investment in long-lived public goods, $g_j, j = 1,2$ is a treatment differentiated by the type of region, $postx$ is the post treatment period, X_p is a vector of variables having an effect on new investments in long-lived public goods, $region_i$ is a set of region dummies and $year_t$ are the time dummies. The error term, ε_{it}, allows for individual specific-time invariant and individual and time variant components. The treatment groups defined by treatment g_j are classified on the basis of identity of the regions. The producing regions with the status of a national republic are one treatment group and the remaining producing regions, without the national recognition at the subnational level, are the second treatment group. All other regions are in the control group. The difference-in-difference-in-differences estimators separately estimate the effect of the policy change on each type of treated group.

The empirical model described in equation (4.1) arising out the theoretical model given in Chapter 2. The theoretical model discussed under Problem 1 in Chapter 2 assumed that the producing regions may have a higher preference for long-lived public goods. This is based on the assumption that if subnational identity is important to the regional community, it may ceteris

paribus choose to invest a higher amount of rents in long-lived public goods. This choice would be in line with using resource rents to preserve productivity for the future generations of the same community. Proposition 1 in Chapter 2 provides an important result showing that the negative effect of rent centralization will be scaled by the preference parameter of producing regions. In other words, if republics have a higher preference for rent investment then the effect of rent centralization will be stronger in republics compared with other producing regions. The empirical model allows testing of this assumption. According to the theoretical model, an increase in the federal share of rents will have a higher negative effect on the regions with stronger preferences for long-lived public goods. If ethnic republics have a higher preferences for public goods than other producing regions (and the control regions) this should be estimated by the coefficient on the interaction term.

The model was estimated using two measures of new investment in long lived public goods. First we used investment in fixed public capital financed by regional budgets and then subnational acquisition of capital. Both measures were real values in 2000 rubles and calculated on per capita basis. The difference-in-difference-in-differences (DDD) estimators, β_k, $k = 1,2$, pick up the average treatment effect on producing republics or regions with an ethnic identity and producing regions (that are not republics) separately. The control variables are the same as used in estimations reported in Chapter 3.

The results of the estimations of the model depicted in equation (1) are given in Table 4.5. New investment in fixed public capital per capita financed by the regional budgets is the dependent variable. The first column reports results of an estimation which used a time trend. The second column has an addition of individual year dummies. The third column is for pooled estimation using a complete range of region and time dummies. The DDD estimator on the

producing republic is negative and significant at 5 percent level in the first column and at 10 percent level in the last column. The coefficient on the remaining producing regions is not statistically significant. This provides some evidence that a decrease in the regional shares of rent revenue has a stronger negative effect on public investment in the republics, as expected according to the theoretical model if as assumed, ethnic republics have a stronger preference for investment of rents. The equation was re-estimated when standard errors are clustered by region to allow an arbitrary correlation matrix within regions. Essentially, the same results are retrieved.

The population measure of by birth residence, an indicator of stronger ties to the region, was also included in this equation. In case of republics the coefficient in negative and significant at 5 percent level. In case of all the regions, the coefficient on this variable is positive but not significant in the first two columns but becomes negative and statistically significant at 1 percent level in the last column. These results are not in accordance with the assumption that communities with stronger ties to the region will invest a higher amount in long-lived public goods. The percentage of ethnic Russians in the population interacted with population growth rate is positive and significant at 1 percent level. To separate the effects of rate change from changes in rent revenue, the dollar denominated values of oil and gas production have been included as control variables. All other variables are qualitatively the same as in the results presented in Chapter 3. The real gross regional product and revenue are endogenous in the model. The excluded variables used in the estimation, paved roads as a percentage of total roads, real value of paid services per capita and residential area per capita, are reasonably strong instruments as shown by the first-stage F-test statistics and Craig-Donald statistics reported in the table.

The model was re-estimated using acquisition of fixed public capital as the dependent variable. This measure captures the investments obtained by subnational governments but made by private sector entities and debt financing of infrastructure in addition to budgetary financing. This estimation attempts to capture the effects on the policy change on all sources of investment in fixed public capital. The results are reported in Table 4.6. The DDD for republics is negative and significant at 5 percent level in the first column in accordance with the theoretical model. It is not significant in the last two columns although has the expected negative sign. Again it is an indication that the decline in new gross investment in long-lived public goods is there. The coefficient on the remaining producing regions is not significant. Increase in percentage of population resident in a producing republic by birth is not statistically significant. The positive sign is in accordance with the expectation that longer residence may promote a stronger attachment to an area leading to higher investment in long-lived assets. Similarly, in all the regions the increase in the percentage of population resident by birth is associated with a higher acquisition of ownership in long-lived public goods.

The DDD was estimated using seemingly unrelated equations approach. The first equation has new investment in fixed public capital per capita as the dependent variable while recurrent public expenditure is the dependent variables in the second equation. Real gross regional product and revenue, both measures as per capita values, are endogenous variables. The results reported in Table 4.7 were estimated with new investment in fixed public capital financed by regional budgets. The DDD on republics is negative and significant at 5 percent level. This indicates a higher decrease in new investments after reduction in the regional shares of rent revenue. The DDD on recurrent expenditure is positive but statistically not significant. The estimators on the DDD estimators for the remaining producing regions are not significant. The

coefficients on the three population measures are significant for investments but not for recurrent expenditure. All other results are qualitatively the same as those reported in Chapter 3. The model was again estimated with new subnational acquisition of fixed public capital. The estimation is reported in Table 4.8. The signs on DDD are as expected but only the estimator on producing regions that are not republics is significant at 5 percent level. The DDD estimator on recurrent expenditure is positive and significant at 5 percent level for the republics. The results for the remaining variables are qualitatively the same.

The results reported in this section provide evidence that republics in Russia with strong claims to distinct identities have a higher preference for investment of rents in long-lived public goods. This could be attributed to strong ownership of land and resources and a preference for converting regional wealth into long term productive assets. Identity preservation through passing on higher levels of public infrastructure to succeeding generations could be another motive. The effects of the policy change, centralization of rent revenue, are captured by the DDD estimators and is in accordance with the theoretical assumptions made in Chapter 2. Although the evidence is specific to one federation and the causative factors for higher investment of rents are speculative, this does point to a link between investment outcomes and rent assignment in federation. Within the general tax assignment question, rent taxes merit a special treatment to ensure higher investment of rents.

Conclusion

The current discussion of the rent tax assignment question addresses efficiency from the taxation point of view. It leaves out efficient expenditure choices for exhaustible resource rents. Mostly the discussions range from treating rent assignment as another source of revenue to

arguments for centralization due to distribution and stability considerations. The approach to rent tax assignment question has not been fully developed as it does not evaluate the effects of assignment choices on public investment of rent monies. It does not consider ethnic identity combined with claims on resource ownership to fall within its purview. However, federations are finely balanced institutional arrangements. If some regions are endowed with natural resources other may not be so blessed. Sharing of benefits derived from natural resource endowments is often seen as a federal contest, sometimes even testing the strengths of the arrangement. Several federations have rich exhaustible resource endowments. A close look at the rent assignment practice reveals that there is no uniform practice in place.

The several ways in which the rent tax assignment question has been discussed fall short of making a comprehensive case for efficiency. Mostly the discussions range from treating rent assignment as another source of revenue to arguments for centralization due to macroeconomic considerations. The approach to rent tax assignment question has not been fully developed as it does not evaluate the effects of assignment choices on public investment of rent monies. More specifically, the discussions about rent assignment do not consider regional identity to be of much consequence. If at all, it is mentioned as an unnecessary intrusion. Despite this, federations have mostly devised ways to share rent revenue with subnational government, with a preponderance of revenue shared with the producing jurisdictions on a derivation basis. The world evidence shows that there is no uniform practice. Different shares have been arrived at in various federations. What is noteworthy, however, is the implicit admission that political stability concerns work their way into rent assignment and sharing decisions.

In this chapter an argument- has been made for reconsidering rent tax assignment. The discussion of federal countries shows that federations are finely balanced institutional

arrangements where resource rent often is a contested commodity. Exhaustible resources and shares of revenue from them are frequently contested areas between the producing regions and the center. Strong community ownership develops into claims on rent that are contested and pursued. A federal arrangement may choose to ignore and confront them or build on the higher sense of ownership. In pursuing the second option, it may attempt to minimize conflict. In addition to any political gains, it should be noted that recognizing subnational claims on rent may not always lead to deleterious effects on the economy. The producing regions may act responsibly and invest rent revenue. If this happens, it has several advantages. The economy is protected from exchange rate appreciation, net fiscal benefits may remain comparably similar across jurisdictions and the subnational economy may gain some sustainability for its productive base.

A valid question however remains as to what extent rent investment is a real possibility at the subnational level. It can be surmised that regions with strong subnational identity may hold a preference for sustaining their productive base currently raised by exhaustible resource extraction. Regions endowed with valuable exhaustible resources and preference for sustaining their productive base will invest rents in long-lived public goods. The case of the Russian Federation examined in this chapter shows that such expectations may not be farfetched. The results show that a decrease in the regional share of rent resulted in a fall in investments in the republics, regions with strong ethnic identity. Republics among the producing regions have historical claims to a distinct identity and may have a preference for preserving their identity. This preference is manifested as higher levels of rent investment. These results provides some evidence that community ownership of exhaustible resource endowments matters to investment choices and it should be included in the assignment question. Following this line of argument, it

can be concluded that rent assignment, through rent tax or revenue assignment, should favor producing regions within the range of stability in a federation.

Chapter 5 General Conclusions

Generally the fiscal federalism literature argues for assignment of exhaustible resource rents to the centeral government. The main arguments in favor of this position are three. The first argument holds that central government is better equipped to absorb commodity price fluctuations and injection of large amounts of rent revenue in the economy. The subnational governments do not have access to monetary policy tools and therefore not well equipped to affect macroeconomic outcomes. The second argument states that subnational governments may not have the capacity to administer resource rent taxes due to complexity of rent calculations. The third argument is a concern about intra-national fiscally induced migration due to the lower tax price of public goods in producing jurisdictions. The literature treats rent assignment as neutral to investment in long-lived public goods. We show that this is not the case. Rent assignment may impact investment if there are differential preferences for investment in long-lived public goods among regions and between regions and federal government.

Another strand in the literature presents descriptive cases of rent assignment. It recognizes that in many countries, especially those with resource mining as a significant part of the gross domestic product, conflict over resource ownership and sharing of revenue develops into a threat to country's stability. Often political resolution can only be achieved by conceding ownership or at least substantial part of the rent to the producing regions. This approach, without presenting any arguments in favor of these resolutions, in fact recognizes an outcome that exists

in many countries. Even in case of stable federations, politics have dictated gradual concessions to producing regions. We show that community claims on rent may be important to investment in long-lived public goods.

In practice, exhaustible resource rents are commonly assigned to the central government as a tax base. This arrangement is made in pursuance of reasons of administrative capacity and in cognizance of potential macroeconomic effects of rent revenue injections in the economy. At the same time, revenue sharing in some countries is devised to provide derivation based higher shares to producing regions. The question studied here is whether these arrangements are neutral with respect to investment in long-lived public goods. The fact that investment of rents in long-lived public goods is a key element in preserving the productive base of the economy is not often brought into the fiscal structure discussion. In the discussion we have presented in the preceding chapters, we have attempted to demonstrate that neutrality may not be the case. Assignment of resource rent tax or revenue sharing, under certain circumstances, affects investment in long-lived public goods. The theoretical model is developed to allow incorporation of differential resource endowments, general tax base, allocation choices and public investment in a rent assignment framework. It shows that increase in federal share may lead to effects on investment if differential preferences are allowed. Then using data on regions of Russia two hypotheses emerging out of the theoretical propositions are tested. These discussions show that assignment of rent taxes or changes in rent shares may have effects on investment in long-lived public goods.

The theoretical model in Chapter 2 and the empirical results from the Russian Federation in the Chapter 3, point toward an important dimension of rent tax assignment in a federation. These results show that ceteris paribus, higher share of rent for the federation may lead to lower

investment in long-lived public goods and may be constrained by stability. In Chapter 4, another argument has been made for reconsidering rent tax assignment. Communities value ownership over land and exhaustible resource endowments in their areas. This may be the case especially if ethnic identity is important to the resource owning community. Due to strong community ownership, claims on rent are made and pursued in the political arena. A federal arrangement that bestows higher shares of rents where there is a higher sense of ownership is not only a political consideration. It works toward a higher investment in long lived public goods. The case of the Russian Federation shows that a decrease in the regional share of rent resulted in a fall in investments in the republics, regions with strong ethnic identity. Republics among the producing regions have historical claims to a distinct identity and may have a preference for preserving their identity. This preference is manifested as higher levels of rent investment. Following this line of argument, it can be concluded that rent assignment, through rent tax or revenue assignment, should favor producing regions within the range of stability in a federation, if the objective is achieving higher investment in long-lived public goods.

We present a model for rent tax assignment that allows variations in preference for long-lived goods and tax base endowments across regions, a situation that closely resembles many federal countries. At the same time, there is a stability constraint implicit in the federal bargain. Specifically, producing regions are willing to share their exhaustible resource rents if they are compensated by benefits of association. The extent of federal share is determined by the value the producing region attaches to the benefits of association. Given these factors, the theoretical model in Chapter 2 brings out a negative relationship between new investment in long-lived public goods and federal share of rent. An increase in the federal share of rent revenue is associated with a decrease in investment in long-lived public goods. If a country recognizes a

preference parameter for long-lived public goods, then the federal share of the rent decreases with an increase in policy preference for long-lived public goods. The model uses tradeoffs between operation and maintenance expenditure and investment in long-lived public goods.

Using a quasi natural experiment and data on the Regions of Russia, we test the theoretical model in Chapter 3. The results demonstrate that an increase in the federal share of the rent was followed by a decline in new investment in long-lived public goods in the producing regions. This was not accompanied by an increase in the non-producing regions. At the same time, there was no increase in the federal investments. The Russian federal government progressively decreased regional shares in oil and gas rent between 2002 and 2005. This decreases applied to all producing regions but for obvious reasons did not affect non-producing regions. This offered a quasi natural experiment setting to test the hypothesis of the model.

The policy parameter of the Russian Federation for long-lived goods is not clear. The results demonstrate that the parameter declined in the last decade and resulted in an increase in the federal share of the rent revenue accruing from the petroleum sector. These changes have not been accompanied by any short run political instability in the federation. The producing regions acquiesced in the decreases in their shares. This means that the federal share is still in the interior of the stability constraint. This could be because the relative preference of the non-producing regions for a higher retention of rent in the producing regions is very low. In other countries, for example Nigeria and Canada, it can be seen that the same (in)tolerance levels for retention of rent in the producing regions are not found. In fact there is a smaller value that the producing regions place on benefits of federation. Due to this reason, the federal share of rent is smaller.

Where investment of rent is a priority, rent assignment should be considered as a special case under the assignment question. If there is evidence that subnational entities have a

differential preference for investment in long-lived public goods, then centralization of rent shares will not be neutral to investment. In such cases, rent tax assignment should favor producing regions if they have a higher preference for long-lived public goods. Development policy goals often include increasing the stock of public infrastructure as well as reducing the possibility of conflict generated by unrequited claims to resource ownership. Assignment of rent revenue or taxes to producing regions will be conducive to development policy goals. Centralization on the other hand may run counter to the goal of increasing investment in long-lived public goods. The macroeconomic considerations will still remain relevant. They should be addressed by setting clear fiscal rules that provide a limited set of allocation choices to producing regions, without necessarily burdening the assignment question with these objectives.

This research has attempted to contribute to the discussion of rent tax assignment and sharing. Following is a summary of important points that emerge from the research:

1. The rent tax assignment literature ignores the community claims on rent often asserted as regional or subnational rights to exhaustible resource rent. This leads to conflict if assignment and sharing arrangements circumvent community claims. The discussion in this dissertation links community concerns and choices with development policy and lays out a way in which the two could be harnessed together to sustain productive base of an economy. This linkage adds to the discussion on rent base assignment question.

2. We develop a theoretical model that incorporates differences in preference for investment, resource endowments and general tax base in a policy framework. It links policy objectives like pursuing increase in public investment to sustain or enhance the productive base of the economy, with expenditure choice made at subnational levels. The

model allows that identity based considerations and their consequent influence on rent investment choices brought into the analytical framework. The model has the flexibility to consider subnational taxes and differences in levels of wealth among regions. It also demonstrates the effect of unconditional and conditional transfers on the outcomes, which this case are investments in long-lived public goods.

3. The first empirical model builds on the theoretical propositions generated by the model. It exploits a range of variations in policy changes and their applications. Consequently, it becomes a multiple treatment model with some capacity to provide insights differentially across various treated units. This adds a new dimension to evaluating impact of tax policy changes.

4. The second empirical model was devised to take into account the time lag in capital investment projects. In being responsive to the medium term planning horizon, a common attribute of capital investment projects of any mentionable size, this model attempts to capture the annualized effects of policy changes on public investment. this model also adds to the discussion of evaluation of impact of policy changes that can only accrue through budgetary processes.

5. The empirical analysis, using data on regions of Russia, presents a case where policy change, namely reduction in subnational rent shares, has adverse effects on investment in long-lived public goods. These results are sufficiently robust across different models and specifications to demonstrate that such policy changes may not be neutral. At least they show they were not so in case of the Russian Federation.

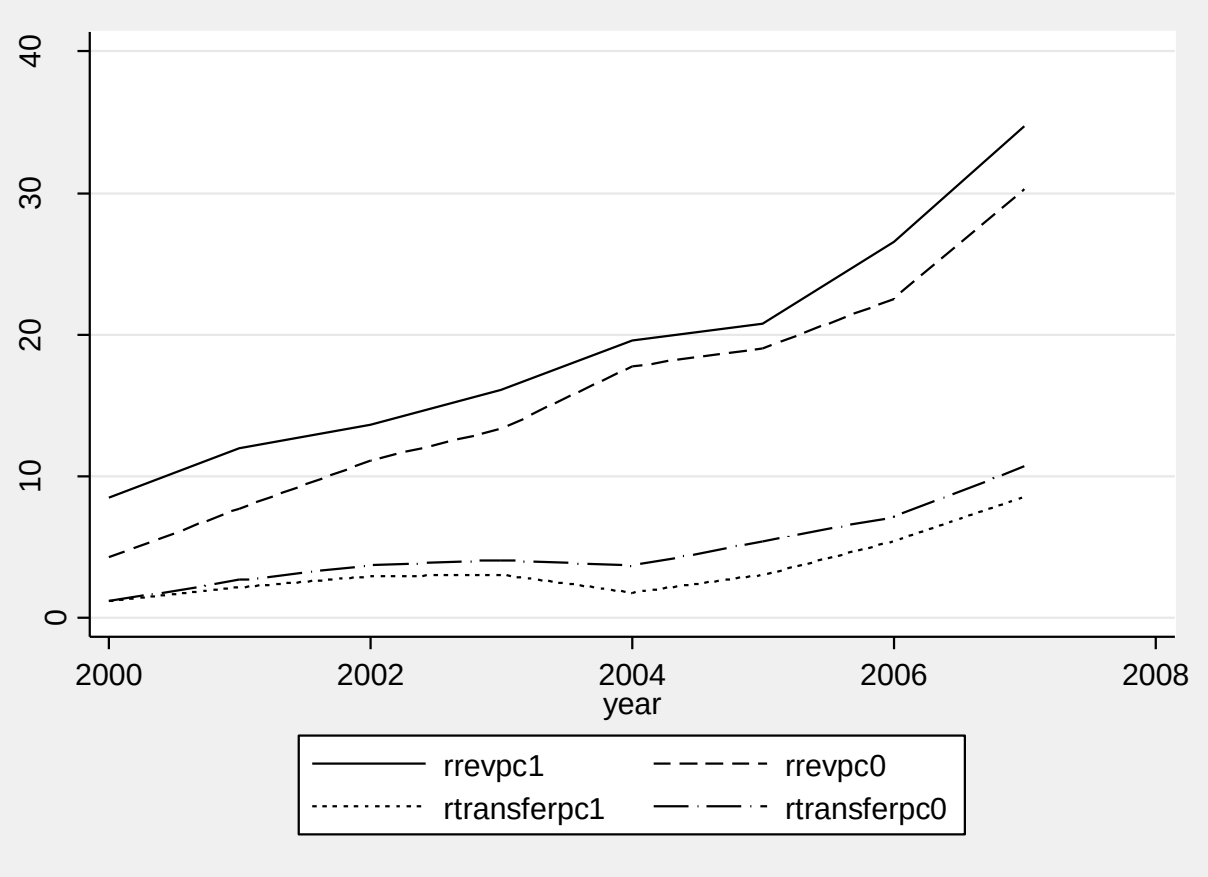
6. A case for determinants of public investment in the regions of Russia has been laid out. This is by no means a final word on the subject, but the inquiry makes a contribution on an otherwise obscure area of research.

7. Regional identity is the elephant in the room of fiscal federalism. The third empirical analysis recognizes its existence and makes use of republic level identities in the Russian Federation. The results show that the decline in investment in long-lived public goods following rent share reductions is higher in republics than other oblasts.

8. The research has raised some questions for further work namely, the extent to which identity drives investment choices of exhaustible resource rents, ways in which fiscal rules could insure decentralized rent taxes with macroeconomic stability, and what is the efficient range of rent shares in a federation for achieving investment according to Hartwick rule.

Figure 3.1

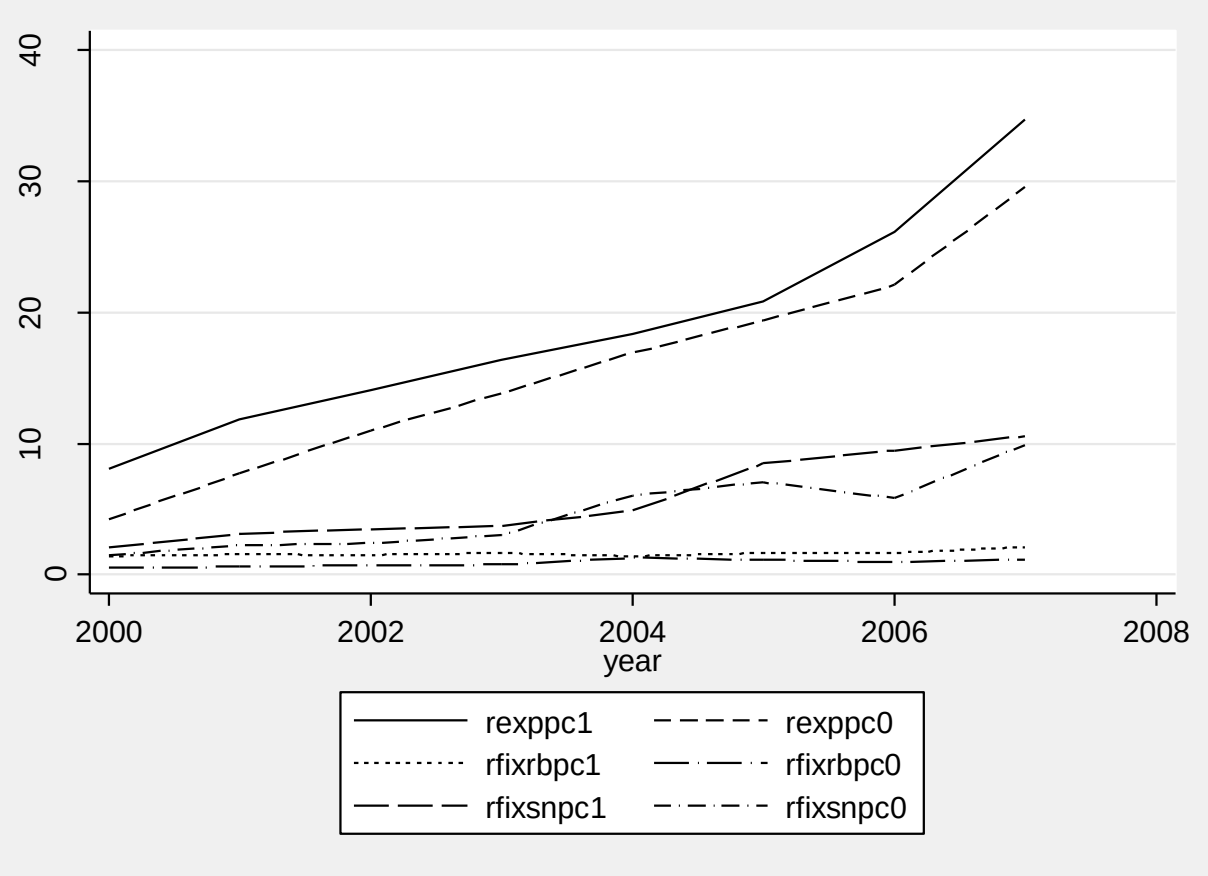
Changes in unconditional mean values of key variables



Variable Key
rrevpc1: average real revenue, per capita, producing regions
rrevpc0: average real revenue, per capita, control group
rtransferpc1: average real federal to region transfers, per capita, producing regions
rtransferpc0: average real federal to region transfers, per capita, control group

Figure 3.2

Changes in unconditional mean values of key variables



Variable Key
rexppc1: average real public expenditure, per capita, producing regions
rexppc0: average real public expenditure, per capita, control group
rfixrbpc1: average real investment in fixed public capital, per capita, by subnational governments, producing regions from their budgets
rfixrbpc0: average real investment in fixed public capital, per capita, by subnational governments, control group from their budgets
rfixsnpc1: average real acquisition of fixed public capital, per capita, by subnational governments, producing regions
rfixsnpc0: average real acquisition of fixed public capital, per capita, by subnational governments, control group

Table 3.1
Summary Statistics by Treatment Status

Variable name[c]	Description	Producing regions[a], g1 = 1 Obs[d]	Mean[e]	Std. Dev.	Min	Max	Control group regions[b], g1 = 0 Obs	Mean	Std. Dev.	Min	Max
A. Expenditure											
rexppc	real expenditure per capita	294	19	23	0	217	368	16	25	2	235
rexpobpc	real fed obligatory exp. per capita[f]	74	933	649	272	4802	92	843	521	96	3020
rexpsocpc	real fixed capital per capita	295	9	11	0	109	368	8	9	1	89
rfixcappc	real social expenditure per capita	295	44198	140110	670	1908022	367	15253	17434	670	146399
employp	public employment, percent of total	287	6	2	2	20	368	6	3	2	24
B. Capital investment											
rfixvalpc	real value of fixed capital, per capita	288	324	547	9	4526	368	187	105	38	798
rfixstatpc	real investment, fixed public capital, regional	295	4	9	0	99	368	5	14	0	147
rfixmunpc	real investment, fixed public capital, municipal	280	1	3	0	15	358	1	1	0	9
rfixpubpc	real investment, fixed public capital, all sources	280	10	14	1	118	357	6	9	1	116
rfixsnpc	real investment, fixed public capital, regional and municipal	280	6	10	0	102	358	5	10	0	127
rfix_fbudgpc	real investment, fixed public capital, federal budget	294	2	2	0	14	368	2	3	0	25
rfix_rbudgpc	real investment, fixed public capital, regional budget	291	3	5	0	38	368	2	4	0	46
C. Revenue											
rrevpc	real revenue, subnational, per capita	295	19	24	0	211	366	16	27	2	275
rsngpc	real tax revenue, subnational, per capita	259	12	18	0	107	321	9	17	1	227
rtransferpc	real transfer, federal to subnational, per capita	293	3	6	-35	43	367	5	13	-17	198
D. Structural variables											
bus_pop	buses per 10,000 population	293	63	31	2	219	368	70	142	9	1982
bus_pass	million passenger kilometers	293	1383	1346	11	6318	368	1663	2094	3	10839
buspub	public owned buses, millions	293	150	152	0	734	368	226	405	0	2726
cars	car owners per 1000 population	295	147	47	34	269	368	143	42	20	266
roaden	km of road per 1000 sq.km. of area	296	101	92	1	442	352	124	86	1	525

raodimp	percentage of improved roads, in total	296	66	24	8	99	352	69	25	0	100
roadpavd	percentage of paved roads, in total	296	88	13	37	100	352	91	12	31	100
roadtrans	goods transported by road, million ton-km	293	1752	1625	0	7814	368	1087	971	30	7059
tonnage	goods transported by rail, million tonnes	293	49	50	0	246	368	40	74	1	815
accid	accidents per 100,000 population	295	124	44	8	262	368	150	44	45	275
railden	km of railway per 10,000 sq.km. of area	280	121	91	1	423	320	201	179	27	1956
railpass	rail passengers, 000s	280	8446	8873	24	45432	335	24515	59250	32	352454
enrolpub	enrolment public schools, percent of total	295	20	9	5	48	368	15	7	0	35
stu_sprof	students in secondary professional education, per 10,000	221	167	44	41	243	276	174	35	53	246
E. Demand variables											
noworkage	population below working age, percent	296	20	5	14	36	360	17	3	12	33
disburd	first time diagnosis, per 1000 population	266	755	150	328	1092	368	754	132	470	1297
imr	infant mortality rate	288	13	4	6	33	360	13	5	4	42
klinout	1000 visits per shift	290	44	29	1	112	368	45	59	3	372
klinik	outpatient visits per 10,000 population	290	235	48	73	403	368	260	63	183	614
docs	# per 10,000 population	290	47	9	21	71	368	45	12	27	84
hosp_bedk	beds per 10,000 population	290	113	23	40	164	368	124	25	86	252
paramed	# per 10,000 population	290	113	20	44	145	368	114	14	73	155
pop_para	population per doctor	290	92	24	69	226	368	89	12	64	137
residpc	residential area per per capita	289	0.03	0.07	0.00	0.50	368	0.04	0.08	0.00	0.59
exec_emp	# employed by subnational governments	288	9042	5532	480	27198	368	7437	5166	1012	31182
rpaidser_pc	real value of paid services, per capita	289	8880	6642	78	39469	368	8342	7781	577	65894
rpension_av	real value of average pension payment	296	1802	938	446	5047	367	1766	878	534	6055
F. Other control variables											
sown	farms all categories, 000 hectares	292	1269	1368	0	4575	351	737	860	0	5424
freshwatpc	million cu ft usage, per capita	295	0.49	0.33	0.12	1.41	368	0.42	0.62	0.04	3.83
recywatpc	million cu ft usage, per capita	295	0.80	1.08	0.00	6.19	368	1.05	1.15	0.01	5.23
wastwat	million cu ft generated	296	207	236	0	1252	368	247	383	0.4	2661
airpoll	from stationary sources, 000 tons	284	682	1686	0	14070	368	792	1577	1	9932

electric	kilowatt-hour, billions	281	15	19	0	89	368	10	12	0	54
indind	aggregate production index, percentage change	288	107	11	43	167	367	107	7	83	130
pop	population, 000s	295	1850	1260	41	5133	368	1683	1816	50	10470
popden	population, 1000 per sq.km. area	295	30	31	0	139	368	303	1443	0	9518
popgr	rate of population growth	296	0	2	-10	31	360	-1	1	-7	2
urb	percentage urbanization	296	68	13	34	91	368	70	14	26	100
migrate	rate of migration, per 10,000 population	296	3	174	-1170	2523	368	-12	75	-704	239
areasqkm	area, sq. km.	296	347	645	4	3084	368	125	172	1	788
G. Economic variables											
rsgrppc	real gross regional product, per capita	267	75028	86160	4844	721465	368	64610	57882	8536	562576
rincpc	real income per capita	287	5477	4742	426	33318	367	4594	3793	754	31177
rconspendpc	real monthly household consumption	287	3332	2471	206	15055	368	2953	2364	421	20445
inc_sub	below subsistence level, percent of population	284	27	14	6	94	368	29	13	9	78
unemrate	unemployment rate	289	0.1	0.3	0.0	4.3	368	0.1	0.2	0.0	3.6
cpi	consumer price index	292	114	5	107	139	368	114	4	106	133
rwage	real wage	295	6315	5418	638	32823	365	5257	3725	805	27109
gas	million cu meter production	240	39504	137611	3	600881					
oil	000 tons production	277	20516	61049	0	325493					

Notes:

a) Producing regions number 37 when the three autonomous okrugs are included; these are Nenets, Yamalia and Khanty-Mansiya

b) The control group comprises of 46 regions.

c) The variable names are abbreviated notations used in the dataset and estimation models.

d) The number of observations is smaller for some variables when the time series does not include all the 8 years.

e) The values have been rounded off. In case of zero, the values may lie between 0 and 1.

f) The obligatory expenditures are for 2006 and 2007 only.

Table 3.2
Normalized Difference in Averages between Producing and Control Regions [a)]

Variable name	Description	Normalized difference
A. Expenditure		
rexppc	real expenditure per capita	0.09
rexpobpc	real fed obligatory exp. per capita	0.11
rfixcappc	real fixed capital per capita	0.21
rexpsocpc	real social expenditure per capita	0.10
employp	public employment, percent of total	-0.07
B. Capital investment		
fix.capital value pc	real value of fixed capital, per capita	0.23
rfixstatpc	real investment, fixed public capital, regional	-0.04
rfixmunpc	real investment, fixed public capital, municipal	0.28
fix.investment public (all sources)	real investment, fixed public capital, all sources	0.21
fix.investment, subnational pc	real investment, fixed public capital, regional and municipal	0.06
fix.investment from federal budget	real investment, fixed public capital, federal budget	-0.02
rfix_rbudgpc	real investment, fixed public capital, regional budget	0.18
C. Revenue		
rrevpc	real revenue, subnational, per capita	0.09
revenue pc	real tax revenue, subnational, per capita	0.13
transfer pc	real transfer pc, federal to subnational, per capita	-0..09
D. Structural variables		
bus_pop	buses per 10,000 population	-0.05
public bus passengers	million passenger kilometers	-0.11
public owned buses	public owned buses, millions	-0.18
car ownership	car owners per 1000 population	0.06
road density pct.	km of road per 1000 sq.km. of area	-0.18
raodimp	percentage of improved roads, in total	-0.10
roadpavd	percentage of paved roads, in total	-0.16
road transported goods, volume	goods transported by road, million ton-km	0.35
tonnage	goods transported by rail, million tonnes	0.10
accidents	accidentsents per 100,000 population	-0.43
railden	km of railway per 10,000 sq.km. of area	-0.40
railpass	rail passengers, 000s	-0.27
public schools enrolment pct.	enrolment public schools, percent of total	0.42
public professional schools enrolment	students in secondary professional education	-0.13
disburd	first time diagnosis, per 1000 population	0.01

E. Demand variables		
dusburd		-0.06
imr	infant mortality rate	-0.02
klinout	1000 visits per shift	-0.36
outpatient visits	outpatient visits per 10,000 population	-0.31
doctors per 10,000	# per 10,000 population	0.10
hospital beds	beds per 10,000 population	-0.34
paramed	# per 10,000 population	-0.06
pop_doc	population per doctor	-0.12
residential area pc	residential area per per capita	-0.06
exec_emp	# employed by subnational governments	0.21
rpaidser_pc	real value of paid services, per capita	0.05
raverage pension	real value of average pension payment	0.03
F. Other control variables		
farmland, hectares	farms all categories, 000 hectares	0.36
fresh water consumption pc	million cu ft usage, per capita	0.10
recywatpc	million cu ft usage, per capita	-0.16
waste water	million cu ft generated	-0.09
airpoll	from stationary sources, 000 tons	-0.05
electric	kilowatt-hour, billions	0.23
indind	aggregate production index, percentage change	0.00
pop	population, 000s	0.08
lpop	natural log of population	0.14
population density	population, 1000 per sq.km. area	-0.19
population growth rate	rate of population growth	0.31
urbanization pct.	percentage urbanization pct.anization	-0.14
migration rate	rate of migration, per 10,000 population	0.08
population below working age	population below working age, percent	0.45
G. Economic variables		
reg. gross product pc'	real gross regional product, per capita	0.08
rincpc	real income per capita	0.15
household monthly consumption	real monthly household consumption	0.11
inc_sub	below subsistence level, percent of population	-0.09
unemployment rate	unemployment rate	0.06
consumer price index	consumer price index	-0.01
rwage	real wage	0.16

Notes

a) The normalized difference for each variable is calculated as: $x_{diff} = \frac{\bar{x}_1 - \bar{x}_0}{\sqrt{s_0^2 + s_1^2}}$ where subscript 1 is for treated group, 0 for control.

Table 3.3

Correlation Matrix 1[a)]

	rfixva~c	rsgrppc	rrevpc	rtrans~c	rsngpc	rexppc
rfixvalpc	1.0000 656					
rsgrppc	0.9053* 632	1.0000 635				
rrevpc	0.5770* 654	0.5664* 632	1.0000 661			
rtransferpc		0.2398* 632	0.6110* 658	1.0000 660		
rsngpc	0.6273* 574	0.5526* 555	0.8826* 578	0.2045* 577	1.0000 580	
rexppc	0.5895* 655	0.5711* 633	0.9938* 660	0.6057* 659	0.8711* 579	1.0000 662

Notes:

a) The asterisk indicates level of significance at 10 percent or below. The first number is the correlation coefficient and the second number below the first is the number of observations. Only correlations that are significant are reported.

Table 3.4

Correlation Matrix 2[a)]

	rfixva~c	rsgrppc	rrevpc	rtrans~c	lpop	popgr	popden
rfixvalpc	1.0000 656						
rsgrppc	0.9053* 632	1.0000 635					
rrevpc	0.5770* 654	0.5664* 632	1.0000 661				
rtransferpc		0.2398* 632	0.6110* 658	1.0000 660			
lpop	-0.1315* 656	0.0950* 634	-0.4123* 661	-0.4449* 660	1.0000 663		
popgr	0.1456* 648					1.0000 656	
popden		0.3019* 634	0.0866* 661	-0.0888* 660	0.2962* 663	0.0857* 655	1.0000 663
urb	0.2620* 656	0.3362* 635	0.1437* 661	-0.1531* 660	0.3152* 663	-0.1748* 656	0.3239* 663
sown	-0.1685* 638	-0.0773 617	-0.2212* 640	-0.1718* 640	0.5986* 642		0.1290* 642
tonnage	0.1248* 656	0.1989* 635		-0.1623* 658	0.4433* 660	0.0680 653	
roadtrans	0.2089* 656	0.4208* 635		-0.2211* 658	0.6477* 660	0.1062* 653	0.2002* 660
cars	0.2867* 656	0.4454* 635		-0.1971* 660	0.2743* 662		0.2352* 662
enrolpub	0.1063* 656	-0.2434* 635	-0.0783* 660			0.3573* 655	-0.2557* 662
hosp_bedk		0.0945* 634	0.3833* 655	0.4776* 655	-0.5018* 657	-0.3960* 650	-0.1138* 657

	urb	sown	tonnage	roadtr~s	cars	enrolpub	hosp_b~k
urb	1.0000 664						
sown	-0.0839* 643	1.0000 643					
tonnage	0.2751* 661	0.2387* 643	1.0000 661				
roadtrans	0.2905* 661	0.4160* 643	0.5871* 661	1.0000 661			
cars	0.4485* 663	0.1156* 643	0.1473* 661	0.3241* 661	1.0000 663		
enrolpub	-0.3178* 663	-0.0651 643	0.2258* 661		-0.2465* 663	1.0000 663	
hosp_bedk	0.1166* 658	-0.1945* 640	-0.2156* 658	-0.2653* 658	-0.1665* 658	-0.1771* 658	1.0000 658

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Notes:

a) The asterisk indicates level of significance at 10 percent or below. The first number is the correlation coefficient and the second number below the first is the number of observations. Only correlations that are significant are reported.

Table 3.5
The effect of change in rent revenue shares on investment in fixed public capital in regions of Russia –a difference-in-differences estimation (multiple treatment model) [a)]

Dependent variable: new real investment in fixed public capital per capita

VARIABLES[b)]	Fixed effects (1) [c)]	Fixed effects (2) [d)]	Pooled [e)]
Real GRP, per capita	-9.59e-06***	-9.55e-06***	-9.55e-06***
	[3.14e-06]	[3.13e-06]	[2.84e-06]
Real revenue, per capita	0.133***	0.134***	0.134***
	[0.0115]	[0.0113]	[0.0103]
Oil only regions	-0.352	-0.343	-0.343
	[0.336]	[0.340]	[0.308]
Gas only regions	-0.152	-0.0993	-0.0993
	[0.355]	[0.346]	[0.313]
Oil & gas regions	-0.131	-0.100	-0.100
	[0.272]	[0.278]	[0.252]
Oil tax share change 1	-0.0214	-0.187	-0.0436
	[0.0884]	[0.241]	[0.0734]
Oil tax share change 2	-0.00281	-0.226	0
	[0.150]	[0.347]	[0]
Oil tax share change 3	0.0697	-0.330	0
	[0.203]	[0.597]	[0]
Gas tax share change 1			0
			[0]
Gas tax share change 2			0
			[0]
Oil & gas tax share change 1			0
			[0]
Oil & gas tax share change 2			0
			[0]
Oil & gas tax share change 3			0
			[0]
DD-1 (oil only)	0.340	0.345	0.345*
	[0.216]	[0.220]	[0.199]
DD-2 (oil only)	0.111	0.122	0.122
	[0.256]	[0.260]	[0.235]
DD-3 (oil only)	0.0633	0.0722	0.0722
	[0.231]	[0.233]	[0.211]
DD-1 (gas only)	0.00305	-0.00756	-0.00756
	[0.468]	[0.463]	[0.420]
DD-2 (gas only)	-0.290	-0.294	-0.294
	[0.234]	[0.227]	[0.206]
DD-1	-0.216*	-0.215*	-0.215**
	[0.117]	[0.118]	[0.107]
DD-2	-0.485*	-0.486*	-0.486**
	[0.253]	[0.255]	[0.232]
DD-3	-0.0224	-0.0278	-0.0278
	[0.143]	[0.143]	[0.129]
Real transfers, per capita	-0.148***	-0.149***	-0.149***
	[0.0108]	[0.0105]	[0.00952]
Population below working age, pct	-0.146*	-0.147*	-0.147**

	[0.0802]	[0.0811]	[0.0735]
Population density	-0.0924*	-0.0960*	-0.0960**
	[0.0504]	[0.0514]	[0.0466]
Population (log)	10.21***	10.56***	10.56***
	[3.882]	[4.077]	[3.696]
Urbanization, pct	0.0689*	0.0693*	0.0693**
	[0.0364]	[0.0370]	[0.0335]
Farmland, hectares per sq km area	0.000635***	0.000634***	0.000634***
	[0.000234]	[0.000244]	[0.000221]
Volume of goods transported via rail	0.00187***	0.00187***	0.00187***
	[0.000675]	[0.000704]	[0.000638]
Volume of goods transported via road	-1.91e-05	-1.66e-05	-1.66e-05
	[7.75e-05]	[8.10e-05]	[7.34e-05]
Car ownership	0.00245	0.00254	0.00254
	[0.00249]	[0.00251]	[0.00227]
Public enrolment, pct	-0.0382	-0.0381	-0.0381*
	[0.0247]	[0.0253]	[0.0230]
Hospital beds, per 10,000 population	-0.000284	-0.000861	-0.000861
	[0.00382]	[0.00414]	[0.00375]
Time trend variable	-0.111	-0.0507	-0.0974*
	[0.0737]	[0.114]	[0.0590]
Constant			113.3
			[122.5]
Observations	600	600	601
R-squared	0.829	0.830	0.929
Number of ob_id	76	76	
First-stage F-statistic	13.34	12.57	
First-stage F-statistic	9.520	9.070	
Craig-Donald statistic	24.72	25.37	

Notes:

a) *Robust standard errors in brackets; *** p<0.01, ** p<0.05, * p<0.1*
b) *Real GRP, per capita and Real revenue, per capita are endogenous. Excluded instruments are: paved roads as percentage of total length of roads a region, real value of paid services per capita and waste water generated per capita.*
c) *A time trend variable is included.*
d) *A full range of year dummies included but not shown in the table.*
e) *A complete set of region dummies and year dummies included but not shown in the table.*

Table 3.6
The effect of change in rent revenue shares on investment in fixed public capital in regions of Russia –a difference-in-differences estimation (multiple treatment model) [a)]

Dependent variable: investment in fixed public capital per capita

VARIABLES[b)]	Fixed effects (1) [c)]	Fixed effects (2) [d)]	Pooled [e)]
Real revenue, per capita	0.107***	0.107***	0.107***
	[0.0168]	[0.0167]	[0.0151]
real value of fixed capital, per capita	-0.00333***	-0.00331***	-0.00331***
	[0.000896]	[0.000883]	[0.000800]
Oil only regions	-0.447	-0.455	-0.455
	[0.388]	[0.396]	[0.358]
Gas only regions	-0.311	-0.259	-0.259
	[0.580]	[0.573]	[0.519]
Oil & gas regions	-0.256	-0.242	-0.242
	[0.469]	[0.481]	[0.436]
Oil tax share change 1	0.0128	-0.201	0.0554
	[0.146]	[0.331]	[0.114]
Oil tax share change 2	0.0964	-0.169	0.0816
	[0.248]	[0.498]	[0.163]
Oil tax share change 3	0.0881	-0.394	0
	[0.345]	[0.805]	[0]
Gas tax share change 1			0
			[0]
Gas tax share change 2			0
			[0]
Oil & gas tax share change 1			0
			[0]
Oil & gas tax share change 2			0
			[0]
Oil & gas tax share change 3			0
			[0]
DD-1 (oil only)	0.307	0.307	0.307
	[0.208]	[0.211]	[0.191]
DD-2 (oil only)	0.0113	0.0212	0.0212
	[0.243]	[0.250]	[0.226]
DD-3 (oil only)	-0.00953	0.00717	0.00717
	[0.228]	[0.236]	[0.213]
DD-1 (gas only)	-0.0579	-0.0736	-0.0736
	[0.486]	[0.475]	[0.430]
DD-2 (gas only)	-0.645*	-0.667**	-0.667**
	[0.338]	[0.333]	[0.302]
DD-1	0.0537	0.0533	0.0533
	[0.195]	[0.195]	[0.176]
DD-2	-0.931**	-0.935**	-0.935***
	[0.393]	[0.394]	[0.357]
DD-3	-0.189	-0.196	-0.196
	[0.155]	[0.155]	[0.141]
Real transfers, per capita	-0.120***	-0.120***	-0.120***

	[0.0276]	[0.0278]	[0.0252]
Population below working age, pct	-0.103	-0.0815	-0.0815
	[0.152]	[0.181]	[0.164]
Population density	-0.00621	0.00129	0.00129
	[0.0779]	[0.0784]	[0.0710]
Population (log)	4.628	4.757	4.757
	[4.558]	[4.779]	[4.329]
Population growth rate	0.0361	0.0431	0.0431
	[0.0538]	[0.0589]	[0.0533]
Farmland, hectares per sq km area	0.000496*	0.000486	0.000486*
	[0.000285]	[0.000302]	[0.000274]
Volume of goods transported via rail	0.00158*	0.00156*	0.00156**
	[0.000822]	[0.000867]	[0.000785]
Urbanization, pct	0.0803**	0.0791**	0.0791**
	[0.0367]	[0.0370]	[0.0335]
Volume of goods transported via road	0.000139	0.000145	0.000145
	[0.000114]	[0.000118]	[0.000107]
Car ownership	0.00181	0.00185	0.00185
	[0.00407]	[0.00408]	[0.00369]
Bus passengers	0.000103	0.000105	0.000105*
	[6.67e-05]	[6.71e-05]	[6.08e-05]
Public enrolment, pct	-0.0582	-0.0587	-0.0587
	[0.0431]	[0.0440]	[0.0399]
Hospital beds, per 10,000 population	-0.00254	-0.00355	-0.00355
	[0.00499]	[0.00536]	[0.00485]
Time trend variable	-0.109	-0.0265	-0.0743
	[0.115]	[0.156]	[0.129]
Constant			107.4
			[277.3]
Observations	624	624	625
R-squared	0.615	0.617	0.896
Number of ob_id	79	79	
First-stage F-statistic	19.88	19.43	
First-stage F-statistic	14.07	14.14	
Craig-Donald statistic	38.82	42.77	

Robust standard errors in brackets

*** p<0.01, ** p<0.05, * p<0.1

Notes:

a) *Robust standard errors in brackets; *** p<0.01, ** p<0.05, * p<0.1*
b) *Real revenue, per capita and real value of fixed capital, per capita are endogenous. Excluded instruments are: paved roads as percentage of total length of roads a region, real value of paid services per capita, waste water generated per capit and residential area per capita.*
c) *A time trend variable is included.*
d) *A full range of year dummies included but not shown in the table.*
e) *A complete set of region dummies and year dummies included but not shown in the table.*

Table 3.7
The effect of change in rent revenue shares on new acquisition of fixed public capital in regions of Russia –a difference-in-differences estimation (multiple treatment model) [a)]

Dependent variable: new acquisition of fixed public capital (real rubles per capita)

VARIABLES [b)]	Fixed effects (1)[c)]	Fixed effects (2)[d)]	Pooled[e)]
Real GRP, per capita	1.54e-05	1.72e-05	2.43e-06
	[1.74e-05]	[1.36e-05]	[9.58e-06]
Real revenue, per capita	0.156	0.137	0.326***
	[0.209]	[0.131]	[0.0737]
Oil only regions	-3.743**	-2.829	-2.880**
	[1.774]	[1.871]	[1.212]
Gas only regions	-2.470	-2.197	-0.506
	[2.759]	[2.501]	[1.700]
Oil & gas regions	-2.404	-1.639	-1.077
	[2.121]	[2.008]	[1.276]
Oil tax share change 1	-1.030**	-3.940***	-1.556***
	[0.479]	[1.273]	[0.370]
Oil tax share change 2	-2.298***	-6.118***	-2.358***
	[0.864]	[1.956]	[0.412]
Oil tax share change 3	-1.696	-8.162***	
	[1.163]	[3.035]	
DD-1 (oil only)	-0.114	-0.105	0.638
	[0.879]	[0.698]	[0.864]
DD-2 (oil only)	-0.318	-0.557	0.253
	[0.976]	[0.816]	[1.102]
DD-3 (oil only)	0.518	0.259	0.682
	[0.802]	[0.711]	[0.891]
DD-1 (gas only)	-1.374	-1.594	-2.269
	[1.052]	[1.176]	[1.823]
DD-2 (gas only)	-0.945	-0.686	-1.216
	[0.928]	[1.066]	[1.328]
DD-1	-0.700*	-0.687*	-0.628
	[0.370]	[0.365]	[0.506]
DD-2	-0.943*	-0.929*	-0.801
	[0.554]	[0.554]	[0.636]
DD-3	-1.369**	-1.377**	-0.972
	[0.583]	[0.573]	[0.599]
Real transfers, per capita	-0.328***	-0.332***	-0.334***
	[0.0347]	[0.0335]	[0.0168]
Population below working age, pct	0.498	-0.188	-0.904***
	[0.541]	[0.470]	[0.245]
Population density	0.261	0.247	0.0694
	[0.474]	[0.200]	[0.181]
Population (log)	6.426		
	[22.81]		
Urbanization, pct	-0.169		
	[0.139]		
Farmland, hectares per sq km	0.00186	0.00145	0.00126

area			
	[0.00117]	[0.00100]	[0.00115]
Volume of goods transported via rail	0.00827***	0.00686***	0.00685**
	[0.00279]	[0.00223]	[0.00302]
Volume of goods transported via road	-9.31e-05	-2.16e-06	5.86e-05
	[0.000155]	[0.000158]	[0.000219]
Car ownership	-0.0261	-0.0244	-0.0186*
	[0.0183]	[0.0170]	[0.00956]
Public enrolment, pct	0.0647	0.0455	-0.0721
	[0.143]	[0.119]	[0.0822]
Hospital beds, per 10,000 population	0.0539	0.0650	0.0627***
	[0.0455]	[0.0464]	[0.0195]
Time trend variable	1.593*	2.370***	0.0320***
	[0.837]	[0.769]	[0.00996]
Constant			0
			[0]
Observations	588	588	588
R-squared	0.717	0.726	
Number of ob_id	76	76	76
First-stage F-statistic	11	10.22	
First-stage F-statistic	9.320	9.650	
Craig-Donald statistic	1.780	4.452	

Notes:

a) *Robust standard errors in brackets; *** p<0.01, ** p<0.05, * p<0.1*
b) *Real GRP, per capita and Real revenue, per capita are endogenous. Excluded instruments are: paved roads as percentage of total length of roads a region, real value of paid services per capita and number of doctors per 10,000 population.*
c) *A time trend variable is included.*
d) *A full range of year dummies included but not shown in the table.*
e) *A complete set of region dummies and year dummies included but not shown in the table.*

Table 3.8
The effect of change in rent revenue shares on new acquisition of fixed public capital in regions of Russia –a difference-in-differences estimation (multiple treatment model) [a)]

Dependent variable: new acquisition of fixed public capital (real rubles per capita)

VARIABLES[b)]	Fixed effects (1)[c)]	Fixed effects (2)[d)]	Pooled[e)]
Real revenue, per capita	0.208	0.188	0.188
	[0.183]	[0.197]	[0.178]
real value of fixed capital, per capita	0.00684	0.00544	0.00544
	[0.00935]	[0.00888]	[0.00802]
Oil only regions	-4.213**	-3.468*	-3.468**
	[1.751]	[1.815]	[1.640]
Gas only regions	-2.062	-1.724	-1.724
	[2.325]	[2.379]	[2.149]
Oil & gas regions	-2.121	-1.373	-1.373
	[1.849]	[1.830]	[1.653]
Oil tax share change 1	-1.056*	-3.401**	-1.264***
	[0.593]	[1.576]	[0.470]
Oil tax share change 2	-2.195**	-5.268**	0
	[1.014]	[2.366]	[0]
Oil tax share change 3	-1.123	-6.440*	0
	[1.281]	[3.755]	[0]
Gas tax share change 1			0
			[0]
Gas tax share change 2			0
			[0]
Oil & gas tax share change 1			0
			[0]
Oil & gas tax share change 2			0
			[0]
Oil & gas tax share change 3			0
			[0]
DD-1 (oil only)	0.717	0.483	0.483
	[0.657]	[0.767]	[0.693]
DD-2 (oil only)	0.755	0.392	0.392
	[0.729]	[0.907]	[0.819]
DD-3 (oil only)	1.176*	0.968	0.968
	[0.653]	[0.697]	[0.630]
DD-1 (gas only)	-1.404	-1.482	-1.482
	[0.983]	[1.112]	[1.004]
DD-2 (gas only)	-0.879	-0.789	-0.789
	[0.865]	[0.992]	[0.896]
DD-1	-0.736*	-0.687*	-0.687*
	[0.406]	[0.389]	[0.352]
DD-2	-0.793	-0.783	-0.783
	[0.580]	[0.570]	[0.515]
DD-3	-1.214*	-1.125*	-1.125**
	[0.619]	[0.582]	[0.526]
Real transfers, per capita	-0.329***	-0.333***	-0.333***
	[0.0316]	[0.0299]	[0.0270]
Population density	-0.138	-0.0284	-0.0284

	[0.300]	[0.356]	[0.321]
Population (log)	22.10	15.97	15.97
	[16.05]	[19.70]	[17.80]
Population growth rate	1.007*	0.814*	0.814*
	[0.559]	[0.481]	[0.435]
Urbanization, pct	-0.192	-0.210	-0.210
	[0.216]	[0.226]	[0.204]
Farmland, hectares per sq km area	0.00130	0.000742	0.000742
	[0.000982]	[0.000902]	[0.000815]
Volume of goods transported via rail	0.00709***	0.00648***	0.00648***
	[0.00250]	[0.00249]	[0.00225]
Volume of goods transported via road	-3.32e-05	7.74e-05	7.74e-05
	[0.000213]	[0.000202]	[0.000183]
Car ownership	-0.0240	-0.0280*	-0.0280*
	[0.0155]	[0.0165]	[0.0149]
bus_pass	0.000515**	0.000549**	0.000549***
	[0.000239]	[0.000231]	[0.000209]
Public enrolment, pct	0.0573	0.0142	0.0142
	[0.143]	[0.129]	[0.117]
Hospital beds, per 10,000 population	0.0546	0.0610	0.0610
	[0.0449]	[0.0477]	[0.0431]
Time trend variable	1.101*	2.140**	1.064**
	[0.569]	[1.060]	[0.417]
Constant			-2,257***
			[761.5]
Observations	588	588	588
R-squared	0.740	0.746	0.964
Number of ob_id	76	76	
First-stage F-statistic	10.51	9.890	
First-stage F-statistic	10.59	8.390	
Craig-Donald statistic	1.193	1.047	

Notes:

a) *Robust standard errors in brackets; *** p<0.01, ** p<0.05, * p<0.1*
b) *Real revenue, per capita and real value of fixed capital, per capita are endogenous. Excluded instruments are: paved roads as percentage of total length of roads a region, real value of paid services per capita, air pollution tons per 1000 real rubles of gross regional product and waste water generated per capita.*
c) *A time trend variable is included.*
d) *A full range of year dummies included but not shown in the table.*
e) *A complete set of region dummies and year dummies included but not shown in the table.*

Table 3.9
The effect of change in rent revenue shares on investment in fixed public capital in regions of Russia –a difference-in-differences estimation (annualized treatment effect model) [a)]

Dependent variable: investment in fixed public capital (real rubles per capita)

VARIABLES[b)]	Fixed effects (1)[c)]	Fixed effects (2)[d)]	Pooled[e)]
Real GRP, per capita	-9.74e-06***	-9.74e-06***	-9.74e-06***
	[2.87e-06]	[2.87e-06]	[2.69e-06]
Real revenue, per capita	0.134***	0.134***	0.134***
	[0.0110]	[0.0110]	[0.0103]
g1			-41.57***
			[15.22]
p1g1	-0.0910	-0.0910	-0.0910
	[0.132]	[0.132]	[0.123]
p2g1	-0.102	-0.102	-0.102
	[0.116]	[0.116]	[0.109]
p3g1	-0.358*	-0.358*	-0.358*
	[0.213]	[0.213]	[0.199]
p4g1	0.0214	0.0214	0.0214
	[0.174]	[0.174]	[0.163]
p5g1	-0.0835	-0.0835	-0.0835
	[0.171]	[0.171]	[0.160]
p6g1	-0.00622	-0.00622	-0.00622
	[0.175]	[0.175]	[0.163]
post1	-0.109	-0.109	0
	[0.121]	[0.121]	[0]
post2	-0.196	-0.196	-0.0349
	[0.200]	[0.200]	[0.0761]
post3	-0.245	-0.245	0
	[0.272]	[0.272]	[0]
post4	-0.212		0.0568
	[0.343]		[0.0984]
post5	-0.341	-0.341	-0.0187
	[0.422]	[0.422]	[0.0892]
post6	-0.376	-0.376	0
	[0.516]	[0.516]	[0]
Real transfers, per capita	-0.150***	-0.150***	-0.150***
	[0.0100]	[0.0100]	[0.00937]
Population below working age, pct	-0.102	-0.102	-0.102
	[0.0784]	[0.0784]	[0.0733]
Farmland, hectares per sq km area	0.000525**	0.000525**	0.000525**
	[0.000230]	[0.000230]	[0.000215]
Volume of goods transported via rail	0.00191***	0.00191***	0.00191***
	[0.000705]	[0.000705]	[0.000659]
Volume of goods transported via road	-1.43e-05	-1.43e-05	-1.43e-05
	[7.95e-05]	[7.95e-05]	[7.43e-05]
Car ownership	0.00196	0.00196	0.00196
	[0.00229]	[0.00229]	[0.00214]
Population density	-0.0845*	-0.0845*	-0.0845*
	[0.0487]	[0.0487]	[0.0455]
Urbanization, pct	0.0694*	0.0694*	0.0694**

	[0.0364]	[0.0364]	[0.0340]
Population (log)	11.10***	11.10***	11.10***
	[3.882]	[3.882]	[3.628]
Public enrolment, pct	-0.0404	-0.0404	-0.0404*
	[0.0250]	[0.0250]	[0.0234]
Hospital beds, per 10,000 population	-0.00152	-0.00152	-0.00152
	[0.00395]	[0.00395]	[0.00369]
Time trend variable	-0.00941	-0.00941	-0.0632
	[0.104]	[0.104]	[0.0581]
Constant			81.18
			[118.1]
Observations	600	600	601
R-squared	0.825	0.825	0.926
Number of ob_id	76	76	
First-stage F-statistic	16.44	16.44	10.74
First-stage F-statistic	10.74	10.74	16.44
Craig-Donald statistic	25.19	25.19	25.19

Notes:

a) *Robust standard errors in brackets; *** p<0.01, ** p<0.05, * p<0.1*
b) *Real GRP, per capita and real revenue, per capita are endogenous. Excluded instruments are: paved roads as percentage of total length of roads a region, real value of paid services per capita and air pollution tons per 1000 real rubles of gross regional product.*
c) *A time trend variable is included.*
d) *A full range of year dummies included but not shown in the table.*
e) *A complete set of region dummies and year dummies included but not shown in the table.*

Table 3.10
The effect of change in rent revenue shares on new acquisition of fixed public capital in regions of Russia –a difference-in-differences estimation (annualized treatment effect model) [a)]

Dependent variable: new acquisition of fixed public capital (real rubles per capita)

VARIABLES[b)]	Fixed effects (1)[c)]	Fixed effects (2)[d)]	Pooled[e)]
Real GRP, per capita	-1.97e-05	-1.97e-05	3.44e-06
	[1.48e-05]	[1.48e-05]	[2.04e-05]
Real revenue, per capita	0.453***	0.453***	0.219
	[0.0892]	[0.0892]	[0.242]
g1			25.05
			[74.91]
p1g1	0.0267	0.0267	-0.188
	[0.451]	[0.451]	[0.371]
p2g1	-0.501	-0.501	-0.686*
	[0.472]	[0.472]	[0.378]
p3g1	-0.480	-0.480	-0.861*
	[0.746]	[0.746]	[0.513]
p4g1	0.0159	0.0159	-0.508
	[0.615]	[0.615]	[0.505]
p5g1	0.0329	0.0329	-0.637
	[0.711]	[0.711]	[0.661]
p6g1	0.506	0.506	-0.259
	[0.862]	[0.862]	[0.850]
post1	-0.622	-0.622	0
	[0.523]	[0.523]	[0]
post2	-0.827	-0.827	-1.288**
	[0.802]	[0.802]	[0.514]
post3	-1.494	-1.494	0
	[1.086]	[1.086]	[0]
post4	-0.147	-0.147	0
	[1.382]	[1.382]	[0]
post5	-0.0961	-0.0961	0
	[1.697]	[1.697]	[0]
post6	1.273	1.273	0
	[2.112]	[2.112]	[0]
Real transfers, per capita	-0.330***	-0.330***	-0.325***
	[0.0563]	[0.0563]	[0.0324]
Population below working age, pct	-0.624	-0.624	-0.267
	[0.391]	[0.391]	[0.343]
Farmland, hectares per sq km area	0.000389	0.000389	0.000950
	[0.00110]	[0.00110]	[0.00127]
Volume of goods transported via rail	0.00645***	0.00645***	0.00742***
	[0.00246]	[0.00246]	[0.00226]
Volume of goods transported via road	0.000140	0.000140	-2.41e-05
	[0.000338]	[0.000338]	[0.000172]
Car ownership	-0.0214	-0.0214	-0.0234
	[0.0155]	[0.0155]	[0.0152]

Population density	0.130	0.130	0.129
	[0.155]	[0.155]	[0.451]
Population (log)			6.428
			[27.52]
Urbanization, pct	-0.0197	-0.0197	-0.137
	[0.127]	[0.127]	[0.168]
Public enrolment, pct	-0.156	-0.156	-0.0309
	[0.0963]	[0.0963]	[0.129]
Hospital beds, per 10,000 population	0.0580	0.0580	0.0672
	[0.0426]	[0.0426]	[0.0446]
Time trend variable	-0.161	-0.161	0.800
	[0.457]	[0.457]	[0.628]
Constant			-1,665
			[1,124]
Observations	588	588	588
R-squared	0.552	0.552	0.958
Number of ob_id	76	76	
First-stage F-statistic	13.47	13.47	16.44
First-stage F-statistic	20.43	20.43	10.74
Craig-Donald statistic	11.99	11.99	25.19

Notes:

a) *Robust standard errors in brackets; *** p<0.01, ** p<0.05, * p<0.1*
b) *Real GRP, per capita and real revenue, per capita are endogenous. Excluded instruments are: paved roads as percentage of total length of roads a region, real value of paid services per capita and air pollution tons per 1000 real rubles of gross regional product.*
c) *A time trend variable is included.*
d) *A full range of year dummies included but not shown in the table.*
e) *A complete set of region dummies and year dummies included but not shown in the table.*

Table 3.11
The effect of change in rent revenue shares on investment in fixed public capital and total public expenditure in regions of Russia –a difference-in-differences estimation
(multiple treatment model using seemingly unrelated equations) [a)]

VARIABLES[b)]	(1) qRfixrbpc[c)]	(2) qRexprpc[d)]
Oil only regions	-0.209	-0.685
	[0.229]	[1.345]
Gas only regions	-0.608*	2.174
	[0.364]	[2.118]
Oil & gas regions	-0.0947	1.777
	[0.231]	[1.577]
Oil tax share change 1	-0.149	0.654
	[0.0946]	[0.528]
Oil tax share change 2	-0.283*	-0.995*
	[0.157]	[0.560]
Oil tax share change 3	-0.139	0
	[0.190]	[0]
Gas tax share change 1	0	0
	[0]	[0]
Gas tax share change 2	0	0.767
	[0]	[1.153]
Oil & gas tax share change 1	0	0
	[0]	[0]
Oil & gas tax share change 2	0	0
	[0]	[0]
Oil & gas tax share change 3	0	0
	[0]	[0]
DD-1 (oil only)	0.334**	1.898**
	[0.163]	[0.917]
DD-2 (oil only)	0.172	2.966**
	[0.206]	[1.206]
DD-3 (oil only)	-0.0342	2.078**
	[0.167]	[0.962]
DD-1 (gas only)	0.736	1.488
	[0.479]	[2.785]
DD-2 (gas only)	0.498	3.200
	[0.375]	[2.212]
DD-1	-0.182*	-0.112
	[0.0976]	[0.558]
DD-2	-0.485***	0.532
	[0.123]	[0.685]
DD-3	-0.327***	-0.214
	[0.105]	[0.610]
Real revenue, per capita	0.148***	0.835***
	[0.00504]	[0.0877]
Real GRP, per capita	-2.48e-05***	8.64e-07
	[3.97e-06]	[4.21e-05]
Real transfers, per capita	-0.144***	0.0506
	[0.00410]	[0.0327]
Population below working age, pct	-0.0788	-0.0924

	[0.0716]	[0.441]
Volume of goods transported via rail	0.00113*	
	[0.000609]	
Volume of goods transported via road	1.10e-06	
	[4.24e-05]	
Car ownership	0.00349*	
	[0.00200]	
Population density	-0.0734**	
	[0.0324]	
Population (log)	6.362***	2.412
	[1.932]	[11.62]
Urbanization, pct	0.0113	0.0385
	[0.0226]	[0.168]
Farmland, hectares per sq km area	0.000447**	
	[0.000227]	
Public enrolment, pct	-0.0113	0.113
	[0.0135]	[0.0814]
Hospital beds, per 10,000 population	0.00620	
	[0.00377]	
Value of oil extracted, real dollars per capita	0.0301***	-0.0106
	[0.00458]	[0.0438]
Value of gas extracted, real dollars per capita	-0.000452*	-0.000345
	[0.000259]	[0.00153]
Time trend variable	0.0878	-0.125
	[0.0815]	[0.824]
Burden of disease		-0.00433
		[0.00598]
Outpatient visits		-0.00646
		[0.0206]
Population growth rate		0.152
		[0.110]
Unemployment rate		-0.0187
		[0.410]
Average pension		0.00124
		[0.00126]
Population below subsistence, pct		0.00168
		[0.0342]
Constant	0	0
	[0]	[0]
Observations	596	596
R-squared	0.956	0.988

Notes:

a) *Standard errors in brackets; *** p<0.01, ** p<0.05, * p<0.1*
b) *Real GRP, per capita and real revenue, per capita are endogenous.*
c) *Dependent variable: investment in fixed public capital, real rubles per capita. A time trend variable and full range of year and region dummies are included. The year and regions dummies not shown in the table.*
d) *Dependent variable: subnational current public expenditure, real rubles per capita. A time trend variable and full range of year and region dummies are included. The year and regions dummies not shown in the table.*

Table 3.12
The effect of change in rent revenue shares on new acquisition of fixed public capital and total public expenditure in regions of Russia –a difference-in-differences estimation (multiple treatment model using seemingly unrelated equations) [a)]

VARIABLES[b)]	(1) qRfixrbpc[c)]	(2) qRexprpc[d)]
Oil only regions	-5.179***	-2.315**
	[1.476]	[1.135]
Gas only regions	-1.117	0.0312
	[1.947]	[1.612]
Oil & gas regions	-2.893*	-0.212
	[1.734]	[1.198]
Oil tax share change 1	-0.493	0.946**
	[0.486]	[0.383]
Oil tax share change 2	-1.140	-0.909
	[0.805]	[0.598]
Oil tax share change 3	-0.451	0
	[0.971]	[0]
Gas tax share change 1	0	0
	[0]	[0]
Gas tax share change 2	0	1.578*
	[0]	[0.890]
Oil & gas tax share change 1	0	0
	[0]	[0]
Oil & gas tax share change 2	0	0
	[0]	[0]
Oil & gas tax share change 3	0	0
	[0]	[0]
DD-1 (oil only)	0.0789	2.160**
	[1.001]	[0.848]
DD-2 (oil only)	0.0877	2.993***
	[1.178]	[1.014]
DD-3 (oil only)	1.022	2.510***
	[0.864]	[0.799]
DD-1 (gas only)	-4.217	0.381
	[3.161]	[2.171]
DD-2 (gas only)	-4.366	0.945
	[3.020]	[1.874]
DD-1	-0.975*	-0.0611
	[0.522]	[0.424]
DD-2	-1.196*	0.345
	[0.628]	[0.518]
DD-3	-1.772***	-0.256
	[0.540]	[0.457]
Real revenue, per capita	0.0287	0.673***
	[0.277]	[0.187]
Real GRP, per capita	0.000108	3.51e-05
	[7.95e-05]	[3.29e-05]
Real transfers, per capita	-0.391***	0.0489**
	[0.0474]	[0.0237]
Population below working age, pct	-0.587	-0.334

	[0.577]	[0.369]
Volume of goods transported via rail	0.0114***	
	[0.00347]	
Volume of goods transported via road	-0.000320	
	[0.000256]	
Car ownership	-0.0360***	
	[0.0113]	
Population density	-0.0131	
	[0.271]	
Population (log)	3.955	7.203
	[13.76]	[7.349]
Urbanization, pct	0.0393	0.102
	[0.147]	[0.123]
Farmland, hectares per sq km area	0.00292	
	[0.00195]	
Public enrolment, pct	0.244	0.121
	[0.188]	[0.108]
Hospital beds, per 10,000 population	0.0299	
	[0.0269]	
Value of oil extracted, real dollars per capita	-0.0939	-0.0435
	[0.0812]	[0.0339]
Value of gas extracted, real dollars per capita	0.00130	-0.000799
	[0.00133]	[0.00112]
Time trend variable	0.316	-0.660*
	[0.487]	[0.364]
Burden of disease		-0.00222
		[0.00233]
Outpatient visits		-0.0108
		[0.00793]
Population growth rate		1.544***
		[0.329]
Unemployment rate		-0.115
		[0.314]
Average pension		0.00170
		[0.00149]
Population below subsistence, pct		-0.0131
		[0.0195]
Constant	-637.3	0
	[1,009]	[0]
Observations	583	583
R-squared	0.947	0.992

Notes:

a) *Standard errors in brackets; *** p<0.01, ** p<0.05, * p<0.1*
b) *Real GRP, per capita and real revenue, per capita are endogenous.*
c) *Dependent variable: new acquisition of fixed public capital, real rubles per capita. A time trend variable and full range of year and region dummies are included. The year and regions dummies not shown in the table.*
d) *Dependent variable: subnational current public expenditure, real rubles per capita. A time trend variable and full range of year and region dummies are included. The year and regions dummies not shown in the table.*

Table 4.1
Settlement of Exhaustible Resource Ownership in Federal Countries

Country	Federal units	Producing units[151]	Natural resource property rights
Argentina	24	7	Provinces own natural resources in their territories[152] and those that lie within 12 miles from the coast; the offshore reserves from 12 miles to the end of the exclusive economic zone in the sea belong to the national government. The national government has regulatory authorities over natural resources[153].
Australia	6+2	2	Onshore resources belong to the states or territory in which they are located. Offshore resources on the other hand are vested in the Commonwealth.
Brazil	27[154]	3	The Union has property rights over natural resources onshore and offshore but subnational governments' right to revenue is guaranteed by law
Canada	10 + 3	5	Provinces own onshore resources located in their jurisdiction[155] with the exception that reserves located in First Nations reservations are owned by the federal government. Offshore resource are owned by the federal government but through political settlements like the Atlantic Accord management rights have been awarded to Newfoundland and Labrador and Nova Scotia for reserves off their respective coasts[156].
India	28	5	States have property rights over natural resources[157] but the central government has management rights over them.
Iraq			Ownership is vested in the people, keeping it open to interpretation in the future.
Pakistan	4 + 3	4[158]	Onshore resource are owned by the provinces with management rights vested in the federal government; offshore staring from the coastline are owned by the federal government

[151] Offshore production is not counted toward any region, state or province.
[152] Section 124, Constitution of the Argentine Nation; Senate (1998)
[153] Section 41, Constitution of the Argentine Nation.
[154] Brazil has 5,563 municipalities that have a constitutional status with claims on rent tax revenues.
[155] Under section 109, of the Constitution Act and Canada Oil and Gas Act 1980-81-82, Black (1986), p.446-447.
[156] Jennifer (2008).
[157] Articles 294-297, Constitution of India.
[158] Oil and gas is mined in all four provinces but in two of them namely Baluchistan and Sindh, the production is significant.

Russian Federation	83	39	Onshore resources are jointly owned by the Federation and its subjects but the management rights are with the Federation; offshore are exclusively owned by the federation.
United Arab Emirates	7	4	Natural resources are owned by the emirate in which they are located. The federation only has limited management rights.
United States	50	6	States have property rights over onshore resources. Offshore resources are the property of the federal government.
Venezuela	23		Mineral and hydrocarbon deposits are the property of the federal government[159]

Table 4.2

Importance of Oil to GDP in federal countries

Federation/country	Oil production (million barrels) [a)]	Oil as percent of GDP [b)]
Argentina	224.78	4.99
Australia	163.17	1.01
Brazil	652.50	2.63
Canada	931.67	3.05
China	1,368.92	2.11
Germany	21.64	0.04
India	243.72	1.48
Indonesia	308.49	4.48
Iraq	858.75	53.87
Kazakhstan	490.20	24.47
Malaysia	270.00	7.44
Mexico	37.32	0.89
Nigeria	699.90	39.59
Pakistan	23.91	0.86
Russian Federation	3,509.10	16.61
Sudan	176.40	13.25
United Arab Emirates	932.40	20.30
United States	1,785.54	0.56
Venezuela, RB	846.60	21.18

Notes:

[159] Article 12, Constitution of the Bolivarian Republic of Venezuela.

[a)] Production of oil for year 2008; calculated using *Oil and Gas Journal* database for monthly oil production.
[b)] Value of oil and gas produced calculated by multiplying production with average weighted world price of crude oil and gas; the monthly production of oil and gas and monthly world weighted prices from *Oil and Gas Journal* database were used. GDP at current US$ from WDI 2008 used for calculation.

Table 4.3
Rent as a percent of total revenues and federal-regional shares

Country	Rent tax revenue as a share of total revenue	Federal share of rent	Subnational share of rent
Argentina	34 percent to 8 percent of total provincial revenue in the producing provinces	22 (export tax)	29 (royalty) [160]; the national government uses export tax to decouple domestic prices from international prices, depressing investment and royalties
Australia	2.9 percent of total government tax revenue[161]	In case of royalty for onshore mining, federal share is 32 to 54.8 percent	In case of royalty for onshore mining, the state shares range from 68 to 45.2 percent
Brazil		39	61 percent of royalties and special entitlements; 48 percent of CIT (through entitlement funds and regional funds)[162]
Canada			
India	3 percent of total revenue	Federal oil and gas taxes not shared with the states except the case mentioned in the next column	50 percent of profit petroleum under the Twelfth Finance Commission Award for some fields
Pakistan	8.4 percent of total tax revenue[163]	2 percent collection charges are retained by the federal government; CIT forms part of the divisible pool; area rent is retained	100 percent of royalty minus 2 percent collection charges; Gas Development Surcharge and specific excise duty on derivation basis
Russian Federation	36.7 percent of total revenue[164]	100 percent of MET, export duties, 40 percent of CIT; all revenue from offshore reserves	60 percent of CIT; no share from offshore revenue[165]
United Arab Emirates	74.3 percent of total government revenue[166]		

[160] Zapata (2010).
[161] Calculated from Australian Petroleum Production & Exploration Association's Financial Survey 2007-2008 and Table 1, Statement 9, Budget Paper No.1, Budget Strategy and Outlook 2007-2008, Australian Government.
[162] Gobetti et al. (2010).
[163] Calculated for fiscal years 2009 and 2010 from Tables 3a and 3b of IMF (2010). Only petroleum surcharge and gas development surcharge have been added in the numerator. According to the revised program, only Gas Development Surcharge is 6.4 percent of total tax revenue in 2010.
[164] Table 4, IMF 2005; the percentage is for the fiscal year 2005.
[165] The shares of the regions have progressively declined from a high 60 percent share of taxes levied on mining operations going to the regions till end of 2001. From 2002, the share of the producing regions declined to 20 percent, then to 15 percent in 2004, to 5 percent in 2005 and to has come to rest at zero in 2010.
[166] It ranged from 77 to 70 percent of total government revenue from 2003 to 2007, with an average of 74.2 percent; Calculated from Table 14, IMF (2009).

Country	Rent tax revenue as a share of total revenue	Federal share of rent	Subnational share of rent
United States			
Venezuela	50 percent of total revenue[167]	75 percent of oil royalty; windfall special contribution[168]	25 percent of oil royalties; 0.7 to producing states and 0.3 to all other states

[167] From 1994 to 1998, oil revenue as a share of total government revenue ranged from 43 to 59 percent with an average value of 51 percent; calculated from Table 30, Statistical Appendix to IMF (1999).
[168] Manzano et al. (2010).

Table 4.4

Type of Taxes Levied to Collect Economic Rent in Federal Countries

Country	Federal levies	Subnational levies
Argentina	Offshore reserves beyond 12 miles of coast: royalty onshore: export and import duties; VAT, CIT, specific taxes on sale of oil products	Onshore and up to 12 miles of coast: royalty
Australia	Onshore: royalty which is 6 to 8.5 percent of the production value; CIT; export levies Offshore: Petroleum Resource Rent Tax, Crude oil excise tax, CIT[169]	Onshore: royalty that is 4 percent of the production value Offshore: royalty only on mining in coastal waters
Brazil	Onshore: royalty; special entitlement, landowner participation, signature bonus, occupation or retention fee, CIT Offshore: same as onshore	No direct levy but guaranteed revenue sharing
Canada	Onshore: CIT[170] Offshore: CIT	Onshore: bonus or bonus bids; royalty (either in cash or kind); land use fees; local property tax Offshore: royalty allowed by joint contracting ; equity participation
India	Onshore: Profit oil, profit gas, dead rent, cess, CIT and sales tax Offshore: royalty	Onshore: royalty Offshore: none
Pakistan	CIT at the rate of 40 percent of corporate income; area rent; GST at the rate of 16 percent	Royalty[171]; Gas Development Surcharge; Specific excise duty[172]
Russian Federation	Onshore: MET on oil and gas production, CIT, export duties Offshore: same as onshore	Onshore: regions get 60 percent of CIT proceeds Offshore: none
United Arab Emirates		

[169] Table 5.1, Productivity Commission (2009). Review of Regulatory Burden on Upstream Petroleum (Oil and Gas) Sector.
[170] From 1977 till recently, royalty payments were not deductible for federal CIT payments.
[171] Collected by the federal government at the rate of 12.5 percent of the quantity sold at prices laid down by the government. The federal government retains 2 percent collection charges.
[172] Collected by federal government and transferred to provinces on derivation basis.

Country	Federal levies	Subnational levies
United States	Onshore: none	Onshore: royalty
	Offshore: royalty	Offshore: none
Venezuela	Only federal levies: royalties, exploitation tax, CIT (rate higher than non-oil companies) and windfall special contribution	

Table 4.5
The effect of rent tax share on investment in fixed public capital on regions of Russia (DDD estimation)[a)]

VARIABLES[b)]	Fixed effects (1)[c)]	Fixed effects (2)[d)]	Pooled (3)[e)]
Real GRP, pc	-2.00e-05***	-2.15e-05***	-2.17e-05***
	(3.59e-06)	(3.89e-06)	(3.59e-06)
Real revenue, pc	0.134***	0.135***	0.134***
	(0.00813)	(0.00783)	(0.00715)
DDD (republics)	-0.316**	-0.253	-0.253*
	(0.156)	(0.166)	(0.151)
DDD (other producing regions)	-0.0214	0.0401	0.0582
	(0.0926)	(0.0973)	(0.0882)
By birth population, pct-republics	-13.39**	-13.99**	-13.84**
	(6.702)	(6.338)	(5.808)
By birth population, pct-all regions	642.8	654.5	-0.00711***
	(395.5)	(398.8)	(0.00210)
Ethnic Russian x population growth rate	0.469***	0.584***	0.577***
	(0.149)	(0.163)	(0.148)
Real transfers, pc	-0.143***	-0.143***	-0.143***
	(0.00755)	(0.00730)	(0.00670)
Population below working age, pct	-0.0445	-0.121	-0.120
	(0.0778)	(0.0833)	(0.0770)
Population growth rate	-0.0227	-0.0301**	-0.0294**
	(0.0144)	(0.0139)	(0.0129)
Population density	-0.0968**	-0.109***	-0.105***
	(0.0399)	(0.0387)	(0.0353)
Population, log	5.470**	4.758*	4.415*
	(2.243)	(2.611)	(2.376)
Urbanization, pct	-0.0248	-0.0372	-0.0390
	(0.0236)	(0.0260)	(0.0242)
Farmland, hectares/sq.km.	0.000619***	0.000525**	0.000555***
	(0.000202)	(0.000212)	(0.000192)
Volume of goods transported via rail	0.00146***	0.00110**	0.00108**
	(0.000457)	(0.000475)	(0.000435)
Volume of goods transported via road	-3.02e-05	3.15e-06	1.10e-06
	(6.25e-05)	(6.35e-05)	(5.75e-05)
Car ownership	0.00263	0.00233	0.00226
	(0.00183)	(0.00183)	(0.00168)
Public bus passengers	1.97e-05	3.24e-05	3.43e-05
	(4.66e-05)	(4.76e-05)	(4.37e-05)
Public school enrolment, pct	0.0121	0.00570	0.00529
	(0.0157)	(0.0158)	(0.0144)
Population per hospital bed	0.00601*	0.00897**	0.00913***
	(0.00311)	(0.00347)	(0.00319)
Oil, value produced	1.09e-08***	1.11e-08***	1.10e-08***
	(4.02e-09)	(3.92e-09)	(3.58e-09)
Gas, value produced	-6.81e-10	-6.67e-10	-6.46e-10

	(4.64e-10)	(4.53e-10)	(4.14e-10)
Time trend	0.0714	0.144	0.0452
	(0.0734)	(0.0917)	(0.0739)
Constant			-88.96
			(155.7)
Observations	600	600	600
R-squared	0.900	0.902	0.958
Number of Regions	76	76	
First-stage F-statistic	17.00	20.01	
First-stage F-statistic	10.88	10.30	
Craig-Donald statistic	84.84	12.68	
size	10		
val	13.43	11.04	
Hansen-J p-value	0.934	0.359	
sizerb		11.04	

endog:Real GRP, pc Real revenue, pc :roadpavd rpaidser_pc residpc

Notes:

a) *Robust standard errors in brackets; *** p<0.01, ** p<0.05, * p<0.1*
b) *Real GRP, per capita and real revenue, per capita are endogenous. Excluded instruments are: paved roads as percentage of total length of roads a region, real value of paid services per capita and residential space per capita.*
c) *A time trend variable is included.*
d) *A full range of year dummies included but not shown in the table.*
e) *A complete set of region dummies and year dummies included but not shown in the table.*

Table 4.6
The effect of rent tax share on acquisition of fixed public capital in regions of Russia (DDD estimation)[a)]

VARIABLES[b)]	Fixed effects (1)[c)]	Fixed effects (2)[d)]	Pooled (3)[e)]
Real GRP, pc	-4.64e-05*	-5.78e-05**	-5.75e-05***
	(2.39e-05)	(2.44e-05)	(2.19e-05)
Real revenue, pc	0.537***	0.531***	0.524***
	(0.124)	(0.117)	(0.105)
DDD (republics)	-1.185**	-0.837	-0.833
	(0.555)	(0.619)	(0.561)
DDD (other producing regions)	-0.604	-0.121	-0.0527
	(0.417)	(0.453)	(0.406)
By birth population, pct-republics	31.02	25.01	25.64
	(25.79)	(29.63)	(26.07)
By birth population, pct-all regions	2,525*	2,672*	-0.0106
	(1,375)	(1,450)	(0.0184)
Ethnic Russian x population growth rate	1.665	2.241*	2.134*
	(1.296)	(1.320)	(1.180)
Real transfers, pc	-0.297***	-0.300***	-0.300***
	(0.0693)	(0.0640)	(0.0572)
Population below working age, pct	0.836**	-0.0897	-0.0832
	(0.394)	(0.358)	(0.323)
Population growth rate	-0.650	-0.880	-0.822
	(0.764)	(0.772)	(0.692)
Population density	-0.277	-0.218	-0.198
	(0.242)	(0.218)	(0.197)
Population, log	28.28**	13.95	12.42
	(11.14)	(11.76)	(10.50)
Urbanization, pct	-0.224*	-0.319**	-0.324**
	(0.135)	(0.146)	(0.133)
Farmland, hectares/sq.km.	-0.000190	-0.000671	-0.000525
	(0.00106)	(0.00107)	(0.000984)
Volume of goods transported via rail	0.00823***	0.00547**	0.00538***
	(0.00246)	(0.00231)	(0.00206)
Volume of goods transported via road	-0.000139	9.25e-05	8.35e-05
	(0.000275)	(0.000278)	(0.000249)
Car ownership	-0.0251	-0.0261*	-0.0264*
	(0.0162)	(0.0152)	(0.0138)
Public bus passengers	0.000341*	0.000406**	0.000416**
	(0.000188)	(0.000189)	(0.000172)
Public school enrolment, pct	0.0235	-0.0369	-0.0365
	(0.0766)	(0.0779)	(0.0702)
Population per hospital bed	0.0629	0.0878*	0.0882**
	(0.0443)	(0.0460)	(0.0418)
Oil, value produced	3.30e-08**	3.34e-08**	3.25e-08**
	(1.65e-08)	(1.61e-08)	(1.45e-08)
Gas, value produced	-2.00e-09	-1.75e-09	-1.65e-09
	(1.66e-09)	(1.62e-09)	(1.46e-09)
Time trend	1.227***	1.810***	0.785**

	(0.414)	(0.623)	(0.328)
Constant			-1,599**
			(670.7)
Observations	588	588	588
R-squared	0.622	0.650	0.951
Number of Regions	76	76	
First-stage F-statistic	11.71	20.01	
First-stage F-statistic	21.24	10.30	
Craig-Donald statistic	11.21	12.68	

Notes:

*a) Robust standard errors in brackets; *** p<0.01, ** p<0.05, * p<0.1*

b) Real GRP, per capita and real revenue, per capita are endogenous. Excluded instruments are: paved roads as percentage of total length of roads a region, real value of paid services per capita, air pollution tons per 1000 real rubles of gross regional product and residential space per capita.

c) A time trend variable is included.

d) A full range of year dummies included but not shown in the table.

e) A complete set of region dummies and year dummies included but not shown in the table.

Table 4.7
The effect of rent tax share on investment in fixed public capital and recurrent expenditures in regions of Russia (DDD estimation)[a)]

VARIABLES[b)]	(1) qRfixrbpc[c)]	(2) qRexprpc[d)]
DDD (republics)	-0.303***	0.947
	[0.116]	[0.687]
DDD (other producing regions)	0.000862	0.483
	[0.0786]	[0.575]
By birth population, pct-republics	-16.04***	42.58
	[6.006]	[53.50]
By birth population, pct-all regions	-0.0335	0.0780
	[0.0400]	[0.570]
Ethnic Russian x population growth rate	0.318**	1.371
	[0.134]	[2.023]
Real revenue, pc	0.137***	0.818***
	[0.00494]	[0.147]
Real GRP, pc	-1.74e-05***	1.86e-05
	[2.43e-06]	[5.04e-05]
Real transfers, pc	-0.146***	0.0568
	[0.00390]	[0.0471]
Population below working age, pct	-0.0614	-0.198
	[0.0634]	[0.478]
Volume of goods transported via rail	0.00161***	
	[0.000569]	
Volume of goods transported via road	-5.79e-05	
	[4.03e-05]	
Car ownership	0.00228	
	[0.00185]	
Population density	-0.0862**	
	[0.0353]	
Population, log	5.297***	0.695
	[1.791]	[10.05]
Urbanization, pct	-0.0112	0.199
	[0.0226]	[0.264]
Farmland, hectares/sq.km.	0.000714***	
	[0.000215]	
Public school enrolment, pct	0.0111	0.115
	[0.0130]	[0.107]
Population per hospital bed	0.00556	
	[0.00348]	
Oil, value produced	9.99e-09***	-4.57e-09
	[9.83e-10]	[1.69e-08]
Gas, value produced	-6.40e-10***	-2.22e-10
	[8.92e-11]	[8.94e-10]
Time trend	0.0351	-0.130
	[0.0608]	[0.873]
New patients requiring treatment		-0.00136
		[0.0109]

Outpatient visits		-0.00784
		[0.0268]
Population growth rate		-0.0172
		[0.208]
Unemployment rate		-0.0275
		[0.442]
Average pension payment		0.000340
		[0.00142]
Population below subsistence income		-0.0276
		[0.0410]
Constant	0	0
	[0]	[0]
Observations	596	596
R-squared	0.958	0.988

Notes:

a) *Standard errors in brackets; *** p<0.01, ** p<0.05, * p<0.1*
b) *Real GRP, per capita and real revenue, per capita are endogenous.*
c) *Dependent variable: new investment in fixed public capital, real rubles per capita. A time trend variable and full range of year and region dummies are included. The year and regions dummies not shown in the table.*
d) *Dependent variable: subnational recurrent public expenditure, real rubles per capita. A time trend variable and full range of year and region dummies are included. The year and regions dummies not shown in the table.*

Table 4.8
The effect of rent tax share on investment in fixed public capital and recurrent expenditures in regions of Russia (DDD estimation)[a)]

VARIABLES[b)]	(1) qRfixsnpc[c)]	(2) qRexprpc[d)]
DDD (republics)	-0.765	1.200**
	[0.629]	[0.608]
DDD (other producing regions)	-1.111**	0.170
	[0.457]	[0.473]
By birth population, pct-republics	58.16	34.68
	[37.59]	[45.71]
By birth population, pct-all regions	-0.407*	0.234
	[0.238]	[0.232]
Ethnic Russian x population growth rate	1.089*	-0.708
	[0.650]	[1.247]
Real revenue, pc	0.244	0.613***
	[0.150]	[0.211]
Real GRP, pc	4.41e-05	5.62e-05
	[3.30e-05]	[3.99e-05]
Real transfers, pc	-0.346***	0.0505**
	[0.0236]	[0.0243]
Population below working age, pct	-0.0944	-0.338
	[0.413]	[0.388]
Volume of goods transported via rail	0.0105***	
	[0.00274]	
Volume of goods transported via road	-0.000317	
	[0.000197]	
Car ownership	-0.0291***	
	[0.00944]	
Population density	-0.287	
	[0.249]	
Population, log	27.71***	2.660
	[9.525]	[8.213]
Urbanization, pct	0.129	0.332*
	[0.153]	[0.185]
Farmland, hectares/sq.km.	0.000643	
	[0.00115]	
Public school enrolment, pct	0.159	0.105
	[0.0985]	[0.0980]
Population per hospital bed	0.0372*	
	[0.0203]	
Oil, value produced	7.21e-11	-2.05e-08
	[1.28e-08]	[1.54e-08]
Gas, value produced	-6.19e-10	5.10e-10
	[6.75e-10]	[7.99e-10]
Time trend	0.526	-0.387
	[0.360]	[0.362]
New patients requiring treatment		0.00161
		[0.00396]
Outpatient visits		-0.00689

		[0.00738]
Population growth rate		1.747***
		[0.678]
Unemployment rate		-0.0767
		[0.304]
Average pension payment		0.000978
		[0.00149]
Population below subsistence income		-0.0263
		[0.0202]
Constant	0	0
	[0]	[0]
Observations	583	583
R-squared	0.949	0.991

Notes:

a) *Standard errors in brackets; *** p<0.01, ** p<0.05, * p<0.1*
b) *Real GRP, per capita and real revenue, per capita are endogenous.*
c) *Dependent variable: new acquisition of fixed public capital, real rubles per capita. A time trend variable and full range of year and region dummies are included. The year and regions dummies not shown in the table.*
d) *Dependent variable: subnational recurrent public expenditure, real rubles per capita. A time trend variable and full range of year and region dummies are included. The year and regions dummies not shown in the table.*

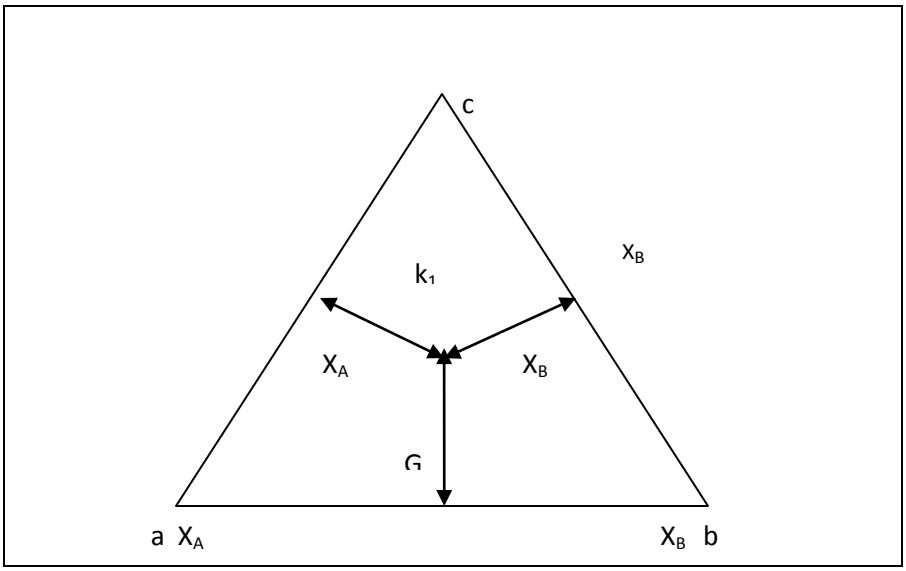
Appendix A.1 Application of the Kolm Triangle Technique to Rent Assignment

At the outset it is useful to demonstrate that assignment leads to nontrivial outcomes of welfare distribution. This alone may not be a sufficient condition for rent assignment but it does create a perspective to show that rent assignment needs to be seen from a number of perspectives. To demonstrate the effect of federal share in royalty and a transfer scheme, we use the Kolm triangle technique. For this purpose let's assume there are two regions A and B which comprise a federation. The federal government produces a public good *G* which is non-rival and non-excludable for residents in both regions. Each region produces a public good X_i which is a local public good or a club good and there is no free riding across the regions. Only region A is endowed with an exhaustible natural resource. We assume that the natural resource can be converted to the regional public good one for one.

Figure A shows a simple Kolm Triangle. It is an equilateral triangle with the base or x-axis representing the level of regional public goods. The length of the base is equal to the sum of the regional public goods. The upper vertex represents the federal public good. Each point *k* in the interior of the triangle represents a bundle of goods, the federal public good and the regional public goods. Let k_1 represent an allocation (G, X_A, X_B), where certain quantities of all three goods are produced. In this Kolm Triangle the regional public goods are represented on the x-axis but unlike an Edgeworth Box, the distance from the origin along the x-axis is not a measure of the level of regional public good. Instead, the shortest distance between the inclined axis and the point is a measure of the level of X in a region. When we draw a line through *k* parallel to the

horizontal axis, the distance between this line and the horizontal axis is the measure of the federal public good as shown in the figure.

Figure A.



A representative agent in each region has preferences over X_i and G. These preferences are depicted by indifference curves, exhibiting all properties of indifference curves. However, to accommodate the indifference maps in the triangle a transformation is carried out. This transformation is:

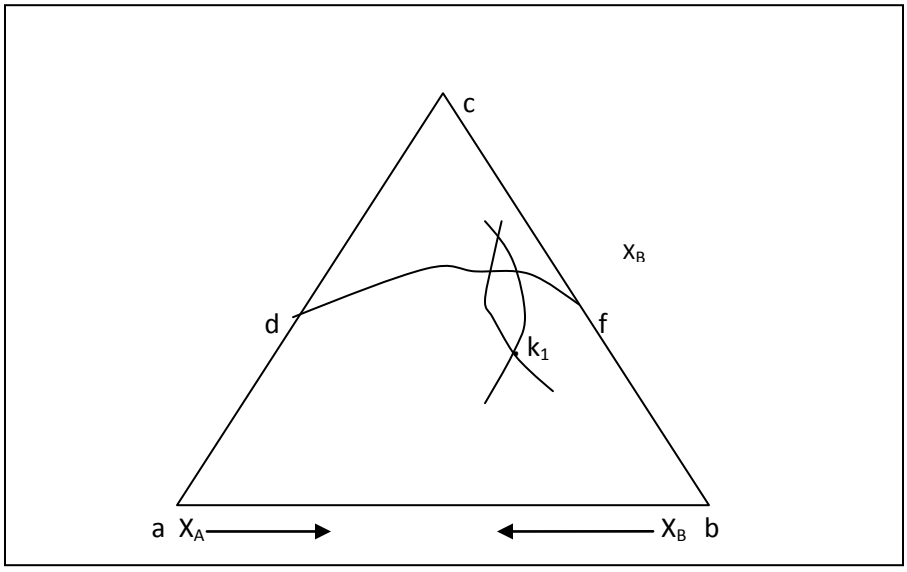
$$x^t = 1/\sqrt{3}(2x^o + y) \quad \text{and} \; y^t = y^o$$

Where superscript *t* is for the transformed variable and *o* is for the original variable.

Now a Pareto region is easily identified in the triangle when the indifference maps of the two representative agents are known. For instance, if the two agents have normal Cobb-Douglas type of preferences then there indifference curves will be as represented below. In this case all

allocations not in the interior of the triangle are not part of the feasible set. Only the points in the interior of the triangle represent the feasible set of allocations in the nation. Given the indifference curves, the Pareto set in this case is the curved line *df*. No individual can be made better off without reducing the welfare of another for any of the points on this line. Points not on the line are not Pareto efficient. At point k_1 there is an allocation which is not Pareto efficient. Both agents can be made better off by moving them to a point inside the area inscribed by the two indifference curves.

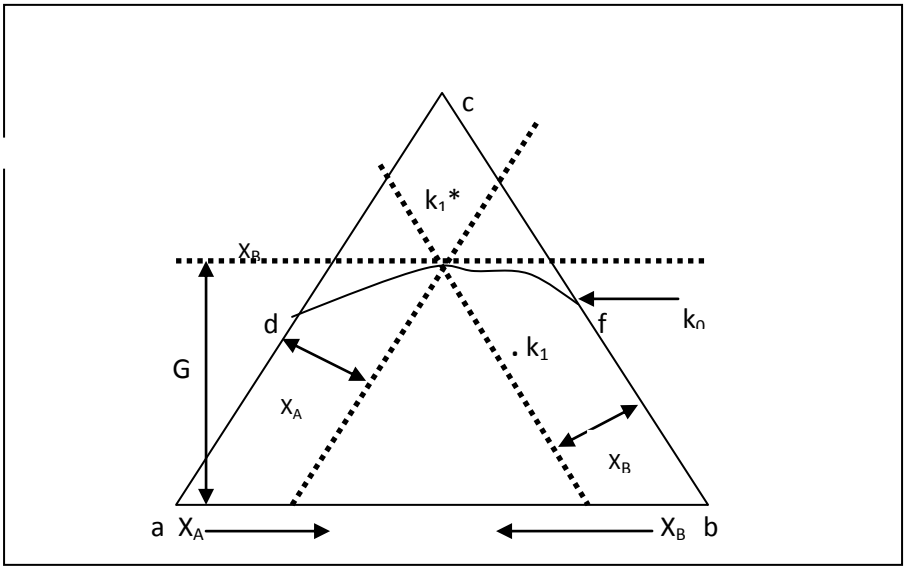
Figure B.



Let's assume that Region A is endowed with all the reserves of the exhaustible resource in the nation. Initially, there is no federal share in exhaustible resource rent. Then k_0 in Figure C below represents the original allocation in the Kolm triangle. Then under the federal arrangement α.M is the federally collected royalty, which is then, through the transfer pool, allocated to region

B. To begin with, keeping it simple, it is a conditional grant which can only be allocated to provision of regional public good X_B. Through this federal arrangement, B gains a share of endowment. It is possible to argue in this manner because region B has a fixed share in transfers which is entirely financed by the federal royalty income. Hence the sum of X_A and X_B is equal to the length of the base of the triangle. Now let's say that with the federal arrangement, the new allocation is k_1. Clearly it is not Pareto efficient. Therefore, through a process of reallocation within the budgets the two regions will reach k_1* which is Pareto efficient. At this point, a bundle comprising G, X_A and X_B are produced in the economy.

Figure C.



The depiction in the triangle is for the sums of amounts of goods over time, the length of time being equal to the period in which the natural resource in exhausted. For the entire duration it is clear that the total amount of X_A under the federal arrangement is less than that which would be without the federal arrangement. But the total amount of X, a regional capital good, produced under the scheme is the same as would have been produced if there had been no federal

intervention. But this result is possible under strict conditions, namely a conditional grant ensuring that region B invests the grant in regional capital formation and certain assumptions on preferences. If these conditions do not hold, region B's investment in the regional public good, under the income and substitution effects may be less than the decrease in public investment in region A, decreasing the sum of regional stocks X.

From this simple depiction it is clear that sharing of exhaustible natural resource revenue outside a region in a federal arrangement may bring the stock of public good (asset) to be created to a lower level. Therefore, the owner region will need a compensation of some sort. But the question of equity can be discussed in the following manner. If the social welfare function assigns a high value to citizens in region B, then the sacrifice is justifiable under the objective function.

Appendix B.1 Proofs

Proposition 1.

Proof.

Government policy affects the choice of tax rates and level of taxes. If the government develops a higher priority for development, there will be sign on the following $\frac{\partial \alpha}{\partial c}$ and $\frac{\partial \vartheta}{\partial c}$.

The social planner maximizes the following objective function:

$$Max_{\{\vartheta,\alpha\}}\, L = c.h + R_1 + \lambda_1((2p-1).\tau - \alpha) + \lambda_2\left(\alpha - \frac{(1-\vartheta)qY}{\pi_A.M}\cdot B\right)$$

Where $R_1 = -\left[\frac{\pi_A(p.(1-\vartheta).Y+(\tau-\alpha)M)+\pi_B.(1-p).(1-\vartheta).Y}{Y+\tau.M}\right] = -\left[\frac{(1-\vartheta).Y(p.\pi_A+(1-p).\pi_B)+\pi_A(\tau-\alpha).M}{Y+\tau.M}\right]$

Or simply as

$$R_1 = -\frac{q(1-\vartheta).Y + \pi_A(\tau-\alpha).M}{E} = -\frac{E_A + E_B}{E}$$

Where $E_i$is the expenditure on long-lived public goods in region *i* and E is the total public expenditure in the nation.

Following are the first order conditions for the maximization problem:

$$\frac{\partial L}{\partial \vartheta} = c.\frac{\partial h}{\partial \vartheta} - \left[-Y.(p.\pi_A + (1-p).\pi_B)\frac{((p.\pi_A + (1-p).\pi_B).(1-\vartheta)Y + \pi_A.(\tau-\alpha).M)^{-1}}{Y+\tau.M}\right] + \lambda_2\left[qY\frac{1}{(1-\vartheta)qY.\pi_A M}\right] = 0$$

$$\frac{\partial L}{\partial \vartheta} = c.\frac{\partial h}{\partial \vartheta} + Y(p.\pi_A + (1-p).\pi_B)\left[\frac{(q(1-\vartheta).Y + \pi_A.(\tau-\alpha).M)^{-1}}{Y+\tau.M}\right] + \lambda_2\left[\frac{1}{(1-\vartheta).\pi_A M}\right] = 0$$

Or

$$\frac{\partial L}{\partial \vartheta} = c.\frac{\partial h}{\partial \vartheta} + qY\left[\frac{1}{E(E_A + E_B)}\right] + \lambda_2\left[\frac{1}{(1-\vartheta).\pi_A M}\right] = 0 \qquad (1.1)$$

And

$$\frac{\partial L}{\partial \alpha} = c.\frac{\partial h}{\partial \alpha} - \left[-M.\pi_A \frac{((1-v).Y(p.\pi_A + (1-p).\pi_B) + \pi_A.(\tau-\alpha).M)^{-1}}{(1-\vartheta).Y + \tau.M}\right] - \lambda_1 + \lambda_2 = 0$$

Or

$$\frac{\partial L}{\partial \alpha} = c.\frac{\partial h}{\partial \alpha} + \pi_A.M\left[\frac{1}{E(E_A + E_B)}\right] - \lambda_1 + \lambda_2 = 0 \qquad (1.2)$$

When $(2p-1).\tau < \alpha < \frac{(1-\vartheta).qY}{M}$, $\lambda_i = 0$, for *i* =1,2. And the first order conditions can be rewritten as:

$$\frac{\partial L}{\partial \vartheta} = c.\frac{\partial h}{\partial \vartheta} + Y\left[\frac{q}{E(E_A + E_B)}\right] = 0 \qquad (1.3)$$

$$\frac{\partial L}{\partial \alpha} = c.\frac{\partial h}{\partial \alpha} + M\left[\frac{\pi_A}{E(E_A + E_B)}\right] = 0 \qquad (1.4)$$

From the first order conditions, it can be seen that

$$c.\frac{\partial h}{\partial \vartheta} = -Y\left[\frac{q}{E(E_A + E_B)}\right] < 0 \qquad (1.5)$$

and

$$c.\frac{\partial h}{\partial \alpha} = -M\left[\frac{\pi_A}{E(E_A + E_B)}\right] < 0 \qquad (1.6)$$

Differentiating equation (1.3) and (1.4) with respect to parameter of preference for long-lived public goods *c*, we get the following equations:

$$\frac{\partial h}{\partial \vartheta} + c\frac{\partial \vartheta}{\partial c}\left[\frac{\partial^2 h}{\partial \vartheta^2} - \frac{q^2.Y^2}{E(E_A + E_B)^2}\right] + c\frac{\partial \alpha}{\partial c}\left[\frac{\partial^2 h}{\partial \vartheta \partial \alpha} - \frac{\pi_A.q.YM}{E.E(E_A + E_B)^2}\right] = 0$$

$$\frac{\partial h}{\partial \alpha} + c\frac{\partial \vartheta}{\partial c}\left[\frac{\partial^2 h}{\partial \alpha \partial \vartheta} - \frac{\pi_A.q.YM}{E(E_A + E_B)^2}\right] + c\frac{\partial \alpha}{\partial c}\left[\frac{\partial^2 h}{\partial^2 \alpha} - \frac{\pi_A^2 M^2}{E(E_A + E_B)^2}\right] = 0$$

These two equations can be written as a system of equations:

$$\begin{bmatrix} c\frac{\partial^2 h}{\partial \vartheta^2} - \frac{q^2.Y^2}{E(E_A+E_B)^2} & c\frac{\partial^2 h}{\partial \vartheta \partial \alpha} - \frac{\pi_A.q.YM}{E(E_A+E_B)^2} \\ c\frac{\partial^2 h}{\partial \alpha \partial \vartheta} - \frac{\pi_A.q.YM}{E(E_A+E_B)^2} & c\frac{\partial^2 h}{\partial^2 \alpha} - \frac{\pi_A^2 M^2}{E(E_A+E_B)^2} \end{bmatrix} \cdot \begin{bmatrix} \frac{\partial \vartheta}{\partial c} \\ \frac{\partial \alpha}{\partial c} \end{bmatrix} = \begin{bmatrix} -\frac{\partial h}{\partial \vartheta} \\ -\frac{\partial h}{\partial \alpha} \end{bmatrix} \quad (1.7)$$

Or in matrix notation as:

$$A.X = B$$

Where ***A*** is the Hessian matrix of second order differentials of the objective function and

$$|A| > 0$$

To demonstrate this we use the following substitutions:

$c\frac{\partial^2 h}{\partial \vartheta^2} = m$, $\frac{q^2.Y^2}{E(E_A+E_B)^2} = n$, $c\frac{\partial^2 h}{\partial \vartheta \partial \alpha} = j$, $\frac{\pi_A.q.YM}{E(E_A+E_B)^2} = x$, $c\frac{\partial^2 h}{\partial \alpha \partial \vartheta} = v$, $\frac{\pi_A.q.YM}{E(E_A+E_B)^2} = t$, $c\frac{\partial^2 h}{\partial^2 \alpha} = d$ and $\frac{\pi_A^2 M^2}{E(E_A+E_B)^2} = w$. Then the determinant = dm-dn+ct-cv-mw+nw-tx+vx

= m(d-w) +t(j-x) +n(w-d) +v(x-j)

= m(d-w) + n(w-d) + t(c-x) +j(x-j) because v = j

= md –mw –nd +nw > 0

Because

md > 0 as a product of two negative terms

mw, nd < 0 and –mn, -nd > 0

nw > 0 as a product of two positive terms.

= dm-dn+jt-jv-mw+nw-tx+vx

=dm –dn–mw+nw-tx+jt +jj+jx

dm > 0 as a product of two negative terms

mw, dn < 0 and –mw, -dn > 0

nw > 0 as a product of two positive terms

tx = nw and tx < 0

j is the cross partial is positive but small in magnitude,

therefore the determinant > 0

Solving the system by Crammer's Rule, we have:

$$\frac{\partial \vartheta}{\partial c} = \frac{|P_1|}{|A|}$$

$$\frac{\partial \alpha}{\partial c} = \frac{|P_2|}{|A|}.$$

Where

$$|P_1| = \frac{\partial h}{\partial \alpha}.\frac{\partial^2 h}{\partial \vartheta \partial \alpha} - \frac{\partial h}{\partial \vartheta}.\frac{\partial^2 h}{\partial^2 \alpha} + \frac{\partial h}{\partial \vartheta}.\frac{\pi_A^2 M^2}{E(E_A + E_B)^2} - \frac{\partial h}{\partial \alpha}.\frac{\pi_A.q.YM}{E(E_A + E_B)^2} < 0$$

Comparing the last two terms

$$\frac{\partial h}{\partial \vartheta}.\frac{\pi_A^2 M^2}{E(E_A + E_B)^2} = \frac{\partial h}{\partial \alpha}.\frac{\pi_A.q.YM}{E(E_A + E_B)^2}$$

We substitute the values of $\frac{\partial h}{\partial \alpha}$ and $\frac{\partial h}{\partial \vartheta}$ from equations (1.3) and (1.4) above. The two sides are equal but have opposite signs. Hence the determinant becomes:

$$\frac{\partial h}{\partial \alpha}.\frac{\partial^2 h}{\partial \vartheta \partial \alpha} - \frac{\partial h}{\partial \vartheta}.\frac{\partial^2 h}{\partial^2 \alpha}$$

The first term is a product of a negative and a positive number and has a negative sign. The second term in a product of two negative numbers but has a negative sign. Therefore, $|P_1| < 0$.

And

$$|P_2| = \frac{\partial h}{\partial \alpha}.\frac{q^2.Y^2}{E(E_A + E_B)^2} - \frac{\partial h}{\partial \alpha}.\frac{\partial^2 h}{\partial \vartheta^2} - \frac{\partial h}{\partial \vartheta}.\frac{\pi_A.q.YM}{E(E_A + E_B)^2} + \frac{\partial h}{\partial \vartheta}.\frac{\partial^2 h}{\partial \alpha \partial \vartheta}$$

First we compare $\frac{\partial h}{\partial \alpha}.\frac{q^2.Y^2}{E(E_A+E_B)^2}$ and $-\frac{\partial h}{\partial \vartheta}.\frac{\pi_A.q.YM}{E(E_A+E_B)^2}$. For this purpose wesubstitute the values of $\frac{\partial h}{\partial \alpha}$ and $\frac{\partial h}{\partial \vartheta}$ from equations mngu and fdru above. The two are equal and have opposite signs. Hence the determinant becomes equal to:

$$-\frac{\partial h}{\partial \alpha}.\frac{\partial^2 h}{\partial \vartheta^2}+\frac{\partial h}{\partial \vartheta}.\frac{\partial^2 h}{\partial \alpha \partial \vartheta}$$

and the sum of two negative terms can but only be negative. Therefore, $|P_2| < 0$

$$\frac{\partial \vartheta}{\partial c} < 0$$

$$\frac{\partial \alpha}{\partial c} < 0$$

If $(2p-1).\tau = \alpha < \frac{(1-\vartheta)qY}{\pi_A M}$, the objective function becomes:

$$Max_{\{\vartheta\}}\, L = c.h(\vartheta,(2p-1).\tau)+R_1$$

Where

$$R_1 = -\left[\frac{(1-\vartheta).qY-\pi_A(2p-1).\tau M+\pi_A \tau M}{Y+\tau M}\right]$$

The first order conditions are:

$$\frac{\partial L}{\partial \vartheta} = c\frac{\partial h}{\partial \vartheta}+(2p-1)\tau+qY\left[\frac{1}{E.\big((1-\vartheta).qY+(2p-1).\tau.\pi_A.M\big)}\right]=0 \qquad (1.8)$$

Or

$$c.\frac{\partial h}{\partial \vartheta} = -(2p-1)\tau-qY\left[\frac{1}{E.\big((1-\vartheta).qY+(2p-1).\tau.\pi_A.M\big)}\right]<0 \qquad (1.9)$$

It is clear that,

$\frac{\partial \vartheta}{\partial c} < 0$

Because differentiating equation (1.6) with respect to *c* yields:

$$\frac{\partial h}{\partial \vartheta}+\frac{\partial \vartheta}{\partial c}\left[\frac{q^2Y^2}{(1-\vartheta).qY+\pi_A(2p-1).\tau M}\right]=0$$

And

$$\frac{\partial \vartheta}{\partial c} = \frac{\partial h}{\partial \vartheta}.\left[\frac{(1-\vartheta)qY + \pi_A(2p-1).\tau M}{q^2Y^2}\right] < 0 \qquad \because \frac{\partial h}{\partial \vartheta} < 0 \text{ from equation (1.11)}$$

And

$$\frac{\partial \alpha}{\partial c} = 0$$

Because equation (1.8) is not a function of α. Intuitively, this means that since α is fixed, there will be no change effected in the rate of federal tax unless a new political agreement is worked out.

Now if $(2p-1).\tau < \alpha = \left[\frac{(1-\vartheta)qY}{\pi_A.M} \cdot B\right]$, the objective function becomes

$$Max_{\{\vartheta\}}\, L = c.h\left(\vartheta, \frac{(1-\vartheta)qY}{\pi_A.M} \cdot B\right) + R_1$$

Where

$$R_1 = -\left[\frac{(1-\vartheta).qY - (1-\vartheta).qY + \tau M}{Y + \tau M}\right] = -\left[\frac{\tau M}{Y + \tau M}\right]$$

The first order conditions are:

$\frac{\partial L}{\partial \vartheta} = c\left[\frac{\partial h}{\partial \vartheta} - \frac{qY}{\pi_A.M}\right] = 0$ and

$$\frac{\partial h}{\partial \alpha} = 0$$

And

$\frac{\partial \vartheta}{\partial c}, \frac{\partial \alpha}{\partial c} = 0$ since optimal ϑ and α are independent of c but $\frac{\partial h}{\partial \vartheta} > 0$. Intuitively, this indicates that fixing α at the highest possible level would have no substitution effect on long-lived goods; any reduction in the fiscal resource in Region A would be adjusted in consumable public goods.

Proposition 2.

Proof.

The social planner solves:

$$Max_{\{\vartheta,\alpha\}}\, L = c.h + R_2 + \lambda_1((2p-1).\tau - \alpha) + \lambda_2\left(\alpha - \frac{(1-\vartheta)qY}{\pi_A.M}\cdot B\right)$$

Where $R_2 = -\left[\frac{(1-\vartheta)qY+\pi_A(\tau-\alpha)M+\pi_{C.\alpha M}}{Y+\tau.M}\right] = -\left[\frac{E_A+E_B+E_C}{E}\right]$

Where π_C stands for the preferential allocation percentage of the fund for long-lived goods and E_C the share of heritage sort of fund facility invested in long-lived public goods.

The first order conditions of the maximization equilibrium are:

$$\frac{\partial L}{\partial \vartheta} = c\frac{\partial h}{\partial \vartheta} + qY\left[\frac{1}{E(E_A+E_B+E_C)}\right] = 0 \qquad (2.1)$$

$$\frac{\partial L}{\partial \alpha} = c\frac{\partial h}{\partial \alpha} + (\pi_A-\pi_C)M\left[\frac{1}{E(E_A+E_B+E_C)}\right] = 0 \qquad (2.2)$$

From equation (2.1) and (2.2), it can be seen that:

$$\frac{\partial h}{\partial \vartheta} = -qY\left[\frac{1}{E(E_A+E_B+E_C)}\right] < 0 \qquad (2.3)$$

$$\frac{\partial h}{\partial \alpha} = -(\pi_A-\pi_C)M\left[\frac{1}{E(E_A+E_B+E_C)}\right] < 0 \qquad (2.4)$$

The second condition is independent of the size of the fund as far as the direction of the effect is concerned. The size of the facility will matter however in determining the magnitude of the effect. A larger fund does not necessarily mean a higher investment in long-lived public goods, if $\pi_A < \pi_C$. If $\pi_A = \pi_C$, then a change in α has no effect on the increase in long-lived public goods in the nation.

Differentiating equations (2.1) and (2.2) with respect to *c* we obtain:

$$\frac{\partial h}{\partial \vartheta} + c\frac{\partial \vartheta}{\partial c}\left[\frac{\partial^2 h}{\partial \vartheta^2} - \frac{q^2Y^2}{E(E_A+E_B+E_C)^2}\right] + c\frac{\partial \alpha}{\partial c}\left[\frac{\partial^2 h}{\partial \vartheta \partial \alpha} - \frac{(\pi_A-\pi_C)\,qYM}{E(E_A+E_B+E_C)^2}\right] = 0 \qquad (2.5)$$

$$\frac{\partial h}{\partial \alpha} + c\frac{\partial \vartheta}{\partial c}\left[\frac{\partial^2 h}{\partial \alpha \partial \vartheta} - \frac{(\pi_A - \pi_C)\, qYM}{E(E_A + E_B + E_C)^2}\right] + c\frac{\partial \alpha}{\partial c}\left[\frac{\partial^2 h}{\partial \alpha^2} - \frac{(\pi_A - \pi_C)^2 M^2}{E(E_A + E_B + E_C)^2}\right] = 0 \qquad (2.6)$$

From the simultaneous equations (2.5) and (2.6), we get the following system:

$$\begin{bmatrix} c\frac{\partial^2 h}{\partial \vartheta^2} - \frac{q^2 Y^2}{E(E_A + E_B + E_C)^2} & c\frac{\partial^2 h}{\partial \vartheta \partial \alpha} - \frac{(\pi_A - \pi_C)\, qYM}{E(E_A + E_B + E_C)^2} \\ c\frac{\partial^2 h}{\partial \alpha \partial \vartheta} - \frac{(\pi_A - \pi_C)\, qYM}{E(E_A + E_B + E_C)^2} & c\frac{\partial^2 h}{\partial \alpha^2} - \frac{(\pi_A - \pi_C)^2 M^2}{E(E_A + E_B + E_C)^2} \end{bmatrix} \begin{bmatrix} \frac{\partial \vartheta}{\partial c} \\ \frac{\partial \alpha}{\partial c} \end{bmatrix} = \begin{bmatrix} -\frac{\partial h}{\partial \vartheta} \\ -\frac{\partial h}{\partial \alpha} \end{bmatrix}$$

Or

$$\ddot{A}\, X = B$$

$$\left|\ddot{A}\right| > 0$$

Because determinant of A = de +ag-ak-bg+cf+bk-df-ce

Where a=$c\frac{\partial^2 h}{\partial \vartheta^2}$, b= $\frac{q^2 Y^2}{E(E_A+E_B+E_C)^2}$, j= $c\frac{\partial^2 h}{\partial \alpha \partial \vartheta}$, d= $\frac{(\pi_A-\pi_C)\, qYM}{E(E_A+E_B+E_C)^2}$, e= $c\frac{\partial^2 h}{\partial \vartheta \partial \alpha}$, f= $\frac{(\pi_A-\pi_C)\, qYM}{E(E_A+E_B+E_C)^2}$, g= $c\frac{\partial^2 h}{\partial \alpha^2}$ and k= $\frac{(\pi_A-\pi_C)^2 M^2}{E(E_A+E_B+E_C)^2}$.

Now ag –ak –bg + de + jf > 0 because each term $\because$ each term ≥ 0

bk = df but have opposite signs so the two terms cancel each other; and

assuming that the revenues from ϑ and α are perfect substitutes, je = 0.

Solving the system by Crammer's Rule, we have:

$$\frac{\partial \vartheta}{\partial c} = \frac{|P_1|}{\left|\ddot{A}\right|}$$

$$\frac{\partial \alpha}{\partial c} = \frac{|P_2|}{\left|\ddot{A}\right|}.$$

Where

$$|P_1| = \frac{\partial h}{\partial \alpha}\cdot\frac{\partial^2 h}{\partial \vartheta \partial \alpha} - \frac{\partial h}{\partial \vartheta}\cdot\frac{\partial^2 h}{\partial^2 \alpha} + \frac{\partial h}{\partial \vartheta}\cdot\frac{(\pi_A - \pi_C)^2 M^2}{E(E_A + E_B + E_C)^2} - \frac{\partial h}{\partial \alpha}\cdot\frac{(\pi_A - \pi_C)\, qYM}{E(E_A + E_B + E_C)^2} < 0 \qquad (2.7)$$

as explained below:

Comparing the last two terms, we claim:

$$\frac{\partial h}{\partial \vartheta}.\frac{(\pi_A-\pi_C)^2M^2}{E(E_A+E_B+E_C)^2}=\frac{\partial h}{\partial \alpha}.\frac{(\pi_A-\pi_C)\,qYM}{E(E_A+E_B+E_C)^2} \qquad (2.8)$$

Substituting for $\frac{\partial h}{\partial \vartheta}$ and $\frac{\partial h}{\partial \alpha}$ from equations (2.3) and (2.4), equation (2.7) can be rewritten as:

$$-\frac{qY}{E(E_A+E_B+E_C)}.\frac{(\pi_A-\pi_C)^2M^2}{E(E_A+E_B+E_C)^2}=-\left[\frac{(\pi_A-\pi_C)M}{E(E_A+E_B+E_C)}\right].\frac{(\pi_A-\pi_C)\,qYM}{E(E_A+E_B+E_C)^2}$$

Or

$$-\frac{(\pi_A-\pi_C)^2M^2qY}{E^2(E_A+E_B+E_C)^3}=-\frac{(\pi_A-\pi_C)^2\,M^2qY}{E^2(E_A+E_B+E_C)^3}$$

Since the two terms are equal but have opposite signs in equation (2.7),

$$|P_1|=\frac{\partial h}{\partial \alpha}.\frac{\partial^2 h}{\partial \vartheta \partial \alpha}-\frac{\partial h}{\partial \vartheta}.\frac{\partial^2 h}{\partial^2 \alpha}$$

Where the first term is a product of a positive and a negative number and is negative and the second term is a product of two negative numbers but has a negative sign.

Using Crammer's Rule,

$$|P_2|=\frac{\partial^2 h}{\partial \alpha \partial \vartheta}.\frac{\partial h}{\partial \vartheta}-\frac{\partial^2 h}{\partial \vartheta^2}\frac{\partial h}{\partial \alpha}+\frac{\partial h}{\partial \alpha}.\frac{q^2Y^2}{E(E_A+E_B+E_C)^2}-\frac{\partial h}{\partial \vartheta}.\frac{(\pi_A-\pi_C)\,qYM}{E(E_A+E_B+E_C)^2} \qquad (2.9)$$

Again substituting for $\frac{\partial h}{\partial \alpha}$ and $\frac{\partial h}{\partial \vartheta}$ from equations (2.3) and (2.4) in equation (2.9) eliminates the last two terms. The first term in (2.9) is a product of a positive and a negative number and has a negative sign. The second term is a product of two negative numbers but has a negative sign. Therefore, $|P_2| < 0$

Using these results, it can be seen that

$$\frac{\partial \vartheta}{\partial c}=\frac{|P_1|}{|\ddot{A}|}<0$$

And

$$\frac{\partial \alpha}{\partial c}=\frac{|P_2|}{|\ddot{A}|}<0$$

However, if $\pi_A < \pi_B$, then $|\ddot{A}| > 0$, $|P_1| < 0$ and $|P_2| < 0$ and the same results are obtained.

If $(2p-1).\tau = \alpha < \frac{(1-\vartheta).qY}{\pi_A M} \cdot B$, the analysis for the condition under Proposition applies. The first order conditions are:

The first order conditions are:

$$\frac{\partial L}{\partial \vartheta} = c\frac{\partial h}{\partial \vartheta} + (2p-1)\tau + qY\left[\frac{1}{E.(E_A + E_B + E_C)}\right] = 0 \qquad (2.10)$$

$$\frac{\partial L}{\partial \alpha} = c\frac{\partial h}{\partial \alpha} = 0 \qquad (2.11)$$

They are the same as equations (1.6) and (1.8) except the addition of a positive number in the denominator in equation (2.10). Therefore, it follows that

$$\frac{\partial \vartheta}{\partial c} < 0$$

$$\frac{\partial \alpha}{\partial c} = 0$$

If $(2p-1).\tau < \alpha = \left[\frac{(1-\vartheta)qY}{\pi_A.M}\right]$, the objective function becomes

$$Max_{\{\vartheta\}}\, L = c.h\left(\vartheta, \frac{(1-\vartheta)qY}{\pi_A.M} \cdot B\right) + R_2$$

Where

$$R_2 = -\left[\frac{(1-\vartheta).qY - (1-\vartheta).qY + \pi_A/\pi_B\,(1-\vartheta).qY + \tau M}{Y + \tau M}\right]$$

$$= -\left[\frac{\pi_A/\pi_B\,(1-\vartheta).qY + \tau M}{Y + \tau M}\right]$$

The first order conditions are:

$$\frac{\partial L}{\partial \vartheta} = c\left[\frac{\partial h}{\partial \vartheta} - \frac{qY}{\pi_A.M}\right] + \pi_A/\pi_B\,.\left[\frac{qY}{Y + \tau M}\right] = 0$$

$$\frac{\partial L}{\partial \alpha} = c.\frac{\partial h}{\partial \alpha} = 0$$

And

$\frac{\partial \vartheta}{\partial c}, \frac{\partial \alpha}{\partial c} = 0$ since optimal ϑ and α are independent of *c* but $\frac{\partial h}{\partial \vartheta} > 0$. Intuitively, this indicates that fixing α at the highest possible level would have no substitution effect on long-lived goods; any reduction in the fiscal resource in Region A would be adjusted in consumable public goods. But the optimal condition for selecting $\frac{\partial h}{\partial \vartheta} = \frac{qY}{\pi_A.M}.\frac{1}{c} - \pi_A/\pi_B \,.\left[\frac{qY}{Y+\tau M}\right]$ yield the following results:

If M is large as compared to Y then an increase in c would need to be compensated by an increase in π_B. Depending upon the relative sizes of Y and M, the effect of $\frac{\partial h}{\partial \vartheta}$ could be negative or positive.

Proposition 3.

The problem is given by the following maximization:

$$Max_{\{\vartheta,\alpha\}} c.h + R_3$$

Subject to the constraints

$$(2p-1).\tau \leq \alpha \leq \frac{(1-\vartheta)qY}{\pi_A.M} \cdot B$$

Where $R_3 = -\left[\frac{(1-\vartheta)q'Y+\pi_A(\tau-\alpha)M}{Y+\tau M}\right] = -\left[\frac{E_A \ddot{E}_B}{E}\right]$ and $q' = p.(\pi_A + \pi_B)$

and $\ddot{E}_B$ is the modified expenditure in Region B with the inclusion of the federal equalization transfer.

The first order conditions are:

$$\frac{\partial L}{\partial \vartheta} = c.\frac{\partial h}{\partial \vartheta} + q'Y\left[\frac{1}{E(E_A + \ddot{E}_B)}\right] + \lambda_2\left[\frac{1}{(1-\vartheta).\pi_A M}\right] = 0 \qquad (3.1)$$

And

$$\frac{\partial L}{\partial \alpha} = c.\frac{\partial h}{\partial \alpha} + \pi_A.M\left[\frac{1}{E(E_A + \ddot{E}_B)}\right] - \lambda_1 + \lambda_2 = 0 \qquad (3.2)$$

These are same as equations (1.1) and (1.2) under proposition 1 with the exception that the expenditure for region B includes federal transfers financed from the general pool and *q* is replaced by *q'*.

Logical deduction concludes with the following results:

If $(2p-1).\tau < \alpha < \frac{(1-\vartheta)qY}{\pi_A.M}$

$$c.\frac{\partial h}{\partial \vartheta} = -q'Y\left[\frac{1}{E(E_A + \ddot{E}_B)}\right] < 0 \qquad (3.3)$$

And

$$c.\frac{\partial h}{\partial \alpha} = -\pi_A.M\left[\frac{1}{E(E_A + \ddot{E}_B)}\right] < 0 \qquad (3.4)$$

And

$$\frac{\partial \vartheta}{\partial c} < 0$$

$$\frac{\partial \alpha}{\partial c} < 0$$

Similarly, the results for the conditions as proved under Proposition 1 for $(2p-1).\tau = \alpha < \frac{(1-\vartheta)qY}{\pi_A.M}$ and $(2p-1).\tau < \alpha = \frac{(1-\vartheta)qY}{\pi_A.M}$ apply.

Proposition 4.

The social planner in this case maximizes an objective function that incorporates this type of transfer but is subject to the same constraints. It is given by:

$$Max_{\{\vartheta,\alpha\}} c.h + R_4$$

Subject to the constraints

$$(2p-1).\tau \leq \alpha \leq \frac{(1-\vartheta)qY}{\pi_A.M} \cdot B$$

Where $R_4 = -\left[\frac{(1-\vartheta)qY-(\pi_A-\pi_B.\varphi).\alpha M+\pi_B.\tau M}{Y+\tau M}\right] = -\left[\frac{E_A''' + E_B'''}{E}\right]$ and $\varphi \in [0,1]$ is the share of the federal rent tax revenue set aside for the transfer pool.

Proof.

The first order conditions are:

$$\frac{\partial L}{\partial \vartheta} = c.\frac{\partial h}{\partial \vartheta} + qY\left[\frac{1}{E(E_A + E_B''')}\right] + \lambda_2\left[\frac{1}{(1-\vartheta).\pi_A M}\right] = 0 \qquad (4.1)$$

And

$$\frac{\partial L}{\partial \alpha} = c.\frac{\partial h}{\partial \alpha} + (\pi_A - \pi_B.\varphi).M\left[\frac{1}{E(E_A + E_B''')}\right] - \lambda_1 + \lambda_2 = 0 \qquad (4.2)$$

These are same as equations (1.1) and (1.2) under Proposition 1 with the exception that the expenditure for Region B includes federal transfers financed from the resource rent pool and equation (4.2) includes the preference for long-lived public goods in both regions in the numerator of the second term.

Logical deduction concludes with the following results:

If $(2p-1).\tau < \alpha < \frac{(1-\vartheta)qY}{\pi_A.M}$

$$c.\frac{\partial h}{\partial \vartheta} = -q'Y\left[\frac{1}{E(E_A + \ddot{E}_B)}\right] < 0 \qquad (4.3)$$

And

$$c.\frac{\partial h}{\partial \alpha} = -(\pi_A - \pi_B.\varphi).M\left[\frac{1}{E(E_A + \ddot{E}_B)}\right] < 0 \qquad (4.4)$$

Clearly, equation (4.4) holds with a negative sing only if $\pi_A > \pi_B.\varphi$. If this condition is relaxed, not only that $\pi_A < \pi_B$ but also that $\pi_A < \pi_B.\varphi$, only then $\frac{\partial h}{\partial \alpha} > 0$. In essence this means, that a policy aiming to achieve a increase in the stock of long-lived public goods would need to ascertain a much higher preference for such goods in the non-resource region even if this region were to be supported by federal equalization transfer.

Since equations (4.1) and (4.2) are the same as equations (1.1) and (1.2), using the analysis under Proposition 1, it can be said that

$$\frac{\partial \vartheta}{\partial c} < 0$$

$$\frac{\partial \alpha}{\partial c} < 0$$

The results will not hold if $\pi_A < \pi_B . \varphi$.

Similarly, the results for the conditions as proved under Proposition 1 for $(2p-1).\tau = \alpha < \frac{(1-\vartheta).qY}{\pi_A M}$ and $(2p-1).\tau < \alpha = \frac{(1-\vartheta).qY}{\pi_A M}$ apply.

Proposition 5.

$$Max_{\{\vartheta,\alpha\}} c.h + R_5$$

Subject to the constraints

$$(2p-1).\tau \leq \alpha \leq \frac{(1-\vartheta)qY}{\pi_A . M} \cdot B$$

Where $R_5 = -\left[\frac{(1-\vartheta)q''Y+\pi_A(\tau-\alpha)M}{Y+\tau M}\right] = -\left[\frac{\ddot{E}_A E_B}{E}\right]$ and $q'' = (1-p).(\pi_A + \pi_B)$[173]

And $\ddot{E}_A$ is the expenditure in Region A inclusive of the federal transfer.

Proof.

Maximization yields the following first order conditions:

$$\frac{\partial L}{\partial \vartheta} = c.\frac{\partial h}{\partial \vartheta} + q'Y\left[\frac{1}{E(\ddot{E}_A + E_B)}\right] + \lambda_2\left[\frac{1}{(1-\vartheta).\pi_A M}\right] = 0 \qquad (5.1)$$

And

$$\frac{\partial L}{\partial \alpha} = c.\frac{\partial h}{\partial \alpha} + \pi_A . M\left[\frac{1}{E(\ddot{E}_A + E_B)}\right] - \lambda_1 + \lambda_2 = 0 \qquad (5.2)$$

These are same as equations (1.1) and (1.2) under Proposition 1 with the exception that the expenditure for Region A includes federal transfers financed from the general pool and q is replaced by q''.

[173] It can be seen that in this case also the federal transfer achieves complete equalization when it is equal to the difference of regional fiscal resources. Hence, the resource in Region A after receipt of transfers becomes:
$\pi_A(1-\vartheta)pY + \pi_A(1-\vartheta)Y[(1-p)-p] = \pi_A(1-\vartheta)Y[p+(1-p)-p]$
$= \pi_A(1-\vartheta)(1-p)Y$
$\therefore \quad R = -\left[\frac{\pi_A((1-p)(1-\vartheta).Y+(\tau-\alpha)M)+\pi_B.(1-p)(1-\vartheta).Y}{Y+\tau.M}\right] == -\left[\frac{(1-\vartheta)q''Y+\pi_A(\tau-\alpha)M}{Y+\tau M}\right]$ and $q'' = (1-p).(\pi_A + \pi_B)$

Logical deduction concludes with the following results:

If $(2p-1).\tau < \alpha < \frac{(1-\vartheta)qY}{\pi_A.M} \cdot B$

$$c.\frac{\partial h}{\partial \vartheta} = -q''Y\left[\frac{1}{E(\ddot{E}_A + E_B)}\right] < 0 \qquad (5.3)$$

And

$$c.\frac{\partial h}{\partial \alpha} = -\pi_A.M\left[\frac{1}{E(\ddot{E}_A + E_B)}\right] < 0 \qquad (5.4)$$

And

$$\frac{\partial \vartheta}{\partial c} < 0$$

$$\frac{\partial \alpha}{\partial c} < 0$$

Similarly, the results for the conditions as proved under Proposition 1 for $(2p-1).\tau = \alpha < \frac{(1-\vartheta)qY}{\pi_A.M} \cdot B$ and $(2p-1).\tau < \alpha = \frac{(1-\vartheta)qY}{\pi_A.M} \cdot B$ apply.

Proposition 6.

The social planner maximizes an objective function that incorporates regional taxes below the efficient level but is subject to the same constraints. It is given by:

$$Max_{\{\vartheta,\alpha\}} c.h + R_6$$

Subject to the constraints

$$(2p-1).\tau \leq \alpha \leq \frac{(1-\vartheta)qY}{\pi_A.M} \cdot B$$

Where $R_6 = -\left[\frac{\pi_A(1-\vartheta)p\gamma Y+\pi_B(1-\vartheta)(1-p)\delta Y-\pi_A(\tau-\alpha)M}{Y+\tau M}\right] = -\left[\frac{\widetilde{E_A}+\widetilde{E_B}}{E}\right]$ and $\gamma, \delta \in (0,1]$ are the level of regional taxes in a region.

Proof.

For simplicity of exposition, let $\ddot{q} = \pi_A p\gamma + \pi_B(1-p)\delta$

The first order conditions are:

$$\frac{\partial L}{\partial \vartheta} = c.\frac{\partial h}{\partial \vartheta} + \ddot{q}Y\left[\frac{1}{E(\widetilde{E_A}+\widetilde{E_B})}\right] + \lambda_2\left[\frac{1}{(1-\vartheta).\pi_A M}\right] = 0 \qquad (6.1)$$

And

$$\frac{\partial L}{\partial \alpha} = c.\frac{\partial h}{\partial \alpha} + \pi_A.M\left[\frac{1}{E(\widetilde{E_A}+\widetilde{E_B})}\right] - \lambda_1 + \lambda_2 = 0 \qquad (6.2)$$

Where $\gamma, \delta = 1$, the problem becomes that same as discussed under Proposition 1.

Equation (6.1) and (6.2) same as equations (1.1) and (1.2) under Proposition 1 with the exception that the expenditures in both Regions vary with the level of local taxation that is allowed to vary in this case.

Logical deduction concludes with the following results:

If $(2p-1).\tau < \alpha < \frac{(1-\vartheta).qY}{\pi_A M}$,

$$c.\frac{\partial h}{\partial \vartheta} = -\ddot{q}Y\left[\frac{1}{E(\widetilde{E_A}+\widetilde{E_B})}\right] < 0 \qquad (6.3)$$

And

$$c.\frac{\partial h}{\partial \alpha} = -\pi_A.M\left[\frac{1}{E(\widetilde{E_A}+\widetilde{E_B})}\right] < 0 \qquad (6.4)$$

The results are independent of the difference in preference for long-lived goods in each region.

Since equations (6.1) and (6.2) are the same as equations (1.1) and (1.2), using the analysis under Proposition 1, it can be said that

$$\frac{\partial \vartheta}{\partial c} < 0$$

$$\frac{\partial \alpha}{\partial c} < 0$$

Similarly, the results for the conditions as proved under Proposition 1 for $(2p-1).\tau = \alpha < \frac{(1-\vartheta).qY}{\pi_A M} \cdot B$ and $(2p-1).\tau < \alpha = \frac{(1-\vartheta).qY}{\pi_A M} \cdot B$ apply.

Differentiating equations (6.3) and (6.4) with respect to γ, we get the following:

$$c\frac{\partial^2 h}{\partial \vartheta \partial \gamma} + (\pi_A.p)q''Y\left[\frac{1}{E(\widetilde{E_A} + \widetilde{E_B})}\right] + (1-\vartheta).\pi_A pYq''Y\left[\frac{1}{E(\widetilde{E_A} + \widetilde{E_B})^2}\right] = 0 \qquad (6.5)$$

$$c\frac{\partial^2 h}{\partial \alpha \partial \gamma} + {\pi_A}^2 M.(1-\vartheta)pY\left[\frac{1}{E(\widetilde{E_A} + \widetilde{E_B})^2}\right] = 0 \qquad (6.6)$$

From equations, (6.5) and (6.6), it can be seen that, $\frac{\partial h}{\partial \gamma} > 0$ because the second order partial differentials are negative by assumption.

Proposition 7.

The objective function is the same as in Proposition 1.

Proof.

The first order conditions are:

$$\frac{\partial L}{\partial \vartheta} = c.\frac{\partial h}{\partial \vartheta} + qY\left[\frac{1}{E(E_A + E_B)}\right] + \lambda_2\left[\frac{1}{(1-\vartheta).\pi_A M}\right] = 0 \qquad (7.1)$$

$$\frac{\partial L}{\partial \alpha} = c.\frac{\partial h}{\partial \alpha} + \pi_A.M\left[\frac{1}{E(E_A + E_B)}\right] - \lambda_1 + \lambda_2 = 0 \qquad (7.2)$$

When $(2p-1).\tau < \alpha < \frac{(1-\vartheta).qY}{M}$, $\lambda_i = 0$, for *i* =1,2. And the first order conditions can be rewritten as:

$$\frac{\partial L}{\partial \vartheta} = c.\frac{\partial h}{\partial \vartheta} + Y\left[\frac{q}{E(E_A + E_B)}\right] = 0 \qquad (7.3)$$

$$\frac{\partial L}{\partial \alpha} = c.\frac{\partial h}{\partial \alpha} + M\left[\frac{\pi_A}{E(E_A + E_B)}\right] = 0 \qquad (7.4)$$

Differentiating with respect to π_A, we get the following equations:

$$c\frac{\partial^2 h}{\partial\vartheta\partial\pi_A} + p.Y\left[\frac{q}{E(E_A+E_B)}\right]\left[1+\frac{1}{E_A+E_B}\right] = 0$$

$$c\frac{\partial^2 h}{\partial\alpha\partial\pi_A} + M\left[\frac{1}{E(E_A+E_B)}\right]\left[1+\frac{\pi_A p}{E_A+E_B}\right] = 0$$

Rewriting the equations:

$$c\frac{\partial h}{\partial\vartheta}.\frac{\partial h}{\partial\pi_A} + p.Y\left[\frac{q}{E(E_A+E_B)}\right]\left[1+\frac{1}{E_A+E_B}\right] = 0$$

$$c\frac{\partial h}{\partial\alpha}.\frac{\partial h}{\partial\pi_A} + M\left[\frac{1}{E(E_A+E_B)}\right]\left[1+\frac{\pi_A p}{E_A+E_B}\right] = 0$$

Or

$$\frac{\partial h}{\partial\pi_A} = -p.Y\left[\frac{q}{E(E_A+E_B)}\right]\left[1+\frac{1}{E_A+E_B}\right]/c\frac{\partial h}{\partial\vartheta} > 0$$

$$\frac{\partial h}{\partial\pi_A} = -M\left[\frac{1}{E(E_A+E_B)}\right]\left[1+\frac{\pi_A p}{E_A+E_B}\right]/c\frac{\partial h}{\partial\alpha} > 0$$

Because from equations (7.3) and (7.4), $\frac{\partial h}{\partial\vartheta}$ and $\frac{\partial h}{\partial\alpha}$ are negative.

Proposition 8.

The objective function is the same as in Proposition 1.

Proof.

The first order conditions are:

$$\frac{\partial L}{\partial\vartheta} = c.\frac{\partial h}{\partial\vartheta} + qY\left[\frac{1}{E(E_A+E_B)}\right] + \lambda_2\left[\frac{1}{(1-\vartheta).\pi_A M}\right] = 0 \qquad (8.1)$$

$$\frac{\partial L}{\partial\alpha} = c.\frac{\partial h}{\partial\alpha} + \pi_A.M\left[\frac{1}{E(E_A+E_B)}\right] - \lambda_1 + \lambda_2 = 0 \qquad (8.2)$$

When $(2p-1).\tau < \alpha < \frac{(1-\vartheta).qY}{M}\cdot B$, $\lambda_i = 0$, for *i* =1,2. And the first order conditions can be rewritten as:

$$\frac{\partial L}{\partial \vartheta} = c.\frac{\partial h}{\partial \vartheta} + Y\left[\frac{q}{E(E_A + E_B)}\right] = 0 \qquad (8.3)$$

$$\frac{\partial L}{\partial \alpha} = c.\frac{\partial h}{\partial \alpha} + M\left[\frac{\pi_A}{E(E_A + E_B)}\right] = 0 \qquad (8.4)$$

Differentiating equations (8.3) and (8.4) with respect to Y and M respectively yield the following set of equations:

$$c.\frac{\partial h}{\partial \vartheta}\frac{\partial h}{\partial Y} + \left[\frac{q}{E(E_A + E_B)}\right] + (1 - \vartheta)Y\left[\frac{q^2}{E(E_A + E_B)^2}\right] = 0 \qquad (8.5)$$

$$c.\frac{\partial h}{\partial \alpha}\frac{\partial h}{\partial M} + \left[\frac{\pi_A}{E(E_A + E_B)}\right] + (\tau - \alpha)M\left[\frac{{\pi_A}^2}{E(E_A + E_B)^2}\right] = 0 \qquad (8.6)$$

Clearly from (8.5), $\frac{\partial h}{\partial Y} > 0$ because $\frac{\partial h}{\partial \vartheta} < 0$ from equation (1.3), and $\frac{\partial h}{\partial M} > 0$ from equation (8.6) because $\frac{\partial h}{\partial \alpha} < 0$ from equation (1.4).

Dividing equation (8.6) by $\frac{\partial h}{\partial \alpha}$ and adding to equation (8.4), we get the following:

$$\frac{\partial h}{\partial M} - \frac{\partial h}{\partial \alpha} = \frac{1}{M} + [(\tau - \alpha) - 1]\left[\frac{\pi_A M}{E(E_A + E_B)}\right] \qquad (8.7)$$

The right hand side will be negative or positive depending upon the size of M relative to total public expenditure. If M is very large compared with the expenditure, or if the general tax base is smaller compared with natural resource revenue, then the first term becomes smaller and the second term becomes bigger, resulting at some point in the right hand side becoming negative. Constraining equation (8.7) to first term being smaller than the second term on the right hand side,

$$1 < -[(\tau - \alpha) - 1]\left[\frac{\pi_A M}{E(E_A + E_B)}\right] \qquad (8.8)$$

Within plausible ranges of α and π_A, a range of M can be delineated for which equation (8.8) will hold. It is also evident that the higher the α the lower will be the ratio of M to the product of total public expenditure and investment on long lived public goods.

Appendix B.2 Choosing federal share of rent with political stability

The following inequalities constrain the value of α, the federal share of exhaustible resource rent, within the unit interval, as given in equation 2.4.

$$0 \leq \frac{(1-\vartheta)p.Y-(1-\vartheta)(1-p).Y}{(1-\vartheta).Y} \leq \frac{\alpha M}{\tau M} \leq \frac{(1-\vartheta).qY}{\tau M}\cdot B \leq 1$$

Where

$$\frac{(1-\vartheta)p.Y-(1-\vartheta)(1-p).Y}{(1-\vartheta).Y} = \begin{cases} \frac{(1-\vartheta)p.Y-(1-\vartheta)(1-p).Y}{(1-\vartheta).Y} & if\ \ (1-\vartheta)p.Y-(1-\vartheta)(1-p).Y \geq 0 \\ 0 \quad otherwise \end{cases}$$

$$\frac{(1-\vartheta).qY}{\tau M}\cdot B = \begin{cases} \frac{(1-\vartheta).qY}{\tau M}\cdot B & if\ \ \frac{(1-\vartheta).qY}{\tau M}\cdot B < 1 \\ 1 \quad otherwise \end{cases}$$

and $= \frac{Benefits\ received\ by\ Region\ A\ from\ the\ federation}{Benefits\ recieved\ by\ Region\ A\ remaining\ in\ isolation}$, $B \in [0,\infty)$ and it depends on transfers to the region and other benefits provided by the federation.

Table 2.1 Conditions on the bounds of the constraints

Condition	Federal share of rent	Region's response	Federal response
$(1-\vartheta)p.Y-(1-\vartheta)(1-p).Y=0$	$\alpha=0$	Indifferent to remaining in federation	Take no rent away from Region A; buys off allegiance by increasing transfers
$(1-\vartheta)p.Y-(1-\vartheta)(1-p).Y<0$	$\alpha=0$	Indifferent to remaining in federation	Take no rent from Region A; Increase transfers to Region A
$\frac{(1-\vartheta).qY}{\tau M}\cdot B > 1,\ \frac{(1-\vartheta).qY}{\tau M} \lessgtr 1\ and\ B>1$	$\alpha=1$	Depends on relative size of benefits and investment rent ratio	Take all the rent; cannot reduce or need to increase transfers to sustain a high benefits ratio
$\frac{(1-\vartheta).qY}{\tau M} \lessgtr 1\ and\ B>1$	$\alpha=1$	Strong commitment to federation	Take all the rent; cannot reduce transfers to Region A or B may fall below 1
$\frac{(1-\vartheta).qY}{\tau M} \geq 1$: investment greater than or equal to total rent (rent small part of economy); $B \geq 1$	$\alpha=1$	Not an important bargaining tool	Take all the rent; benefits ratio may be sustained through transfers
$\frac{(1-\vartheta).qY}{\tau M} \geq 1$: investment greater than or equal to rent (investment very high); $B \geq 1$	$\alpha=1$	Benefits of association outweigh cession	Take all the rent; keep benefits ratio (transfers) at current level

$\frac{(1-\vartheta).qY}{\tau M} > 1; \quad B \leq 1$	$\alpha = 1$	Indifferent to remaining in federation	Take all the rent; increase transfers to Region A
$\frac{(1-\vartheta).qY}{\tau M} \leq 1; \quad B = 1$	$\alpha = 1$	Indifferent to remaining in federation	Take all the rent; increase transfers to Region A
$\frac{(1-\vartheta).qY}{\tau M} > 1; \quad B = 0$	$\alpha = 1$	No commitment to federation	Take all the rent; increase transfers to Region A and fights to retain control
$\frac{(1-\vartheta).qY}{\tau M} \leq 1; \quad B = 0$	$\alpha = 1$	No commitment to federation	Take all the rent; increase transfers to Region A and fights to retain control

All the ten cases shown in Table 2.1 are where α is equal to the lower or the upper bound of the interval. In all cases, the federation becomes politically unstable. In all these cases, federal rent share needs to be compensated by transfers. In other words, the effective share will always be fixed away from 0 and 1. In other words, $\alpha \in (0,1)$.

The above description all provides an important intuitive explanation. Only large regions with potentially a smaller benefits ratio B may raise an issue with the federation. For small subnational jurisdictions like a district or a county, the benefits ratio B is very large and claims to rent will be weak.

Appendix C.1 Description of Variables in the Data

Variable Name	Variable Description
I. Identity variables	
ob_id	unique identity code for region *i*
year	year of observation
oblast	name of region *i*
II. Investment in fixed capital variables	
rfixcappc	fixed investment, million rubles, real per capita
fixcappc	fixed investment, 000 rubles, at current prices
fixgross	fixed investment, at current prices, million rubles
fix_index	fixed investment index as percentage of previous year
fix_stat	fixed investment by regions, percentage of total investment
fix_mun	fixed investment by municipalities, percentage of total investment
fix_priv	fixed investment private, percentage of total investment
fix_mix	fixed investment mixed all governments, percentage of total investment
fix_equity	fixed investment as equity, percentage of total investment
fix_liab	fixed investment as liabilities, percentage of total investment
fix_bank	fixed investment financed by bank loan, percentage of total investment
fix_budg	fixed investment budgetary funds, percentage of total investment
fix_fbudg	fixed investment federal budget, percentage of total investment
fix_rbudg	fixed investment regional budgets, percentage of total investment
fix_hous	fixed investment in housing, percentage of total investment
fix_bild	fixed investment in building other than housing, percentage of total investment
fix_mach	fixed investment in machinery and equipment, percentage of total investment
fix_oth	fixed investment other, percentage of total investment
fix_val	fixed investment, value of fixed assets end of year full book value, million rubles
rfixvalpc	fixed investment, value of fixed assets end of year full book value, million real rubles per capita
rfixsnpc	real investment in fixed capital, subnational governments, million ruble
rfixpubpc	real investment in fixed capital, subnational governments all sources, million ruble
rfix_rbudgpc	real investment in fixed capital, subnational governments, million ruble source identified as regional budget
rfixfbudgpc	real investment in fixed capital, subnational governments, million

Variable Name	Variable Description
	ruble
	source identified as federal budget
build_debt	Building financed by debt
deprec	Beginning of year, depreciation of fixed assets, in percent
III. Revenue and expenditure variables	
rrevpc	regional revenue, million real rubles, per capita
rsngpc	regional subnational tax, million real rubles, per capita
rtransferpc	transfer to the region, million real rubles, per capita
nontax	regional nontax revenue, million real rubles, per capita
rexppc	total expenditure, million real rubles, per capita
rexpsocpc	total on social sectors million real rubles, per capita
rexpobpc	exp for the obligations of the Russian Federation, million real rubles, per capita
penfin	million rubles, intake in pension fund
penfexp	million rubles, expenditure from pension fund
mhealint	million rubles, intake in mandatory health insurance fund
mhealexp	million rubles, expenditure from mandatory health insurance fund
mhealexp	million rubles, expenditure from mandatory health insurance fund
ssecint	million rubles, intake in social security fund
ssecexp	million rubles, expenditure from social security fund
IV. Structural variables	
resid	residential area, 000 sq meters
newres	000 sq m of total area added as new residences
newapart	apartment units added in a year
construct	value of new construction at current prices, million rubles
bus_pop	buses per 100 000 population
bus_pass	million passenger kilometers
buspub	millions of buses
cars	# shareholders per 1000 population
roaden	km of road per 1000 sq km area
raodimp	percentage of improved roads
roadpavd	percentage of paved roads
roadtrans	million ton-kilometers transported by road
tonnage	million tonnes transported by rail
accid	accidents per 100 000
railden	km of ways to 10 000 sq km area
railpass	000s of rail passengers
V. Demand variables (for public services)	

Variable Name	Variable Description
enrolpub	enrolment in public as percent of total enrolment
stu_sprof	students in secondary public professional education on 10000 population
disburd	first time diagnosis per 1000 population
imr	number <1year deaths per 1000 live births
klinout	1000s visits per shift in public hospitals
klinik	public outpatient visits per 10 000 population
docs	# per 10 000 population
hosp_bedk	hospital beds per 10 000 population
paramed	# per 10 000 population
pop_para	population per paramedical service
lsgempl	# of employ in government bodies
employp	fraction employed by subnational government
pop_hospbed	persons per hospital bed
pop_doc	persons per doctor
exec_emp	# employ of executive power, Subjects & LSG
rpaidser_pc	real value of paid services per capita, million rubles
pension_av	1000 rubles
VI. Other control variables	
sown	farms all categories, 000s of hectares
forest	000 hectares
freshwatpc	millions of cu ft usage, per capita
recywatpc	recycled and consistently used, million cu m, per capita
wastwat	discharge into surface water bodies, million cu m
airpoll	1000 tons from stationary sources
areasqkm	area in sq km
VII. Economic variables	
rgrppc	gross value added, per capita, 000 real rubles
rsgrppc	gross value added, per capita, 000 real rubles (National Accounts)
rgrppc2	calculated, million rubles per capita
rincpc	income per capita per month, real rubles 000s
rconspendpc	average per capita per month, real rubles 000s
rconsfin	final consumption of households, 000 real rubles
coal	000 tons
gas	million cu meters
oil	000 tons, including gas condensate
pindex_m	mineral production index, percentage change
indind	aggregated production index, percentage change
electric	billion kilowatt-hours

Variable Name	Variable Description
unempreg	registered unemployed, in percent
unemployed	unemployed in 1000s
unemrate	unemployment rate, calculated
wage_nom	av nominal wage, rubles 000s
rwage	nominal wage/deflator
cpi	CPI, Dec to Dec in percent
deflator	indices, GDP deflators
VIII. Demographic variables	
pop	1000s end of year
lpop	natural log of regional population
urb	urban population as percent of total
popden	population density, # per sq km of area
migrate	migration, per 10 000 population
noworkage	population below working age, percent of total
inc_sub	below subsistence level, percentage of population
oiltot	oil production total rublesia
gastot	gas production total rublesia
oilprice	$ per ton, 7.3 barrel eq @ 33API, international price
gasprice	$ per 000 cu meter, for domestic industy
IX. Treatment variables	
treat	producing region dummy, =1 if region *i* producing, 0 otherwise
g1	dummy for producing region, =1 for producing, 0 otherwise
post1	year=2002
post2	year=2003
post3	year=2004
post4	year=2005
post5	year=2006
post6	year=2007
p1g1	interaction: g1 times post1
p2g1	interaction: g1 times post2
p3g1	interaction: g1 times post3
p4g1	interaction: g1 times post4
p5g1	interaction: g1 times post5
p6g1	interaction: g1 times post6
postx	dummy for post treatment period, =1 if year >=2002&<=2007
	0 otherwise
pxg1	interaction: g1 times postx

Appendix C.2 Determinants of investment in long-lived public goods in Regions of Russia

Table C.1.1
The determinants of investment in fixed public capital in regions of Russia [a)]

Real GRP, pc	-2.65e-05***	-2.08e-05***	-2.08e-05***
	[4.18e-06]	[3.55e-06]	[3.25e-06]

Dependent variable: new real investment in fixed public capital per capita

VARIABLES[b)]	Fixed effects (1) [c)]	Fixed effects (2) [d)]	Pooled [e)]
Real revenue, pc	0.143***	0.138***	0.138***
	[0.00926]	[0.0102]	[0.00936]
Real transfer, pc	-0.139***	-0.143***	-0.143***
	[0.00830]	[0.00882]	[0.00806]
Population below working age, pct	0.0693	-0.0304	-0.0304
	[0.0768]	[0.0705]	[0.0645]
Population density	-0.0501	-0.00999	-0.00999
	[0.0382]	[0.0374]	[0.0343]
Population (log)	4.621*	0.752	0.752
	[2.600]	[2.721]	[2.489]
Urbanization, pct	0.0131	-0.0393	-0.0393*
	[0.0224]	[0.0247]	[0.0226]
Farmland, hectares per sq km area	0.000494**	0.000564**	0.000564***
	[0.000201]	[0.000222]	[0.000203]
Volume of goods transported via rail	0.000915**	0.00117**	0.00117***
	[0.000416]	[0.000471]	[0.000431]
Volume of goods transported via road	-9.01e-06	-3.58e-06	-3.58e-06
	[6.07e-05]	[6.15e-05]	[5.62e-05]
Car ownership	0.00247	0.00147	0.00147
	[0.00189]	[0.00183]	[0.00167]
Public enrolment, pct	-0.00807	-0.000548	-0.000548
	[0.0172]	[0.0180]	[0.0164]
Hospital beds per 10,000 population	0.00656**	0.00938***	0.00938***
	[0.00330]	[0.00361]	[0.00330]
Value of oil extracted, real dollars		1.24e-05***	1.24e-05***
		[4.72e-06]	[4.32e-06]
Value of gas extracted, real dollars		-6.74e-07	-6.74e-07
		[5.59e-07]	[5.11e-07]
Oil price, dollars	0.141***	0.405*	0.115***
	[0.0379]	[0.214]	[0.0443]
Gas price, dollars	-0.0481**	0.119**	-0.00159
	[0.0188]	[0.0581]	[0.0183]
Time trend	0.271**	-1.147*	0
	[0.107]	[0.619]	[0]
Value of oil extracted, real rubles pc	0.0311***		

	[0.0117]		
Value of gas extracted, real rubles pc	-0.000401		
	[0.00126]		
Constant			-1.028
			[12.71]
Observations	600	600	601
R-squared	0.890	0.897	0.957
Number of ob_id	76	76	
First-stage F-test	13.34	9.070	
First-stage F-test	9.520	12.57	
Craig-Donald statistic	24.72	25.37	

Notes:

*f) Robust standard errors in brackets; *** p<0.01, ** p<0.05, * p<0.1*

g) Real GRP, per capita and Real revenue, per capita are endogenous. Excluded instruments are: paved roads as percentage of total length of roads a region, real value of paid services per capita and waste water generated per capita.

h) A time trend variable is included.

i) A full range of year dummies included but not shown in the table.

j) A complete set of region dummies and year dummies included but not shown in the table.

Table C.1.2
The determinants of new acquisition of fixed public capital in regions of Russia [a)]

Dependent variable: new acquisition of fixed public capital (real rubles per capita)

VARIABLES [b)]	Fixed effects (1)[c)]	Fixed effects (2)[d)]	Pooled[e)]
Real GRP, pc	-3.88e-05	-2.96e-06	-2.96e-06
	[7.41e-05]	[6.08e-05]	[5.56e-05]
Real revenue, pc	0.397	0.219	0.219
	[0.362]	[0.390]	[0.357]
Real transfer, pc	-0.292***	-0.317***	-0.317***
	[0.0606]	[0.0432]	[0.0395]
Population below working age, pct	0.730	-0.0486	-0.0486
	[0.478]	[0.367]	[0.335]
Population density	-0.0291	0.0795	0.0795
	[0.403]	[0.255]	[0.233]
Farmland, hectares per sq km area	0.000706	0.00102	0.00102
	[0.00205]	[0.00181]	[0.00166]
Volume of goods transported via rail	0.00687***	0.00578***	0.00578***
	[0.00248]	[0.00205]	[0.00188]
Volume of goods transported via road	-0.000138	-5.80e-05	-5.80e-05
	[0.000223]	[0.000187]	[0.000171]
Car ownership	-0.0232	-0.0240	-0.0240*
	[0.0167]	[0.0158]	[0.0144]
Public enrolment, pct	0.00772	0.0358	0.0358
	[0.167]	[0.111]	[0.102]
Hospital beds per 10,000 population	0.0672	0.0777	0.0777
	[0.0472]	[0.0528]	[0.0483]
Value of oil extracted, real dollars		1.20e-05	1.20e-05
		[3.09e-05]	[2.83e-05]
Value of gas extracted, real dollars		-6.92e-07	-6.92e-07
		[1.69e-06]	[1.55e-06]
Oil price, dollars	0.803***	1.470	0.912***
	[0.266]	[1.323]	[0.282]
Gas price, dollars	-0.178	0.851**	0.0565
	[0.118]	[0.361]	[0.147]
Time trend	1.397**	-5.392	0
	[0.623]	[3.276]	[0]
Population (log)	10.30		
	[17.58]		
Urbanization, pct	-0.144		
	[0.116]		
Value of oil extracted, real rubles pc	0.0458		
	[0.0765]		
Value of gas extracted, real rubles pc	0.00156		
	[0.00387]		

Constant			-15.77
			[38.14]
Observations	588	588	588
R-squared	0.663	0.719	0.960
Number of ob_id	76	76	
First-stage F-test	11	10.22	
First-stage F-test	9.320	9.650	
Criag-Donald statistic	1.780	4.452	

Notes:

*f) Robust standard errors in brackets; *** p<0.01, ** p<0.05, * p<0.1*

g) Real GRP, per capita and Real revenue, per capita are endogenous. Excluded instruments are: paved roads as percentage of total length of roads a region, real value of paid services per capita and number of doctors per 10,000 population.

h) A time trend variable is included.

i) A full range of year dummies included but not shown in the table.

j) A complete set of region dummies and year dummies included but not shown in the table.

Table C.1.3
The determinants of investment in fixed public capital in regions of Russia [a)]

Dependent variable: investment in fixed public capital per capita

VARIABLES[b)]	Fixed effects [c)]	Fixed effects [d)]	Pooled [e)]
Real revenue, pc	0.115***	0.116***	0.121***
	[0.0173]	[0.0172]	[0.0147]
rfixvalpc	-0.00640***	-0.00711***	-0.00650***
	[0.00206]	[0.00230]	[0.00113]
Real transfer, pc	-0.124***	-0.127***	-0.126***
	[0.0265]	[0.0260]	[0.0227]
Population below working age, pct	0.153	0.0623	-0.111
	[0.185]	[0.187]	[0.156]
Population density	0.0547	0.0515	-0.0223
	[0.0904]	[0.0912]	[0.0631]
Population (log)	3.197	2.320	2.009
	[5.133]	[5.552]	[4.068]
Population growth rate	0.0495	0.0448	0.00714
	[0.0499]	[0.0513]	[0.0433]
Farmland, hectares per sq km area	0.000502*	0.000323	0.000689**
	[0.000290]	[0.000342]	[0.000287]
Volume of goods transported via rail	0.00174*	0.00159*	0.00210***
	[0.000899]	[0.000920]	[0.000805]
Urbanization, pct	0.0887***	0.0754**	0.0397
	[0.0326]	[0.0368]	[0.0270]
Volume of goods transported via road	0.000138	0.000180	5.24e-05
	[0.000118]	[0.000128]	[7.57e-05]
Car ownership	0.00231	0.00141	0.00244
	[0.00325]	[0.00333]	[0.00316]
bus_pass	8.07e-05	8.93e-05	1.53e-05
	[6.68e-05]	[7.38e-05]	[4.98e-05]
Public enrolment, pct	-0.0647	-0.0855*	-0.0298
	[0.0410]	[0.0436]	[0.0322]
Hospital beds per 10,000 population	-0.00212	0.00256	0.00788*
	[0.00544]	[0.00588]	[0.00427]
Value of oil extracted, real dollars			-5.40e-07
			[1.38e-06]
Value of gas extracted, real dollars			8.03e-07***
			[2.13e-07]
Oil price, dollars	0.141	0.820	0.232
	[0.101]	[0.504]	[0.149]
Gas price, dollars	-0.0880**	0.190	-0.0447
	[0.0436]	[0.127]	[0.0522]
Time trend	0.383	-2.196	0
	[0.250]	[1.354]	[0]
Value of oil extracted, real rubles pc	0.000722	0.00123	
	[0.00188]	[0.00204]	
Value of gas extracted, real rubles pc	0.000552**	0.000632**	
	[0.000257]	[0.000287]	

Constant			-20.14
			[35.23]
Observations	624	624	625
R-squared	0.568	0.556	0.891
Number of ob_id	79	79	
First-stage F-test	19.88	19.43	
First-stage F-test	14.07	14.14	
Criag-Donald statistic	38.82	42.77	

Notes:

*f) Robust standard errors in brackets; *** p<0.01, ** p<0.05, * p<0.1*

g) Real revenue, per capita and real value of fixed capital, per capita are endogenous. Excluded instruments are: paved roads as percentage of total length of roads a region, real value of paid services per capita, waste water generated per capita and residential area per capita.

h) A time trend variable is included.

i) A full range of year dummies included but not shown in the table.

j) A complete set of region dummies and year dummies included but not shown in the table.

Table C.1.4
The determinants of new acquisition of fixed public capital in regions of Russia [a)]

Dependent variable: new acquisition of fixed public capital (real rubles per capita)

VARIABLES[b)]	Fixed effects (1)[c)]	Fixed effects (2)[d)]	Pooled[e)]
Real revenue, pc	-0.0686	-0.00208	-0.00208
	[0.257]	[0.300]	[0.274]
Real value of fixed capital, pc	0.0374	0.0178	0.0178
	[0.0269]	[0.0302]	[0.0275]
Real transfer, pc	-0.318***	-0.323***	-0.323***
	[0.0554]	[0.0427]	[0.0390]
Population density	-0.417	-0.0252	-0.0252
	[0.316]	[0.318]	[0.290]
Population (log)	32.73	10.82	10.82
	[20.85]	[24.49]	[22.33]
Population growth rate	0.436	0.646	0.646
	[0.574]	[0.505]	[0.460]
Urbanization, pct	-0.302	-0.274	-0.274*
	[0.220]	[0.167]	[0.152]
Farmland, hectares per sq km area	0.00110	0.000801	0.000801
	[0.00106]	[0.000915]	[0.000834]
Volume of goods transported via rail	0.00522**	0.00462**	0.00462**
	[0.00220]	[0.00216]	[0.00197]
Volume of goods transported via road	-0.000297	-3.03e-05	-3.03e-05
	[0.000236]	[0.000239]	[0.000218]
Car ownership	-0.0211	-0.0261*	-0.0261*
	[0.0149]	[0.0153]	[0.0140]
bus_pass	0.000817***	0.000646***	0.000646***
	[0.000299]	[0.000228]	[0.000208]
Public enrolment, pct	0.154	0.0770	0.0770
	[0.106]	[0.0911]	[0.0830]
Hospital beds per 10,000 population	0.0496	0.0665	0.0665*
	[0.0362]	[0.0409]	[0.0373]
Value of oil extracted, real dollars		6.35e-07	6.35e-07
		[1.79e-05]	[1.63e-05]
Value of gas extracted, real dollars		-1.03e-06	-1.03e-06
		[8.01e-07]	[7.31e-07]
Oil price, dollars	0.625***	0.997	0.817***
	[0.210]	[1.541]	[0.215]
Gas price, dollars	0.0196	0.709	0.125*
	[0.146]	[0.431]	[0.0714]
Time trend	0.301	-3.597	0
	[0.531]	[4.664]	[0]
Value of oil extracted, real rubles pc	-0.0143		
	[0.0270]		
Value of gas extracted, real rubles pc	-0.00696		
	[0.00687]		
Constant			-86.89

			[168.5]
Observations	588	588	588
R-squared	0.636	0.714	0.960
Number of ob_id	76	76	
First-stage F-test	10.51	8.390	
First-stage F-test	10.59	9.890	
Criag-Donald statistic	1.193	1.047	

Notes:

*f) Robust standard errors in brackets; *** p<0.01, ** p<0.05, * p<0.1*

g) Real revenue, per capita and real value of fixed capital, per capita are endogenous. Excluded instruments are: paved roads as percentage of total length of roads a region, real value of paid services per capita, air pollution tons per 1000 real rubles of gross regional product and waste water generated per capita.

h) A time trend variable is included.

i) A full range of year dummies included but not shown in the table.

j) A complete set of region dummies and year dummies included but not shown in the table.

Table C.1.5
The determinants of investment in fixed public capital and total public expenditure in regions of Russia (using seemingly unrelated equations) [a)]

VARIABLES[b)]	(1) qRfixrbpc[c)]	(2) qRexprpc[d)]
Real revenue, pc	0.147***	0.865***
	[0.00519]	[0.0848]
Real GRP, pc	-2.20e-05***	5.38e-06
	[3.59e-06]	[4.37e-05]
Real transfer, pc	-0.146***	0.0457
	[0.00421]	[0.0335]
Population below working age, pct	0.0433	-0.221
	[0.0707]	[0.459]
Volume of goods transported via rail	0.00133**	
	[0.000614]	
Volume of goods transported via road	-4.64e-05	
	[4.34e-05]	
Car ownership	0.00261	
	[0.00198]	
Population density	-0.0771**	
	[0.0326]	
Population (log)	7.088***	1.431
	[1.927]	[11.60]
Urbanization, pct	0.0319	0.0914
	[0.0221]	[0.169]
Farmland, hectares per sq km area	0.000520**	
	[0.000228]	
Public enrolment, pct	-0.00251	0.128
	[0.0135]	[0.0884]
Hospital beds per 10,000 population	0.00330	
	[0.00370]	
Value of oil extracted, real rubles pc	0.0269***	-0.0160
	[0.00435]	[0.0456]
Value of gas extracted, real rubles pc	-0.000451*	-8.38e-05
	[0.000256]	[0.00153]
Time trend	0.114	0.0978
	[0.0702]	[0.716]
Burden of disease		-0.00521
		[0.00574]
Outpatient visits		-0.0120
		[0.0205]
Population growth rate		0.0783
		[0.115]
Unemployment rate		0.0935
		[0.433]
Average pension		0.000534
		[0.00121]
Population below subsistence, pct		0.00144
		[0.0317]
Constant	-265.1*	-206.5
	[144.5]	[1,499]

Observations	596	596
R-squared	0.952	0.986

Notes:

*e) Standard errors in brackets; *** p<0.01, ** p<0.05, * p<0.1*

f) Real GRP, per capita and real revenue, per capita are endogenous.

g) Dependent variable: investment in fixed public capital, real rubles per capita. A time trend variable and full range of year and region dummies are included. The year and regions dummies not shown in the table.

h) Dependent variable: subnational current public expenditure, real rubles per capita. A time trend variable and full range of year and region dummies are included. The year and regions dummies not shown in the table.

Table C.1.6
The determinants of new acquisition of fixed public capital and total public expenditure in regions of Russia (using seemingly unrelated equations) [a)]

VARIABLES[b)]	(1) qRfixrbpc[c)]	(2) qRexprpc[d)]
Real revenue, pc	0.0414	0.791***
	[0.280]	[0.219]
Real GRP, pc	0.000134	3.16e-05
	[8.18e-05]	[3.94e-05]
Real transfer, pc	-0.399***	0.0607**
	[0.0491]	[0.0274]
Population below working age, pct	-0.433	-0.559
	[0.669]	[0.422]
Volume of goods transported via rail	0.0125***	
	[0.00365]	
Volume of goods transported via road	-0.000565**	
	[0.000267]	
Car ownership	-0.0362***	
	[0.0124]	
Population density	-0.320	
	[0.279]	
Population (log)	9.146	2.351
	[14.50]	[8.097]
Urbanization, pct	0.205	0.167
	[0.163]	[0.133]
Farmland, hectares per sq km area	0.00270	
	[0.00197]	
Public enrolment, pct	0.297	0.0618
	[0.191]	[0.124]
Hospital beds per 10,000 population	0.0193	
	[0.0275]	
Value of oil extracted, real rubles pc	-0.128	-0.0422
	[0.0839]	[0.0406]
Value of gas extracted, real rubles pc	0.00210	-0.000111
	[0.00142]	[0.00125]
Time trend	0.00541	-0.511
	[0.520]	[0.426]
Burden of disease		-0.00215
		[0.00276]
Outpatient visits		-0.00915
		[0.00906]
Population growth rate		0.994**
		[0.416]
Unemployment rate		-0.0407
		[0.352]
Average pension		0.000706
		[0.00156]
Population below subsistence, pct		-0.0201
		[0.0215]
Constant	0	1,026
	[0]	[892.4]

Observations	583	583
R-squared	0.932	0.989

Notes:

*e) Standard errors in brackets; *** p<0.01, ** p<0.05, * p<0.1*

f) Real GRP, per capita and real revenue, per capita are endogenous.

g) Dependent variable: new acquisition of fixed public capital, real rubles per capita. A time trend variable and full range of year and region dummies are included. The year and regions dummies not shown in the table.

h) Dependent variable: subnational current public expenditure, real rubles per capita. A time trend variable and full range of year and region dummies are included. The year and regions dummies not shown in the table.

Appendix C.3 Average Treatment Effects: Matching & Propensity Score Estimation

The application of the models is based on identification of treatment effects.

Identification of treatment effects

The models specified above estimate treatment effects. Three types of treatment effects are relevant here although the DD estimators provide only the average treatment effect. The matching estimators on the other hand provides the average treatment effects (ATE), average treatment effect on the treated (ATT) and average treatment effect on the control (ATC). For all the regions i, $i = 1, \dots, 83$, theoretically all the regions in the population being exchangeable, $\{Y_i(0), Y_i(1)\}$ are the potential outcomes of investment in long lived public goods in region i. $Y_i\,(0)$ is the outcome of region i when it not exposed to treatment and $Y_i(1)$ is the treatment when it is exposed to the treatment namely reduction in resource rent tax share. Only one of the two outcomes is observable. Either the treatment is applied to a region or not. Depending upon the application, either $Y_i\,(0)$ or $Y_i(1)$ is observed. Out of the total regions, N_1 are treated and N_0 are not treated and form the control group. The treatment is binary in application but varies in intensity for the treated regions. The average treatment effects are defined below[174]:

$$\tau_{pop}^{ATE} = E\{Y(1) - Y(0)\}$$

$$\tau_{sample}^{ATE} = \frac{1}{N}\sum_{i=1}^{N}\{Y_i(1) - Y_i(0)\}$$

For the treated group of regions, the average treatment effect is[175]

[174] These definitions are based on Abadie and Imbens (2002) and Imbens (2004).
[175] To simplify notation, I drop the subscript sample since I am interested in sample treatment effects.

$$\tau^{ATT} = \frac{1}{N_1}\sum_{i|W_i=1}^{N_1}\{Y_i(1) - Y_i(0)\}$$

for the control group of regions, the average treatment effect is

$$\tau^{ATC} = \frac{1}{N_0}\sum_{i|W_i=0}^{N_1}\{Y_i(1) - Y_i(0)\}$$

where $W_i \in \{0,1\}$ denoates treatment received, $N_1 = \sum_i W_i$ are the number of treated regions and and $N_0 = \sum_i (1 - W_i)$ are the number of control regions.

Estimation uses the fact that only one of the potential outcomes is observed. Hence, the observed outcome for each region (after Imbens, 2004) is given by

$$Y_i = Y_i(W_i) = \begin{cases} Y_i(0) & if\ W_i = 0 \\ Y_i(1) & if\ W_i = 1 \end{cases}$$

and estimates the unobserved outcome for each region in the data.

The data comes from observational study instead of a randomized experiment. That is quite in the nature of many economic inquiries. The fact that data are not random introduces a concern about the identification of the estimates. We employ three estimation methods to invoke assumptions on the data to identify the treatment effects.

Assumptions

Before discussing the empirical models, we introduce five assumptions that apply to the data. The various empirical models are based on these assumptions:

Assumption 1: Unconfoundedness

$$W_i \perp (Y_i(0), Y_i(1))|X_i$$

Where W_i is the treatment indicator, $i = 0,1$. In other words, the potential outcomes are independent of the treatment conditional on the observed covariates. This is a standard assumption in such analysis. However, it has a component that the outcomes are independent of

the unobservables, which is too strong[176]. Nevertheless, conditional on the covariates, the outcome is independent of the treatment. We relax the unconfoundedness assumption later on.

It has been argued that if the difference in the choice of treatment is based on the differences in unobserved that in turn are not correlated with the outcomes then unconfoundedness is a valid assumption when using observational data (Imbens and Wooldridge, 2007). Now regions maximize social welfare approximated by a choice of investments in long lived public goods and current public goods while choosing tax rates (and shares). Here the objective of the region is different from the variable of interest of the outcome. The regions maximize social welfare while the outcome of interest is the investment in fixed capital. For the present, let's assume the shares and taxes are chosen by the regions.

Let fixed capital investments in regions be $Y_i = f(W, \varepsilon_i)$ and investment is stochastic conditional on the covariates X_i and the individual specific error term ε_i[177]. Each region maximizes social welfare denoted by a function that is a sum of long lived public goods and a reduction in the ratio between expenditure on long lived public goods and the total regional expenditure. The region chooses a the tax share (or rate) as available in the treatment *W*.

$$W_i = \arg max_w \, E[h + R|\pi_i]$$

$$= \arg max_w \, E[h(X_i) + R|\pi_i]$$

where π_i is an unobserved preference for long lived public good investments arising out of considerations like identity preservation or lower discount rates for utility of the future generations.

Or

$$W_i = 1\,\{E[h(X_i, 1) + R - h(X_i, 0) + R|\pi_i]$$

[176] Imbens and Wooldrdige (2009), p.26 consider this to be controversial since this is equivalent to independence of the error term and W_i and refer to Imbens (2004) where

[177] This characterization follows Imbens and Wooldridge (2007), p.8.

The preferences for long lived public goods are unobserved and they are uncorrelated to the error term otherwise influencing investment in fixed public capital. Due to this reason, the unconfoundedness assumption holds. This means that

$$(f(1,\varepsilon_i), f(0,\varepsilon_i) \perp \pi_i$$

Assumption 3: Common Support

Following Rosenbaum and Rubin (1983),

$$0 < \Pr(W_i = 1 | X_i = x) < 1, \forall x.$$

In other words, the probability that the support of the conditional distribution of X_i given $W_i = 0$ has a complete overlap with the conditional distribution of X_i when $W_i = 1$. The assumption that the probability of assignment to treatment is bounded away from 0 and 1 is necessary to create the common support in some of the matching estimators we employ for estimation.

The combination of unconfoundedness and common support assumption are in accordance with Rosenbaum and Rubin (1983). When both inequalities in Assumption 2 hold, according to Rosenbaum and Rubin (1983), it implies strong ignorability. Because of strong ignorability, the average treatment effects for the sample and the population are identified as demonstrated by Imbens and Wooldridge (2009).

The two assumptions are the same as in program evaluation using observational data. The following two additional assumptions are however, needed because of the specific nature of the data.

Assumption 3': Local effects of the outcome variable

The outcome variable, real investment in fixed public capital, is a local public good. Its effects are excluded from other jurisdictions. The level of treatment received by one region does

not affect the outcomes in other regions. This assumption is equivalent to the Stable Unit Treatment Value Assumption (Rubin, 1978). This assumption is based on the notion that reduction is tax share of one region will not affect investment in another region[178].

Assumption 4: Exogenous covariates

Covariates X_{1k} are exgoneous and X_{2k} are endogenous. The first class of covariates include some of the determinants of investment in long lived public goods as well control variables. However, all the determinants cannot be argued to be exogenous. In particular, real gross regional product and real public expenditure by the region are correlated with the error term for each region. They may very well be correlated across time for each region. This is plausible since in general gross regional product and public expenditure are serially correlated.

Assumption 5: Valid instruments

A set of variables Z_m exists that fulfill the exclusion restriction and are valid instruments for X_{2k}. This assumption is made here to employ an estimation method. In the analysis this is validated as well.

Given strong igonarability (Assumptions 1 and 2), the average treatment effects are identified. If unconfoundedness and common support assumptions are weakened as below, the average treatment effect on the treated is still identified (Heckman, Ichimura and Todd, 1997):

Assumption 1': Weak unconfoundedness

$$Y_i(0) \perp W_i$$

Another version of this assumption is due to Imbens (2000), which is useful for estimation of the average effects of multi-valued treatment. It is stated as

Assumption 1'': Weak unconfoundedness with multi-valued treatment

[178] Heckman et al. (1999) provide evidence from simulations that violation of this assumption may lead to bias in estimates.

Assignment to multi-valued treatment is weakly unconfounded given the covariates, if

$$W(t) \perp Y(t)|X \qquad \forall\, t \in T$$

Assumption 2': Weak common support

$$\Pr\,(W_i = 1\,|X_i) < 1$$

In equations (1), (2), (3) and (4), the coefficients listed below have the meanings described here:

$plim\ \hat{\beta}_0$ = average value of outcome in control group is pretreatment period

$plim\ \hat{\beta}_l$ = difference between the averge value of outcome in the control group in post-treatment period and the same group in the pretreatment period

$plim\ \hat{\beta}_j$ = difference between the average value of outcome in the treatment group in the pretreatment time period and the control group in the pretreatment time period

$plim\ \hat{\beta}_k$ = difference between the difference in the average value of outcome in the treatment group in post-treatment period and control group in post-treatment period and the average value of the treatment group in the pretreatment time period and control group in the pretreatment time period.

In the above model, $\hat{\beta}_k$ provides an estimate of the average treatment effect. Employing, instrumental variables, this model is estimated as a fixed effect model including the complete vector of year dummies. Under certain assumptions, Murtazashvilli and Wooldridge (2008) show that the fixed effect instrumental variable estimator is consistent[179]. The linear estimation model

[179] Another application of IV model to estimate treatment effects is provided by Chernozhukov and Hansen (2005) for quintile treatment effects; Hoderline et al. (2009) show that average effects are identified in the presence of explanatory variables that are correlated with the error term.

is plausible as the normalized differences between covariates by treatment status generally do not exceed one quarter[180].

[180] This rule of thumb is provided in Imbens and Wooldridge (2009), p.24 quoting Imbens and Rubin (forthcoming).

I. Average Treatment Effects on Gross Investment in Fixed Public Capital

Matching on value of stock of fixed capital, real GRP per capita, real public expenditure per capita, real transfers per capita, population below working age, population density and volume of goods transported via rail. The observations for both the pre-treatment years and the corresponding year of observation on all variables were used. Matching was required for 4 observations. The same number was used for robustness. The estimates were bias adjusted.

Table C.3.1 Matching Estimators
[acquisition of fixed capital, per capita, by subnational governments is the dependent variable]

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES	2002	2002	2002	2003	2003	2003	2004	2004	2004
SATE	-1.106***			-1.734***			-1.433**		
	[0.000709]			[5.52e-07]			[0.0412]		
SATT		-3.455***			-4.017***			-0.778	
		[0]			[0]			[0.249]	
SATC			0.739***			0.223			-1.966*
			[0.00478]			[0.460]			[0.0589]
Observations	75	75	75	78	78	78	78	78	78

	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
VARIABLES	2005	2005	2005	2006	2006	2006	2007	2007	2007
SATE	1.542			-5.165***			-11.02***		
	[0.159]			[6.59e-08]			[0]		
SATT		4.854***			-12.94***			-18.16***	
		[0.00843]			[0]			[0]	
SATC			-1.286			1.284*			-5.374***
			[0.212]			[0.0606]			[2.10e-06]
Observations	76	76	76	75	75	75	77	77	77

Notes

a) ATE, ATT and ATC are separately estimated using 4 matches, bias adjustment for all variables and 8 matches for standard error estimation. Variable list for matching: real value of fixed capital pc population below working age population density tonnage public expenditure pc transfer pc real GRP pc (values in 2000 and 2001) and contemporaneous real values of fixed capital pc, urbanization pct., farmland, hectares, population below working age, population density, tonnage, public expenditure pc, transfer pc, and real GRP. The dependent variable is acquisition of ownership of fixed public capital in each year.
b) Robust standard errors in brackets
c) *** $p<0.01$, ** $p<0.05$, * $p<0.1$

II. Propensity Score Matching Method

Table C.3.2

Propensity Score Adjustment [a)]

Matching method	Number of treated[b)]	Number of controls[b)]	ATT	Std. Err.	t
Nearest neighborhood (equal weights)	246	144	-0.542	0.840	-0.645
Random draw	246	144	-0.542	0.605	-0.897

Notes:

a) The propensity score was computed using real value of fixed capital pc, regional gross product pc', revenue pc, transfer pc, population below working age, population density, public bus passengers, car ownership, road transported goods, volume, public schools enrolment pct., outpatient visits and time dummy.
b) The numbers of treated and controls refer to actual nearest neighbor matches.

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