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Is the Impact of Public Investment Neutral Across the Regional Income Distribution? Evidence from Mexico

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Abstract: This article investigates the contribution of public investment to the reduction of regional inequalities, with a specific application to Mexico. We examine the impact of public investment according to the position of each region in the conditional distribution of regional income by using quantile regression as an empirical technique. The results confirm the hypothesis that regional inequalities can indeed be attributed to the regional distribution of public investment; the observed pattern shows that public investment mainly helped to reduce regional inequalities among the richest regions.

Key words: regional development, public investment, quantile regression.

Globalization has stimulated the emergence of a worldwide system of regional economies that are subject to geographic constraints (Agnew and Corbridge 1995; Storper 1992). In light of this process, a key feature of recent economic geography is that despite the increasing integration of regional economies, economic disparities remain endemic and, to some extent, have intensified as transport and communication costs have fallen (Scott 1998). Typically, regions that benefit the most from regional integration arrangements have either prior advantages from economic agglomeration (Krugman and Livas 1996) or location-specific externalities resulting from regional neighborhood effects, as well as productive and natural-resource endowments that give rise to the formation of industrial centers (Hanson 1997, 2001). Thus, a central research issue for economic geographers is to disentangle the determinants of regional inequalities and to elucidate when public

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policies are successful in smoothing these regional disparities.

The search for simple trends in regional disparities is confounded by increasingly complex regional economic changes. Indeed, both in developed and developing countries, regional inequalities have reached unprecedented scales. Thus, it is important to gain a better understanding of the processes that cause region-specific economic growth. Another issue is whether governmental policies that target the specific spatial allocation of public investment have succeeded in reducing regional inequalities. These regional policies are commonly grounded in the "hypothesis of regional redistribution." This hypothesis states that regional inequalities may decline as a result of a specific distribution of public investment (designed to encourage regional economic convergence). In other words, it implies an allocation of public investment that fosters a higher economic growth rate for poor regions than for wealthier ones. This feature, which Myrdal (1957) called the "trickle-down" effect, results from governmental efforts to increase economic activity and income in less-developed regions. Although the issue has motivated a greater amount of research within multiple social science disciplines, the regional redistribution hypothesis is still an open question that may benefit from additional theoretical and empirical research.

Regional disparities result from the complex interweaving of the determinants of the spatial location of economic activity and population. The most relevant regional policies to address regional disparities are the ones that deal with public investment, natural resources, technological development, and participation in regional trade liberalization (Hanson 1997, 1998; Silva and Leichenko 2004). However, in recent years, governmental regional policies have been characterized largely by investment in infrastructure based on the hypothesis of region redistribution. These policies have been justified by a number of authors on the grounds of positive gains in efficiency that arise from the impact of public investment on regional economic growth (Aschauer 1989; Munnell 1990a, 1990b; Gramlich 1994; Fernald 1999). However, in examining country-specific evidence, one sees that there are also marked effects on the distribution of economic activity and, subsequently, on the generation of regional inequalities.

The new context of economic integration in North America and Europe has led to a reconsideration of the role of public investment as a way of smoothing out regional inequalities. Although structural funds are not the only source of public investment, evidence from the European Union has revealed that regardless of substantial public efforts in investment, regional disparities have not decreased (Boldrin and Canova 2001), which implies that regional investment policies are ineffective in achieving some expected goals of redistribution. However, public investment may reduce inequalities solely in one set of regions (e.g., the richer ones), but it may be ineffective in the remaining set (e.g., the poorer regions). Indeed, following the predictions of Krugman (1991), if transport costs decline (e.g., owing to investment in the infrastructure), nominal wages in a region generate a "demand linkage" that increases incomes in other regions. Thus, the demand linkage should produce a regional wage gradient whereby nominal wages decrease with the distance from industrial centers. These predictions were tested by Hanson (1996), who estimated a negative relationship between relative nominal wages and distance to Mexico City. However, this relationship weakened after the liberalization of trade was instituted in the mid-1980s. It is interesting that this feature is argued to be tightly dependent on the reduction of transport costs, which are determined to some extent by public investment in the infrastructure. Still, limited research on the influence of public investment has been undertaken.

Mexico has often been seen as a paradigmatic example of the role of geography in economic activity. The population of Mexico, a legally federal state that is organized into 31 separate states (henceforth referred to as "regions") plus Mexico City, was estimated by the government to be approximately 100 million people in 2000 (see Table 1). By the 1980s, Mexico had become essentially an urban country, and the organization of its national space has increasingly depended on the demographic and economic dynamics of cities, in line with the so-called urban recentralization process (Cheshire 1995). The population density is significantly heterogeneous—the density is from about 275 persons per square kilometer in Mexico City to 14 persons per square kilometer in the northern region. Therefore, taken together, the majority of the population lives in the smallest land area in the central part of the country. It is interesting that no significant changes are observed in

Table 1

Geographic Distribution of the Mexican States (Percentage)

Location	1971 Population	1999 Population
North	15	15
Baja California		
Coahuila		
Chihuahua		
Nuevo León		
Sonora		
Tamaulipas		
Capital	14	9
Distrito Federal		
Center	37	42
México		
Morelos		
Puebla		
Querétaro		
Michoacán		
Guanajuato		
Hidalgo		
Tlaxcala		
Veracruz		
South	13	14
Chiapas		
Guerrero		
Oaxaca		
Quintana Roo		
Yucatán		
Center-North	19	18
Aguascalientes		
Baja California Sur		
Colima		
Durango		
Jalisco		
Nayarit		
San Luis Potosí		
Sinaloa		
Zacatecas		
Oil	2	3
Campeche		
Tabasco		

the distribution of national and urban population between 1970 and 1995.

The Mexican economy is moving toward expanding the service sector, especially in Mexico City, where it accounts for 46 percent of regional economic activity. Mexico City, the center of the country's political and financial power, is the site of the federal bureaucracy, the largest universities, leading services, and commercial enterprises. Secondary-sector activities are the strongest in the north and central parts of the country and lag in the south. Monterrey, the city of the northeast, leads all of the regions, with 36 percent of the gross domestic product (GDP) in the secondary sector. Agricultural activities are the highest in the southern and eastern regions. The southern area is the poorest in the country, whereas the eastern regions are important corridors of industry and the northwest regions are highly tied to economic activity with the United States. The opening of the Mexican economy to international trade in 1985 has led to significant changes in the distribution of economic activity, including the development of new industrial centers in northern Mexico and the northern regions bordering the United States.

Mexico has been frequently taken as an example of where to test the hypothesis of the so-called new economic geography. Hanson (1998) found that the liberalization of trade shifted regional Mexican industrial employment so that it became negatively associated with distance to the U.S. border after 1985. Agglomeration effects are noticeable in the oil-producing regions and the areas surrounding Mexico City. A great deal of economic activity is concentrated in Mexico City because of the city's large skilled workforce, consumer market, low distribution costs, and proximity to governmental decision makers. These features, as it has been argued, have led to the breakdown of a regional wage gradient, whereby distance to industrial centers has had a negative influence on relative wages in Mexico (Hanson 1997, 2001).

Regional economic disparities in Mexico are important, with a developed north and large agglomeration economies in Mexico City, which have been partly attributed to the concentration of capital and political power in the Mexico City region, plus the modernizing north and the lagging south (Barkin 1990). Estimates suggest that Mexico City accounted for 16 percent of the GDP in 1990 and 34 percent in 1999 (Barkin 1999). This effect is consistent with the rapid growth of urban areas that has occurred throughout the world. Indeed, Mexico City was the Third World's largest metropolitan area in 1990 (Scott 1998). Although the federal government has ultimate control of regional funds, Scott (1998) found that remarkable differences coexist across regions in both the allocation of public investment and the number of federal programs that are implemented.

In this article, we explain the relationship between public investment and regional income in Mexico across regional income distribution. We examine the issue using an interdisciplinary approach by examining the economic geography literature, along with mainstream economic and public policy debates. The empirical part of the article reports an unexplored statistical method in economic geography, quantile regression, that allowed us to examine the impact of geographic gradients across the income distribution. We also question whether different types of public investment have an equal influence on regional productivity. That is, we assess whether specific types of public investment (infrastructure or social investment) are equally influential in explaining regional income. When public investment is split into different sources, infrastructure (or productive) investment appears to raise productivity considerably, whereas the effect of social investment is much less marked. The explanation for this effect may well be that social investment impacts indirectly through the long-term accumulation of human capital, rather than a short-run effect, while investment in the infrastructure plays a role in the short run in that it reduces transaction costs among regions. Finally, whereas geographers have a good understanding of the factors underlying economic growth, they know much less about how these factors combine in different places (Schoenberger 1989). Therefore, we stress the nature of the application setting. Indeed, we believe that studies that are based on middle-income countries reveal geographically specific patterns that are worth studying.

We first provide an outline of the institutional setting, the evolution of regional disparities, and the distribution of public investment in Mexico, followed by a discussion of the theoretical framework and a brief survey of the literature. The remainder of the article describes the model and data, discusses the results, and presents our conclusions.

Public Investment and Regional Economic Performance

The economic channels that explain the influence of public investment are central to our analysis. However, within the literature on economic geography, there is a vast array of theoretical perspectives that deal with the issue of economic performance (see Scott 1998). Classical location theory examines the issue of physical transportation costs on economic activity to estimate the resulting geometric layout of the economic landscape (Weber 1922; Woglom and Stolper 1954; Isard 1956). Other authors (Scott 1998) have referred to the interactions of transaction costs, spatial heterogeneity, and externalities to highlight the complexity in elucidating the determinants of the spatial location of economic activity. Scott (1998) argued that a wide-ranging phenomenon is the formation of superclusters, along with agglomeration economies, whereby the per capita costs of public investment will be lower in large agglomerations.

In neoclassical economics, public investment is envisaged as leading to gains in efficiency through economic growth, which, in turn, expands productive capacity and increases regional productivity both in the infrastructure and social investment. The infrastructure incorporates goods or activities that hypothetically increase productivity in the private sector. Furthermore, social investment is believed to benefit demand directly by increasing the welfare of future generations and subsequently improving future productive capital. Nevertheless, these benefits occur mainly under two sets of circumstances: when the services that are provided respond efficiently to effective demand (World Bank 1994) and when the government supplies the capital in cases in which the existence of high externalities prevents private investors from financing goods and services.

The majority of the literature on the impact of public investment has suggested that an expansion of public investment should have a major impact on private output. More specifically, public investment is thought to increase the rate of return to private capital, and this stimulates private investment. Aschauer (1989), Hansen (1965), and Munnell (1990a, 1990b) agreed that regions with higher levels of public investment tend to experience higher output when private investment and a growth in employment precede public investment.[1] An increase in utility-type expenditures leads to a decrease in the rate and growth of savings; while both tend to rise initially in response to productive governmental expenditures, they subsequently decline (Barro 1990). Other empirical contributions have found a null or even a negative effect of public investment. Therefore, the impact of public investment is clearly linked to the way in

[1] The rationale for including public expenditure in the growth equation is that private inputs may not be close substitutes for public inputs.

which investment is allocated among areas. In middle-income countries like Mexico, there is an observed pattern of the scattering of funds among a large number of small and dispersed regions (Hirschman 1958). One reason that has been put forward for the broad spatial scattering of investment is a government's endeavor to win political support in all regions (Costa-i-Font, Rodriguez-Oreggia, and Luna 2003). Another reason is the belief that economic progress is a force that affects all regions equally; governments are depicted as being unprepared and unwilling to make decisions about spatial priorities and sequences for investment. Nevertheless, Hirschman's argument leaves the choice of the direction of public investment to the planners, which could imply that it could be manipulated, to a certain extent, for electoral ends.

In the framework of the new economic geography, some scholars have examined the role of public investment in affecting regional disparities. Martin and Rogers (1995) and Martin (1999) suggested that the public infrastructure may play an important role in attracting industries from other regions, but in a context in which there are negative effects of industrial concentration. Improvements in interregional infrastructures, which, in turn, are channeled through reductions in transaction costs, may discourage firms from localizing in poor areas, which may increase regional disparities (Martin and Rogers 1995; Martin 1999). However, little empirical research in economic geography has been conducted to provide a comprehensive explanation of the relationship between regional inequalities and public investment.

This study examined regional disparities according to the position of the regions on the income distribution scale and the effect exerted by public investment in this process. Evidence that growth does not necessarily reduce inequalities can also be found in Chatterji (1992). Thus, the division between poor and rich regions could hypothetically be deepening, even though the aggregate measure for convergence shows a process of convergence. All of these problems suggest that additional tests for regional disparities should be applied.

Empirical Strategy and the Data

The Empirical Strategy

The empirical strategy used in this study was driven by the analysis of the role of public investment (g) in regional per capita income in levels (y), the latter being the dependent variable.[2] However, measuring the effect of public and private investment in developing and middle-income economies for which data on capital stocks are not available often implies that assumptions need to be made to capture the influence of both public and private investment. Indeed, in this study, only the flow of public investment (g) was available, not the stock, which, in turn, was measured in per capita terms. However, in the absence of capital stock, it is common practice to interpret that investment as a proxy for total capital. Yet, to deal with a possible simultaneous bias between regional per capita GDP and public investment, we introduced several lags in the variable referring to public investment (referred to as $g(1)$ and $g(2)$). We introduced time lags to capture potential delays in the productivity of public investment that may differ between both investment types and regions. Two lags were finally considered, since further lags were systematically nonstatistically significant and no evidence of further autocorrelation was identified. However, in interpreting the time-lag coefficients, one should bear in mind that in the short run, they may reflect an expendi-

[2] Following a neoclassical economic model, we could argue that we depart from the conventional production function $Y_{it} = F(K_{it}, G_{it}, L_{it})$, where K_{it} is the stock of capital of the economy, G_{it} refers to public investment, and L_{it} is the total employed population. Assuming constant returns to scale, the same technology can be represented at a steady state as $y_{it} = f(k_{it}, g_{it}, 1)$, where $y = Y/L$, $k = K/L$, and $g = G/L$.

ture effect, rather than, as hypothesized, the productive impact of the investment. In addition, we used a variable for private capital (k) in the analysis to take into account the hypothetical complementary role of private investment. As a result, we would expect a positive sign for these variables in the income equation, which would suggest a potential to reduce the level of income disparities among regions.

According to the literature, certain control variables should be included when estimating determinants of regional income. As we noted in the theoretical section, we included (y_0) as a covariate variable referring to the initial per capita GDP to capture the effects of previous regional income advantage. No fixed effects were included because the initial income is already time invariant. However, we introduced a set of regional dummies as proxies for differences in the steady-state value of per capita income, such as dummy variables that isolate the effect of being an oil producer (oil), a region in the north of the country, or a region in the center of the country.[3] We also included time effects to control for variables that may have common effects across states in a specific year. As a result, the model specified is the following:

$$y_{it} = \alpha_0 + \beta_1 y_{0it} + \beta_2 oil + \beta_3 north + \beta_4 center\ \beta_5 g_{it} + \beta_6 g_{it-1} + \beta_7 g_{it-2} + \beta_8 k_{it} + \lambda_t + \mu_{it} \quad (1)$$

where α and β refer to the parameters for the determinants of regional income, μ denotes the error term, and λ refers to time effects.

Nevertheless, equation (1), although informative, provides little information on the effects of public investment within groups of regions according to their position on the regional income distribution scale. We took this issue a step further by using quantile regression analysis, which enabled us to distinguish regions according to their position on the income distribution scale.

Typically, in ordinary regression models, we cannot distinguish whether inequalities appear across the entire spectrum of the distribution or if they are concentrated on one part of the scale. To elucidate this issue, we developed a quantile regression model, based on Koenker and Bassett (1978), which has been used extensively in labor economics to study wage inequalities. We used this method to analyze the effects of public investment on regional income and at different points on the income distribution scale. Let (y_{it}, $PUBINV_{it}$) be a sample of two main explanatory variables for a given period. The relation between these two variables may be formulated as

$$y_{it} = \beta_0 PUBINV_{it} + \mu_{0i} \quad (2)$$

Thus, the quantile regression can be expressed as

$$Quant_\theta(y_{it}) \,/\, \beta_0 PUBINV_{it} = \beta_0 PUBINV_\theta \quad (3)$$

where $Quant$ denotes the conditional quantile (θ) of y_{it}; the conditional explanatory variable is public investment $PUBINV_{it}$, assuming that $Quant_\theta(\mu_{\theta i} \,/\, PUBINV_{it}) = 0$; and $\mu_{\theta i}$ denotes the error term. The estimation results, $Qu\hat{a}nt(y_{it} \,/\, PUBINV_{it}) = \hat{\beta}_\theta PUBINV$ indicate how the conditional expectation of income varies as θ increases along the distribution scale. The quantile coefficients therefore elucidate the marginal change in the conditional quantile that is due to a marginal change in $PUBINV$.

Quantile regression models are similar to ordinary least-squares (OLS) regression models, but the conditional expectation of the dependent variable is allowed to vary across its distribution taking any percentile.[4] It has the advantage of allowing statistical inferences in much the same way as classical

[3] States that were included in the dummy variables were: oil: Campeche and Tabasco; North: Baja California, Coahuila, Chihuahua, Nuevo León, Sonora, and Tamaulipas; and Center: Distrito Federal (Mexico City), México, Morelos, Puebla, and Querétaro.

[4] Any one-dimensional statistic (including the least-squares estimator) for estimating a parameter of location can be readily extended to the regression context.

regression methods that are grounded on minimizing sums of residuals and displays additional properties of invariance and robustness (Koenker and Bassett 1978). As a result, by computing regression quantiles, we could estimate whether the effect of public investment is more pronounced at different points of the regional income distribution scale.

The Data

We used a panel of Mexican regions that we obtained from public sources for the period 1993–98, which coincided with an ongoing regional integration process. Data for GDP and public investment were gathered from the website of the Instituto Nacional de Estadística, Geografía e Informática, INEGI (available online at http://www.inegi.gob.mx). To calculate per capita GDP, we used population data from the Population Census (also by INEGI), as well as available figures from the statistical annexes of the Presidential Address to the Nation (Presidencia de la República). Data on public investment were collected from the same statistical annexes as well as from INEGI for various years. We split public investment into social and infrastructure investment.[5] The data we used were defined in constant prices using a different deflator for each region that was applied to different variables.

As in any standard model of growth, we included private investment as a separate independent variable. Hypothetically, private investment is supposed to play either a complementary or a supplementary role to public investment. Since this variable is not available for Mexican regions, we approximated it on the basis of the percentage of private credits that each region received. We assumed that the share of private investment is not significantly different from the share of private credits, and we distributed the national gross private formation of capital on that basis. Data on the regional percentage of private credits were taken from the statistical annexes of the Presidential Address to the Nation (Presidencia de la República). Finally, we used regional dummy variables to approximate differences in the steady-state values of per capita income and to absorb fixed regional effects in the error term.

[5] Social investment includes spending by the central government for education, health, labor, urban development, sewerage, ecology, solidarity and regional development, and social supply programs. The infrastructure comprises investment in communication and transport systems. Total public investment includes social and infrastructure investment, plus other investment, such as for justice and energy.

Regional Disparities and the Allocation of Public Investment in Mexico

Regional Disparities and the Macroeconomic Context

Since the early 1970s, Mexico has undertaken a broad range of economic, financial, and political reforms that have led to its current regional policy. Throughout the 1970s and at the beginning of the 1980s, the country was under a populist government. The motors of growth during this period can be traced to public investment, which was financed by issuing debt as a result of the high international oil prices—a sector that had dominated the economy for many years—which led to a deep economic crisis in 1982 (Zedillo 1986). Subsequent economic and political adjustments were directed toward correcting the oversized public sector, which lead to less-intensive public investment (Cardenas 1996).

Table 2 presents an overview of the evolution of disparities among the regions. Regional disparities were measured by the coefficient of variation of per capita GDP over a set of geographic areas from 1970 to 1998. Because the *relative size* of the population for different regions did not vary significantly during this period, we expect the coefficient of variation to be comparable over time. In addition, we present the data for specific years to avoid repetitive results.

Table 2

Coefficient of Variation of Per Capita GDP

Year	All Regions[a]	Center	North	South[a]
1970	0.41	0.43	0.20	0.39
1980	0.36	0.41	0.20	0.42
1985	0.32	0.38	0.18	0.28
1988	0.41	0.46	0.18	0.47
1993	0.42	0.51	0.17	0.57
1998	0.44	0.51	0.16	0.54

[a] Excluding Campeche and Tabasco.

In doing so, we selected those years when there was a change in the coefficient of variation. The results show that disparities in per capita GDP dropped from 1970 to 1985. After 1985, Mexico opened up trade, which led to important structural economic changes. In particular, the big leap in the dispersion of income among the regions occurred between 1985 and 1988. As a result, inequalities in income rose significantly in the central and southern regions, although the average remained almost constant. Average disparities during the second half of the 1990s were higher than ever before.[6] However, inequalities were noticeably different across geographic areas. The income disparities in the northern states were the lowest and displayed a downward trend, whereas those in the southern states were the highest—consistent with other studies, such as that by Juan-Ramon and Rivera-Batiz (1996).[7]

Allocation of Public Investment in Mexico

The allocation of federal investment in Mexican regions has always been centralized. In the early 1980s, efforts were made to improve transparency in the distribution of public investment through the General Sharing Fund, which distributes investment according to three criteria: population (based on 1980 estimates), fiscal effort (the share of federal tax revenues), and a per capita percentage of the revenue received in the previous two years (both included in 1991). However, within the period analyzed, only 20 percent of the total federal revenue was distributed according to this formula, leaving the remainder to be distributed according to criteria established by the central government. In addition, the distribution was significantly uneven, as can be noted in Table 3.

With regard to the resulting distribution, Mexico City (known as the Distrito Federal) has traditionally taken the lion's share of public investment. Although during the 1970s and early 1980s, the allocation of public investment was driven by the central government's pragmatic response in pursuit of political interests, this situation changed after the liberalization of the economy. The continual decline in public investment followed the new orientation of the economy

[6] Despite the economic reforms that were undertaken for many years, political instability and the interruption of capital flows led to a devaluation of the Mexican peso, creating another deep economic crisis in the mid-1990s (Calvo and Mendoza 1996; Gil-Díaz and Cartens 1996). Restrictions on public finance were again reinstated.

[7] Migration between states led to a convergence process during the 1970s and early 1980s. This migration flowed mainly toward Mexico City. The flow of migration was then redirected toward the northern states, which displayed more dynamic economies, although interstate migration did decrease, as flows to the United States became more important (e.g., Chavez-Galindo 1999; Escobar-Latapi 1999). Nevertheless, these flows did not preclude regional disparities from persisting over time, especially after 1988. In this sense, regional inequality may not be strongly affected by migration flows.

Table 3

Allocation of Per Capita Public Investment (Average = 100)

State	Total	Social	Infrastructure
Aguascalientes	73	103	133
Baja California	47	66	56
Baja California Sur	142	181	190
Campeche	700	212	175
Coahuila	84	86	86
Colima	90	137	139
Chiapas	99	120	154
Chihuahua	45	69	80
Distrito Federal	230	303	261
Durango	55	101	69
Guanajuato	35	52	38
Guerrero	65	116	68
Hidalgo	119	108	58
Jalisco	25	42	35
México	30	44	70
Michoacán	37	59	81
Morelos	49	64	87
Nayarit	110	119	90
Nuevo León	55	74	61
Oaxaca	81	110	239
Puebla	28	52	57
Querétaro	66	98	94
Quintana Roo	90	134	146
San Luis Potosí	41	67	118
Sinaloa	62	77	60
Sonora	72	99	120
Tabasco	357	91	60
Tamaulipas	94	69	108
Tlaxcala	52	126	77
Veracruz	77	50	61
Yucatán	60	102	70
Zacatecas	33	68	61

toward a more private-based sector and a market-driven economy (Lächler and Aschauer 1998).[8]

Results

Table 4 presents the results for equation (1) and the estimates of regression quantiles for equation (3) using OLS. Table 5 shows the results when nonlinearities are included in the model, as is discussed later. The results for panel-data models and quantile regressions are presented for total, social, and infrastructure investment. Quantile categories of income distribution are high-income regions, in which income corresponds to the 0.75 quantile; medium-income regions, in which income is at the median (corresponding to the 0.5 quantile); and low-income regions in which income corresponds to the 0.25 quantile. Thus, the conditional mean will differ across the regional income distribution scale. An additional advantage of using quantile regression is that the coefficients are easy to interpret. By subtracting

[8] However, there are still claims that public investment has been allocated in a manner that has reinforced centralism and authoritarian presidentialism.

Table 4

Per Capita GDP in the Mexican Regions, 1993–1998

	Total Investment				Social Investment				Infrastructure Investment			
		Income Group				Income Group				Income Group		
Variable	All	Low	Medium	High	All	Low	Medium	High	All	Low	Medium	High
g	0.044***	0.050	0.044***	0.046**	–0.003	0.002	–0.0001	0.018	0.014	0.016	0.023***	0.018*
	(0.0178)	(0.032)	(0.014)	(0.023)	(0.019)	(0.027)	(0.021)	(0.022)	(0.010)	(0.011)	(0.009)	(0.011)
g (1)	0.012	0.003	0.002	0.010	0.023	0.013	0.022	0.033*	0.014	0.014	0.009	0.012
	(0.015)	(0.029)	(0.013)	(0.024)	(0.018)	(0.022)	(0.019)	(0.020)	(0.010)	(0.011)	(0.010)	(0.012)
g (2)	0.011	–0.017	–0.015	–0.020	0.044***	0.024	0.014	–0.002	0.011	0.010	0.006	0.013
	(0.14)	–(0.026)	–(0.012)	–(0.023)	0.044***	(0.022)	(0.018)	–(0.023)	(0.010)	(0.009)	(0.009)	(0.011)
y_0	0.716***	0.881***	0.891***	0.967***	0.738***	0.833***	0.908***	0.935***	0.763***	0.837***	0.896***	0.939***
	(0.047)	(0.047)	(0.020)	(0.030)	(0.047)	(0.032)	(0.025)	(0.029)	(0.045)	(0.030)	(0.024)	(0.027)
k	0.100***	0.0678***	0.038***	0.010	0.087***	0.072***	0.031***	0.011	0.089***	0.080***	0.041***	0.020**
	(0.0197)	(0.020)	(0.008)	(0.011)	(0.019)	(0.014)	(0.010)	(0.010)	(0.019)	(0.013)	(0.010)	(0.011)
Oil	–0.165***	–0.196***	–0.159***	–0.196***	–0.062	–0.130***	–0.094***	–0.103***	–0.059	–0.127***	–0.088***	–0.084***
	(0.059)	(0.045)	(0.022)	(0.032)	(0.049)	(0.019)	(0.021)	(0.024)	(0.048)	(0.023)	(0.021)	(0.027)
North	0.082***	0.004	0.057***	0.062***	0.089***	0.027	0.061***	0.096***	0.071**	0.030*	0.067***	0.070***
	(0.035)	(0.023)	(0.013)	(0.023)	(0.034)	(0.019)	(0.017)	(0.021)	(0.032)	(0.017)	(0.015)	(0.020)
Center	0.049	–0.022	0.032***	0.076***	0.049	0.004	0.033***	0.070***	0.027	–0.023	0.031***	0.056***
	(0.034)	(0.023)	(0.012)	(0.021)	(0.033)	(0.018)	(0.016)	(0.020)	(0.032)	(0.016)	(0.015)	(0.019)
1994	0.0096	0.025	0.011	–0.009	0.006	0.007	–0.003	–0.016	0.008	0.021	–0.009	–0.013
	(0.015)	(0.028)	(0.14)	(0.024)	(0.015)	(0.021)	(0.018)	(0.021)	(0.017)	(0.019)	(0.017)	(0.022)
1995	–0.016	–0.019	–0.039***	–0.086***	–0.049***	–0.055***	–0.076***	–0.111***	–0.043**	–0.025	–0.072***	–0.120***
	(0.021)	(0.034)	(0.015)	(0.024)	(0.021)	(0.025)	(0.021)	(0.024)	(0.020)	(0.022)	(0.018)	(0.021)
1996	–0.076***	–0.088***	–0.105***	–0.128***	–0.096***	–0.120***	–0.118***	–0.133***	–0.097***	–0.077***	–0.121***	–0.154***
	(0.019)	(0.033)	(0.015)	(0.027)	(0.019)	(0.023)	(0.020)	(0.023)	(0.017)	(0.021)	(0.017)	(0.022)
1997	–0.099***	–0.125***	–0.138***	–0.134***	–0.105***	–0.120***	–0.140***	–0.143***	–0.117***	–0.105***	–0.151***	–0.158***
	(0.017)	(0.031)	(0.014)	(0.022)	(0.018)	(0.023)	(0.019)	(0.022)	(0.018)	(0.021)	(0.017)	(0.021)
1998	–0.091***	–0.120***	–0.113***	–0.123***	–0.094***	–0.105***	–0.130***	–0.127***	–0.108***	–0.100***	–0.135***	–0.156***
	(0.017)	(0.030)	(0.014)	(0.024)	(0.017)	(0.023)	(0.018)	(0.021)	(0.017)	(0.019)	(0.017)	(0.022)
Constant	–0.300**	–0.299***	–0.063	–0.037	–0.183	–0.211***	–0.046	–0.004	–0.084	–0.246***	–0.055	0.019
	(0.132)	(0.109)	(0.055)	(0.084)	(0.124)	(0.077)	(0.069)	(0.066)	(0.102)	(0.067)	(0.057)	(0.070)
R^2	0.9667	0.8413	0.8552	0.8491	0.9696	0.8427	0.8564	0.8533	0.9688	0.8438	0.8564	0.8509

N = 192; standard errors in parentheses.
* Significant at 10%.
** Significant at 5%.
***Significant at 1%.

Table 5

Per Capita GDP in the Mexican Regions, 1993–1998 (Nonlinearities Included)

	Total Investment				Social Investment				Infrastructure Investment			
		Income Group				Income Group				Income Group		
Variable	All	Low	Medium	High	All	Low	Medium	High	All	Low	Medium	High
g	0.048***	0.051	0.042***	0.044***	0.039	0.029	0.021	0.037	0.040***	0.023	0.038***	0.044***
	(0.018)	(0.034)	(0.014)	(0.018)	(0.025)	(0.034)	(0.035)	(0.032)	(0.017)	(0.023)	(0.014)	(0.016)
g (1)	0.015	0.004	0.004	0.002	0.022	0.012	0.015	0.033*	0.012	0.010	0.005	0.003
	(0.015)	(0.022)	(0.013)	(0.018)	(0.018)	(0.031)	(0.025)	(0.020)	(0.010)	(0.014)	(0.009)	(0.010)
g (2)	0.017	–0.017	–0.020	–0.018	0.046***	0.033	0.028	0.001	0.010	0.010	0.009	0.005
	(0.015)	–(0.020)	–(0.012)	–(0.016)	(0.017)	(0.026)	(0.024)	(0.022)	(0.010)	(0.011)	(0.008)	(0.009)
y_0	0.751***	0.876***	0.898***	0.958***	0.746***	0.839***	0.902***	0.947***	0.773***	0.842***	0.902***	0.947***
	(0.047)	(0.038)	(0.021)	(0.024)	(0.048)	(0.043)	(0.034)	(0.029)	(0.047)	(0.038)	(0.021)	(0.027)
k	0.091***	0.068***	0.037***	0.018**	0.082***	0.067***	0.027**	0.017	0.087***	0.075***	0.042***	0.021**
	(0.019)	(0.015)	(0.008)	(0.009)	(0.019)	(0.018)	(0.013)	(0.011)	(0.019)	(0.016)	(0.008)	(0.009)
Oil	–0.200***	–0.180***	–0.151***	–0.170***	–0.071	–0.106***	–0.105***	–0.118***	–0.062	–0.134***	–0.097***	–0.091***
	–(0.059)	–(0.036)	–(0.025)	–(0.029)	–(0.051)	–(0.033)	–(0.031)	–(0.024)	–(0.049)	–(0.029)	–(0.019)	–(0.025)
North	0.058*	0.006	0.055***	0.064***	0.072**	0.042	0.058***	0.068***	0.068**	0.028	0.056***	0.056***
	(0.035)	(0.022)	(0.014)	(0.018)	(0.035)	(0.027)	(0.023)	(0.021)	(0.033)	(0.021)	(0.013)	(0.017)
Center	0.037	–0.020	0.034***	0.076***	0.039	0.008	0.040**	0.070***	0.029	–0.015	0.029	0.069***
	(0.033)	–(0.019)	(0.013)	(0.015)	(0.034)	(0.022)	(0.021)	(0.020)	(0.032)	–(0.021)	(0.012)	(0.016)
1994	0.006	0.025	0.011	–0.006	0.003	0.008	0.002	–0.014	0.001	0.022	–0.013	–0.031
	(0.015)	(0.021)	(0.014)	–(0.018)	(0.015)	(0.026)	(0.023)	–(0.021)	(0.017)	(0.025)	–(0.015)	–(0.019)
1995	–0.016	–0.019	–0.044***	–0.079***	–0.033	–0.055*	–0.069***	–0.088***	–0.039**	–0.020	–0.067***	–0.114***
	(0.020)	(0.025)	(0.016)	(0.018)	(0.021)	(0.030)	(0.027)	(0.023)	(0.020)	(0.028)	(0.016)	(0.019)
1996	–0.073***	–0.087***	–0.106***	–0.127***	–0.080***	–0.087***	–0.107***	–0.125***	–0.097***	–0.080***	–0.121***	–0.152***
	(0.018)	(0.025)	(0.015)	(0.020)	(0.019)	(0.031)	(0.026)	(0.024)	(0.017)	(0.025)	(0.014)	(0.018)
1997	–0.097***	–0.121***	–0.141***	–0.133***	–0.089***	–0.104***	–0.115***	–0.128***	–0.116***	–0.097***	–0.143***	–0.152***
	(0.017)	(0.024)	(0.014)	(0.017)	(0.018)	(0.029)	(0.025)	(0.023)	(0.018)	(0.026)	(0.015)	(0.018)
1998	–0.091***	–0.114***	–0.116***	–0.144***	–0.082***	–0.100***	–0.113***	–0.116***	–0.108***	–0.097***	–0.131***	–0.149***
	(0.016)	(0.023)	(0.014)	(0.019)	(0.017)	(0.027)	(0.025)	(0.023)	(0.017)	(0.024)	(0.014)	(0.018)
gmed	–0.008	–0.020	0.004	0.037***	–0.026	–0.041	–0.010	0.005	–0.024	–0.024	–0.011	0.001
	(0.014)	(0.016)	(0.010)	(0.013)	(0.017)	(0.024)	(0.022)	(0.021)	(0.017)	(0.022)	(0.014)	(0.017)
ghigh	–0.046**	–0.003	0.006	0.007	–0.073***	–0.038	–0.037	–0.042	–0.049**	–0.016	–0.024	–0.037
	(0.020)	(0.026)	(0.015)	(0.018)	(0.026)	(0.039)	(0.035)	(0.036)	(0.026)	(0.034)	(0.021)	(0.027)
Constant	–0.388***	–0.304***	–0.050	–0.038	–0.389***	–0.353***	–0.147	–0.179	–0.167	–0.228**	–0.120**	–0.032
	(0.133)	(0.100)	(0.065)	(0.076)	(0.146)	(0.139)	(0.138)	(0.119)	(0.113)	(0.109)	(0.064)	(0.077)
R^2	0.9665	0.8427	0.8554	0.8524	0.9691	0.8442	0.8576	0.8567	0.9694	0.8451	0.8571	0.8532

N = 192; standard errors in parentheses.
* Significant at 10%.
** Significant at 5%.
*** Significant at 1%.

the coefficients of two quantiles, we obtained the interquantile variation, revealing how much returns to public investment differ according to regional income distribution. The empirical models were estimated using Stata 7.0, although alternative software could have been used.

We start by examining the impact of public investment on regional income—the so-called return to public investment—since this is the central issue that motivated this article. To do so, we examine the coefficient of public investment in Tables 4 and 5. When the impact of public investment is evaluated across the conditional income distribution, there is a significant contemporaneous—no lags were statistically significant—positive effect of public investment. This pattern applies to all the other income quantiles as well, as is shown in Table 5 when nonlinearities are included, as we explain later. However, as we hypothesized, when different sources of public investment are split and their effect is examined in isolation, the results are largely heterogeneous. Tables 4 and 5 show that while contemporaneous infrastructure investment is largely significant, social investment does not exert a significant effect when it is evaluated at the mean conditional expectation. Social investment is significant only when a two-year lag is included, except in the case of the top income quantile, where the first lag appears to be significant at the 10-percent level. However, these results should be interpreted with caution, since the impact of social investment may involve identification problems, as well as unobserved heterogeneity. Unlike social investment, infrastructure investment exerts a significant contemporaneous effect on income in the medium- and high-income, but not the low-income, quantiles. This finding is consistent with the fact that—unlike social investment—the effect of infrastructure investment is channeled through reductions in transaction costs and thus, unlike social investment, may exert a more-immediate effect on regional income. The immediacy of returns to infrastructure investment results from the feature that no significant lags were identified.

Returns for private investment (k) are significant, and, on average, the coefficients do not change significantly with the type of public investment. However, they do change when they are evaluated at different points on the income distribution scale. The effect of private investment is always significant and displays similar coefficients. The coefficient is higher for the low and medium quantiles, suggesting diminishing returns to scale. Therefore, the inverse effect of public and private investment is the result of a hypothetically complementary role of both sources of investment in Mexico.

The coefficient for initial per capita GDP (y_0) is positive and significant in all the quantiles, revealing the existence of some path dependency (catching up) in the evolution of regional income, as is consistent with the findings of Scott (1998). However, the coefficients are higher at higher income quantiles, suggesting a stronger influence of prior income among richer regions. The effect of private capital (k) is positive and significant. In addition, the coefficients for initial per capita GDP (y_0) are higher for the total sample than for specific quantiles because quantile regression captures part of the unobserved heterogeneity.

An additional issue is the effect of geographic dummy variables, such as location (north, center, or south) and regions being oil producers. The former variable is informative of the possible effects of economic integration, since the significant, positive coefficients for the northern and center regions that are closer to the U.S. frontier indicate a positive effect on the evolution of economic performance. Conversely, the coefficient of oil-producing regions displays a negative coefficient, as expected from the evolution of oil prices, as well as the availability of natural resources.

Another interesting issue is that the estimated impact of public investment may depend on existing levels of public investment. Some authors (Arrow and Kurz 1970; Barro 1990) have referred to the connections between private and public capital and the diminishing returns in the benefits of public capital while the costs of providing public capital rise constantly. Consequently, for relatively low levels of public capital, an increase in public investment raises the rate of economic growth, but for higher levels of public capital, an increase in public investment decreases the rate.

The respecification of the model did not lead to the removal of any of the variables. Following Röller and Waverman (2001), we included two dummy variables that correspond to medium (gmed) and high (ghigh) levels of public investment.[9] The interpretation of the results for the levels of medium and high public investment could be as follows: positive values of gmed and ghigh would signal a critical mass, at which public investment is relevant at those levels but insignificant at lower levels, whereas a positive value for *g* but negative values for gmed and ghigh would be an endorsement of the diminishing returns hypothesis. In general, nonlinearities—as shown in Table 5—are significant at the conditional mean regression; in particular, the dummy variable for the low-income group is significant. The striking aspect of this finding is that in the conditional mean equation (All), the ghigh variable is significant but with a negative sign; this finding may suggest that, on average, there are diminishing returns to the use of public investment across the Mexican states. However, a critical mass seems to be operating in the case of total public investment when evaluated in the top regional income quantiles. The implication here is that there may be increasing returns to scale for the richer regions because of agglomeration economies (Scott and Storper 2003). The same result does not apply for social and infrastructure investment. Estimates in Table 5 do not support the results for increasing returns in the high-income regions, which may suggest that this finding may be the result of the existent heterogeneity of public investment (for example, other forms of public investment, such as energy, may be relevant).

Finally, the estimated models were corrected by some general estimation tools. We first tested the existence of differential variation when regional income varies using a White heteroscedasticity test. The results rejected the hypothesis of heteroscedasticity at a 1-percent critical value. Second, we tested the existence of multicollinearity with variance inflation factors (VIF) smaller than 5 and the mean VIF of 2.84. Finally, we identified the existence of serial autocorrelation and corrected it by introducing two lags in the dependent variable, as was noted earlier. However, specific spatial-related misspecification problems may arise (Anselin 1988). The first potential problem is the existence of *spatial autocorrelation* resulting from dependence between the position of some observations (regions) in the space; that is, whether the spatial distribution of the variables is random or shows a pattern of spatial dependence. The second problem is the existence of *spatial heterogeneity*, which generally means that the parameters of the empirical model vary in some systematic way across space. We identified a relevant possible type of spatial heterogeneity derived from the spatial position of Mexican states.

As we noted, the relevance of spatial autocorrelation and spatial heterogeneity compelled us to conduct some diagnostic tests. We dealt with the existence of spatial autocorrelation by using the Moran I test (Cliff and Ord 1973). The results led us to reject the null hypothesis of spatial independence of regional income and public investment in space. However, we acknowledge that the Moran I test is not well tailored to a quantile regression framework.

[9] The levels were calculated after the variable *g* was normalized with respect to the arithmetic mean. Medium levels were fixed for a value range between 0.8 and 1.2, while high levels were fixed above the value 1.2. About 25 percent of the sample fell within the high category, and approximately 35 percent fell within the medium category. Several alternatives were considered, such as an increase or decrease in the values for the levels, and confidence intervals were taken, including a band of three and four times the standard error. We achieved similar results.

Therefore, if spatial dependence is present when variables are evaluated at different quantiles, inference should rely on maximum likelihood ML estimates, rather than on the results of OLS regression.

Regarding the existence of spatial heterogeneity that is due to the agglomeration effects associated with the capital, we may expect the existence of some specific spatial distribution determined by distance from Mexico City. In Table 5, we assumed a different constant term for regions, depending on their level of public investment and hence introduced spatial heterogeneity into the model. In addition, we conducted a geographically weighted regression to test whether the distance of each region from Mexico City did exert an appreciable effect on our estimates, following an approach similar to McMillen (1996). We rejected the hypothesis of spatial heterogeneity using a likelihood ratio test at the usual 5-percent level. The results are consistent with the hypothesis that spatial heterogeneity and spatial dependence are often related.

Conclusions

The purpose of this article has been to provide insights into the influence of public investment on regional income disparities at different points on the regional income distribution scale. We have presented evidence of the heterogeneous impact of public investment in shaping economic performance. The results were obtained using quantile regression as a methodological tool, which allowed us to isolate the impact of public investment according to where the income of a region falls within the conditional distribution of regional income. In particular, we showed that public investment has smoothed over regional inequalities in Mexico, although this effect has occurred mainly within the relatively richer regions. Contrary to the hypothesis of regional redistribution, public investment has exerted no relevant effect on low-income regions and has been ineffective in reducing regional inequalities.

This finding confirms what some economic geographers have defined as the "complexity of regional economic changes." Consistent with Scott (1998), spatial-dependent transaction costs and high externalities may lead to the emergence of superclusters in certain (richer) areas that stimulate regional growth. In the same vein, one possible interpretation of these findings may be found on the basis of some theoretical frameworks of the so-called new economic geography (Krugman and Venables 1995). Indeed, economic activity has concentrated in some specific areas, namely, the north and the capital of the country, following a sequence that resembles a core periphery model. This pattern is consistent with new economic geography models (Hanson 1996, 1997) indicating that nominal wages decrease with the distance from industrial centers and Mexico City.

A striking finding of our study is that the increasing income of richer regions concentrates the effects of public investment on infrastructure, rather than on social investment. That is, investment in the infrastructure has had a heterogeneous regional impact on regional inequalities, the pattern being that public investment causes richer regions to become wealthier. From an economic geography perspective, this finding indicates that the effects of public investment foster large agglomerations (Scott 1998; Scott and Storper 2003). Our results confirm a previous hypothesis that stated that whereas infrastructure investment has an immediate effect on economic performance by reducing transaction costs, social investment may have an effect in the long run. Furthermore, this finding reinforces the hypothesis that Mexico is at the first stage of Hirschman's (1958) development strategy, if public investment lags do not reveal a pure expenditure effect.[10] The empirical findings

[10] The fact that the coefficient for public investment varies at different points of the income distribution scale may be interpreted as evidence that expenditure effects are less prominent, since hypothetically they should have similar effects across the entire income distribution scale.

are consistent with Hirschman's (1958) and Myrdal's (1957) framework.

Consistent with previous theoretical predictions (Martin 1999; Scott 1998), our results indicate that the effect of public investment, particularly investment in the infrastructure, increases across the income distribution function, suggesting increasing returns to public investment. The geographic interpretation of this evidence may be explained by "localization economies" that arise because of the formation of a pool of skilled labor and the presence of supporting industries (Sunley 2000). There is abundant evidence to indicate that skilled labor determines differences in regional income and wages (McCall 2001). Furthermore, in light of new location models (Sunley 2000), investment in large cities and industrial regions can be explained by the existence of several externalities, such as having access to larger markets (pecuniary externalities), a wider variety of intermediate inputs (productivity externality), and a higher technological capacity (innovation externality). These findings seem to be consistent with the hypothesis that the allocation of public investment in Mexico is directed toward regions that have economic agglomeration economies.

The final finding confirms the importance of the effects of economic integration, for example, those resulting from existing agglomerations, natural resource endowments, and the areas surrounded by rich neighbors. Evidence of these effects is captured through the statistically significant coefficients for north–south latitude and for oil-producing regions, both of which are predictors of economic performance across the regions' income distribution.

Current regional policies in Mexico, combined with the effects of economic globalization, may intensify the concentration of economic activity in a few regions, giving rise to so-called polycentric concentration in these regions. However, this type of public investment is not irrelevant in determining regional income. Whereas social investment has long-term effects on regional inequality in all regions, investment in the infrastructure in Mexico has lifted the performance of richer and industrialized regions. Therefore, an interesting policy implication of our results is that social investment, rather than infrastructure investment, may be a potential tool for smoothing regional disparities in countries like Mexico, although its effects appear in the long run. Other issues could benefit from additional research. There is a need for analysis of the potential transition from one group to another within the regional income distribution, although the lack of data preclude such an analysis for Mexico. Also, when data on the North American Free-Trade Agreement become available in the future, it will be possible to test the effects of the liberalization of trade on the distribution of regional income.

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