DOCUMENTS DE TREBALL
DE LA FACULTAT DE CIÈNCIES ECONÒMIQUES
I EMPRESARIALS

Col·lecció d'Economia

IS THE IMPACT OF PUBLIC INVESTMENT NEUTRAL ACROSS THE REGIONAL INCOME DISTRIBUTION? EVIDENCE FROM MEXICO

Joan Costa Font [a,b]
Eduardo Rodriguez-Oreggia [c]

[a] London School of Economics, London UK.
[b] Departament de Teoria Economica & CREPS Universitat de Barcelona, Spain.
[c] Inter-American Conference on Social Security, Mexico.

Contact Address
Dr Joan Costa i Font
Department of Economic Theory
Universitat de Barcelona.
Diagonal 690,08034
Barcelona (Catalonia), Spain.
Email: jcosta@eco.ub.es
Fax: +34934021937
Tel:+34934024333

*****This article has benefited from comments at its different stages. We would especially like to acknowledge the comments from two anonymous referees as well as those from Gilles Duranton, Lucy Eyre, Jordi Pons, Elisenda Paluzie , Andres Rodriguez-Pose, Raymond J.G.M. Florax and participants in the workshops at the London School of Economics, at the University of Barcelona and the European University Institute in Florence. Joan Costa is grateful for funds received from the Comision Interministerial de Ciencia y Tecnologia, number CICYT-SEC2002-0321.

Abstract: This paper investigates the contribution of public investment to the reduction of regional inequalities, with a specific application to Mexico. We use quantile regressions to examine the impact of public investment on regional disparities according to the position of each region in the conditional distribution of regional income. Results confirm the hypothesis that regional inequalities can indeed be attributed to the regional distribution of public investment, where the observed pattern shows that public investment mainly helped to reduce regional inequalities between the richest regions.
JEL classification: R11, H50, C39

Key words: regional development, public investment, quantile regression

Resum: Aquest article examina la contribució de la inversió pública en la reducció de les desigualats regionals, amb una aplicació específica Mèxic. Utilitzem la regressió quantílica per examinar l'impacte de la inversió pública en reduir les disparitats regional dependent de la posició de cada regió en la distribució condicional de la renda regional. Els resultants confirmen la hipòtesi pel la qual les desigualtats regional poden atribuir-se a la distribució de la inversió pública de manera que ha contribuït a reduir les desigualtats entre les regions més riques.

1 Introduction

In recent years regional policies have largely been characterised by a tendency to invest in infrastructure. These policies are justified by a number of authors on the grounds of positive efficiency gains that arise from the impact of public investment on regional economic growth (Aschauer, 1989; Munnell, 1990a, 1990b; Gramlich, 1994; de la Fuente, 1996a; Fernald, 1999). However there are also marked effects on the distribution of economic activity, and subsequently, on the generation of regional inequalities (de la Fuente, 1996b). Geography is important in determining economic activity within countries, and thus affecting the regional income distribution and the structure of production among space. Therefore, arguably regional policies might have a role in influencing the geography of economic activity in order to smooth regional disparities.

The “hypothesis of regional redistribution” establishes that inequalities may decline as a result of a specific distribution of public investment designed to encourage regional convergence, whereby poor regions are intended to grow more than richer ones. Although the Structural Funds are not the unique source of public investment, evidence from the European Union (EU) shows that regional disparities have not decreased. Poorer regions have not grown faster than richer regions, and hence regional policies do not seem to have significantly influenced the decline of regional inequalities (Boldrin and Canova, 2001). A comprehensive explanation suggest that improvements in inter-regional infrastructures which are channelled through reductions in transaction costs, potentially discourage firms from localising in poor areas, which in itself may increase the regional income gap (Martin and Rogers, 1995 and Martin, 1999). Alternatively, Sala i Martin (1994) points out that empirical findings revealing similar convergence coefficients from growth models between sufficiently heterogeneous regions can be interpreted as evidence of the ineffectiveness of regional investment policies in achieving redistribution goals. However, the equality of convergence coefficients across heterogeneous regions might still be the result of an insufficient redistribution effort (De la Fuente, 2001).We can conclude then, that the relationship between regional inequalities and public investment is still problematic and requires further attention.

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. Mexico has been taken as a paradigmatic example where to study the role of geography on economic activity. Indeed, Mexico has an estimated population of 100 million people in 2000 and is a federal state organised into 31 separate states (henceforth referred to as ‘regions’) plus Mexico City as is exhibited in Table A1 (in the appendix) . Interestingly, regional economic disparities in Mexico are important, with a developed north and large agglomeration economies in Mexico City. Although the federal government has ultimate control of regional funds, important differences exist across regions both in the allocation of public investment and in the number of federal programmes implemented.

The geographical gradients of Latin American countries are dramatic, and Mexico is not an exception. In 1985 Mexico opened its economy to international trade which has lead to the development of new industry centres in Northern Mexico. Typically, regions benefiting the most from regional integration arrangements either have prior advantages from economic agglomeration (Krugman and Livas, 1996), or productive and natural resource endowments. And, in the case where countries involved are sufficiently large and heterogeneous, economic activity might be the result of having rich neighbours. In Mexico examples of the latter would be the northern regions bordering the USA, and examples of the former the oil producing regions and the areas surrounding Mexico City. Mexico City because of its large skilled work force, consumer market, low distribution costs and proximity to government decision makers concentrated a large part of the economic activity. These has been argued to have lead to the breakdown of a regional wage gradient (Hanson, 1997).

This paper explores the hypothesis that public investment displays a divergent influence on the distribution of regional income. We hypothesise that an assessment of the way income is regionally distributed could provide us with some insights. For instance, one might expect public investment to reduce inequalities solely in one set of (e.g., the richer) regions, whereas it might not be effective in the remaining set (e.g., the poorer regions). Unlike the previous literature, we employ quantile regressions to investigate the contribution of public investment at different points of the regional income distribution function. Furthermore, this study also questions whether different types of public investment have an equal influence on regional productivity, particularly in developing countries. That is, are specific sorts of public investment (infrastructure or social investment) equally influential along the conditional regional distribution scale? Aschauer (1989) has shown that investment sources do matter in explaining regional income. When splitting public investment into different sources, infrastructure (or productive) investment appears to raise productivity considerably, whereas the effect of social investment is much less marked (Mas et al., 1996). The explanation for this effect might well be that social investment has an indirect influence through human capital accumulation instead of a short-run effect, while infrastructure investment plays a role in the short run in that it reduces transaction costs between regions. Moreover, following Martin (1999) a reduction in transaction costs would benefit the more dynamic regions, typically those in the upper quantile of regional income distribution. Therefore, the impact of infrastructure investment should be especially prominent in this group of regions. Finally, as highlighted in the title, we should stress the nature of the application setting. Studies based on middle income countries may reveal geographical specific patterns.

We shall first provide an outline of the institutional setting, the evolution of regional disparities and the distribution of public investment in Mexico. Section 3 includes a discussion of the theoretical framework and a brief survey of literature. Section 4 describes the model and data. Results are discussed in Section 5, followed by conclusions in the final section.

2 The role of public investment in economic performance

The economic channels that explain the influence of public investment are central to our analysis. Public investment[1] brings efficiency gains through economic growth, which in turn expands productive capacity and increases regional productivity. Infrastructure incorporates goods or activities which hypothetically increase private sector productivity. Furthermore, public (social) investment is believed to directly benefit demand as well by increasing the welfare of future generations and subsequently improving future productive capital. Nevertheless, these benefits occur mainly under two sets of circumstances. Firstly, when services provided respond efficiently to effective demand (World Bank, 1994), and secondly,

[1] Public investment can comprise diverse concepts. It is mainly divided into two categories (World Bank 1994; Hansen 1965): economic investment, which includes transport, communication and related issues; and social investment, which includes education, health, ecology, etc.

where the existence of high externalities prevents private investors from financing goods and services, in such cases the government should supply the capital.

The majority of the literature analysing the impact of public investment originates from the studies by Aschauer (1989) and Munnell (1990a, 1990b). Aschauer suggests that an expansion of public investment spending should have a major impact on private output. More specifically, public investment is thought to increase the rate of return to private capital, stimulating private investment expenditure. Aschauer (1989) and Munnell (1990a, 1990b) both agree that regions with higher levels of public investment tend to experience higher output, where private investment and employment growth were assumed to have preceded public investment[2]. An increase in utility-type expenditure leads to a fall in the savings rate and in growth; while both tend to rise initially in response to productive government expenditure 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 investment is allocated among areas. In middle-income countries like Mexico there is an observed pattern of scattering of funds among a large number of small and dispersed regions (Hirschman, 1958). One reason put forward for a broad spatial scattering of investment is the government's endeavour to win political support in all regions. Another reason is the belief that economic progress is a force which equally affects all regions; governments are depicted as being unprepared and unwilling to take decisions about spatial priorities and sequences for investment. Nevertheless, Hirschman's argument leaves the choice of the direction of public investment in the planners' hands, which could imply that it could to a certain extent be manipulated for electoral ends.

First attempts to establish optimal timing for regional allocation of public investment are found in Ramah (1963) and Intriligator (1964), who confronted the trade-off between national maximisation and regional disparities in living standards. Beyond these findings, Okuno and Yagi (1990) examined aspects of public investment that tend to balance inter-regional income equality and efficiency of the economy as a whole. By including private investment in their model, they found that a public investment switch from rural to urban is an optimal policy, although this switch is not optimal when private investment is ignored. They found that regional income inequality is affected by public investment, but that investment aimed at reducing regional output inequality does not always produce the desired effect. In the framework of the new economic geography, Martin and Rogers (1995) and Martin (1999) suggest that 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 of infrastructure should be addressed intra-regionally rather than inter-regionally. Otherwise the process of divergence will accelerate.

This study takes these issues further and examines regional disparities according to the position of these 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.

3 Empirical model

We depart from the conventional production function $Y_{it} = F(K_{it}, G_{it}, L_{it})$ where K_{it} is stock of capital of the economy, G_{it} refers to public investment and L_{it} total employed population. Assuming constant reruns 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 $g = G/L$. The empirical strategy used in this study is 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.

Measuring the effect of public and private investment in developing and transition economies where data on capital stocks is not available often implies undertaking some assumptions to capture the influence of both public and private. Indeed, in this study for Mexico only the flow of public investment (g) was available rather than the stock which in turn was measured in per capita terms. However, is common practice in the absence of capital stock to interpret that investment as a proxy for total capital. Yet, in order to deal with a possible simultaneous bias between regional per capita GDP and public investment, we introduce several lags in the

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

variable referring to public investment (referred as g(1) and g(2)). Time lags have been introduced to capture potential delays in productivity of public investment, which, hypothetically, might differ both between investment types and regions. Two lags were finally considered, as further lags were systematically non-statistically significant. However, one should bear in mind when interpreting the time lag coefficients in the short-run that they might reflect an expenditure effect rather than, as hypothesised, the productive impact of the investment. Additionally, a variable for private capital (k) was used 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 previous literature, there are certain control variables that should be included when estimating regional income determinants. As noted in the theoretical section, we include (y_0) as a covariate variable referring to the initial per capita GDP in order to capture the effects of previous regional income advantage. No fixed were included as far as the initial income is already time invariant. effect were included to avoid although we introduce 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), or in the (centre) of the country.[3] Furthermore, we also include time effects in order to control for variables that might have common effects across states in a specific year. As a result, the model specified is the following :

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

Where β and δ refer to the parameter for the determinants of regional income, μ denotes the error term and λ refers to time effects.

3.1 The quantile regression model

[3] States included in the dummy variables are as follows:
OIL: Campeche and Tabasco.
NORTH: Baja California, Coahuila, Chihuahua, Nuevo León, Sonora and Tamaulipas.
CENTRE: Distrito Federal (Mexico City), México, Morelos, Puebla, and Querétaro.

Equation (1). although informative, provides little information on the effects of public investment within groups of regions according to their position in terms of regional income distribution. A way of taking this issue a step forward is by employing quantile regression analysis, which enables 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 distribution or if they are concentrated around one part of the scale. In order to elucidate this issue, we have developed a quantile regression model, based on Koenker and Basset (1978), which has been used extensively in labour economics to study wage inequalities. We use this method to analyse the effects of public investment on regional income and at different points of 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:

$$y_{it} = \beta_o PUBINV_{it} + \mu_{0i} \qquad (2)$$

Then the quantile regression can be expressed as:

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

where the *Quant* denotes the conditional quantile (θ) of y_{it}, where the conditional explanatory variable is public investment $PUBINV_{it}$ assuming that $Quant_{\theta}(\mu_{oi} / PUBINV_{it}) = 0$, where $\mu_{\theta i}$ denotes the error term. The estimation results $\hat{Quant}(y_{it} / PUBINV_{it}) = \hat{\beta}_{\theta} PUBINV$ indicate how the conditional expectation of income varies as θ increases along the distribution scale. The quantile coefficients therefore elucidate on the marginal change in the conditional quantile 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 regression methods grounded on minimising sums of residuals and displays additional properties of invariance and robustness (Koenker and Bassett, 1978). As a result, by computing regression quantiles we can go on to estimate whether the effect of public investment is more pronounced at different points of the regional income distribution scale.

3.2 The data

We use a panel of Mexican regions obtained from public sources for the period 1993–98. The period coincides with an ongoing regional integration process that seems to have influenced public investment efficiency (Poder Ejecutivo Federal, 1989, 1995). Data for GDP and public investment were gathered from the Instituto Nacional de Estadística, Geografia e Informática (INEGI)[5]. To calculate per capita GDP, we use 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. Data on public investment were collected from the same statistical annexes as well as INEGI for various years[6]. We split public investment into social and infrastructure investment.[7] Data employed have been 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 have included private investment as a separate independent variable. Hypothetically, it is supposed to play either a complementary or supplementary role to public investment. Since this variable is not available for Mexican regions, it has been approximated on the basis of the percentage of private credits each region receives. We assume that the share of private investment is not significantly different from the share of private credits, and we distribute national gross private formation of capital on that basis. Data on the region percentage of private credits were taken from the statistical

[4] Any one-dimensional statistics (including the least squares estimator) for estimating a parameter of location can be readily extended to the regression context.
[5] National Institute for Statistics, Geography and Information Systems — INEGI webpage, available at www.inegi.gob.mx.
[6] Data for population were extracted from the Statistical Annexes of the Presidential Address to the Nation, various years, and the INEGI database
[7] Social investment includes central government spending in education, health, labour, urban development, sewerage, ecology, solidarity and regional development and social supply programmes. Infrastructure comprises investment in communication and transport systems. Total public investment includes social and infrastructure investment, plus other investment, such as justice and energy.

annexes of the Presidential Address to the Nation. Finally, regional dummies approximate differences in steady-state values of per capita income and also absorb fixed regional effects in the error term.

4 Regional disparities and the allocation of public investment in Mexico

4.1 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 a regional policy as it now stands. 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. Public investment was financed by issuing debt as a result of the high international oil prices — a sector which 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 towards correcting the oversized public sector, which implied less intensive public investment (Cardenas, 1996).

INSERT TABLE 1

Table 1 provides an initial overview of the evolution of disparities among regions. Regional disparities have been measured by the coefficient of variation of per capita GDP over a set of geographical areas between 1970 and 1998. Because the *relative size* of the population for different regions has not varies among the years examined significantly we expect the coefficient of variation to be comparable over time. In addition, we present the data for specific years in order to avoid repetitive results. In doing so we have selected those years where there was a change in the coefficient of variation. Results show that disparities in per capita GDP dropped during the period from 1970 to 1985. After 1985, Mexico opened up trade, which led to an important structural economic change. In particular, the big leap in income dispersion between regions occurred between 1985 and 1988. Interestingly, inequalities 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.[8] However, inequalities were noticeably different across geographical areas. Inequalities between northern states have been the lowest and have displayed a downward trend, whereas states in the south display the highest income disparities — consistent with other studies such as Juan-Ramon and Rivera-Batiz (1996) .[9]

4.2 Allocation of public investment in Mexico

The allocation of federal investment in Mexican regions has always been centralised. 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 the federal tax revenues); and finally, a per capita percentage of the revenue received in the previous two years (both included in 1991). However, within the period analysed, only 20 per cent of the total federal revenue was distributed according to this formula, leaving the remainder to central government criteria. In addition, the distribution has been significantly uneven, as can be noted in Table 2.

INSERT TABLE 2

When looking at 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 a pragmatic response on the part of the government in pursuit of political interests , this situation changed after the liberalisation of the economy. The continual decline of public investment followed the new orientation of

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

[9] Migration between states led to a convergence process during the 1970s and early 1980s. This migration flowed mainly towards Mexico City. Migration flows then re-directed towards the northern states, which displayed more dynamic economies, although inter-state migration did decrease, as flows to the USA became more important. See, for example, Chavez-Galindo (1999) and Escobar-Latapi (1999). Nevertheless, these flows have not precluded regional disparities from persisting over time, especially after 1988. In this sense, regional inequality may not be strongly affected by migration flows.

the economy towards a more private-based sector and a market-driven economy (Lächler and Auschauer, 1998).[10]

5 Results

5.1 General results

Table 3 shows results for equation (1) and the estimates of regression quantiles for equation (3) estimated using OLS. Table 4 exhibits results when non-linearities are included in the model as discussed further on. Results for panel data models and quantile regressions are presented for total, social and infrastructure investment. Quantile categories of income distribution read as follows: regions in which income corresponds to the 0.75 quantile are named as "high" referring to high income; regions in which income is placed in the median (0.5 quantile) are called "medium"; and finally regions in the 0.25 quantile are called low (referring to low income regions). This means that the conditional mean will differ across the regional income distribution scale. An additional advantage of using the quantile regression is that coefficients are easy to interpret. By subtracting the coefficients of two quantiles, we obtain 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 is available.

INSERT TABLE 3 and TABLE 4

Now, let us start by examining the impact of public investment on regional income –so called 'the return to public investment'-, as this is the central issue motivating this paper. To do so, we should examine the coefficient of public investment in both Tables 3 and 4. 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 shown in Table 4, when non-liniarities are included, as explained below. However, as we hypothesise, when different sources of public investment are split and their effect examined in isolation,

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

results were largely heterogeneous. Tables 3 and 4 shows that while contemporaneous infrastructure investment was largely significant, social investment did not exert a significant effect when evaluated at the mean conditional expectation. Social investment was only significant when a two year delay was included, except in the case of the top income quantile where the first lag appears to be significant at a ten per cent level. However, these results should be interpreted with caution, as the impact of social investment may involve identification problems as well as unobserved heterogeneity. Unlike social investment, infrastructure investment exerted a significant contemporaneous effect on income when evaluated in medium and high income, but not low quantiles. This result is consistent with the hypothesis that — unlike social investment — the effect of infrastructure investment is channelled through reductions in transaction costs (Martin,1999)[11] and thus, unlike social investment might have exerted an 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, coefficients do not significantly change with public investment type. However, they do change when evaluated at different points of the income distribution scale. The effect of private investment both when evaluated either with social or infrastructure investment is significant and similar coefficients. It was observed that the coefficient was higher when evaluated in low and medium quantiles suggesting diminishing returns to scale. Therefore, an inverse effect of public and private investment is identified resulting from a hypothetically complementary role of both investment sources in Mexico. However, this effect is among the scope of this paper and deserves specific examination.

As expected from previous studies, the coefficient for initial per capita GDP (y_0) is positive and significant in all quantiles, which reveals the existence of some path dependency (catching up) in the evolution of regional income. However, the coefficients rise when evaluated in 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

[11] Martin (1999) notes that typically investment is allocated to regions where transaction costs can be reduced due to the concentration of industry. Investment in poor regions will thus lead to an increase in prices because of dispersion of industry. The potential outcome is a decrease in welfare and greater divergence. However, in the future, the fall in prices due to industry concentration will lead to higher overall welfare and benefits for poor regions.

coefficients for initial per capita GDP (y_0) was higher when were where examined at the total sample rather than at specific quantiles because quantile regression captures part of the unobserved heterogeneity.

An additional issue is the effect of geographical dummy variables such as location (north-centre-south) as well as regions being oil producers. The former variable is informative of possible effects resulting from economic integration where coefficients for northern and centre regions along which are closer to the US frontier were significant and indicating a positive effect on the evolution of economic performance. Conversely, the coefficient of oil producing regions turn display a negative coefficient as expected from the evolution of oil prices.

5.2 The effect of non-linearities

The estimated impact of public investment might depend on how public investment is allocated to a specific region. One way to identify the hypothetically "true relationship" might be to introduce dummy variables or an equivalent non-linear relationship. From a review of the literature we have found two explanations of the existence of non-linearities in public investment. The first was highlighted in Arrow and Kurz (1970) and refers to a misallocation of the aggregate capital stock when the marginal product of public capital is equal to the marginal product of private capital. The second, noted by Barro (1990) refers to the fact that there are diminishing returns in the benefits of public capital, while the costs of providing public capital may rise at a constant rate. Consequently, for relatively low levels of public capital, an increase in public investment raises the economic growth rate, however, for higher levels of public capital an increase in public investment would lead to a decrease in growth.

The re-specification of the model did not lead to the removal of any of the variables. Following Röller and Waverman (2001) we include two dummies that correspond to medium (gmed) and high (ghigh) levels of public investment. The levels were calculated after normalisation for the variable g 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 per cent of the sample falls within the high category, while approximately 35 per cent falls within the medium category. Several alternatives were considered: for instance, 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.

The interpretation of results for the levels of medium and high public investment could be as follows. If the values of gmed and ghigh are positive, this will signal a critical mass, at which public investment is relevant when made at those levels, but which is insignificant at low levels. However, if the variable g is positive but gmed and ghigh are negative, there will be an endorsement for a diminishing returns hypothesis.

In general, non-linearities — as shown in Table 4 — were significant at the conditional mean regression. This had an impact both on elasticities and on the significance of some variables. In particular, the dummy variable for the low income group becomes 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 might suggest that, on average, there are diminishing returns to the use of public investment across states. However, there seems to be a critical mass 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. Interestingly, the same result does not apply for social and infrastructure investment. Estimates in Table 4 do not support results for increasing returns in the high income regions, which might 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 might be relevant here).

5.3 Misspecification issues

The estimated models have been corrected by some general estimation tools. We first tested the existence of differential variation when regional income varies using a White heteroscedasticity test (White, 1980). Results rejected the hypothesis of heterocestaticity at a 1% critical value. Secondly we tested the existence of multicollinearity employing variance inflation factors (VIF) being all smaller than 5 and being the mean VIF was 2.84; and finally we identified the existence of serial autocorrelation and corrected it by introducing two lags in the dependent variable, as noted earlier. However, specific spatial-related misspecification problems might 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*. Generally speaking, this means that the parameters of the empirical model vary in some systematic way across space. We identify a relevant possible type of spatial heterogeneity derived from the spatial position of Mexican states.

As noted above, the relevance of spatial autocorrelation and spatial heterogeneity compels us to undertake some diagnostic tests. We have dealt with the existence of spatial autocorrelation here by employing the Moran I test (Cliff and Ord, 1973). Results do lead to a rejection of the null hypothesis of spatial independence of regional income and public investment in the space[12]. However, we should acknowledge that the Moran's I test is not well tailored to a quantile regression framework. Therefore, if spatial dependence is present when variables were evaluated at different quantiles inference should rely on ML estimates rather than OLS regression results.

Regarding the existence of spatial heterogeneity due to the agglomeration effects associated with the capital, we might expect the existence of some specific spatial distribution determined by distance from Mexico City. As explained in the next section, in Table 4 we have assumed a different constant term for regions depending on their level of public investment. We therefore introduce spatial heterogeneity into the model. Additionally, we have undertaken a geographically-weighted regression to tests whether the distance of each region from Mexico City, following an approach similar to McMillen (1996). The hypothesis of spatial heterogeneity was rejected using a Likelihood Ratio Test at a usual 5% level. The results obtained are consistent with the hypothesis that spatial heterogeneity and spatial dependence are often related.

[12] The value of the Moran test for the dependant variables regional income and for public investment was respectively of 1.2 and 0.74.

6 Conclusions

This article has sought to empirically examine the influence of public investment on regional income disparities at different points of the regional income distribution scale. This study is informative to the geography of development as far as it provides evidence on the heterogeneous impact of public investment in shaping economic performance. From a methodological standpoint, employing quantile regression has shown some advantages with respect to other methods often employed in the past e.g., a pure decomposition of income inequality. Therefore, introducing quantile regression in the analysis of disparities seems to have offered appealing insights. Indeed, the method allows one to isolate the impact of public investment according to the position of each region in the conditional distribution of regional income.

A *first* and most notable finding is that public investment has effectively smoothed over regional inequalities in Mexico but mainly among the average and relatively richer regions. We find that public investment only has a robust positive impact on rising regional income when evaluated at high and medium levels of regional income. Contrary to what might have been expected but consistent with Martin (1999), public investment had no relevant effect on low-income regions, and in turn on reducing regional inequalities. Arguably, a possible interpretation of these findings might be found on the basis of some theoretical frameworks of the so-called “new economic geography” (Krugman and Venables, 1995). In the period analysed, labour mobility mainly flowed towards the USA rather than within Mexico and, thus, following Krugman and Venables (1995), this might lead to the domain of “centripetal” forces over “centrifugal forces”. Therefore, economic activity would have concentrated in some specific areas, namely the north and the capital of the country, following a sequence that resembles a core- periphery model. However, our empirical model does allow the testing of such ambitious predictions.

The *second* finding of our study pints out that the effects on public investment on increasing regional income of richer regions is particularly concentrated in infrastructure investment rather than social investment. That is, infrastructure investment allocation has had an heterogeneous regional impact on regional inequalities, the pattern being that public investment leads to richer regions to become similarly richer. These result suggests that whereas infrastructure investment has an immediate effect on economic performance by reducing transaction costs Martin (1999), social investment might place its effect in the long run. Furthermore, this result reinforces the hypothesis that Mexico is at the first stage of Hirschman's development strategy, if (as we believe) public investment lags do not reveal a pure expenditure effect.[13] The empirical findings are consistent with the Hirschman (1958) framework. The strategy in the allocation of public investment may have followed a set of phases whereby Mexico is at a first stage where richer regions where social infrastructure is already relatively more develop perform better.

A *third* remarkable finding suggests that the effect of public investment, and in particular infrastructure investment (when controlling by existing non-linearities) increases across the income distribution function – thus, suggesting 'increasing returns' to public investment - . The effect of infrastructure investment alone across the regional income distribution suggests that investment in richer regions is significantly more effective in rising regional income as compared to the rest. Our findings are potentially consistent with the hypothesis that the allocation of public investment in Mexico is directed towards regions that show economic agglomeration economies.

A final collateral finding confirms the importance of the effects resulting from economic integration -either due to existing agglomerations, areas with strong natural resource endowments and the areas surrounded by rich neighbours - . Evidence of these effects is captured through the statistical significance of the coefficients for north-south latitude along with those for oil producing regions turned to be significant predictors of the economic performance across the regions income distribution.

Other issues remain for future research, such as the question of optimal dynamics of public investment allocation and spill-over effects that arise as a result of investment in more dynamic regions, often in the top quantile of regional income distribution. Another aspect that demands further analysis is the existence of a transition from one group to another within the regional income distribution. Furthermore, the future availability of data on the impact of the North American Free-Trade Agreement (NAFTA) may permit researchers to test the effect of trade liberalisation on the distribution of regional income by incorporating additional

[13] The fact that the coefficient for public investment varies when evaluated at different points of the income distribution scale might be interpreted as evidence that expenditure effects are less prominent, as hypothetically they should have similar effects across the whole income distribution scale.

evidence into the debate. Possible caveats may be solved in future research, such as the extent to which the patterns of regional integration modify the impact of public investment on economic activity.

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Table 1. Coefficient of variation of per capita GDP

Year	All regions*	Centre	North	South*
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

*Excluding Campeche and Tabasco.

Table 2. 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

Table 3. 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)	(0.017)	(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)
Centre	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 parent.

* Significant at 10% ** Significant at a 5%. ***Significant at 1%

Table 4. 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)
Centre	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 parent.

Significant at 10% ** Significant at a 5%. ***Significant at 1%

A1. Geographical distribution of Mexican states

NORTH Baja California Coahuila Chihuahua Nuevo Leon Sonora Tamaulipas 15 % Population 1971 15% Population 1999	**CAPITAL** Distrito Federal 14 % Population 1971 9 % Population 1999	**CENTRE** Mexico Morelos Puebla Queretaro Michoacan Guanajuato Hidalgo Tlaxcala Veracruz 37 % Population 1971 42 % Population 1999
SOUTH Chiapas Guerrero Oaxaca Quintana Roo Yucatan 13 % Population 1971 14% Population 1999	**CENTRE-NORTH** Aguascalientes Baja California Sur Colima Durango Jalisco Nayarit San Luis Potosi Sinaloa Zacatecas 19 % Population 1971 18 % Population 1999	**OIL** Campeche Tabasco 2 % Population 1971 3 % Population 1999