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Abstract

We assess the economic effects of different scenarios of regional allocation of the current interregional transfers' scheme in Colombia, highlighting potential tradeoffs between regional equity and efficiency. The simulations conducted in this work, using an interregional computable general equilibrium model, contribute to the analysis of the growth impact related to some of the broad objectives that central governments pursue when allocating subnational transfers to local governments. We simulate counterfactual scenarios in which redistributive policies are designed to assess potential Gross Regional Product (GRP) outcomes had they been applied to the Colombian economy. The results show that when the distribution is carried out based on regional population shares, there are potential gains in national growth together with an increase in regional disparities. However, when the distribution is carried out according to other redistributive criteria, such as the number of people impoverished or the horizontal equity gaps, there is a potential improvement in regional inequality despite negative growth effects. In this sense, if we prioritize the redistributive criterion in order to offset the reduction of growth, regions that face a net increase in transfers should allocate the additional resources to improve in terms of Total Factor Productivity (TFP), specifically, in long-term TFP-enhancing investments, such as human capital in the form of education and health outcomes.

Keywords: Decentralization, regional inequalities, subnational transfers.
JEL Codes: H77, R12, R13, D58, O54.

Resumen

En este trabajo se evalúan los efectos económicos de diferentes escenarios de asignación regional empleados en el esquema actual de transferencias interregionales en Colombia, destacando los posibles compromisos entre la eficiencia y la equidad regional. Las simulaciones realizadas en el trabajo, utilizando un modelo de equilibrio general computable interregional, contribuyen al análisis del impacto del crecimiento relacionado con algunos de los objetivos generales que persiguen los gobiernos centrales al asignar transferencias sub-nacionales a los gobiernos locales. En este sentido, se simulan escenarios contra factuales en los que las políticas redistributivas están diseñadas para evaluar los posibles resultados del Producto Bruto Regional. Los resultados muestran que cuando la distribución se lleva a cabo sobre la base del tamaño de la población regional, hay ganancias potenciales en el crecimiento nacional junto con un aumento en las disparidades regionales. Sin embargo, cuando la distribución se lleva a cabo de acuerdo con otros criterios redistributivos, como el número de personas en condición de pobreza o las brechas horizontales de equidad fiscal, existen mejoras potenciales en la desigualdad regional, a pesar de estar acompañadas de efectos negativos del crecimiento. En este sentido, si se prioriza el criterio redistributivo para compensar la reducción del crecimiento, las regiones que enfrentan un aumento neto en las transferencias deben asignar los recursos adicionales para mejorar en términos de Productividad Total de los Factores (PTF), específicamente, priorizando en inversiones que mejoran la PTF en el largo plazo, tales como aquellas en capital humano enfocadas a la educación y la salud.

Palabras clave: descentralización, desigualdades regionales, transferencias subnacionales.
Códigos JEL: H77, R12, R13, D58, O54.

1. Introduction

Inequalities in Colombia, as well as poverty rates, have been documented to be persistent over time (Bonet and Meisel, 2001; Galvis and Meisel, 2010). The same conclusion is achieved when studying other social variables. For instance, Galvis et al. (2017) have found a high correlation between the literacy rates in 1912 compared to 1938, 1951, 1973, 1993, and 2005, other years for which there is available data from the Censuses. There is, thus, evidence of the persistence of poor conditions in the population since various decades in the past. There is also evidence of regional disparities in those characteristics. For instance, the Pacific region shows consistently lower living standards than the rest of the country (Galvis, 2017).

One of the available instruments to reduce spatial economic disparities is fiscal equalization policies (Albouy, 2012; Rodriguez-Pose, 2018). Such policies aim at redistributing tax revenues from areas with high financial capacity to poorer regions, and thus allowing lagging regions to offer more public goods (Henkel et al., 2018). Fiscal equalization strategies are used in different countries, both in the developed and developing worlds: Germany (Juben, 2006; Buettner, 2009; Baskaran et al.; 2017), USA (Buchanan, 1950; Kline and Moretti, 2014; Austin et al., 2018), Australia (Groenewold et al., 2003; Groenewold and Hagger, 2007), Japan (Otsuka et al., 2010), OECD countries (Kyriacou et al., 2015 and 2016), and Brazil (Haddad et al., 2013).

According to the debate on fiscal federalism, distribution of subnational transfers should rely both on efficiency and equity criteria (Musgrave, 1959; Gramlich, 1977). Given existing market imperfections in spatial economic systems, one of the roles of central governments would be to help local governments in the provision of a basket of public goods to different population groups, distributed across different regions, trying to ensure a more equitable distribution of those goods.

In Colombia, transfers from the Central National Government (CNG) are targeted to alleviate the problems of the lack of resources in the periphery. For this reason, we highlight that transfers should be more focused on reducing the gaps of the periphery with respect to the core. Despite the relevance of policies to reduce regional inequalities in Colombia, some of them reviewed in the literature (e.g. Bonet, 2006; Bird, 2012; Bonet and Ayala-García, 2015; Ter-Minassian, 2016), we do not have enough evidence about the implications of fiscal transfers for the Colombian economy. Thus, in order to address this issue, we calibrate an interregional general equilibrium model for Colombia (CEER model) and simulate different counterfactual scenarios related to the distribution of interregional transfers. More specifically, we carry out an analysis of the distribution of CNG resources evaluating different allocations across regions in Colombia, simulating alternative redistribution schemes using the participation of territorial entities in terms of population, the number of poor people and the gaps in terms of horizontal fiscal equity.

The results show that when the distribution is carried out based on the number of inhabitants, there are gains in the growth of the aggregate income. However, when the distribution is carried out according to other redistributive criteria, such as the number of poor or the horizontal equity gaps, the growth of aggregate income is reduced, although we foresee a potential decrease in regional inequality. In this sense, in order to overcome the reduction in growth, it would be necessary to have concomitant increases in the productivity of the regions that receive the greatest amount of resources, so that the Colombian economy would maintain the baseline growth trend. In the forthcoming discussion, we highlight the importance of the tradeoff between equity and efficiency.

The remainder of the paper is structured as follows. Section 2 gives the motivation for the impact assessment of interregional transfers in the context of regional inequality in Colombia. Section 3 presents in detail the model used in the simulations. Section 4 designs the simulation experiments, whose results we presented and discussed in Section 5. A final section concludes and discusses the broad implications in terms of regional policy.

2. **Regional Inequalities and Subnational Transfers**

There is a long-lasting debate in economics regarding the effect of different dimensions of inequality on economic development. A vast literature has pointed out that inequalities harm the advancement of economic development. For instance, Alesina and Rodrik (1994) found a negative relation between inequalities and economic growth. Similar results have been documented by Persson and Tabellini (1994) as well as by Deininger and Squire (1996), who have studied the relation between initial inequalities and economic growth in a sample of 108 countries around the world. Furthermore, Engerman, and Sokoloff (2002) compare North and South America, finding that, in the long-run, that negative relation is also present.

One of the mechanisms through which inequalities are dealt with is by means of redistribution of income from more prosperous regions to the more impoverished. The distribution of transfers from central government is grounded on the principles of fiscal federalism. The theory of fiscal federalism provides key elements to answer a series of questions, such as: (i) What are the factors that determine the optimal degree of federalism? (ii) What should be the functions of each layer of the government levels? (iii) What should be the corresponding sources of funding for such functions? And (iv), in the case of imbalances, what is the optimal mechanism to solve the problems of lack of equity and efficiency?

The approach by Musgrave (1959) emphasizes the decentralization of the responsibilities of spending and the centralization of tax collection. This would help achieving greater efficiency and equity. Likewise, it considers the possibility of the appearance of vertical and horizontal imbalances, so the existence of transfers is required to achieve higher levels of equity. Other approaches call for greater efforts by local governments to promote economic growth and prosperity among its constituents. In this way, mechanisms are proposed to achieve equalization objectives without undermining the incentives of local governments to promote economic prosperity. In this line of thought, there should be greater decentralization both in the responsibilities that each local government has with its taxpayers, and in the collection of taxes, fostering efficiency in such collection. There is, however few examples in which this objective is achieved. Bird (1999) points out that in most of the cases local governments depend upon transfers from other tiers at a higher level to be able to cope with the responsibilities they have assigned. In such cases, subnational transfers may be necessary.

The structure of government in Colombia is comprised by three tiers: the central government, the departments (32 units plus Bogotá) and the municipalities (1,122 units). Those spatial units are not homogeneous in terms of disposable income or standards of living. In fact, in Colombia, the persistent history of inequality and poverty is a common finding in the academic literature (e.g. Bonet and Meisel, 2008; Galvis and Meisel, 2010; Royuela and García, 2015; Lozano and Julio, 2016).

The regional policy models followed by the CNG to reduce regional disparities and poverty in the country are based on decentralization policies that redistribute resources to the municipalities and departments. The process of decentralization in Colombia, in the political aspects, had its beginnings in the 1980s. Specifically, the Law 78 of 1986 decreed the popular election of mayors in each municipality. Later, the reforms introduced by the Constitution of 1991 also decreed the popular election of governors in each department. With these reforms, decentralization was complemented by granting more resources to those mayors and governors. Such resources would come from the taxes collected by CNG in each tier, which would return to them in the form of territorial transfers. Finally, decentralization migrated to the administrative realms, where the responsibilities and obligations concerning each subnational government were consolidated and defined, emphasizing the education and health sectors (Bonet et al., 2016).

In 2001, the Legislative Act 01 created the general participation system, SGP (by its acronym in Spanish). This Act implemented Law 715 of 2001 and reformed articles 356 and 357 of the 1991 Constitution. Those articles established a dependence on transfers on the current revenues of the nation, ICN (by its acronym in Spanish). This represented disadvantages because the ICN maintain a certain variability that in turn implies greater uncertainty for the territorial entities regarding the future resources to be received.

Legislative Act 01 managed to break the link between the growth of SGP funds and the ICN up until 2016. Specifically, SGP resources would grow based on the inflation observed plus a constant real growth of 2%, between 2002 and 2005, and then 2.5%, during the period 2006 to 2008. Additionally, during the years in which the economy experienced a rate of growth beyond 4%, there would be an additional bonus for the SGP funds, equivalent to that extra growth beyond the rate of 4% (Bonet et al., 2016).

In relation to the way resources are assigned to the local authorities, the creation of the SGP brought about certain changes. In addition to the specific destination (earmarked) portion to be spent in health and education, a general purpose item was included that could be spent in projects of water and basic sanitation (APSB, by its acronym in Spanish); recreation, culture and sports, and finally, a fraction that would be of discretional use. On the other hand, there would also be transfers for the following items: the indigenous reservations, the school nutrition programs, the National Pension Fund of the Territorial Entities (FONPET, by its acronym in Spanish), and for the riverside municipalities of the Magdalena river.

The distribution of resources in the aforementioned areas, as stated in Law 715 of 2001, began with the assignation of 4.0% of the transfers to be redistributed among the indigenous reserves (0.52%), riverside municipalities of Magdalena (0.08%), municipalities and districts for school feeding programs (0.5%) and for FONPET (2.9%). Once those resources are discounted, the remainder is distributed to the education sector with 58.5%, health, another 24.5%, and the general purpose items, the remaining 17.0%.

In 2007 a new constitutional reform took place through the Law 1176. This Law separated the funds for APSB from the share devoted to general purpose, which is now an independent item that receives 5.4% of the resources. In that sense, the share of general purpose decreased from 17% to 11.6%. The education and health items remained at 58.5% and 24.5%, respectively.

This reform also modified the rate at which the resources allocated to the SGP would grow annually, stating that it would continue to be based on inflation observed in addition to a fixed real growth of 4.8% from 2011 to 2016. Out of that extra growth, 1.8 percentage points should be allocated to improve the coverage and quality of the education sector.

In sum, the CNG redistributes revenues to the municipalities and departments by means of subnational transfers. Most of the transfers as we have mentioned are earmarked and then should only be used to foster growth of sectors such as education, health, and water sanitation. Nonetheless, there are 42 criteria with which the resources are distributed among the subnational governments.

There has been a recent discussion regarding the way the resources are distributed among the subnational units. Zapata and Concha (2016) show that the CNG employs around 42 different criteria to define the share of the resources that goes to each municipality or department. The 42 criteria are divided into five major groups: i) efficiency, ii) coverage, iii) population, iv) poverty and v) others.

Efficiency takes into account allocation of resources based on performance indicators built by the National Planning Department; the coverage item distributes the resources according to the conditions of covered population as well as the ones out of the system of health and education; the population item assigns the SGP according to the number of people in each municipality. In this category, there are different shares for municipalities with less than 25.000 inhabitants, or with the presence of indigenous reservations. On the other hand, the poverty criteria allocate resources according to components of the poverty indexes. Finally, the group of other criteria includes those that are complementary to the previous ones, such as the shares for sports, culture, the municipalities along the Magdalena river, among others.

The authors conclude that there are too many criteria and that it would be possible to employ only 14 of those, achieving better results in terms of the administration of the resources as well as in terms of the incentives for the local administrators to improve their tax revenue collection and usage of the resources.

Similarly, Bonet et al. (2016) have shown that the law that regulates the transfers is not consistent with the many functions that are assigned to the subnational units. Effectively, there is a vast amount of tasks that are to be carried out by municipalities and departments, using the same resources. Galvis (2016) also showed that there is inefficiency in the use of the resources assigned to the municipalities. Using the main "receivers" of resources, the author has shown that with fewer resources the municipalities could improve coverage and quality of the health and education services. That is why the distribution of resources originating from subnational transfers should also take into account this fact.

In summary, the way transfers are distributed among the subnational administrative units may be reviewed, to follow other criteria that relates to equity in the way resources are allocated. This is a topic that we develop in the following sections.

3. Specification of the CEER Model

In this section, we present the analytical, functional and numerical structures of the interregional general equilibrium model for Colombia, the CEER model. The specification of the linearized form of the model is provided, based on different groups of equations. The notational convention uses uppercase letters to represent the levels of the variables and lowercase for their percentage-change representation. Superscripts *(u)*, *u = 0, 1j, 2j, 3, 4, 5*, 6 refer, respectively, to output *(0)* and to the six different regional-specific users of the products identified in the model[3]: producers in sector *j (1j)*, investors in sector *j (2j)*, households *(3)*, purchasers of exports *(4)*, regional governments *(5)*, and central government *(6)*; the second superscript *(r)* identifies the domestic region where the user is located. Inputs are identified by two subscripts: the first *(i)* takes the values *1, ..., g*, for commodities, *g + 1*, for primary factors; the second subscript identifies the source of the input, being it from domestic region *b (1b)* or imported *(2)*, or coming from labor *(1)* or capital *(2)*, the two primary factors in the model. The symbol (•) is employed to indicate a sum over an index.

We define the following sets: $G = \{1, \dots, g\}$, where g is the number of composite goods; $G^* = \{1, \dots, g, g+1\}$, where $g+1$ is the number of composite goods and primary factors, with $G^* \supset G$; $H = \{1, \dots, h\}$, where h is the number of industries;

[3] We have specified a seventh residual user, *(7)*, to deal with statistical discrepancies in the balancing of the model's absorption matrix based on the Colombian interregional input-output system (IIOS). See Haddad et al. (2018).

$U = \{(3), (4b), (5), (6), (kj)\}$ for $k = (1), (2)$ and $j \in H$, is the set of all users in the model; $U^* = \{(3), (5), (6), (kj)\}$ for $k = (1), (2)$ and $j \in H$, with $U \supset U^*$, is the subset of domestic users; $S = \{1, \dots, r, r + 1\}$, where $r+1$ is the number of all regions (including foreign); $S^* = \{1, \dots, r\}$, with $S \supset S^*$, is the subset with the r domestic regions; and $F = \{1, \dots, f\}$ is the set of primary factors. In the CEER model, $g = h = 7$, $r = 33$, and $f = 2$.

We model the sourcing of composite goods based on multilevel structures, which enable a great number of substitution possibilities. We employ nested sourcing functions for the creation of composite goods, available for consumption in the regions of the model. We assume that domestic users, i.e. firms, investors, households, and government, use combinations of composite goods specified within two-level CES nests. At the bottom level, bundles of domestically produced goods are formed as combinations of goods from different regional sources. At the top level, substitution is possible between domestically produced and imported goods. Equations (1) and (2) describe, respectively, the regional sourcing of domestic goods, and the substitution between domestic and imported products.

$$x_{(i(1b))}^{(u)r} = x_{(i(1\bullet))}^{(u)r} - \sigma 1_{(i)}^{(u)r} \left(p_{(i(1b))}^{(u)r} - \sum_{l \in S^*} \left(\frac{V(i,1l,(u),r)}{V(i,1\bullet,(u),r)} \right) \left(p_{(i(1l))}^{(u)r} \right) \right)$$

$$i \in G;\ b \in S^*; (u) \in U^*;\ r \in S^* \qquad (1)$$

where $x_{(i(1b))}^{(u)r}$ is the demand by user *(u)* in region r for good i in the domestic region *(1b)*; $p_{(i(1b))}^{(u)r}$ is the price paid by user *(u)* in region r for good i in the domestic region *(1b)*; $\sigma 1_{(i)}^{(u)r}$ is a parameter measuring the user-specific elasticity of substitution between alternative domestic sources of commodity i, known as the regional trade Armington elasticity; and $V(i, 1l, (u), r)$ is an input-output flow coefficient that measures purchasers' value of good i from domestic source l used by user *(u)* in region r.

$$x_{(is)}^{(u)r} = x_{(i\bullet)}^{(u)r} - \sigma 2_{(i)}^{(u)r}\left(p_{(is)}^{(u)r} - \sum_{l=1\bullet,2}\left(\frac{V(i,l,(u),r)}{V(i,\bullet,(u),r)}\right)\left(p_{(il)}^{(u)r}\right)\right)$$

$$i \in G;\ s = 1\bullet, 2; (u) \in U^*;\ r \in S^* \qquad (2)$$

where $x_{(is)}^{(u)r}$ is the demand by user *(u)* in region *r* for either the domestic composite or the foreign good i; $p_{(is)}^{(u)r}$ is the price paid by user *(u)* in region *r* for either the domestic composite or the foreign good i; $\sigma 2_{(i)}^{(u)r}$ is a parameter measuring the user-specific elasticity of substitution between the domestic bundle and imports of good i, known as the international trade Armington elasticity; and $V(i, l, (u), r)$ is an input-output flow coefficient that measures purchasers' value of good i from either the aggregate domestic source or the foreign source l used by user *(u)* in region *r*.

In addition to goods used as intermediate inputs, firms in the model also demand primary factors of production. The equations that describe the industry j's demands inputs are derived under the assumption of Leontief technology with Armington nests (imperfect substitution between inputs of the same type from different sources). In our specification of the nested production functions, we assume firms to use combinations of composite intermediate inputs, formed according to Equations (1) and (2), and primary factor composites. In the case of the primary factor bundle, substitution is possible among different types of primary factors. Equation (3) specifies the substitution between labor and capital in the model, and is derived under the assumption that industries choose their primary factor inputs to minimize costs subject to obtaining sufficient primary factor inputs to satisfy their technological requirements (nested Leontief/CES specification). We have included technical change variables to allow for factor-specific productivity shocks. We model the combination of intermediate inputs and the value added (primary factors) aggregate in fixed proportions, at the very top of the nested production function, assuming that there is no substitution between primary factors and other inputs. The Leontief specification is presented in Equation (4). More flexible functional forms have been rarely introduced in multi-regional models, mainly due to data availability constraints. In addition to a technical coefficient in the relation between the sectoral demand for the primary factor composite and the total output, we have also included a scale parameter. This modeling procedure has been based on previous studies made by Haddad and Hewings (2005) which allows for the introduction of Marshallian agglomeration (external) economies, by exploring local properties of the CES function.

$$x_{(g+1,s)}^{(1j)r} - a_{(g+1,s)}^{(1j)r} = \alpha_{(g+1,s)}^{(1j)r} x_{(g+1,\bullet)}^{(1j)r} - \sigma 3_{(g+1)}^{(1j)r} \left(p_{(g+1,s)}^{(1j)r} + a_{(g+1,s)}^{(1j)r} - \sum_{l \in F} \left(\frac{V(g+1,l,(1j),r)}{V(g+1,\bullet,(1j),r)} \right) \left(p_{(g+1,l)}^{(1j)r} + a_{(g+1,l)}^{(1j)r} \right) \right)$$

$$j \in H;\ s \in F;\ r \in S^* \qquad (3)$$

where $x_{(g+1,s)}^{(1j)r}$ is the demand by sector *j* in region *r* for each primary factor; $a_{(g+1,s)}^{(1j)r}$ is the exogenous sector-specific variable of (saving) technical change for primary factor *s* in region *r*; $p_{(g+1,s)}^{(1j)r}$ is the price paid by sector *j* in region *r* for primary factor *s*; $\sigma 3_{(g+1)}^{(1j)r}$ is a parameter measuring the sector-specific elasticity of substitution among different primary factors; and $V(g+1,l,(1j),r)$ is an input-output flow coefficient that measures purchasers' value of factor *l* used by sector *j* in region *r*.

$$x_{(i\bullet)}^{(1j)r} = \mu_{(g+1,\bullet)}^{(1j)r} z^{(1j)r} + a_{(i)}^{(1j)r}$$

$$j \in H;\ i \in G^*;\ r \in S^* \qquad (4)$$

where $x_{(i\bullet)}^{(1j)r}$ is the demand by sector *j* in region *r* for the bundles of composite intermediate inputs and primary factors *i*; $z^{(1j)r}$ is total output of sector *j* in region *r*; $a_{(i)}^{(1j)r}$ is the exogenous sector-specific variable of technical change for composite intermediate inputs and primary factors in region *r*; and $\mu_{(i\bullet)}^{(1j)r}$ is a scale parameter measuring the sector-specific returns to the composite of primary factors in each region.

Units of capital stock are created for industry *j*, at minimum cost. Commodities are combined via a Leontief function, as specified in Equation (5). As described in Equations (1) and (2), regional, and domestic and imported commodities are combined, respectively, via a CES specification (Armington assumption). No primary factors are used in capital creation. The use of these inputs is recognized through the capital goods producing sectors in the model, mainly machinery and equipment industries, construction, and support services.

$$x_{(i\bullet)}^{(2j)r} = z^{(2j)r} + a_{(i)}^{(2j)r}$$

$$j \in H;\ i \in G;\ r \in S^* \tag{5}$$

where $x_{(i\bullet)}^{(2j)r}$ is the demand by sector *j* in region *r* for the bundles of composite capital goods *i*; $z^{(2j)r}$ is total investment of sector *j* in region *r*; $a_{(i)}^{(2j)r}$ is the exogenous sector-specific variable of technical change for changing the composition of the sectoral unit of capital in region *r*.

In deriving the household demands for composite commodities, we assume that households in each region behave as a single, budget-constrained, utility-maximizing entity. The utility function is of the Stone-Geary or Klein-Rubin form. Equation (6) determines the optimal composition of household demand in each region. Total regional household consumption is determined as a function of real household income. The demands for the commodity bundles in the nesting structure of household demand follow the CES pattern established in Equations (1) and (2), in which an activity variable and a price-substitution term play the major roles. In Equation (6), consumption of each commodity *i* depends on two components: first, for the subsistence component, which is defined as the minimum expenditure requirement for each commodity, changes in demand are generated by changes in the number of households and tastes; second, for the luxury or supernumerary part of the expenditures in each good, demand moves with changes in the regional supernumerary expenditures, changes in tastes, and changes in the price of the composite commodity. The two components of household expenditures on the composite commodities are weighted by their respective shares in the total consumption of the composite commodity.

$$V(i,\bullet,(3),\mathrm{r})\left(p_{(i\bullet)}^{(3)r}+x_{(i\bullet)}^{(3)r}-a_{(i\bullet)}^{(3)r}\right)$$
$$=\gamma_{(i)}^{r}P_{(i\bullet)}^{(3)r}Q^{r}\left(p_{(i\bullet)}^{(3)r}+x_{(i\bullet)}^{(3)r}-a_{(i\bullet)}^{(3)r}\right)$$
$$+\beta_{(i)}^{r}\left(C^{r}-\sum_{j\in G}\gamma_{(j)}^{r}P_{(j\bullet)}^{(3)r}Q^{r}\left(p_{(j\bullet)}^{(3)r}+x_{(j\bullet)}^{(3)r}-a_{(i\bullet)}^{(3)r}\right)\right)$$

$i \in G;\ r \in S^{*}$ (6)

where $p_{(i\bullet)}^{(3)r}$ is the price paid by household in region *r* for the composite good *i*; $x_{(i\bullet)}^{(3)r}$ is the household demand in region *r* for the composite good *i*; $a_{(i\bullet)}^{(3)r}$ is the commodity-specific variable of regional taste change; Q^{r} is the number of households in region *r*; $C^{r}$is the total expenditure by household in region *r*, which is proportional to regional labor income; $\gamma_{(i)}^{r}$ is the subsistence parameter in the linear expenditure system for commodity *i* in region *r*; $\beta_{(i)}^{r}$ is the parameter defined for commodity *i* in region *r* measuring the marginal budget shares in the linear expenditure system; and $V(i,\bullet,(3),\mathrm{r})$ is an input-output flow coefficient that measures purchasers' value of good *i* consumed by households in region *r*.

As noted by Peter et al. (1996), a feature of the Stone-Geary utility function is that only the above-subsistence, or luxury, component of real household consumption, $utility^{(r)}$, affects the per-household utility, as described in Equation (7).

$$utility^{(r)} = \left(C^r - \sum_{j \in G} \gamma_{(j)}^r P_{(j\bullet)}^{(3)r} Q^r \left(p_{(j\bullet)}^{(3)r} + x_{(j\bullet)}^{(3)r} - a_{(i\bullet)}^{(3)r}\right)\right) - q^r - \sum_{i \in G} \beta_{(i)}^r \, p_{(i\bullet)}^{(3)r}$$

$$r \in S^* \qquad (7)$$

where q^r is the percentage change in the number of households in each region.

In Equation (8), foreign demands (exports) for domestic good i depend on the percentage changes in a price, and three shift variables which allow for vertical and horizontal movements in the demand curves. The price variable which influences export demands is the purchaser's price in foreign countries, which includes the relevant taxes and margins. The parameter $\eta_{(is)}^r$ controls the sensitivity of export demand to price changes.

$$\left(x_{(is)}^{(4)r} - fq_{(is)}^{(4)r}\right) = \eta_{(is)}^r \left(p_{(is)}^{(4)r} - phi - fp_{(is)}^{(4)r}\right)$$

$$i \in G;\ r, s \in S^* \qquad (8)$$

where $x_{(is)}^{(4)r}$ is foreign demand for domestic good i produced in region s and sold from region r (in the model there is no re-exports, so that $r = s$); $p_{(is)}^{(4)r}$ is the purchasers' price in domestic currency of exported good i demand in region r; phi is the nominal exchange rate; and $fq_{(is)}^{(4)r}$ and $fp_{(is)}^{(4)r}$ are, respectively, quantity and price shift variables in foreign demand curves for regional exports.

Governments consume mainly public goods provided by the public administration sectors. Equations (9) and (10) show the movement of government consumption in relation to movements in real tax revenue, for regional governments and the central government, respectively.

$$x_{(is)}^{(5)r} = taxrev^r + f_{(is)}^{(5)r} + f^{(5)r} + f^{(5)}$$

$$i \in G;\ s = 1\text{b}, 2;\ r, b \in S^* \qquad (9)$$

$$x_{(is)}^{(6)r} = nattaxrev + f_{(is)}^{(6)r} + f^{(6)r} + f^{(6)}$$

$$i \in G;\ s = 1\text{b}, 2;\ r, b \in S^{*} \tag{10}$$

where $x_{(is)}^{(5)r}$ and $x_{(is)}^{(6)r}$ are the regional *(5)* and central *(6)* governments demand in region *r* for good *i* from region *s*; $f_{(is)}^{(5)r}$, $f^{(5)r}$ and $f^{(5)}$ are, respectively, commodity and source-specific shift term for regional governments expenditures in region *r*, shift term for regional governments expenditures in region *r*, and an overall shift term for regional governments expenditures. Similar shift terms ($f_{(is)}^{(6)r}$, $f^{(6)r}$ and $f^{(6)}$) appear in Equation (10) related to central government expenditures. Finally, $taxrev^{r}$ is the percentage change in real revenue from indirect taxes in region *r*, and $nattaxrev$ refers to percentage change in aggregate real revenue from indirect taxes, so that government demand moves with endogenous changes in regional and national tax bases.

Equation (11) specifies the sales tax rates for different users. They allow for variations in tax rates across commodities, and their sources and destinations. Tax changes are expressed as percentage-point changes in the *ad valorem* tax rates.

$$t_{(is)}^{(u)r} = f_i + f_i^{(u)} + f_i^{(u)r}$$

$$i \in G;\ s = 1\text{b}, 2;\ b, r \in S^{*};\ u \in U \tag{11}$$

where $t_{(is)}^{(u)r}$ is the power of the tax on sales of commodity (*is*) to user (*u*) in region *r*; and f_i, $f_i^{(u)}$, and $f_i^{(u)r}$ are different shift terms allowing percentage changes in the power of tax.

Equations (12) and (13) impose the equilibrium conditions in the market's domestic and imported commodities. Notice that there is no margin commodity in the model. Moreover, there is no secondary production in the model. In Equation (12), demand equals supply for regional domestic commodities.

$$\sum_{j\in H} Y(l,j,r)x_{(l1)}^{(0j)r} = \sum_{(u)\in U} B(l,1b,(u),r)x_{(l1)}^{(u)r}$$

$$l \in G, b, r \in S^* \qquad (12)$$

where $x_{(l1)}^{(0j)r}$ is the output of domestic good l by industry j in region r; $x_{(l1)}^{(u)r}$ is the demand of the domestic good l by user *(u)* in region *r*; $Y(l,j,r)$ is the input-output flow measuring the basic value of output of domestic good l by industry j in region *r*; and $B(l,1,(u),r)$ is the input-output flow measuring the basic value of domestic good l used by *(u)* in region *r*.

Equation (13) imposes zero pure profits in importing. Where $p_{(i(2))}^{(0)}$ is the basic price in domestic currency of good i from foreign source; $p_{(i(2))}^{(w)}$ is world (Cost, Insurance and Freight) C.I.F. price of imported commodity i; phi is the nominal exchange rate; and $t_{(i(2))}^{(0)}$ is the power of the tariff. i.e. one plus the tariff rate, on imports of i. Equation (13) thus, defines the basic price of a unit of imported commodity i – the revenue earned per unit by the importer – as the international C.I.F. price converted to domestic currency, including import tariffs.

$$p_{(i(2))}^{(0)} = p_{(i(2))}^{(w)} - phi + t_{(i(2))}^{(0)}$$

$$i \in G \qquad (13)$$

Together with Equation (13), Equations (14) and (15) constitute the model's pricing system. The price received for any activity is equal to the costs per unit of output. As can be noticed, the assumption of constant returns to scale adopted here precludes any activity variable from influencing basic prices, i.e., unit costs are independent of the scale at which activities are conducted. Thus, Equation (14) defines the percentage change in the price received by producers in regional industry j per unit of output as being equal to the percentage change in j's costs, which are affected by changes in technology and changes in input prices.

$$\sum_{l \in G} Y(l,j,r)\left(p_{(l1)}^{(0)r} + a_{(l1)}^{(0)r}\right) = \sum_{l \in G^*,F} \sum_{s \in S} V(l,s,(1j),r) p_{(ls)}^{(1j)r}$$

$$j \in H;\ r \in S^* \qquad (14)$$

where $p_{(l1)}^{(0)r}$ is the basic price of domestic good i in region r; $a_{(l1)}^{(0)r}$ refer to technological changes, measured as a weighted average of the different types of technical changes with influence on j's unit costs; $p_{(ls)}^{(1j)r}$ is the unit cost of sector j in region r; $Y(l,j,r)$ is the input-output flow measuring the basic value of output of domestic good l by industry j in region r; and $V(l,s,(1j),r)$ are input-output flows measuring purchasers' value of good or factor l from source s used by sector j in region r.

Equation (15) imposes zero pure profits in the distribution of commodities to different users. Prices paid for commodity i from region s in industry j in region r by each user equate to the sum of its basic value and the costs of the relevant taxes.

$$V(i,s,(u),r) p_{(is)}^{(u)r} = \left(B(i,s,(u),r) + T(i,s,(u),r)\right)\left(p_{(is)}^{(0)} + t_{(is)}^{(u)r}\right)$$

$$i \in G;\ s = 1\text{b}, 2;\ b, r \in S^*;\ u \in U \qquad (15)$$

where $p_{(is)}^{(u)r}$ is the price paid by user *(u)* in region r for good *(is)*; $p_{(is)}^{(0)}$is the basic price of domestic good *(is)*; $t_{(is)}^{(u)r}$ is the power of the tax on sales of commodity *(is)* to user *(u)* in region r; $V(i,s,(u),r)$ are input-output flows measuring purchasers' value of good i from source s used by user *(u)* in region r; $B(i,s,(u),r)$ is the input-output flow measuring the basic value of good *(is)* used by *(u)* in region r; and

$T(i,s,(u),r)$ is the input-output flow associated with tax revenue of the sales of *(is)* to *(u)* in region *r*.

The theory of the allocation of investment across industries is represented in Equations (16) to (19). The comparative-static nature of the model restricts its use to short-run and long-run policy analysis. When running the model in the comparative-static mode, there is no fixed relationship between capital and investment. The user decides the required relationship on the basis of the requirements of the specific simulation. Equation (16) defines the percentage change in the current rate of return on fixed capital in regional sectors. Under static expectations, rates of return are defined as the ratio between the rental values and the cost of a unit of capital in each industry – defined in Equation (17) –, minus the rate of depreciation.

$$r_{(j)}^{r} = \psi_{(j)}^{r}\left(p_{(g+1,2)}^{(1j)r} - p_{(k)}^{(1j)r}\right)$$

$$j \in H;\ r \in S^{*} \qquad (16)$$

where $r_{(j)}^{r}$ is the regional-industry-specific rate of return; $p_{(g+1,2)}^{(1j)r}$ is the rental value of capital in sector *j* in region *r*; $p_{(k)}^{(1j)r}$ is the cost of constructing units of capital for regional industries; and $\psi_{(j)}^{r}$ is a regional-industry-specific parameter referring to the ratio of the gross to the net rate of return.

Equation (16) defines $p_{(k)}^{(1j)r}$ as:

$$V(\bullet,\bullet,(2\mathrm{j}),\mathrm{r})\left(p_{(k)}^{(1j)r} - a_{(k)}^{(1j)r}\right) = \sum_{i\in G}\sum_{s\in S} V(\mathrm{i},\mathrm{s},(2\mathrm{j}),\mathrm{r})\left(p_{(is)}^{(2j)r} - a_{(is)}^{(2j)r}\right)$$

$$j \in H;\ r \in S^{*} \qquad (17)$$

where $p_{(is)}^{(2j)r}$ is the price paid by user *(2j)* in region *r* for good *(is)*; $a_{(k)}^{(1j)r}$ and $a_{(is)}^{(2j)r}$ are technical terms; and $V(\mathrm{i},\mathrm{s},(2\mathrm{j}),\mathrm{r})$ represents input-output flows measuring purchasers' value of good *i* from source *s* used by user *(2j)* in region *r*.

Equation (18) says that if the percentage change in the rate of return in a regional industry grows faster than the national average, capital stocks in that industry will increase at a higher rate than the average national stock. For industries with lower-than-average increase in their rates of return to fixed capital, capital stocks increase at a lower-than-average rate, i.e., capital is attracted to higher return's industries. The shift variable, $f_{(k)}^{(1j)r}$, exogenous in long-run simulation, allows shifts in the industry's rates of return.

$$r_{(j)}^{r} - \omega = \varepsilon_{(j)}^{r}\left(x_{(g+1,2)}^{(1j)r} - x_{(g+1,2)}^{(\bullet)r}\right) + f_{(k)}^{(1j)r}$$

$$j \in H;\ r \in S^{*} \qquad (18)$$

where $r_{(j)}^{r}$ is the regional-industry-specific rate of return; ω is the overall rate of return on capital; $x_{(g+1,2)}^{(1j)r}$ is the capital stock in industry *j* in region *r*; $f_{(k)}^{(1j)r}$ the capital shift term in sector *j* in region *r*; and $\varepsilon_{(j)}^{r}$ measures the sensitivity of capital growth to rates of return of industry *j* in region *r*.

Equation (19) implies that the percentage change in an industry's capital stock, $x_{(g+1,2)}^{(1j)r}$, is equal to the percentage change in industry's investments in the period, $z^{(2j)r}$.

$$z^{(2j)r} = x_{(g+1,2)}^{(1j)r} + f_{(k)}^{(2j)r}$$

$$j \in H;\ r \in S^{*} \qquad (19)$$

where $f_{(k)}^{(2j)r}$ allows for exogenous shifts in sectoral investments in region *r*.

In the specification of the labor market, Equation (20) defines the regional aggregation of labor prices (wages) across industries. Equation (21) shows movements in regional wage differentials, $wage\_diff^{(r)}$, defined as the difference between the movement in the aggregate regional real wage received by workers, and the national real wage.

$$V(\mathrm{g}+1{,}1,\bullet,\mathrm{r})\left(p_{(g+1,1)}^{(\bullet)r}-a_{(g+1,1)}^{(\bullet)r}\right)=\sum\nolimits_{j\in H}V(\mathrm{g}+1{,}1,(1\mathrm{j}),\mathrm{r})\left(p_{(g+1,1)}^{(1j)r}-a_{(g+1,1)}^{(1j)r}\right)$$

$$r \in S^{*} \qquad (20)$$

where $p_{(g+1,1)}^{(1j)r}$ is the wage in sector j in region *r*, $a_{(g+1,1)}^{(1j)r}$ is a technical term, and $V(\mathrm{g}+1{,}1,(1\mathrm{j}),\mathrm{r})$ represents input-output flows measuring sectoral labor payments in region *r*.

$$wage\_diff^{(r)} = p_{(g+1,1)}^{(\bullet)r} - cpi - natrealwage$$

$$r \in S^{*} \qquad (21)$$

where cpi is the national consumer price index, computed as the weighted average of $p_{(is)}^{(3)r}$ across regions r and consumption goods *(is)*; and $natrealwage$ is the national consumer real wage.

Regional population is defined through the interaction of demographic variables, including interregional migration. Links between regional population and regional labor supply are provided. Demographic variables are usually defined exogenously, and together with the specification of some of the labor market settings, labor supply can be determined together with either interregional wage differentials or regional unemployment rates. In summary, either labor supply and wage differentials determine unemployment rates, or labor supply and unemployment rates determine wage differentials.

Equation (22) defines the percentage-point change in regional unemployment rates in terms of percentage changes in labor supply and employed workers.

$$LABSUP(r)del\_unr^{(r)} = EMPLOY(r)\left(labsup^{(r)} - x_{(g+1,1)}^{(\bullet)r}\right)$$

$$r \in S^* \tag{22}$$

where $del\_unr^{(r)}$ measures percentage-point changes in regional unemployment rate; $labsup^{(r)}$ is the variable for regional labor supply; and the coefficients $LABSUP(r)$ and $EMPLOY(r)$ are the benchmark values for regional labor supply and regional employment, respectively. The variable $labsup^{(r)}$ moves with regional workforce participation rate, proportional to the regional population, and population of working age. Equation (23) defines regional population changes in the model as ordinary changes in flows of net regional migration ($d\_rm^{(r)}$), net foreign migration ($d\_fm^{(r)}$), and natural population growth ($d\_g^{(r)}$).

$$POP(r)pop^{(r)} = d\_rm^{(r)} + d\_fm^{(r)} + d\_g^{(r)}$$

$$r \in S^* \tag{23}$$

where $POP(r)$ is a coefficient measuring regional population in the benchmark year.

Equation (24) shows movements in per-household utility differentials, $util\_diff^{(r)}$, defined as the difference between the movement in regional utility, and the national overall utility (agg_util), including a shift variable, $futil^{(r)}$.

$$util\_diff^{(r)} = utility^{(r)} - agg\_util + futil^{(r)}$$

$$r \in S^* \tag{24}$$

Finally, we can define changes in regional output as weighted averages of changes in regional aggregates, according to Equation (25) below:

$$GRP^r grp^r = C^r x_{(\bullet\bullet)}^{(3)r} + INV^r z^{(2\bullet)r} + GOV^{(5)r} x_{(\bullet\bullet)}^{(5)r} + GOV^{(6)r} x_{(\bullet\bullet)}^{(6)r} + \left(FEXP^r x_{(\bullet\bullet)}^{(4)r} - FIMP^r x_{(\bullet 2)}^{(\bullet)r}\right) + \left(DEXP^r x_{(\bullet(1r))}^{(\bullet)s} - DIMP^r x_{(\bullet(1s))}^{(\bullet)r}\right)$$

$$r \in S^*; s \in S^* \text{ for } s \neq r \qquad (25)$$

where grp^r is the percentage change in real Gross Regional Product in region *r*; and the coefficients GRP^r, INV^r, $GOV^{(5)r}$, $GOV^{(6)r}$, $FEXP^r$, $FIMP^r$, $DEXP^r$, and $DIMP^r$ represent, respectively, the following regional aggregates: investments, regional governments spending, central government spending, foreign exports, foreign imports, domestic exports and domestic imports. National output, GDP, is, thus, the sum of GRP^r across all regions *r*. Notice that regional domestic trade balances cancel out.

To close the model, we set the following variables exogenously, which are usually exogenous both in short run and long run simulations: $a_{(g+1,s)}^{(1j)r}$, $a_{(i)}^{(1j)r}$, $a_{(i)}^{(2j)r}$, $a_{(i\bullet)}^{(3)r}$, $fq_{(is)}^{(4)r}$, $fp_{(is)}^{(4)r}$, $f_{(is)}^{(5)r}$, $f^{(5)r}$, $f^{(5)}$, $f_{(is)}^{(6)r}$, $f^{(6)r}$, $f^{(6)}$, f_i, $f_i^{(u)}$, $f_i^{(u)r}$, $p_{(i(2))}^{(w)}$, $t_{(i(2))}^{(0)}$, $a_{(l1)}^{(0)r}$, $a_{(k)}^{(1j)r}$, $a_{(is)}^{(2j)r}$, $a_{(g+1,1)}^{(\bullet)r}$, ω, $f_{(k)}^{(2j)r}$, $d\_fm^{(r)}$, $d\_g^{(r)}$, and $futil^{(r)}$. To complete the short run environment, used in our forthcoming exercises, we also set unchanged current stocks of capital ($x_{(g+1,2)}^{(1j)r}$), the national real wage ($natrealwage$), regional wage differentials, ($wage\_diff^{(r)}$), and regional population, by keeping regional migration unchanged ($d\_rm^{(r)}$).[4]

There are other definitions of variables computed by using outcomes from simulations based on the system of equations (1)-(25). Of special interest to our discussion is the definition of regional/national GDP and its components, whose results will be reported later on.

[4] In a long run closure, the assumptions on interregional mobility of capital and labor are relaxed by swapping variables $x_{(g+1,2)}^{(1j)r}$, $natrealwage$, $wage\_diff^{(r)}$ and $d\_rm^{(r)}$, for $f_{(k)}^{(1j)r}$, $del\_unr^{(r)}$ and $util\_diff^{(r)}$.

Calibration

The calibration of the model requires two subsets of data to define its numerical structure so that we are able to implement the model empirically. First, we need information from an absorption matrix derived from interregional input-output sources (Table 1) to calculate the coefficients of the model based on the following input-output flows:

- $B(i, 1b, (u), r)$, with $i \in G^*, (u) \in U, b, r \in S^*$
- $M(i, s, (u), r)$, with $i \in G^*, s \in S, (u) \in U, r \in S^*$[5]
- $T(i, s, (u), r)$, with $i \in G^*, s \in S, (u) \in U, r \in S^*$
- $V(i, s, (u), r)$, with $i \in G^*, s \in S, F, (u) \in U, r \in S^*$
- $Y(i, j, r)$, with $i \in G^*, j \in H, r \in S^*$

We complete this information with supplementary demographic data from the Colombian National Department of Statistics (DANE) to calibrate the coefficients $LABSUP(r)$, $EMPLOY(r)$ and $POP(r)$, with $r \in S^*$. Because these estimates are based on snapshot observations for a single year revealing the economic structure of the economic system, this subset of data is denoted "structural coefficients" (Haddad et al., 2002).

The second piece of information, necessary to calibrate the model, is represented by the subset of data defining various parameters, mainly elasticities. These are called "behavioral parameters". Empirical estimates for some of the parameters of the model are not available in the literature. We have thus relied on "best guesstimates" based on usual values employed in similar models. We set to 2.0 the values for both regional trade elasticities, $\sigma 1_{(i)}^{(u)r}$ in Equation (1) and international trade elasticities, $\sigma 2_{(i)}^{(u)r}$ in Equation (2), in the manufacturing sector and to 1.0 in

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[5] In the presentation of the model, we have included margin-commodities, $M(i, s, (u), r)$, in $B(i, 1b, (u), r)$.

the other sectors. Substitution elasticity between primary factors, $\sigma 3_{(g+1)}^{(1j)r}$ in Equation (3) was set to 1.0. The current version of the model runs under constant returns to scale, so that we set to 1.0 the values of $\mu_{(g+1,\bullet)}^{(1j)r}$ in Equation (4). The marginal budget shares in regional household consumption, $\beta_{(i)}^{r}$ in Equation (6), were calibrated from the input-output data, assuming the average budget share to be equal to the marginal budget share, and the subsistence parameter $\gamma_{(i)}^{r}$, also in Equation (6), was associated with a Frisch parameter equal to -3.0. We have set to -2.0 the export demand elasticities, $\eta_{(is)}^{r}$ in Equation (8). The ratio of gross to net rate of return, $\psi_{(j)}^{r}$ in Equation (15), was set to 1.0. Finally, we set to 4.0 the parameter for sensitivity of capital growth to rates of return, $\varepsilon_{(j)}^{r}$ in Equation (17).

Table 1.
Aggregate Flows in the Absorption Matrix: Colombia, 2012
(values in current Pesos billions)

LABELS	User (1j)^r	User (2j)^r	User (3)^r	User (4)	User (5)^r	User (6)^r	User (7)	TOTAL
i G, s S*	B(i,1b,(1j),r)	B(i,1b,(2j),r)	B(i,1b,(3),r)	B(i,1b,(4))	B(i,1b,(5),r)	B(i,1b,(6),r)	B(i,1b,(7))	B(i,1b,(•),•)
i G, s S-S*	B(i,2,(1j),r)	B(i,2,(2j),r)	B(i,2,(3),r)	B(i,2,(4))	B(i,2,(5),r)	B(i,2,(6),r)	B(i,2,(7))	B(i,2,(•),•)
i G, s S	M(i,s,(1j),r)	M(i,s,(2j),r)	M(i,s,(3),r)	M(i,s,(4))	M(i,s,(5),r)	M(i,s,(6),r)	-	M(i,s,(•),•)
i G, s S	T(i,s,(1j),r)	T(i,s,(2j),r)	T(i,s,(3),r)	T(i,s,(4))	T(i,s,(5),r)	T(i,s,(6),r)	-	T(i,s,(•),•)
s F	V(g+1,s,(1j),r)	-	-	-	-	-	-	V(g+1,s,(•),•)
TOTAL	Y(•,•,r)	V(•,•,(2j),r)	V(•,•,(3),r)	V(•,•,(4))	V(•,•,(5),r)	V(•,•,(6),r)	V(•,•,(7))	V(•,•,(•),•)

2012	User (1j)^r	User (2j)^r	User (3)^r	User (4)	User (5)^r	User (6)^r	User (7)	TOTAL
i G, s S*	384,903	133,785	306,341	95,927	62,174	45,126	-1,726	1,026,536
i G, s S-S*	60,172	13,440	44,509	-	1,017	106	-	119,244
i G, s S	34,520	7,254	34,753	4,928	474	343	-	82,272
i G, s S	22,825	4,699	21,062	2,255	63	188	-	51,092
s F	606,388	-	-	-	-	-	-	606,388
TOTAL	1,108,808	159,178	406,665	103,110	63,728	45,763	-1,726	1,885,532

Source: Haddad, E. A. et al. (2018)

4. Fiscal Transfer Scenarios

What if existing transfers (SGP) were redistributed according to regional population, regional poverty or regional fiscal gap? Let us first define the scenarios of interregional transfers in the context of our model specification. We depart from the benchmark values $V(\bullet,\bullet,(5),r)$, which refer total expenditures of regional governments, $GOV^{(5)r}$ in Equation (25). We assume that transfers from the central government are used to finance part of regional governments spending in region r, so that we can isolate intergovernmental transfers from $GOV^{(5)r}$, for each r. Information for expenditures and transfers (SGP) of *Municipios* and *Departamentos*, obtained from a panel built by the Center for Economic Development Studies (CEDE) and the Ministry of Finance, were aggregated for each Department and their respective shares in total regional governments expenditures were calculated for each region r. These shares were then applied to regional government expenditures in the CEER model ($GOV^{(5)r}$) in order to estimate transfers to be redistributed.

We have reallocated the estimated transfers for each department according to different parameters for the three scenarios discussed below. With that information, we could calculate the size of the "shock" by imposing regional-specific changes in $f^{(5)r}$, the shift term for government expenditures in region r, that are proportional to changes in $GOV^{(5)r}$ according to each redistribution scheme.

In order to evaluate the impact of interregional transfers in Colombia, our simulations are carried out under the two standard closures described above, referring to short-run and long-run. The simulations with the CEER model capture the effects in a comparative-static framework. The distinction between the short-run and the long-run closures are thus related to the treatment of capital stocks and labor mobility.

4.1. Fiscal Scenarios

Colombia has large regional disparities in terms of per capita income, social services, and infrastructure (Rueda, 2004). This heterogeneity affects the tax-raising capacity and the provision of public services across different regions. Thus, regional policy has been formulated to fight these disparities, either through transfers to territorial entities or through public expenditures executed directly by the central government. In this sense, interregional transfers during the 2000s accounted for 52.0% to 58.0% of the Colombian central government spending (Bird, 2012).

However, such redistributive policies face several problems, mainly because the criteria on which resources are distributed are not just efficiency or equity, but there are various interests associated with lobbying groups (Rueda, 2004). Thereby, there is an extensive discussion about the efficiency related to the decentralization of public spending in Colombia (Bonet, 2006; World Bank, 2009; Bonet and Ayala–García, 2015; Lozano and Julio, 2016). Nevertheless, if transfers are considered as an important mechanism to reduce regional economic disparities in Colombia, an active policy based on the decentralization of public expenditures may be part of the central government actions. In this sense, this study contributes to this debate by the analysis of three different scenarios of redistribution of Colombia's interregional government transfers using the CEER model.

In the current distribution of the subnational transfers, Bogotá, Valle del Cauca and Antioquia receive the highest share (Figure 1).[6] As those are the main economies of the country, it seems that the resources are mainly transferred to the more prosperous areas. In what follows, we propose different stylized scenarios in which the prevalent regional gaps may be potentially reduced by means of a change in the way transfers are distributed among the Colombian departments.

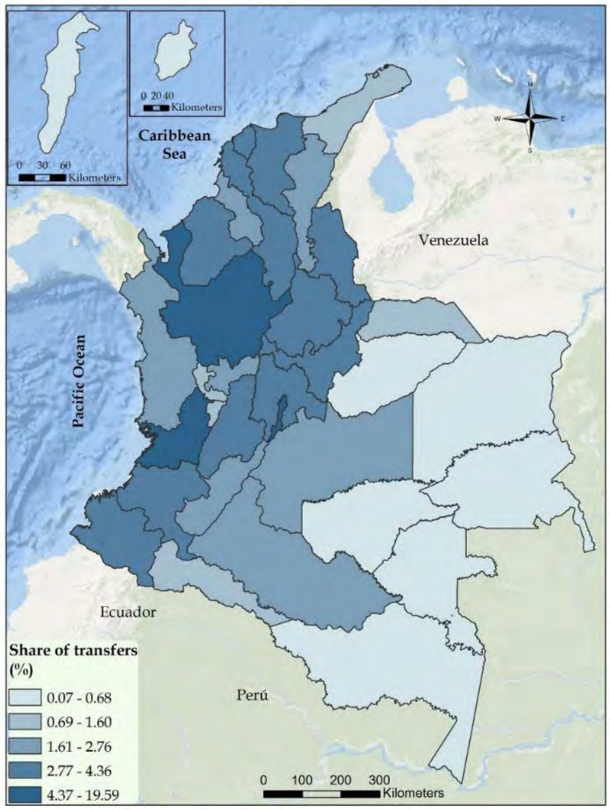
[6] The benchmark shares are available in the Appendix, Table A.1.

When defining the scenarios, we have taken into account previous literature that has dealt with this topic. Zapata and Concha (2016) study the current distribution of transfers among the municipalities in Colombia and show that there are some criteria that may incentive the local authorities to improve in terms the socioeconomic indicators of the municipality, as well as some that reduce such incentives. The latter incentives are related to fiscal laziness. In this case the size of the population is among the criteria that provides incentives for mayors to improve coverage of basic services. On the contrary, poverty is among the criteria that induces fiscal laziness.

Thus, the first scenario takes into account the share of the population of each department. In that case, the transfers are proportional to the size of the population of each administrative unit. This means that most populous departments such as Bogotá, Antioquia, Valle, and Atlántico, are the ones with the highest share in the redistribution of transfers. Since these departments are the main economies in the country in terms of the generation of regional product, with higher potential to exploit agglomeration economies in the main urban areas, this suggests that this scenario follows a redistributive criterion that is more closely related to efficiency.

Figure 1.

Benchmark shares of transfers from the Central Government in 2012



Source: Calculations by the authors based on budget execution reports from National Planning Department of Colombia.

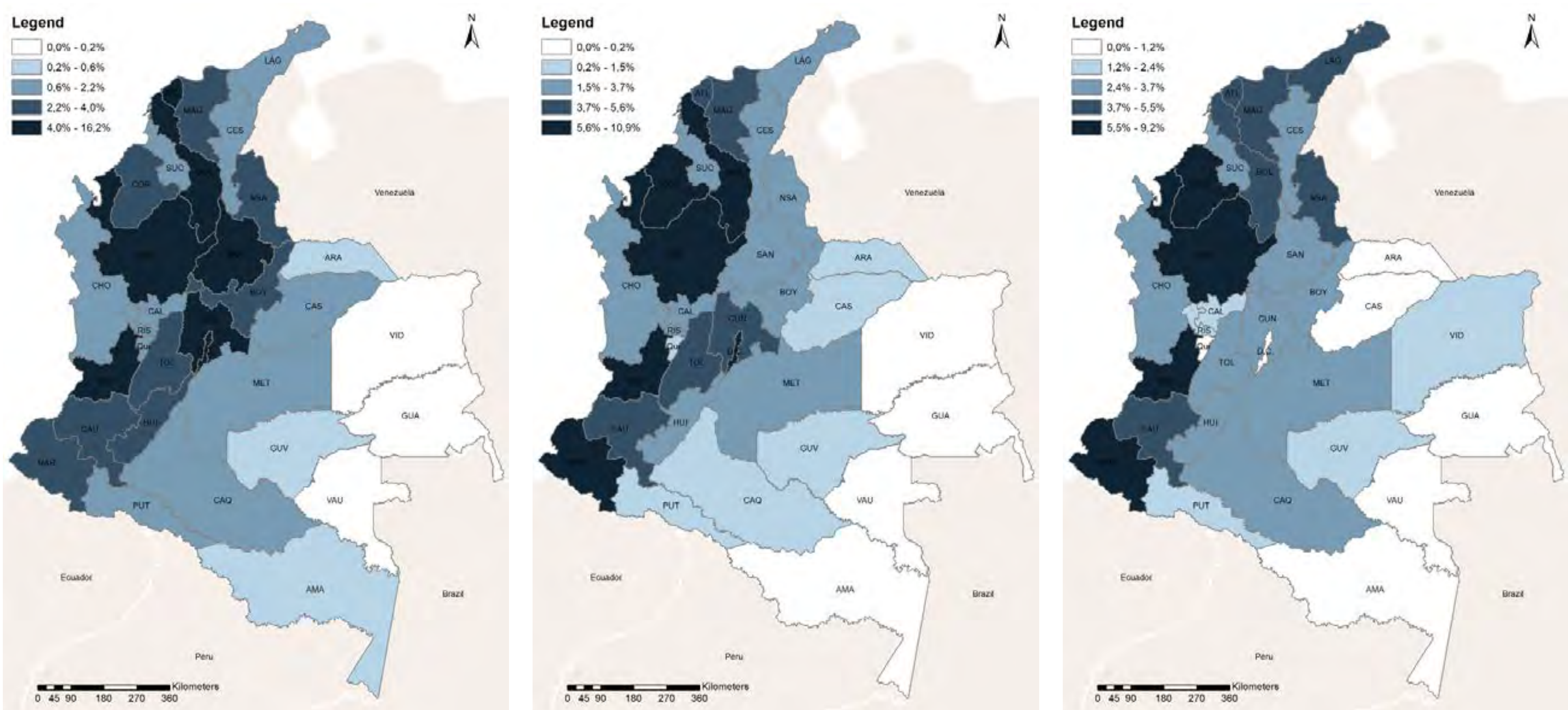
We also simulate two alternative scenarios to compare to the efficiency one, using redistributive criteria that target regional disparities in the country. In this case, the way we define the shares used are more consistent with equity criteria. The first "equity" scenario takes into account the share of impoverished people of each administrative unit. Note that this is not based on the poverty rates. In this case, departments with the highest participation on the number of poor inhabitants receive the highest amount of transfers. This is an intermediate scenario that goes beyond the share of population, taking into account the needs of each administrative unit to redistribute resources to the most needed population.

The last scenario is built using a measure of the fiscal gaps in terms of horizontal equity. The calculations were done employing the results of a measure of the horizontal fiscal disparities by Bonet and Ayala-García (2017). Shares are calculated as follow. First, the authors obtain the per capita spending needs in a given administrative unit, according to the spending groups (water, education, health, housing etc.). Once they have the per capita values, the total expenditures are calculated using the population for each municipality. Next, the authors use the Data Envelopment Analysis (DEA) to calculate the potential revenues for each municipality. The comparison of potential revenues with the spending needs corresponds to the fiscal gaps. The results of the work by Bonet and Ayala-García show that the poorest municipalities are the ones with the largest fiscal gaps. We employ a measure of the share of the needs to propose the scenario of equity in the redistribution of central government transfers.

The following maps depict the three scenarios discussed previously. In relation to population share (Figure 2a), we can highlight the importance of departments such as Valle, Cundinamarca, Antioquia, Santander (along the Andean Mountains) Bolívar, and Atlántico (in the Caribbean coast) and the capital city of Bogotá. Notice that when using the extreme poverty shares, there are more departments in the Caribbean and the Pacific that end up with higher weight in the distribution (Figure 2b) – those are the most impoverished areas in the country. Calculations for the shares to be assigned to the departments, following fiscal gap considerations, are shown in (Figure 2c). In this case, Córdoba, Antioquia, Valle, and Nariño are the ones that would receive the highest shares of transfers.

Figure 2. **Simulated shares of transfers from the Central Government**

(a) **Population share** **(b)** **Extreme poverty share** **(c)** **Fiscal gap share**



Source: Calculations by the authors.

4.2. Shocks representation in each scenario

Tables 2-4 show the current share of the distributed resources as well as the proposed scenarios following the population, extreme poverty or horizontal fiscal gap criteria. For example, Table 2, column (A), shows the current amount of regional expenditures for each Colombian Department. Column (B) shows how much of those expenditures come from SGP resources, transferred from the CNG. If we take the total amount of SGP and redistribute it based on the population share, we obtain column (C). This means that Antioquia would receive 3,766.56 million COP instead of receiving 2,438.30 million COP. In such case, there is a net transfer redistribution of 1,328.26 million COP that is shown in column (D).

In order to apply the shock to the spatial CGE model, we have calculated the proportion of the original amount in $GOV^{(5)r}$ that represents the new amount to be redistributed. Thus, we have calculated the ratio of column (D) over column (A) in the last column of Table 2. The numbers of this column represent, for instance, that on top of the current regional government expenditures, Antioquia would receive 18.98% more transfers, if we redistribute the SGP resources based on population shares. Analogously, we may read Tables 3 and 4; however, based on extreme poverty and horizontal fiscal gap, respectively.

As we can see from Table 2, changing the current distribution to the population criterion implies that local economies such as Atlántico, La Guajira, Antioquia, Risaralda, and Vaupés are those with more direct benefits. This seems to be good news for some of those economies, which are also located in the poorest regions of the country, but we can notice as well that other poorer departments would experience a reduction in transfers, such as Chocó, Sucre, Amazonas, Vichada, among others.

When using the extreme poverty criterion, the main recipients of the shock in the redistribution of transfers are the departments of La Guajira, Cauca, Córdoba, Chocó, and Huila. From an equity perspective, it is favorable to find out that La Guajira (the poorest department in the Caribbean coast) and Chocó (the poorest in the Pacific) are among the more benefited departments based on such criterion of redistribution (Table 3).

The last scenario is the one related to the needs of the departments in relation to fiscal gap. In this case, the region that is more privileged in terms of the redistribution of transfers is the New Departments. In this sense, the departments of Vaupés, Guainía, Amazonas, and Guaviare from the Amazon region are among the most important receivers of transfers (Table 4).

Table 2.

Scenario 1: Subnational transfers based on population, 2012 (Billions COP)

Region	Department	BAS5	Transfers to be redistributed	Transfer redistribution based on the population share	Net transfer redistribution based on the population share	Shock (f5gen)
		(A)	(B)	(C)	(C) - (B) = (D)	(D)/(A)*100
D1	Antioquia	6997.49	2438.30	3766.56	1328.26	18.98
D2	Atlántico	2066.11	984.82	1436.90	452.08	21.88
D3	Bogotá, D.C.	20615.79	5525.26	4583.54	-941.72	-4.57
D4	Bolívar	1877.53	1199.59	1226.24	26.65	1.42
D5	Boyacá	1507.04	898.49	769.52	-128.97	-8.56
D6	Caldas	901.54	507.88	594.61	86.73	9.62
D7	Caquetá	767.40	639.59	278.18	-361.41	-47.10
D8	Cauca	1162.87	885.93	812.81	-73.11	-6.29
D9	Cesar	1007.47	608.89	600.29	-8.61	-0.85
D10	Chocó	712.56	566.90	293.94	-272.96	-38.31
D11	Córdoba	1408.01	958.15	988.37	30.22	2.15
D12	Cundinamarca	2911.02	1229.62	1548.33	318.72	10.95
D13	La Guajira	598.99	400.87	529.42	128.55	21.46
D14	Huila	891.54	575.82	673.15	97.33	10.92
D15	Magdalena	1062.14	820.23	740.91	-79.32	-7.47
D16	Meta	1952.73	606.28	548.96	-57.32	-2.94
D17	Nariño	1557.35	1135.00	1017.52	-117.48	-7.54
D18	Norte de Santander	1270.88	837.35	799.57	-37.78	-2.97
D19	Quindío	537.52	311.64	336.49	24.85	4.62
D20	Risaralda	841.32	450.87	566.58	115.71	13.75
D21	Santander	2068.39	995.15	1229.39	234.24	11.32
D22	Sucre	1139.40	778.48	500.52	-277.97	-24.40
D23	Tolima	1810.21	1110.84	845.13	-265.70	-14.68
D24	Valle del Cauca	4913.10	2493.09	2708.69	215.61	4.39
D25	Amazonas	122.32	82.30	44.62	-37.69	-30.81
D26	Arauca	557.54	273.15	153.50	-119.64	-21.46
D27	Casanare	766.96	192.68	204.55	11.87	1.55
D28	Guainía	61.71	41.30	23.96	-17.35	-28.11
D29	Guaviare	211.33	141.51	64.40	-77.10	-36.48
D30	Putumayo	523.59	354.41	201.74	-152.67	-29.16
D31	Archipiélago de San Andrés	141.93	37.23	45.13	7.89	5.56
D32	Vaupés	49.74	19.31	25.66	6.35	12.77
D33	Vichada	176.30	98.78	40.51	-58.27	-33.05
Total		**63189.83**	**28199.71**	**28199.71**	**0.00**	

Note: In the CEER Model, BAS5 is the total expenditures of regional governments, $GOV^{(5)r}$; and *f5gen* is in the shift term for government expenditures in region r, $f^{(5)r}$.

Source: Calculations by the authors.

Table 3.

Scenario 2: Subnational transfers based on extreme poverty, 2012 (Billions COP)

Region	Department	BAS5	Transfers to be redistributed	Transfer redistribution based on the extreme poverty share	Net transfer redistribution based on the extreme poverty share	Shock (f5gen)
		(A)	(B)	(C)	(C) - (B) = (D)	(D)/(A)*100
D1	Antioquia	6997.49	2438.30	2933.57	495.27	7.08
D2	Atlántico	2066.11	984.82	649.37	-335.45	-16.24
D3	Bogotá, D.C.	20615.79	5525.26	881.45	-4643.81	-22.53
D4	Bolívar	1877.53	1199.59	1556.38	356.79	19.00
D5	Boyacá	1507.04	898.49	813.91	-84.58	-5.61
D6	Caldas	901.54	507.88	594.61	86.73	9.62
D7	Caquetá	767.40	639.59	272.83	-366.76	-47.79
D8	Cauca	1162.87	885.93	2657.28	1771.35	152.33
D9	Cesar	1007.47	608.89	923.52	314.62	31.23
D10	Chocó	712.56	566.90	1150.32	583.42	81.88
D11	Córdoba	1408.01	958.15	2594.46	1636.31	116.21
D12	Cundinamarca	2911.02	1229.62	937.93	-291.69	-10.02
D13	La Guajira	598.99	400.87	1410.10	1009.23	168.49
D14	Huila	891.54	575.82	1074.45	498.63	55.93
D15	Magdalena	1062.14	820.23	1239.60	419.37	39.48
D16	Meta	1952.73	606.28	485.62	-120.66	-6.18
D17	Nariño	1557.35	1135.00	1682.82	547.82	35.18
D18	Norte de Santander	1270.88	837.35	822.64	-14.72	-1.16
D19	Quindío	537.52	311.64	391.50	79.86	14.86
D20	Risaralda	841.32	450.87	348.67	-102.21	-12.15
D21	Santander	2068.39	995.15	543.77	-451.38	-21.82
D22	Sucre	1139.40	778.48	611.21	-167.28	-14.68
D23	Tolima	1810.21	1110.84	1243.32	132.49	7.32
D24	Valle del Cauca	4913.10	2493.09	1927.34	-565.75	-11.52
D25	Amazonas	122.32	82.30	25.14	-57.16	-46.73
D26	Arauca	557.54	273.15	86.49	-186.66	-33.48
D27	Casanare	766.96	192.68	115.25	-77.43	-10.10
D28	Guainía	61.71	41.30	13.50	-27.80	-45.06
D29	Guaviare	211.33	141.51	36.29	-105.22	-49.79
D30	Putumayo	523.59	354.41	113.67	-240.74	-45.98
D31	Archipiélago de San Andrés	141.93	37.23	25.43	-11.81	-8.32
D32	Vaupés	49.74	19.31	14.46	-4.85	-9.75
D33	Vichada	176.30	98.78	22.83	-75.96	-43.08
Total		**63189.83**	**28199.71**	**28199.71**	**0.00**	

Note: In the CEER Model, BAS5 is the total expenditures of regional governments, $GOV^{(5)r}$; and *f5gen* is in the shift term for government expenditures in region *r*, $f^{(5)r}$.

Source: Calculations by the authors.

Table 4.

Scenario 3: Subnational transfers based on horizontal fiscal gap, 2012 (Billions COP)

Region	Department	BAS5	Transfers to be redistributed	Transfer redistribution based on the fiscal gap share	Net transfer redistribution based on the fiscal gap share	Shock (f5gen)
		(A)	(B)	(C)	(C) - (B) = (D)	(D)/(A)*100
D1	Antioquia	6997.49	2438.30	2593.92	155.62	2.22
D2	Atlántico	2066.11	984.82	1279.67	294.85	14.27
D3	Bogotá, D.C.	20615.79	5525.26	0.00	-5525.26	-26.80
D4	Bolívar	1877.53	1199.59	1438.76	239.17	12.74
D5	Boyacá	1507.04	898.49	857.72	-40.77	-2.71
D6	Caldas	901.54	507.88	586.57	78.69	8.73
D7	Caquetá	767.40	639.59	940.73	301.14	39.24
D8	Cauca	1162.87	885.93	1438.76	552.83	47.54
D9	Cesar	1007.47	608.89	968.40	359.50	35.68
D10	Chocó	712.56	566.90	850.81	283.91	39.84
D11	Córdoba	1408.01	958.15	1618.61	660.46	46.91
D12	Cundinamarca	2911.02	1229.62	802.39	-427.23	-14.68
D13	La Guajira	598.99	400.87	1113.66	712.79	119.00
D14	Huila	891.54	575.82	899.23	323.40	36.27
D15	Magdalena	1062.14	820.23	1238.16	417.94	39.35
D16	Meta	1952.73	606.28	892.31	286.03	14.65
D17	Nariño	1557.35	1135.00	1701.61	566.61	36.38
D18	Norte de Santander	1270.88	837.35	1113.66	276.30	21.74
D19	Quindío	537.52	311.64	328.56	16.92	3.15
D20	Risaralda	841.32	450.87	504.95	54.08	6.43
D21	Santander	2068.39	995.15	760.88	-234.27	-11.33
D22	Sucre	1139.40	778.48	947.65	169.16	14.85
D23	Tolima	1810.21	1110.84	919.98	-190.86	-10.54
D24	Valle del Cauca	4913.10	2493.09	1584.02	-909.06	-18.50
D25	Amazonas	122.32	82.30	268.38	186.08	152.13
D26	Arauca	557.54	273.15	290.52	17.37	3.12
D27	Casanare	766.96	192.68	298.82	106.14	13.84
D28	Guainía	61.71	41.30	214.43	173.13	280.56
D29	Guaviare	211.33	141.51	389.43	247.93	117.32
D30	Putumayo	523.59	354.41	473.13	118.72	22.67
D31	Archipiélago de San Andrés	141.93	37.23	0.00	-37.23	-26.23
D32	Vaupés	49.74	19.31	219.96	200.66	403.40
D33	Vichada	176.30	98.78	664.04	565.26	320.62
Total		**63189.83**	**28199.71**	**28199.71**	**0.00**	

Note: In the CEER Model, BAS5 is the total expenditures of regional governments, $GOV^{(5)r}$; and *f5gen* is in the shift term for government expenditures in region r, $f^{(5)r}$.

Source: Calculations by the authors.

5. Simulation Results

In this section we present the results of the simulated scenarios. The changes in local output that may follow if the distribution of transfers changed to any one of the scenarios are displayed in Table 5. To evaluate the spatial distribution of the winners and losers' regions, we plot the results on the Appendix for each department in the short-run (Figure A.1) as well as in the long-run (Figure A.2). In this case, we have calculated the results of the redistribution of transfers under the two closures of the model.

5.1. Effects of redistribution of transfers on gross regional product

The results of the simulations point that, on one hand, in short-run Colombia shows a decrease in national GDP in all redistribution scenarios. On the other hand, in the long-run, only in the first scenario we foresee overall growth. This means that if we privileged the redistributive scenario in which more transfers are assigned progressively with poverty rates or fiscal gap, the Colombia's general economy would perceive a potential decrease in GDP.

The results for the three scenarios also allow us to evaluate the impact of redistribution of interregional transfers in terms of regional inequalities. In the short run, all regions that receive more transfers present a positive impact on the regional product. Nevertheless, in the long run, some regions that foresee increases in transfers also show a reduction in regional product (Figures A.3. and A.4 in Appendix). This reduction in GRP is justified by the competition between regions for resources. The free mobility of the factors of production in the long run allows changes in the distribution of the stock of capital and the labor force, which affects the marginal returns of these factors. Therefore, some regions which receive more transfers may lose factors of production for the other regions since they have less competitive advantages; thus, they may face potential reductions in GRP. Henkel et al. (2018) have also found that changes in the distribution of fiscal transfers in Germany would drive a process of migration from less productive to more productive regions. This would affect the allocation of productive resources and regional growth.

Table 5.

Effect on Gross Regional Product (in percentage change)

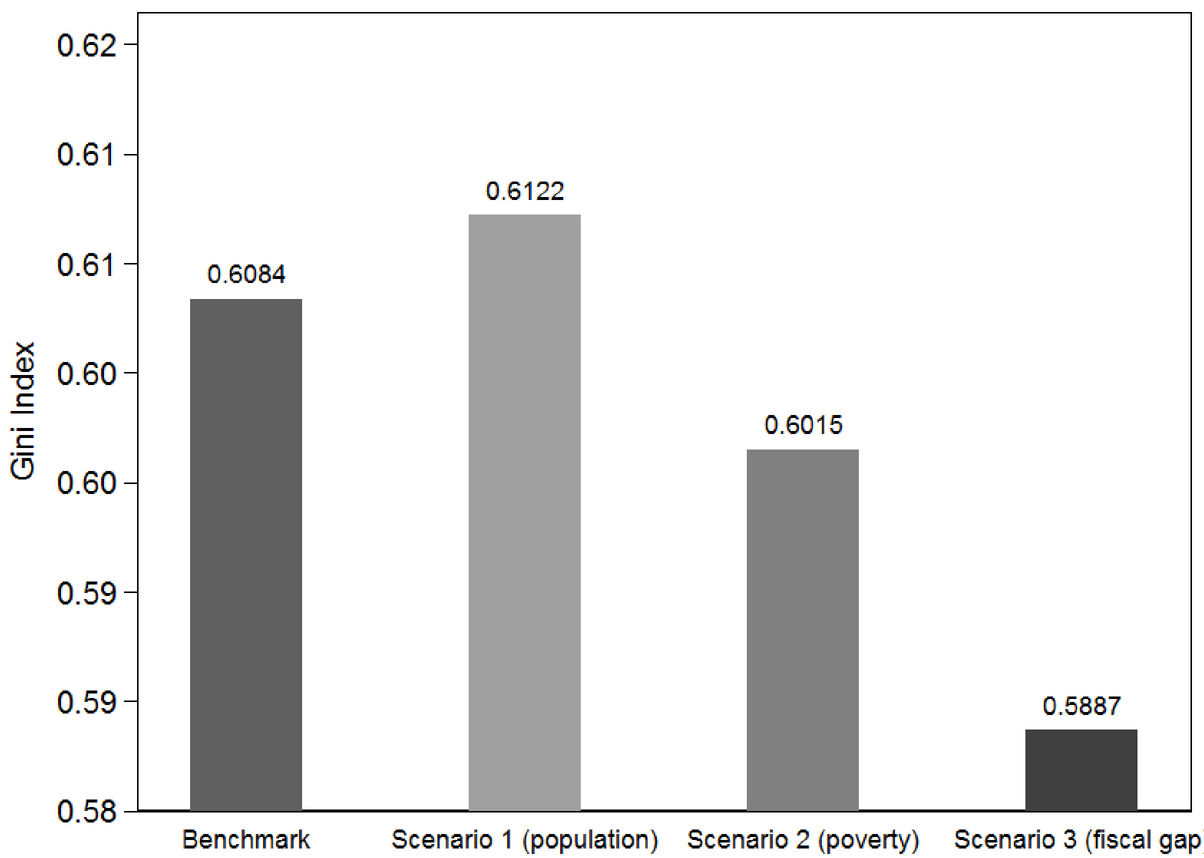
Region	Department	Scenario 1		Scenario 2		Scenario 3	
		Short-run	Long-run	Short-run	Long-run	Short-run	Long-run
D1	Antioquia	1.305	5.508	0.915	5.547	0.345	1.813
D2	Atlántico	1.197	3.958	-0.453	-1.831	1.195	4.020
D3	Bogotá, D.C.	-0.442	-1.726	-2.189	-9.321	-2.574	-10.110
D4	Bolívar	0.144	1.933	0.875	-1.568	0.773	1.178
D5	Boyacá	-0.592	-1.562	-0.860	-8.543	-0.719	-7.298
D6	Caldas	0.663	1.563	0.378	-2.069	0.298	-2.683
D7	Caquetá	-7.782	-17.913	-8.036	-19.254	6.172	11.398
D8	Cauca	-0.731	-3.015	12.764	27.405	3.814	7.006
D9	Cesar	-0.029	1.123	1.248	-5.136	1.533	-0.779
D10	Chocó	-5.854	-10.587	11.744	18.370	5.346	6.772
D11	Córdoba	0.673	4.936	7.905	16.464	3.161	6.106
D12	Cundinamarca	0.430	-0.123	-1.293	-9.492	-1.647	-10.023
D13	La Guajira	0.969	3.370	7.552	7.593	5.328	7.498
D14	Huila	0.317	-0.391	2.219	1.049	1.269	-0.711
D15	Magdalena	-0.299	1.455	2.700	3.275	2.902	6.734
D16	Meta	-0.100	1.386	-0.259	-10.595	0.422	-5.086
D17	Nariño	-1.214	-4.981	3.723	8.719	4.137	10.211
D18	Norte de Santander	-0.259	-0.298	-0.368	-6.101	1.500	0.712
D19	Quindío	0.268	0.111	0.778	-1.029	-0.062	-4.016
D20	Risaralda	0.857	1.682	-0.788	-3.811	0.200	-2.943
D21	Santander	0.447	1.297	-1.001	-5.599	-0.511	-2.935
D22	Sucre	-3.473	-6.450	-2.291	-6.489	1.981	4.023
D23	Tolima	-1.241	-3.062	0.114	-5.078	-1.395	-8.118
D24	Valle del Cauca	0.151	-0.663	-0.591	-2.504	-1.211	-5.162
D25	Amazonas	-7.304	-16.537	-11.530	-29.889	35.953	79.921
D26	Arauca	-1.345	1.412	-2.178	-8.713	0.160	-4.595
D27	Casanare	0.022	1.595	-0.402	-11.171	0.382	-5.647
D28	Guainía	-6.434	-13.933	-10.952	-27.854	62.419	135.093
D29	Guaviare	-10.077	-24.830	-14.200	-38.329	31.603	74.454
D30	Putumayo	-3.244	-4.547	-4.589	-12.899	2.590	1.424
D31	Archipiélago de San Andrés	0.868	2.043	-1.215	-3.478	-4.172	-12.522
D32	Vaupés	2.879	7.740	-4.335	-15.157	100.989	282.631
D33	Vichada	-14.408	-35.443	-19.293	-51.795	138.809	350.552
COLOMBIA		-0.021	0.358	-0.037	-3.339	-0.034	-2.787

Source: Calculations by the authors.

Are the aggregate growth outcomes accompanied by equity gains? To address this issue, we calculate, for each scenario, the long-run Locational Gini Index. Compared to the benchmark, we observe in scenarios 2 and 3 a reduction in the concentration of output among the Colombian regions (Figure 3). It is worth mentioning that this change in output concentration, and the consequent reduction in regional disparities, occur only partly due to the higher growth of the poorer regions. Part of this outcome is related to the negative growth effect in richer regions. Thus, the result of this redistributive policy, while having positive effects in terms of equity, may undermine national growth in the long run.

Figure 3.

Locational Gini Index under the alternative scenarios



Source: Calculations by the authors.

These results suggest a trade-off between encouraging economic activity in peripheral regions and limiting the growth of other regions. However, when we look at national welfare, measured in terms of equivalent variation, and income concentration in relation to our benchmark specification, we have found that the trade-off can be compensated by an increase in national welfare. In our counterfactual scenario based on extreme poverty, the income concentration decreased by 1.13% and the national welfare increased by 0.10% (Table 6). When transfers are redistributed based on the fiscal gap, the income concentration decreased by 3.23% and welfare increased by 0.04%. These results are consistent with the findings of Royuela and García (2015) that after interregional transfers policies, although rich regions remain rich in production terms (GDP), the new income is more equally distributed over time, which reduces regional inequalities. Finally, in the counterfactual scenario based on population, the national GDP would increase by 0.36%, however, welfare decreases by 0.01%, and income concentration in relation to our benchmark specification increases 0.63%. Henkel et al. (2018) also found a similar result, where abolishing fiscal equalization, by fiscal transfers, may increase national GDP but not welfare.

Table 6.

Long-run effects under the alternative scenarios (in % change)

Scenario	*National GDP*	*Locational Gini Index*	*Relative equivalent variation*
(1) Population	0.358	0.625	-0.014
(2) Extreme poverty	-3.339	-1.134	0.100
(3) Fiscal gap	-2.787	-3.238	0.041

Note: Equivalent variation is measured by the ratio of the equivalent variation to pre-shock regional household disposable income.

Source: Calculations by the authors.

The Bogotá region exerts a marked economic polarization in the production of the other Colombian departments (Bonet and Meisel, 2008). Per capita income in Bogotá is more than the double of the national average and more than eight times per capita income of Chocó, the poorest Colombian department. Furthermore, Colombia has experienced a process of polarization in per capita departmental production (Vásquez and Bara, 2009; Royuela and García, 2015), which has increased during the 1990s (Barón, 2003). Some economic policies established in the 1990s (deregulation and economic openness) have strengthened agglomeration forces around the main departments, Bogotá, Antioquia and Valle; further, those policies have not presented a positive impact on disparities reduction among the Colombian departments (Vásquez and Bara, 2009). Such spatial dynamics led to further concentration of the population (26,4%) and economic activity (37.0%) in the major cities, Bogotá, Medellin and Cali, the capitals of three departments mentioned above (Royuela and García, 2015), hence calling for policies aiming at addressing regional inequality in the country.

In spite of its negative impacts on regional inequality, increasing spatial concentration was also able to generate gains from agglomeration economies. In this perspective, Duranton (2016a) shows the relevance of the production structure concentration in some Colombian cities for the country's economic growth. The author also stresses the importance of investing in urban infrastructure, such as water, roads, schools or sanitation, to take advantage of the dynamism of these cities that concentrate a large share of the population. Duranton (2016b) presents the mechanisms related to the generation of these benefits originating from the effects of agglomeration economies for Colombia.

Thus, the role of regional development policies is to devise strategies to boost local economic growth, but without losing the externalities created by agglomeration economies. Therefore, the three scenarios proposed in our study allow us to evaluate the impact of different redistributive policies on the performance of each Colombian department. In this way, they may help policy makers with the formulation of strategies which takes into account potential regional equity-efficiency trade-offs.

Thereby, our results are similar to Lozano and Julio (2016), which identified the effects of fiscal decentralization in Colombia on regional economic growth, and Bonet (2006), which identified that the Colombian fiscal decentralization process increased regional income disparities. Bonet and Meisel (2008) have also stressed that decentralization policies had not presented a positive impact on regional inequalities in terms of long run trends. During the period that the decentralization policy was strengthened, the income concentration increased in Bogotá.

However, Royuela and García (2015) have found a process of regional convergence of real household disposable income, in spite of regional per capita GDP having remained concentrated in Colombia. Transfers through regional remittances were identified by the authors as having a key role in this process. The authors conclude that the major redistribution policies affecting the country's health and education facilities, together with the expansion of its transport infrastructure, may have contributed to balance regional social growth.

Baskaran et al. (2017), analyzing the German regions, have also identified that intergovernmental transfers are harmful for economic growth. Nonetheless, Juben (2006) have found evidence for Germany that the fiscal transfer system achieves a substantial reduction of long term disparities between regions.

The apparent regional concentration in the production structure, as well as in income, can be justified by how the departments manage the received resources. Departments in Colombia have resources earmarked and most of them are allocated to payroll from education and health services or to cover health expenditures from people in the subsidized health system. Thus, they may be allocated as current expenditures, rather than as capital expenditures in the form of investment or infrastructure (Bird, 2012; Bonet and Ayala-García, 2015).

Therefore, the long run trend in the increase in income disparities may be the result of the absence of adequate incentives to promote the efficient use of these resources by the regional governments (Bonet, 2006), which could promote productivity gains in regions benefitted by the transfers from the Central government. [7]

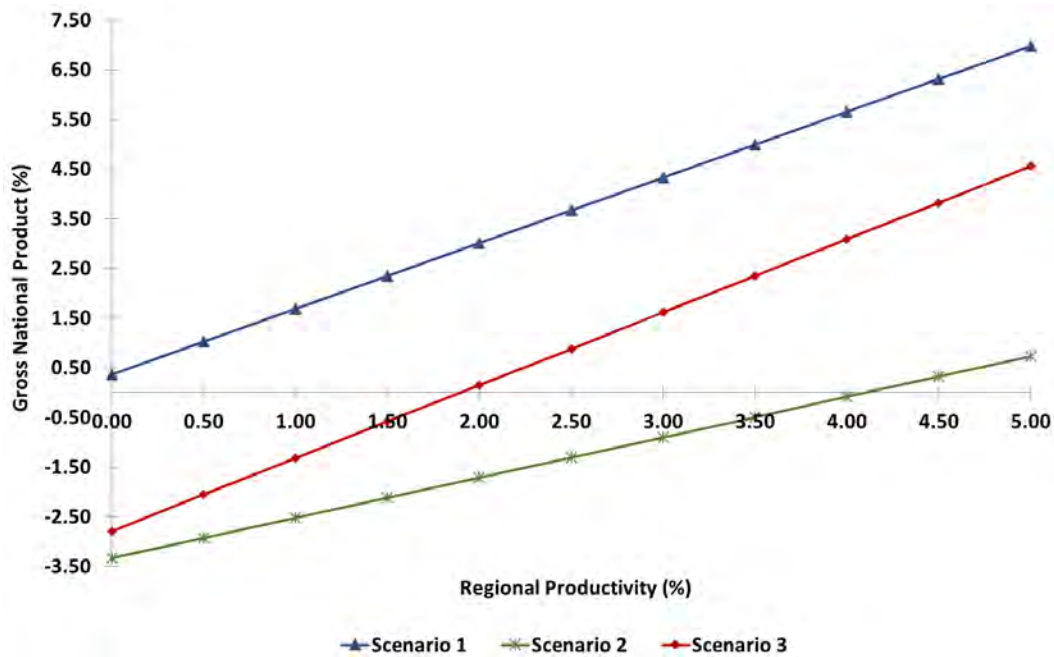
From this perspective, we look at our scenarios considering that the redistribution of transfers to be accompanied by productivity gains. Thus, we assume counterfactual scenarios where the increase in local resources received through transfers is necessarily used for investments that result in productivity gains. In this counterfactual scenarios, we assume the same changes in regional government scenarios as previously; however, we also assume uniform increases in productivity in the use of primary production factors for those regions that increase their resources received through transfers, keeping productivity constant in the remaining regions.

In this context, the results show potential growth in Colombian GDP in long-run for all scenarios after a threshold gain in productivity in the regions that perceive net increases in their transfers. In scenario 1 there is a positive growth for all values of regional productivity (Figure 4). Under Scenario 2 (based on extreme poverty shares), regional productivity should grow at least 4.1% to compensate for the loss in resources that undergo the largest regional economies. In Scenario 3 (based on fiscal gap), the threshold beyond which the growth in regional productivity offsets the losses in regional output is 1.9%.

[7] Kyriacou et al. (2015 and 2016) showed that fiscal decentralization has the potential to reduce income differences across regions but that this potential may not be realized because of governance problems associated with subnational authorities. Rodríguez-Pose (2018) has shown that regional development policies based on fiscal transfers in declining areas may present limited returns, when subject to the measures of populist governments and that, as a consequence, it would be best to invest in more prosperous places.

Figure 4.

Threshold for regional TFP growth that offsets national GDP loss



Source: Calculations by the authors.

5.2. Sensitivity analysis

Qualitative sensitivity analysis is carried out in order to grasp a better understanding on the role played by the introduction of external non-constant returns to scale in the modeling framework. More specifically, the goal is to assess the role played by increasing returns in the manufacturing sector in Bogotá and Cundinamarca, the richest, most industrialized region in Colombia and for which there is evidence that it is the focal point of agglomeration economies in the country (Haddad et al. 2009). In order to test the sensitivity of our results related to the parameter specification, we have hypothetically varied the values for the parameter measuring returns to scale in the Bogotá-Cundinamarca region, $\mu_{(i\bullet)}^{(1j)r}$ in Equation (4), for r equals to Bogotá and

Cundinamarca. This region represents 30.6% of Colombia's GDP in manufacturing.[8] Such concentration of the productive structure can be reinforced by further increases in returns to scale due to the economic externalities originated by agglomeration economies (Haddad and Hewings, 2005; Duranton, 2016b). Thus, we have tested the effect of changes in the degree of returns to scale in Bogotá on regional growth repeating all the simulated scenarios. The stronger the scale economies exhibited by the core region, the better its expected relative performance. We tested these results using the CEER model with a special set of values for the scale economies parameters. We assume constant returns in every sector in every region. The only exception is the manufacturing sector in Bogotá and Cundinamarca, for which we consider an interval in the increasing returns to scale (IRTS) curve, ranging from high increasing returns to decreasing returns to scale in the manufacturing sector. A series of simulations is run for various values of the parameter in the assumed interval. Results are presented in Figure 5 Theoretical results are partially confirmed in the empirical experimentation with the CEER model. As it becomes evident from the aggregate results for Bogotá and Cundinamarca, the further down the IRTS curve, the better the region's performance in terms of GRP growth. However, as noticed before, the core region of Bogotá and Cundinamarca perform below the rest of the Colombia.

The role of spatial dependence is also revealed in Figure 5. On one hand, as economies of scale fade away, the relative performance of the core region is further hampered. On the other hand, the performance of the rest of country go in the opposite direction, indicating spatial competition with Bogotá-Cundinamarca.

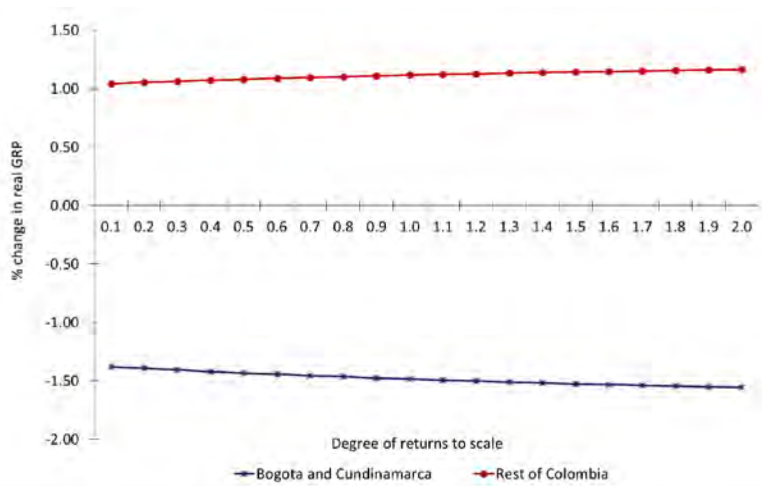
[8] Bonet and Meisel (2008) show that, in 2009, Bogotá concentrated 49% of the income generated by the Government, 68% of that generated by non-financial corporations and 80% of that generated by financial corporations.

Figure 5.

Sensitivity Analysis: effects on gross regional product (GRP) in the long-run

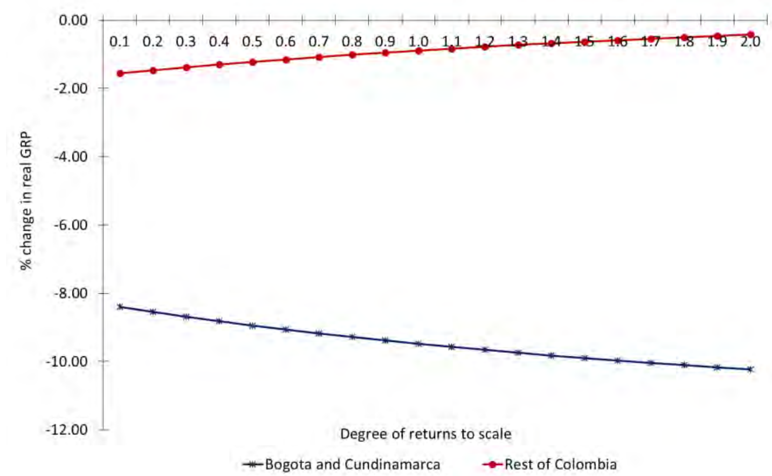
(a)

Scenario 1 (population)



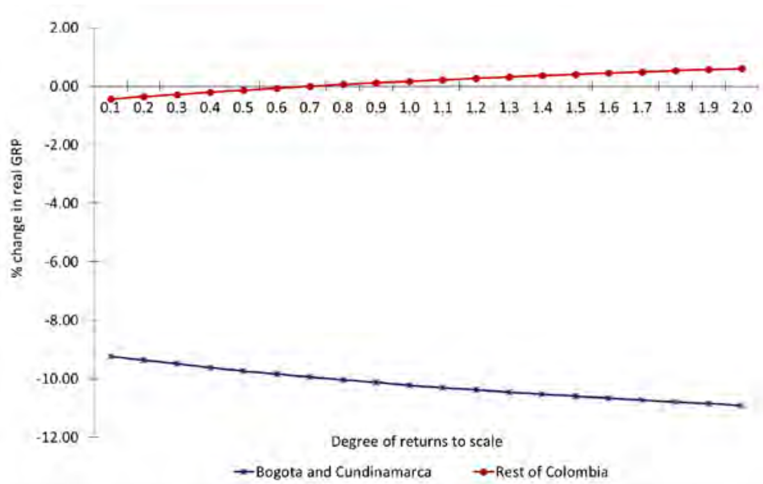
(b)

Scenario 2 (extreme poverty)



(c)

Scenario 3 (fiscal gap)



Source: Calculations by the authors.

6. Concluding Remarks

The Gini index for Colombia is 0.53, which implies that it is the second-most unequal country in Latin America, only surpassed by Honduras (0.537). In order to reduce disparities, decentralization policies have introduced mechanisms to redistribute revenues from the Central National Government (CNG); nonetheless, regional inequalities still persist in the country.

This study has analyzed the effects of different scenarios of regional allocation of the current transfers and their impacts on the Colombian economy. The simulations conducted in this work contribute to the analysis of the growth impact related to some of the broad objectives that central governments pursue when allocating subnational transfers to local governments. We have simulated counterfactual scenarios in which redistributive policies are designed to assess potential GRP outcomes had they been applied to the Colombian economy.

Our results provide quantitative answers that help better understanding how fiscal transfers affect the national economic activity in the Colombian interregional system. The scenarios proposed have suggested that fiscal transfers result in a significant increase in regional GDP in those areas that benefit from net increases in resources, reducing regional disparities in the country.

In spite of the improvement in regional cohesion, the more redistributive scenarios may hamper overall growth. In order to compensate for the potential overall GDP loss, it would be necessary that additional transfers beyond the benchmark values should be directed to long-run TFP-enhancing expenditures. The scenario of redistribution based on fiscal gap is the one that requires a more modest rate of growth in TFP, simultaneously achieving better regional equity outcomes.

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Appendix

Table A.1.

Benchmark shares

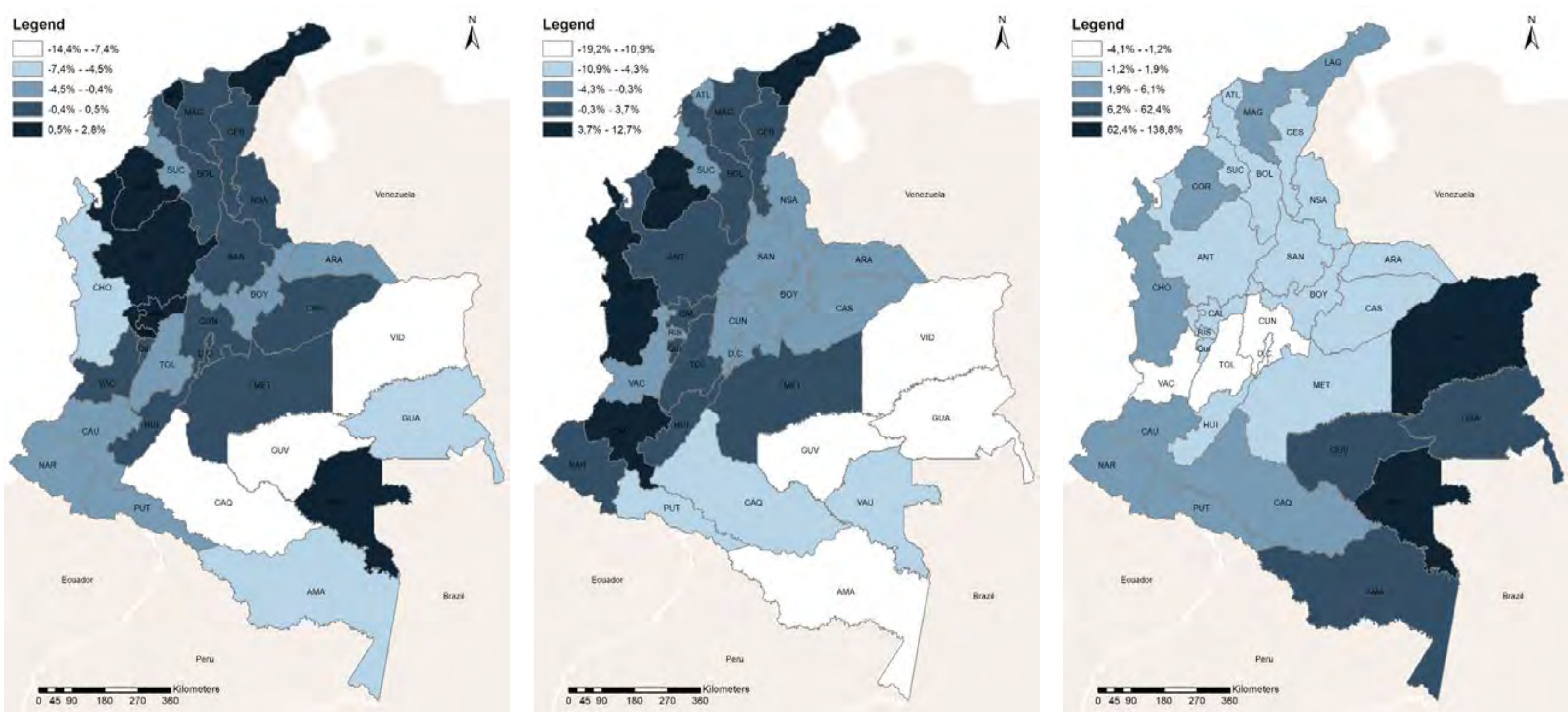
Region	Department	%Transfer	%Pop	%Poverty	%Fiscal Gap
D1	Antioquia	8.647	13.357	10.941	9.198
D2	Atlántico	3.492	5.095	5.289	4.538
D3	Bogotá, D.C.	19.593	16.254	5.770	0.000
D4	Bolívar	4.254	4.348	5.880	5.102
D5	Boyacá	3.186	2.729	2.971	3.042
D6	Caldas	1.801	2.109	2.280	2.080
D7	Caquetá	2.268	0.986	1.269	3.336
D8	Cauca	3.142	2.882	5.470	5.102
D9	Cesar	2.159	2.129	3.049	3.434
D10	Chocó	2.010	1.042	2.166	3.017
D11	Córdoba	3.398	3.505	6.457	5.740
D12	Cundinamarca	4.360	5.491	3.915	2.845
D13	La Guajira	1.422	1.877	3.351	3.949
D14	Huila	2.042	2.387	3.317	3.189
D15	Magdalena	2.909	2.627	4.204	4.391
D16	Meta	2.150	1.947	1.756	3.164
D17	Nariño	4.025	3.608	5.607	6.034
D18	Norte de Santander	2.969	2.835	3.501	3.949
D19	Quindío	1.105	1.193	1.418	1.165
D20	Risaralda	1.599	2.009	1.747	1.791
D21	Santander	3.529	4.360	2.768	2.698
D22	Sucre	2.761	1.775	2.794	3.360
D23	Tolima	3.939	2.997	3.876	3.262
D24	Valle del Cauca	8.841	9.605	7.894	5.617
D25	Amazonas	0.292	0.158	0.128	0.952
D26	Arauca	0.969	0.544	0.441	1.030
D27	Casanare	0.683	0.725	0.587	1.060
D28	Guainía	0.146	0.085	0.069	0.760
D29	Guaviare	0.502	0.228	0.185	1.381
D30	Putumayo	1.257	0.715	0.579	1.678
D31	Archipiélago de San Andrés	0.132	0.160	0.130	0.000
D32	Vaupés	0.068	0.091	0.074	0.780
D33	Vichada	0.350	0.144	0.116	2.355

Figure A.1. Effects on Gross Regional Product: short-run

(a) **Scenario 1: population share**

(b) **Scenario 2: extreme poverty share**

(c) **Scenario 3: fiscal gap share**



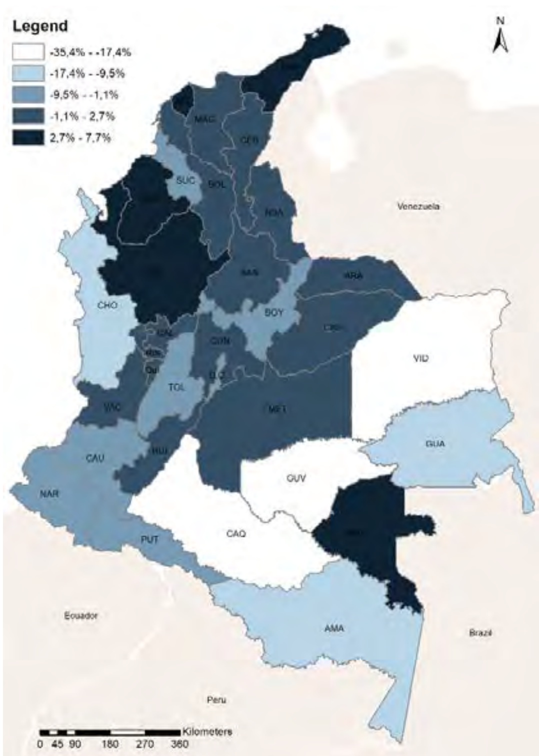
Source: calculations by the authors.

Figure A.2.

Effects on Gross Regional Product: long-run

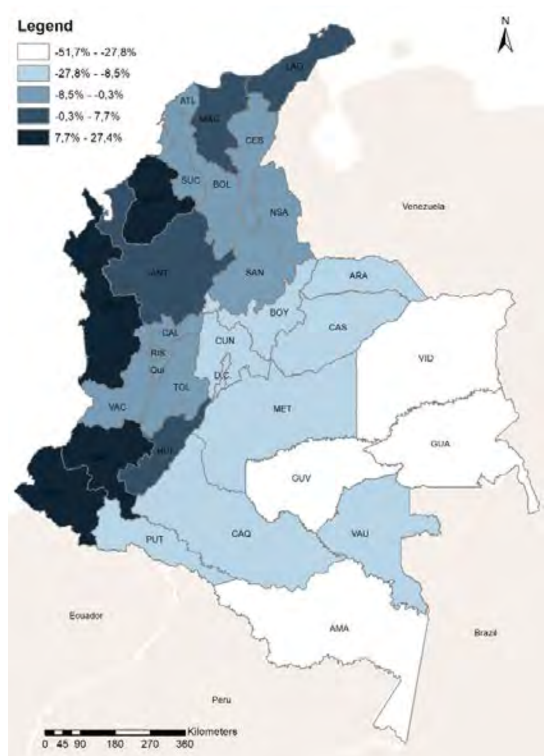
(a)

Scenario 1: population share



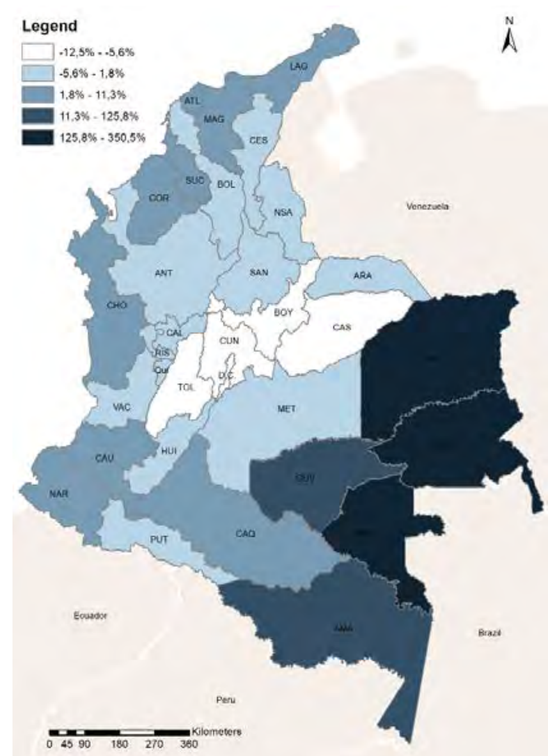
(b)

Scenario 2: extreme poverty share



(c)

Scenario 3: fiscal gap share



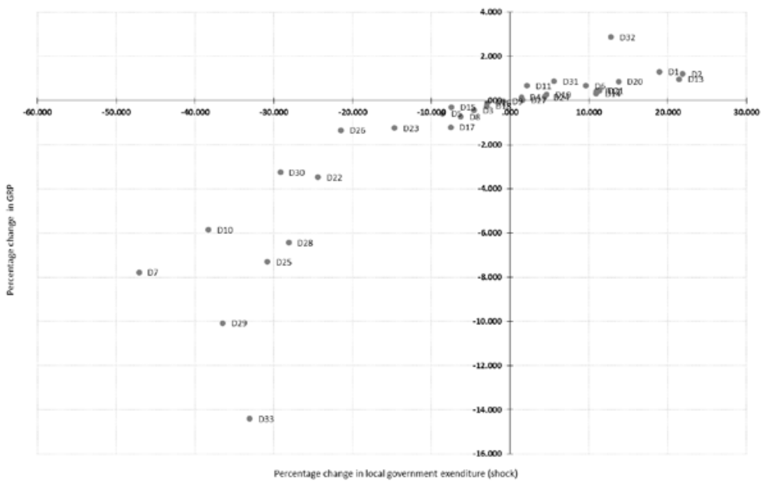
Source: calculations by the authors.

Figure A.3.

Change in GRP and change in local government expenditure – short-run

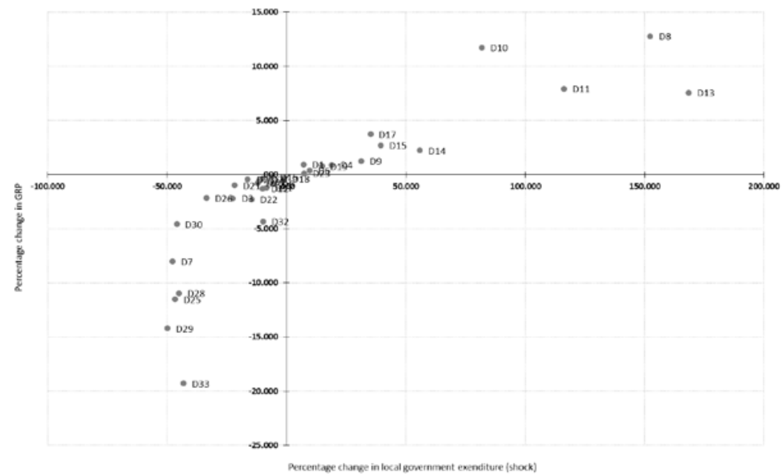
(a)

Scenario 1 (population)



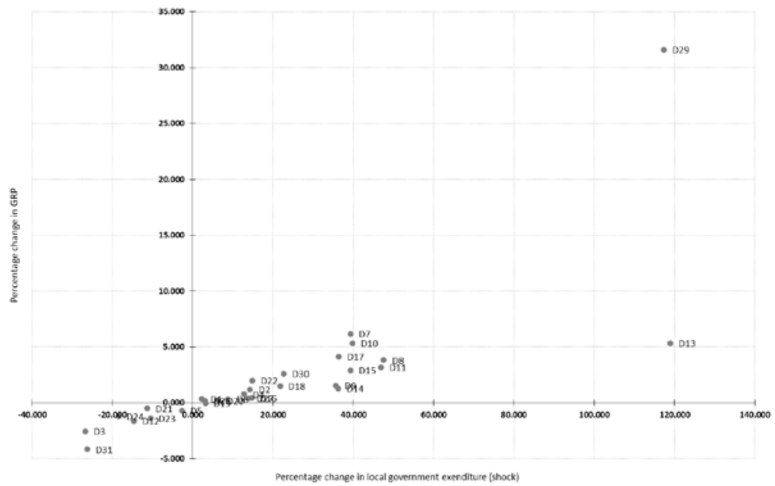
(b)

Scenario 2 (extreme poverty)



(c)

Scenario 3 (fiscal gap)



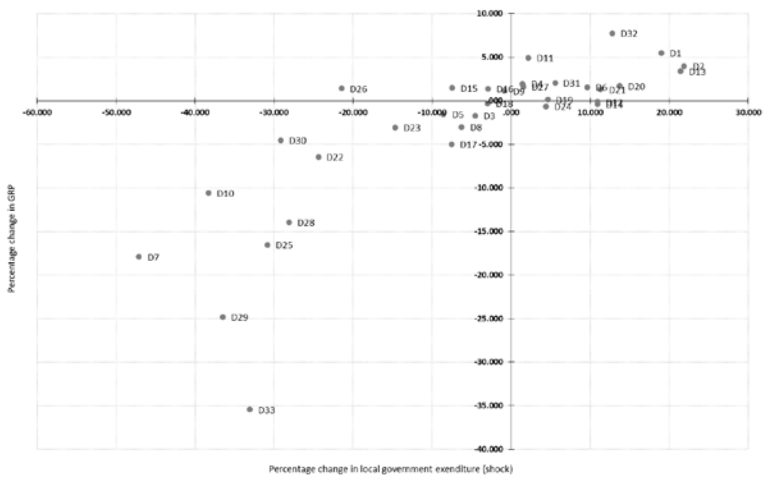
Source: calculations by the authors.

Figure A.4.

Change in GRP and change in local government expenditure – long-run

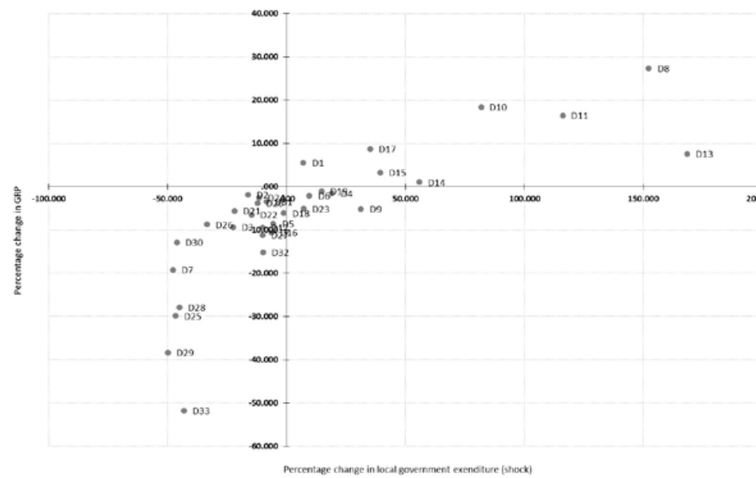
(a)

Scenario 1 (population)



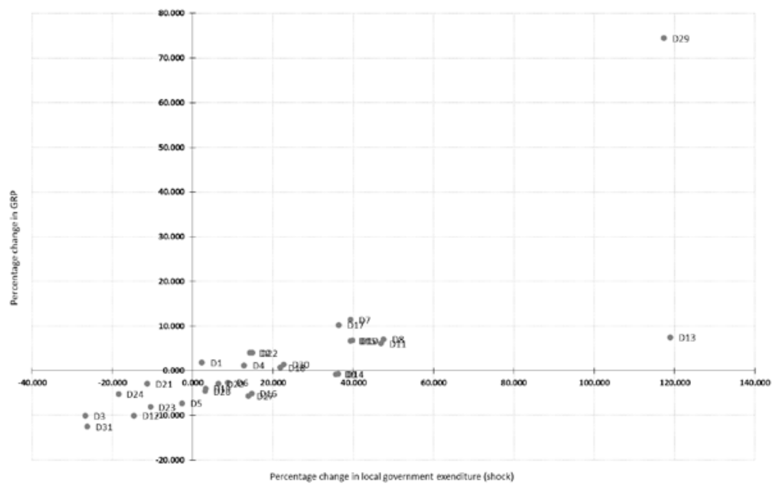
(b)

Scenario 2 (extreme poverty)



(c)

Scenario 3 (fiscal gap)



Source: calculations by the authors.