10 Subnational Development and Fiscal Federalism

In previous chapters, we conducted studies using data at the national level as we emphasised the differences in development outcomes between countries and regions. This approach is typically relevant to academics and international organisations, as they tend to attend to the so-called global challenges. However, in most countries, governments face challenges that are highly specific to their context and are relevant to lower administrative levels. For instance, it is well known that many public policies associated with the SDGs can only be implemented at the subnational level. This practice has steadily become more common during the last two decades of the twentieth century since many government programmes have been undertaking a decentralisation process (Ivanyna and Shah, 2014; Forman et al., 2020).[1]

Subnational governments are endowed with the responsibilities of (1) building datasets with information at the regional/state/municipal/city level; (2) establishing budgetary priorities at the subnational level in a high-dimensional policy space; and (3) looking for evidence-based advice that supports regional development decision making and the design of fiscal federalism.[2] All these features call for the creation of innovative analytical tools capable of accounting for the complex network of interactions between policy issues and dealing

[1] A related but broader concept is that of 'devolution' (Jeffery, 2006). Subnational governments (especially local governments) to whom certain faculties (financial, legislative, and others) have been transferred from the national public administration are also referred to as 'devolved' governments

[2] Formally speaking, fiscal federalism refers to the decentralisation of taxation and government spending at the subnational level. See a meta-study for OECD countries by Forman et al. (2020), and an analysis for Latin America by Wiesner (2003) to learn more about various types of fiscal federalism.

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with inefficiencies in the use of public resources.[3] In this chapter, we demonstrate how PPI can be used as one such method.[4]

We investigate how federal transfers can boost subnational development. In particular, with PPI, we analyse the case of Mexico and its 32 federal states. For this, we assemble a balanced dataset with 103 social, economic, and environmental indicators for each state.[5] We design a simulation strategy and employ the impact metric developed in Chapter 9 to produce counterfactual analyses. First, we study how federal transfers impacted state-level development during the sample period. Second, we analyse how changes in the distribution of transfers across states affect the indicators' average evolution when attempting to foster all SDGs or each of them in particular.

We find that 'fiscal contributions' – a particular form of government transfers aimed at equalising regional disparities – exert an average impact on SDGs of around 25%–45%. Such an impact varies depending on the state's level of human development. Likewise, our simulations indicate that it is possible to achieve substantial impact gains when using an 'optimal fiscal transfer' to allocate the total federal transfers across subnational central governments (SCGs). Optimised transfer distributions are very different from the distribution observed in the data, suggesting that the most populated state (the State of Mexico), could have developed similarly but with fewer resources. Before proceeding to the description of the data, methods, and results, let us provide some background of the literature on fiscal federalism and the Mexican context.

[3] The SDG literature recognises that policymaking at the subnational level (states/municipalities/cities) is crucial if the 2030 Agenda is to succeed (Bruyninckx et al., 2012; Happaerts, 2012; Lucci and Lynch, 2016; Kawakubo et al., 2018; Patole, 2018).

[4] Much of this chapter builds on our earlier work on this topic, published in Guerrero et al. (2022). We are grateful to Florian Juárez-Chávez, Georgina Trujillo, and Lucy Hackett for their work in compiling these data and for their insights.

[5] It is extremely rare to find data for many development indicators, years, and subnational regions. Mexico is one of those exceptions. Moreover, this case is interesting because its political economy and regional disparities have produced severe fiscal imbalances in the last four decades, which motivate the study of federal transfers (Diaz-Cayeros, 2019).

10.1 ON FISCAL FEDERALISM

Some scholars of fiscal federalism argue that allocating spending capabilities to SCGs reinforces the provision of public goods and services. They assert that fiscal decentralisation helps to diminish personal and regional income disparities. In these discussions, Oates (1972) provides arguments in favour of fiscal decentralisation, while Prud'homme (1995); Tanzi (1995) argue against it. Independently of whether this approach is the best solution to a problem of optimal spending, there always exist trade-offs to be taken into account.

For example, two problems are likely to ensue if the transfer of spending capabilities comes along with the total decentralisation of taxation: double taxation and the disappearance of economies of scale in tax collection. For this reason, national governments are reluctant to grant full taxation autonomy to SCGs. From the point of view of institutional incentives, some degree of autonomy is necessary to encourage local fiscal capacity and a setting conducive to improving social and public infrastructure. Hence, governments usually promote a certain degree of decentralisation on the revenue side to preclude high vertical fiscal imbalances.

As with other development fields, econometric analyses dominate quantitative studies of fiscal federalism and its potential impacts. Likewise, these studies suffer from similar shortcomings as those highlighted in previous chapters. For example, to quantify the potential benefits of fiscal federalism, econometric strategies consider a single measure of performance at a time (e.g., poverty alleviation, inequality, regional convergence, or economic growth). This approach stands in stark contrast with the multidimensional dimensions of sustainable development. Another common limitation of this literature is its scope. Typically, an empirical study would focus on one specific type of transfer, for example, in health, education, and social infrastructure (Martinez-Vazquez et al., 2017; Stossberg et al., 2017; Dougherty and Akgun, 2018; Dougherty et al., 2019; Lastra-Anadón and Mukherjee, 2019). Such a level of specificity ignores the complexity of development in terms of the interdependencies between policy

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issues. As we argue in the previous chapters, econometric studies on fiscal federalism tend to focus on aggregate variables. Thus, their corresponding analysis is prone to endogeneity problems.

10.1.1 Fiscal Decentralisation in Mexico

Let us turn from a theoretical review to a more pragmatic example in the context of Mexico. Mexican fiscal federalism has various specificities that make it an interesting case of study. Perhaps the most salient point is that this fiscal federalism has deep vertical fiscal imbalances. Such imbalances result from a political economy that has produced a weak fiscal capacity and unequal decentralisation ratios at the state and municipal levels. Allow us to be more specific. In Mexico, subnational tax revenue was close to 5% of the total government tax revenue in 2017. In the same year, subnational spending represented nearly 40% of total government spending. Because of this imbalance, the federal government has to distribute considerable sums of fiscal revenues across 32 states whose economic structures and fiscal revenues vary considerably.[6] To distribute these resources across the 32 states in a systematic way in each fiscal cycle, the Mexican national government established, in 1978, the Fiscal Coordination Act.[7]

The Fiscal Coordination Act facilitates the distribution of fiscal resources across states and municipalities. The federal government uses two main conduits for allocating these funds. First, it uses the so-called participations (or *participaciones* in Spanish). These are unconditional transfers allowing SCGs to pursue their objectives.[8] The second conduit is what is known as 'contributions' (or *aportaciones* in Spanish), referring to conditional transfers legally tied to broad

[6] Consider that Mexico's inequality across states is among the highest in the world, not only in terms of income, but also when it comes to access to food, housing, human capital, and other dimensions of human development.

[7] This law had substantial reforms in 1998 and 2007.

[8] Although the literal translation of *participaciones* is 'shares', we prefer to use the term 'participations' to avoid confusion with the shares of a budget and other related concepts. Participations are also referred to as 'shared revenues' in the literature on Mexican fiscal federalism. However, this term does not differentiate between conditional and unconditional transfers, something important in this study.

activities in specific sectors such as health, education, and social infrastructure. While contributions are not supposed to be fungible, evidence shows that, in practice, there is a certain leeway on how they are employed. The reader should be aware that contributions correspond to approximately 80% of the shareable tax revenues of the Federation, which is composed of income tax, value added tax, special taxes on goods and services, and taxes on oil and mining extraction.

On the one hand, participations are consolidated in a budget tranche known as *Ramo 28* of the national budget. According to official documents, the main objective of this tranche is to compensate state governments for the federal taxes collected within their territories. These revenues are transferred back to the state's governments by employing a mathematical formula that relies heavily on population size (Arechederra Mustre and Urzúa, 2017). On the other hand, contributions correspond to the *Ramo 33* of the national budget. This tranche of shared revenues comprises eight different funds, aiming to equalise regional disparities in specific dimensions of development. Each of these funds has specific procedures for allocating transfers into SCGs.[9]

Figure 10.1 presents a map of Mexico and the distribution of per capita state budgets during the 2005–2018 period. We have coloured the states according to three clusters determined by their human capital indices. This classification allows us to understand the Mexican case in terms of the wide inter-state disparities and to highlight a few relevant features from these data. First, we decompose the budgets into locally collected revenues and federal transfers. Second, we divide the Federal transfers into participations and contributions. From this figure, it is clear that, in every state, federal transfers are much larger than local revenues.

Figure 10.1a also suggests that per capita participations are larger than contributions in just one state: Mexico City (CMX). Likewise, contributions tend to lose their relative weight with the

[9] For more details on the Mexican system of fiscal coordination see Giugale et al. (2000); Hernández and Rabling (2007); Chiguil (2014); Diaz-Cayeros (2019); Sánchez and Ballinez (2020).

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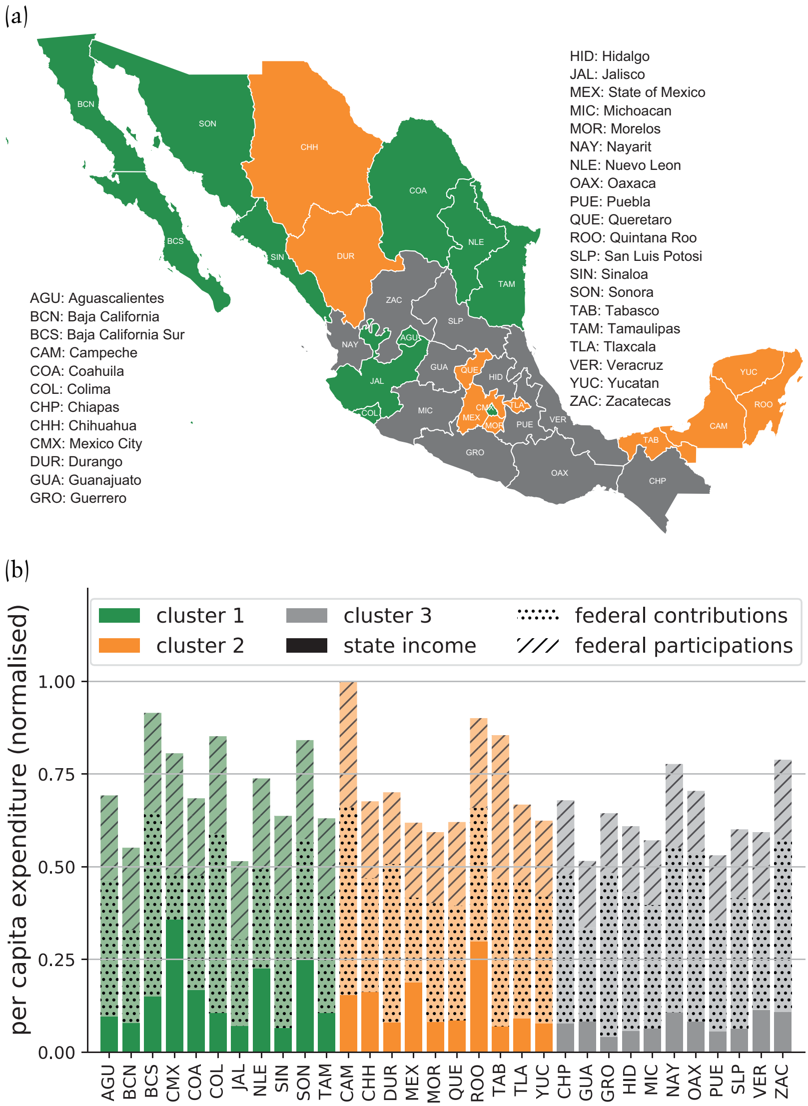

FIGURE 10.1 State budgets. (a) Mexico's 32 states and (b) average state budgets, 2005–2018.

Notes: Green states: upper tier of the Human Development Index (HDI) (cluster 1); orange states: middle tier of the HDI (cluster 2); grey states: bottom tier of the HDI (cluster 3). We calculate the total budgets for the entire sample period and disaggregate them into state income (solid bars) and federal transfers (translucent bars). In turn, we decompose the latter into contributions (dotted bars) and participations (striped bars).

Sources: INEGI.

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states' level of development. Thus, the highest ratios correspond to states in the human development cluster 3.[10] Only a few states of clusters 1 and 2 (e.g., CMX, NLE, SON, MEX, and ROO) can procure a significant local tax collection. On the contrary, all the states of cluster 3 have extremely weak capabilities for generating local revenues. In summary, the data show unevenness in federal transfers, thus, it makes sense to expect development impacts when re-distributing these resources.[11]

10.2 DATA

10.2.1 Development Indicators

We built a balanced panel of 103 development indicators for the 32 Mexican states from 2005 to 2018. We group the indicators into eight SDGs. These data come from several sources: government agencies, NGOs from Mexico and international organisations such as the World Bank and the SDG platforms of the UN (UNSDG). We show the complete list of these variables in Table 10.1. The normalisation procedure of these data follows the same principles described in Chapter 3.[12]

10.2.2 Development Clusters

As in the previous chapters, our simulations are specific to each entity, in this case, states. Hence, we produce the estimates at the level of each indicator within each state. However, for clarity of exposition, we present the results aggregated into state clusters and SDGs. This course of action does not imply that aggregate visualisations are the best way to interpret our results, especially when trying to derive policy recommendations from them. Our visualisations are rather

[10] For more details on these clusters, see Section 10.2.2.

[11] The reader should be aware that federal transfers are not the only mechanisms used by the federal government to spend in states and municipalities. There are also matching grants for projects in public infrastructures and social assistance programmes (e.g., cash-transfer programmes such as *Procampo* and *Oportunidades*). The later transfers are directly allocated. Hence, they are not under the control of subnational governments.

[12] The reader can find other details about these data and their sources in Guerrero et al. (2022) and its appendices.

Table 10.1 *Indicators for the subnational analysis of Mexico*

SDG	Indicator name	Instrumental
1	Human Development Index	no
1	Percentage of young people aged 19–29 with income below the welfare line	no
1	Percentage of the population in extreme poverty	yes
1	Percentage of homes with some level of overcrowding	yes
1	Percentage of the population vulnerable because of low income	yes
1	People who left poverty	no
2	Percentage of the population lacking adequate access to food	yes
3	Mortality rate of HIV/AIDS (per 100,000 inhabitants)	no
3	Proportion of births attended by a trained medical professional	yes
3	Mortality rate of diabetes mellitus per 100,000 inhabitants	yes
3	Doctors in public health institutions that have contact with patients per 1,000 inhabitants	yes
3	Licensed hospital beds per 100,000 inhabitants	yes
3	Infant mortality rate	no
3	Life expectancy at birth	no
3	Maternal mortality (deaths per 100,000 live births estimated)	no
3	Neonatal mortality rate	yes
3	Nurses in public health institutions per 1,000 inhabitants	yes
3	Proportion of 1-year-old infants with a full basic vaccination record	yes
3	Percentage of the population lacking adequate access to health services	yes
3	Fertility rate of women aged 15–19	no

4	Absorption rate in undergraduate education	yes
4	Absorption rate in high school	yes
4	Net enrollment rate in pre-school education (aged 2–5)	yes
4	Net enrollment rate in middle school (aged 12–14)	yes
4	Terminal efficiency in high school	no
4	Libraries per 100,000 inhabitants	yes
4	Museums per 100,000 inhabitants	yes
4	Percentage of the population aged 16+ or born after 1982 with educational deficiencies	no
4	Literacy rate in young adults (aged 15–24)	yes
4	Proportion of the labour force with high school education or more	no
5	Percentage of working mothers aged 15+ with access to childcare	yes
5	Annual brute rate of deaths due to homicides of female victims	yes
5	Ratio of men:women in the National System of Researchers (SNI)	no
5	Ratio of men:women aged 15+ in the economically active population	no
5	Proportion of institutions within the organisational structure of public administration headed by women	yes
5	Proportion of non-agricultural workers aged 15+ who are women	no
6	Population with access to sewage and basic sanitary services	yes
6	Proportion of the population with access to running water	yes
6	Percentage of homes with water provided by truck	yes
6	Spending on operations in industrial wastewater treatment plants	yes
6	Surface water quality index	yes
6	Percentage coverage in treatment of waste waters	yes
6	Operational water treatment capacity	yes

Table 10.1 *(cont)*

SDG	Indicator name	Instrumental
8	Agricultural productivity (Value/hectare)	no
8	Business start-up costs index (% of income per capita)	no
8	Construction permit cost index (% of income per capita)	no
8	Costs of contract enforcement index (% of income per capita)	no
8	Direct foreign investment	no
8	Net employment rate for adults aged 15+	no
8	GDP per capita	no
8	Rate of informal employment	no
8	International Commerce	no
8	Labour productivity index based on the employed labour force	no
8	Workers enrolled in IMSS as a percentage of the total population	no
8	Property registry costs index (% of income per capita)	no
8	Rate of underemployment	no
8	Unemployment rate of young people aged 15–29	no
9	Number of commercial banks and ATMs per 100,000 inhabitants	no
9	Budget assigned to science and technology in mixed state funds	yes
9	Credit cards per 10,000 inhabitants	no
9	Debit cards per 10,000 inhabitants	yes
9	Natural disaster resilience index	yes
9	Energy intensity of the economy (MWh per 1,000,000 GDP per year)	yes
9	Hotel nights per capita	no

9	Number of patents solicited per 1,000,000 inhabitants	no
9	Paved highways as a percentage of all highways	yes
9	Government-registered researchers per 100,000 economically active adults	yes
10	Index of equity in access to drainage	yes
10	Index of equity in access to health services	yes
10	Index of educational equity in middle school	yes
10	State Gini coefficient	no
11	Percentage of the population lacking adequate access to basic services to their home	no
11	Property registration	yes
11	Volume of garbage and waste generated (kg. per person)	no
12	Businesses certified as green per 1,000 businesses	yes
15	Budget assigned to the CONAFOR national program for forests as a proportion of the area supported	yes
15	Area supported by the Forest Development Program as percentage of forest	yes
15	Forest fires: affected surface area (percentage of total forest surface)	yes
15	Reforested area as a percentage of forest cover	yes
15	Vegetation planted per km. square of reforested areas	yes
16	State budget information index	no
16	Total progress in budget and impact evaluation (PbR-SED)	no
16	Home burglary rate	yes
16	Rate of commercial burglary	yes
16	Number of computers per 100 public servants in state public administration	yes
16	Crime rate per 100,000 inhabitants aged 18–29	yes
16	Extortion rate	no

Table 10.1 *(cont)*

SDG	Indicator name	Instrumental
16	Financial autonomy	no
16	Index of transparancy and availability of state fiscal information	no
16	Government income as a percentage of GDP	yes
16	Rate of registered intentional homicide	no
16	Investment capacity (percentage of govt. spending on investment)	no
16	Judges per 100,000 inhabitants	yes
16	Kidnapping rate	yes
16	Debt service as a proportion of total income	yes
16	Participation of the eligible population to vote in federal elections	no
16	Percentage of the population who has been a victim of corruption in at least one government process	yes
16	Rate of resolution in the penal justice system	yes
16	Perception of corruption in the federal government	yes
16	Political system sub-index	no
16	Number of public prosecutors per 100,000 inhabitants yes	
16	Total unpaid to the federal contribution fund	no
16	Rate of vehicle theft with or without violence	yes

Notes: See Section 4.1 for an explanation of instrumental indicators. All the indicators in SDG 8 are collateral because the associated government programmes operate at the national level. In other words, state-level policies have little room to enact policies funded by contributions that directly impact these indicators. For this reason, the presentation of our results omits SDG 8.
Sources: INEGI, World Bank, and UNSDG.

stylised descriptions that facilitate communicating to the audience the nature of our analysis.

Grouping states into clusters according to their level of development is particularly relevant in the context of Mexico. Not only the country has large development disparities across states, but Mexican political discourse is also replete with inequality discussions. This feature prevails in Mexican politics and permeates the legal sphere. For instance, in part, the Fiscal Coordination Act has been justified in Congress on the grounds of a more equitable federation and the closure of historical development gaps between states.

We use the Human Development Index (HDI) to construct our state clusters. For that, we specify three tiers according to two thresholds: the 33.33 and 66.66 percentiles. The clusters are defined as follows: below the 33.33 percentile, between the 33.33 and the 66.66 percentiles, and above the 66.66 percentile.[13] Figure 10.1b shows the geographical distribution of the three clusters across the Mexican territory. This clustering scheme helps us appreciate the heterogeneous levels of development that coexist among the Mexican states. Notice how, except for Mexico City, all states in cluster 1 (in green) are in the northern and Pacific regions. In contrast, the states with the lowest human development (in grey) are in the central and southwest regions. This picture indicates that neighbouring states tend to share socioeconomic affinities.

10.2.3 Expenditure Data

For the budgetary data, we use the information on the total annual spent budget (in constant pesos) for each of the states in the federation. This information is obtained from INEGI, disaggregated by source, and differentiates between state-collected revenues and federal transfers. Following the protocol adopted in previous chapters, we compute

[13] The HDI measures multidimensional human development (health, education, and standard of living) and allows making comparisons between countries. Likewise, Smits and Permanyer (2019) develop a Subnational Human Development Database. This Subnational HDI presents data for 161 countries, which includes Mexico for the 1990–2018 period.

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the inter-temporal average expenditure of each state and divide it by their population sizes to obtain per capita levels. Figure 10.1a shows the distribution of this per capita expenditure across the 32 states and its breakdown into state-generated income, participations, and contributions. The reader should be aware that the expenditure data are reported by INEGI as total state-level spending, so it is not disaggregated into SDGs nor in terms of government programmes. In any case, we use the latter type of data in Chapters 11 and 12.

10.3 SIMULATION STRATEGY

Our interest in this chapter focuses on measuring the impact that federal transfers produce on subnational development and on learning the potential ways that their redistribution among states helps to propel it. For this reason, we estimate the influence exerted by contributions in a setting of multidimensional development as they constitute the biggest component of federal transfers. As we explained above, contributions are legally tied to specific policy issues. Nevertheless, in reality, SCGs may engage in fungibility when using these resources; even more, such re-purposing may frequently be entirely lawful.

In this application, the government agent of the model represents Mexico's Finance Ministry (SHCP) and Congress. Together, these entities formulate and approve a particular contribution regime in which each state receives a share of this tranche of the national budget. The reallocation of federal transfers among states aims to improve particular development dimensions that we define ex ante. The simulation strategy considers that once each state receives its corresponding contribution, the SCG has to allocate these funds across the different government programmes composing the SDGs.[14] We can investigate how different distributional regimes (i.e., allocations across states) might improve the federation's goals. In the

[14] In other words, we assume that the federal government is aware of the policymaking process undertaken in the state's public administration.

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context of the 2030 Agenda, this would mean that a subset of indicators belonging to an SDG could define an objective function in the exercise of reallocating contributions optimally.

The first part of our simulation strategy estimates the impact of the contributions. As previously mentioned, we employ the impact metric developed in Chapter 9. We calibrate the model for each state individually for the 2005–2018 period, using state-level total budgets and networks of interdependent indicators.[15] For a given state, a baseline simulation consists of the output generated with the total budget. In contrast, a counterfactual consists of running the model without the contribution component of the budget. After computing Monte Carlo simulations for the baseline and counterfactual, we estimate the impact of the contributions.

The second part of the simulation strategy seeks to find the optimal distribution of federal transfers across the different states. Then, it conditions the objective function of the optimisation procedure to focus on specific development dimensions (SDGs). In other words, we find allocations of contributions that optimise development outcomes in a given SDG. Our optimisation tasks deploy a heuristic algorithm with great popularity in the computer science literature: *differential evolution* (Storn and Price, 1997). In computer science, there exist many heuristic optimisation methods designed to deal with problems where the objective function (or 'fitness landscape') is not easy to handle with more traditional convex optimisation methods (e.g., dynamic fitness landscapes, non-continuous functions, or multiple local optima). As we have already shown in Chapter 8, a fitness landscape in the case of policy prioritisation can be rugged, so heuristic optimisation is a suitable strategy. We choose differential evolution as it is not difficult to understand and implement, and considering that it performs well in this study.

15 For the estimation of the state-level networks, we use the method described in Chapter 5.

The intuition behind differential evolution is straightforward. Suppose that we have a distribution of normalised (i.e., they are in fractional terms) contributions across the 32 states described by a vector

$$V = v_1, v_2, \ldots, v_{32}, \tag{10.1}$$

such that $\sum_i v_i = 1$.

V represents a tentative solution to the optimisation problem, and v_i is the contribution allocated to the ith state. Then, we can build a population of n tentative solutions

$$\begin{aligned} V_1 &= v_{1,1}, v_{1,2}, \ldots, v_{1,32} \\ V_2 &= v_{2,1}, v_{2,2}, \ldots, v_{2,32} \\ &\vdots \\ V_n &= v_{n,1}, v_{n,2}, \ldots, v_{n,32}, \end{aligned} \tag{10.2}$$

such that each solution also fulfils the normalising constraint of adding up to one.

In differential evolution, this population goes through a process that selects the fittest solutions and, eventually, leads to a candidate that is close to the global optimal of the fitness landscape. In our application, we define fitness in terms of how far the indicators might have advanced by 2018. That is, for a given distribution of contributions different from the empirical distribution, the average level of the simulated indicators in 2018 across states would provide the fitness level of such a solution. Formally, fitness is

$$F = \frac{1}{N \times 32} \sum_i \sum_j \bar{I}_{i,j,T}, \tag{10.3}$$

where $\bar{I}_{i,j,T}$ is the point estimate (across Monte Carlo simulations) of the simulated indicator i in state j in the last period T. N is the number of indicators.

Without becoming too technical, let us describe the optimisation heuristic in the following way. First, the algorithm ranks each solution in the population using the fitness function. Second, it eliminates the worst-performing half of them. Third, it picks two survivors at random; then picks a partition point for both vectors (also randomly), creates a new vector combining one partitioned part from each solution, and re-normalises the new solution (so that the vector adds up to one). Fourth, the previous step is repeated until there are enough new solutions to replace those that were discarded in step two. This algorithm mimics the cross-breeding process through which individuals combine their chromosomes to produce offspring. Fourth, each new solution experiences a mutation process that alters some of the vectors' entries with a given probability. Fifth and final, the entire (replenished) population is evaluated according to its fitness scores, and the entire process repeats itself.[16]

As we mentioned before, in the first part of the simulation strategy, we apply this optimisation scheme using all the indicators in the objective function to evaluate the average development achieved in 2018. Then, in the second part, we isolate indicators belonging to only one SDG and obtain SDG-specific fitness.[17] The idea behind isolating an SDG is to consider alternative government objectives in which the contributions aim to impact a specific development dimension. For example, much of the political parlance in the discussions involving the Fiscal Coordination Act revolves around SDG 1. Mexican policymakers argue strongly that a proper scheme of fiscal transfers should seek to end poverty as one of its immediate goals. Presumably, if the federation aims to tackle specific development dimensions through fiscal transfers to the states, their distribution should look different depending on the proposed dimensions. We present all our results in the following section and discuss their

[16] We perform the algorithm for a population of 24 solutions (a standard parameter in this literature) for 100 generations (there are no significant improvements after 100 generations, even in independent optimisations).

[17] Thus, we redefine Equation 10.3 to account for only those indicators in the chosen SDG.

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implications in the context of fiscal federalism and how one could allocate contributions among states.

10.4 RESULTS

10.4.1 The Impact of Contributions

We start analysing the impact that contributions had during the sample period. For visualisation purposes, we present in Figure 10.2 three panels describing the impact metric aggregated at the level of SDGs and development clusters. First, notice that the impact is heterogeneous across development clusters and SDGs. As expected, the average impact is much lower for states in cluster 1 (slightly above 25%) than for states in cluster 3 (slightly above 35%). It is important to recall that this metric estimates the impact of contributions along the indicator's trajectory relative to the baseline outcome (i.e., using the total budget). Second, in cluster 1, SDG 5 (gender equality) experiences the strongest impact: 55%. Third, in clusters 2 and 3, the highest impact occurs in indicators belonging to SDG 2 (zero hunger): 45% and 54%, respectively. Fourth, in all clusters, the impact on SDG 10 (reduced inequalities) is relatively small (close to 7%), at least when compared with other SDGs. This last result is particularly relevant to the Mexican context as it speaks of potential structural bottlenecks in reducing inequalities. A topic that is closely related to major development policies and fiscal federalism.

10.4.2 Optimising Contributions

Next, we perform a new round of simulations in which the baseline distribution of contributions is not empirical but optimal, considering all the SDGs in the objective function. That is to say, we deploy the differential evolution algorithm to find the optimal distribution of contributions across the 32 states and use it as the baseline. Then, we run the counterfactual of removing contributions. This exercise allows us to re-estimate the impacts of contributions and to calculate their difference relative to those obtained in Figure 10.2.

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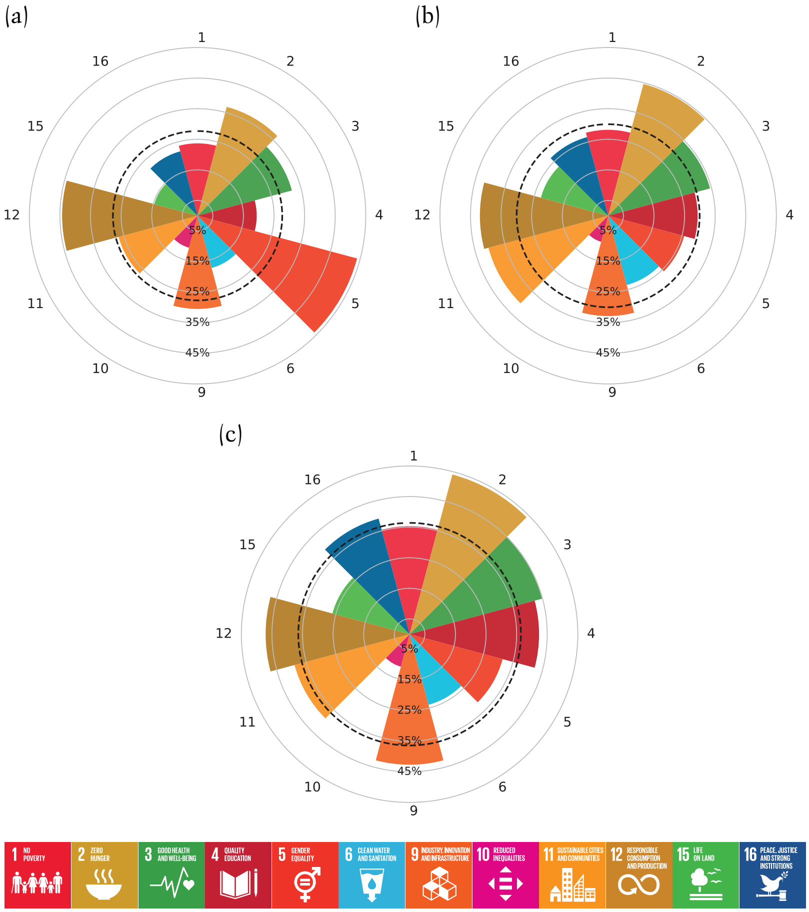

FIGURE 10.2 SDG-level impact metric of federal contributions by state cluster. (a) Cluster 1, (b) cluster 2, and (c) cluster 3.

Notes: Each panel displays the impact metric, at the SDG level, for all the states in each development cluster. The dotted ring denotes the average impact metric of the cluster.

Sources: Authors' calculations.

Figure 10.3a shows the suggested budgetary changes in each state and the empirical allocations. Notice that Baja California (BCS) and Quintana Roo (ROO), both touristic enclaves, exhibit the two largest increases in contributions, while the State of Mexico (MEX) and Jalisco (JAL) suffer the largest reductions. Surprisingly, it is

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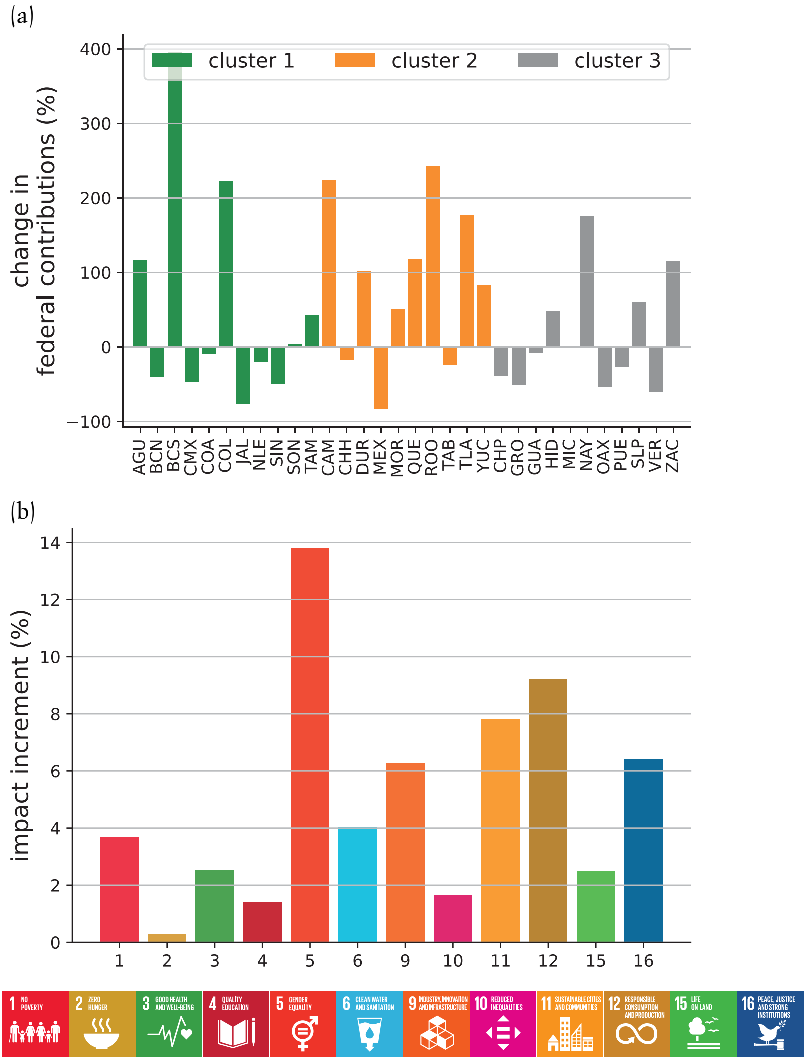

FIGURE 10.3 Results from optimising the distribution of federal contributions across states. (a) Suggested budgetary adjustments and (b) impact gains under optimal budget.

Notes: The objective function of this optimisation is the average level (across indicators and states) of the indicators' final values. Figure 10.3a shows the difference between the empirical allocation of contributions and the optimal allocation in percentage changes (relative to the empirical allocation of contributions). Figure 10.3b presents the difference between the impact metrics calculated in Figure 10.2 and those obtained by assuming the optimal distribution of contributions. These impact metrics are constructed at the level of each SDG, aggregating all states.

Sources: Authors' calculations.

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not the case that states in cluster 3 are the most benefited in the application of this optimisation algorithm. We see that seven out of 11 states present a drop in contributions. These simulation outcomes suggest that, as long as structural problems are not addressed in the least developed states, federal transfers, by themselves, will not contribute sufficiently to the states' development. Presumably, when considering all the SDGs in the optimisation of contributions, the result favours a reallocation inclined towards cluster 2.

Figure 10.3b indicates the size of impact gains for each of the 13 SDGs. In other words, when optimally targeted, contributions play a more important role in subnational development. Notice that such gains are always positive. Hence, this reallocation produces, on average, improvements across all the SDGs. We can observe that SDG 5, which has a small impact in the baseline scenario, benefited the most. On the contrary, SDG 2, a development dimension heavily promoted in public discourse, only experiences a marginal gain under the optimised contributions.

10.4.3 Policy Priorities and Contributions

Now we shift our attention to a variation of the optimisation procedure in which we modify the objective function. The idea is to learn how an optimal distribution of contributions changes if the federation does not aim at improving development across all policy dimensions (SDGs) but rather on a subset of them. The empirical motivation is straightforward, as documents such as the Fiscal Coordination Act tend to emphasise the role of specific development issues (e.g., poverty). In addition, subnational entities tend to have heterogeneous capabilities, constraints, structural factors, and institutional settings. Rather than focusing on the impact outcomes, we prefer to show how the optimal distribution of contributions would look should the Mexican Congress target particular SDGs. Thus, in the following analysis, instead of calculating a fitness function across all SDGs, we define 13 functions specifying an isolated SDG in each.

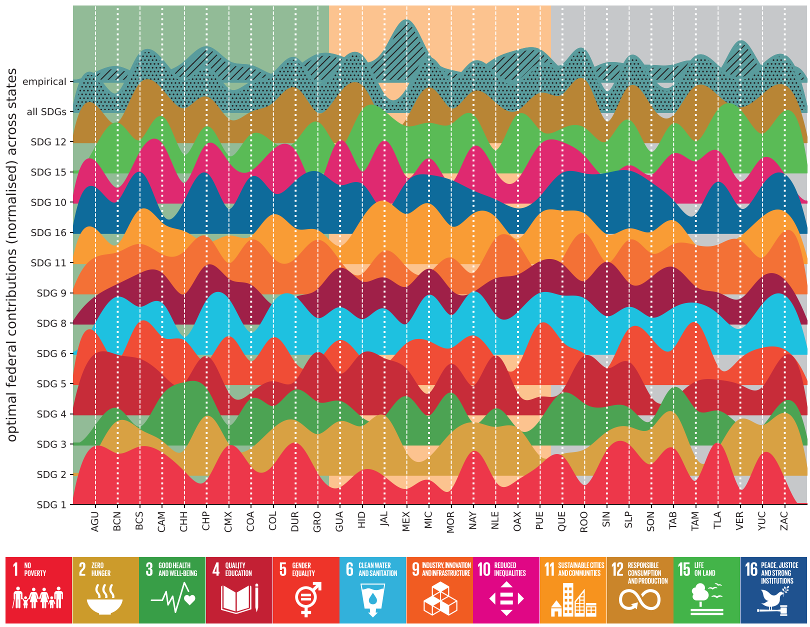

FIGURE 10.4 Optimal distributions of federal contributions.
Notes: Each mountain ridge represents a distribution of contributions across states. For each ridge, we normalise the units using their highest peak. Thus, the heights of the hills are comparable within the same mountain ridge but not between them. The top ridge corresponds to the empirical distribution of contributions between 2005 and 2018 (average). The second denotes the optimal distribution when the objective function considers all the SDGs, i.e., the one used to produce Figure 10.3. The rest of the ridges correspond to optimisations made isolating one SDG and are coloured accordingly.
Sources: Authors' calculations.

We present in Figure 10.4 our results. This visualisation indicates that the states' contributions (the height of each 'hill' in a mountain ridge) vary within each optimisation. The roughness of these ridges reflects a noticeable heterogeneity. That is to say, different fitness functions produce distinctive allocation regimes. For instance, when the fitness function considers SDG 6, the ridge looks more regular than the others, suggesting certain commonalities in water and sanitation-related problems across the states. In contrast, a fitness function with SDG 4 produces a very irregular ridge.

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Notice that the empirical mountain ridge exhibits one salient high pick: the State of Mexico (MEX). This pattern does not occur in any of the simulation exercises. In fact, MEX does not receive the largest share of contributions in any of these cases. Likewise, a poor state like Chiapas (CHP) receives substantial contributions for some fitness functions, but this outcome does not always hold. None of the optimisation procedures generates an allocation regime (mountain ridge) close to the one observed in the empirical data. This finding suggests that, for these objective functions, there is room for improvements with an alternative federalist pact.

10.5 SUMMARY AND CONCLUSIONS

While much of the discussions around the SDGs revolve around national-level policies, subnational-level implementation is a major component in real-life practices that should not be left aside. The study conducted in this chapter is relevant for two main reasons. First, it shows that PPI is a helpful tool at the subnational level, perhaps the most relevant setting for implementing public policies devoted to promoting SDGs. Second, it extends the analytic power of PPI by combining it with other relevant algorithms, such as differential evolution, illustrating their relevance for understanding the allocation of contributions and participations. In particular, policymakers should set their objectives straight and clearly to discover allocation regimes conducive to significant advances in development.

Our results indicate that contributions matter for multidimensional development. This remark comes from the estimated impact on the trajectories of most indicators. Likewise, if the federal government's objective is to boost all SDGs (on average, across states and using an equal weight), then our results indicate a misallocation of contributions (e.g., MEX receives too much in the empirical data). Such an outcome implies that there is room for strengthening the impact on indicators' trajectories for all SDGs through an alternative contribution regime. In the analysis, we observe impact gains for SDGs 5, 11 and 12. Finally, our simulations generate a diversity

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of allocation regimes depending on which SDG defines the federal government's fitness function, and the contributions granted vary considerably across states in most cases.

This type of simulation helps to produce evidence-based allocation regimes. Neither an expert judgement nor a mathematical formula can decipher the consequences of the intricacies behind spillover effects and a multidimensional setting across a spectrum of states. For instance, our results do not show a clear-cut relationship between the contributions' size and the level of development. Likewise, if, for political reasons, a federalist pact promotes an explicit formula in the legislation, then the model is convenient for studying its implications for the country's development. At least, with sensible legislators, this evidence can be employed as advice to change some parameters in the formula and start a new round of discussion among stakeholders.