The efficiency–equity trade-off of schooling outcomes: public education expenditures and welfare in Mexico

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Abstract

We analyze how a central government allocates resources to states in the education sector. In particular, we use two relevant criteria in the decision-making process: the equity–efficiency trade-off and unequal concern with respect to the characteristics of states. We perform empirical tests of Mexican state-level education expenditure by the Federal Government and examine changes in allocation patterns by comparing 1980 and 1990 cross sections. A two-sector model is considered in a welfare maximizing context, which allows for a theoretical as well as econometric solution for jointly determined educational expenditure and production. This joint modeling is important, and we provide for a straightforward and easily replicable solution. The addition of the roads sector provides an instrument for endogenously determined expenditure in schooling production. We find that the Federal Government trades some efficiency for gains in equity, but in doing so treats states differently, and that results have changed over time. © 2001 Elsevier Science Ltd. All rights reserved.

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1. Introduction

The connection between educational attainment and economic development, as well as the effect education has on distributional concerns, have been widely accepted in the development literature (e.g. Lau, Jamison, Liu & Rivken, 1993; Park, 1996; World Bank, 1991). The trade-off between efficiency and equity implicit in the way in which governments allocate educational resources across geographical areas has also received attention (Behrman & Birdsall, 1988).

But analysis and measurement of the efficiency–equity trade-off face various theoretical and methodological difficulties. First, most attempts have modeled only the distribution of expenditures (see for example, Crouch, 1996; Marais, 1995), whereas the distribution of educational outcomes are truly the measure of interest. Second, models measuring the efficiency–equity trade-off almost uniformly contain unaddressed problems of endogeneity.1 Behrman (1996, p. 347) states that failing to control for unobservables is one of the major flaws of much analysis of schooling policies in developing countries: “A major question for centralized policy makers

1 The paper by Behrman and Birdsall (1988) contains an example of both difficulties, as does much of the basic analytic work on the determinants of education expenditure by development institutions (see for instance World Bank, 1998).
and for analysts is whether it is possible to control for unobservables and for the relevant behavioral incentives in analysis of school policies.” He goes on to list instrumental variable approaches as among the most promising and calls for more research in this area. This study helps to answer that call (see also Akerhielm, 1995).

We therefore model and estimate a welfare function that reveals the efficiency–equity trade-off resulting from the allocation of primary and secondary school expenditures by the Federal Government in Mexico. In doing so, we quantify the trade-off with respect to the educational outcomes observed in the 31 states, and we develop a methodology that considers the simultaneous determination of educational expenditures and outcomes. In addition, we explicitly account for the correlation between expenditure and average student endowments in the schooling production function.

In particular, we analyze the Federal Government’s allocations to states, and we explore two criteria often considered relevant in the decision-making process: (1) the equity–efficiency trade-off and (2) different treatment of states based on their socio-economic and political characteristics. The underlying structural welfare relation cannot be estimated directly because welfare is not observed; however, our analysis derives expressions in terms of behavioral input and output variables in order to unveil critical parameters of the welfare function. This is important because official policy statements from the Government never reveal such parameters and, while qualitative analysts such as Morales-Gómez and Torres (1990) have shown a keen acumen in discerning such parameters, such political analyses need sound quantitative studies to support them in the policy arena. In short, while other Latin American countries (e.g., Chile) have made advances in using formula grants to allocate educational resources transparently to sub-national jurisdictions, Mexico has not. Our analysis shows that the Mexican allocation pattern does not obviously incorporate rational or effective allocation patterns.

We follow a model developed by Behrman and Craig (1987) and Craig (1987) in which a government with central authority allocates fixed total resources in a sector among the various localities under its control. In order to control for endogenously determined production of the public service, in their case crime prevention, Behrman and Craig (1987) use an instrumental variable approach whereas Craig (1987) uses 3SLS to estimate the whole public service expenditure–production system. In contrast to Behrman and Craig (1987), our model involves the simultaneous determination of two public service sectors, education and roads, which will allow for various different solutions to the endogeneity of production problem. Specifically, while it is straightforward to address the simultaneous determination of educational expenditures and outcomes, this is only possible if, in the schooling production function, average student endowments are not correlated with educational expenditures. Since we cannot reasonably make this assumption, we must use expenditures from another public service, such as roads, to serve as an instrument for educational expenditure. This joint modeling is important and we provide for a straightforward and easily replicable solution. We thus hope to help fill the gap highlighted in Behrman (1996) (p. 348) by providing a useful “statistical procedure to control for choices in the presence of unobserved variables.”

We hypothesize that this central government allocates resources in the education sector as if to maximize a social welfare function, considering public service outcomes as a function of inputs. The model yields the distributional concerns (vis-a-vis localities under its control) of the central government implicit in the observed choice of outcome allocation.

We test the model on Mexican state-level data from 1980 and 1990. We also provide an empirical exploration of several phenomena widely analyzed by political scientists in a more qualitative manner, such as the influence of voting behavior and political opposition on federal allocations.

2. A model of Mexican literacy and schooling

Education in Mexico has traditionally been a centrally financed public good. The Federal Government is responsible for approximately 80% of total expenditure on education. Although the 1970s saw a significant increase in educational expenditures, the growth slowed down in the 1980s and 1990s. This was due to several factors, including economic constraints and political influence.

In Mexico, the educational system is overseen by the Secretaría de Educación Pública (SEP) and the Consejo Nacional de Ciencia y Tecnología (CONACYT). The SEP is responsible for primary and secondary education, while CONACYT focuses on higher education and research.

The SEP allocates resources based on a formula that takes into account various factors such as the number of students, the school’s location, and the state’s socioeconomic status. This formula is designed to ensure equity in resource allocation across different states.

We developed a model to analyze the school expenditure–production system. The model considers the simultaneous determination of educational expenditures and outcomes, taking into account the equity–efficiency trade-off.

In our model, we assume that the central government maximizes a welfare function. The welfare function is a function of inputs and outputs, where inputs include public service expenditures and outputs include educational outcomes.

The model is estimated using instrumental variable approaches, which allow us to control for endogeneity in the production of public services. We use expenditures from another public service, such as roads, as instruments for educational expenditures.

We tested the model on Mexican state-level data from 1980 and 1990. The results indicate that the central government allocates resources in the education sector as if to maximize a social welfare function, considering public service outcomes as a function of inputs.

We also provided an empirical exploration of several phenomena widely analyzed by political scientists in a more qualitative manner, such as the influence of voting behavior and political opposition on federal allocations.

In conclusion, our model helps to fill the gap highlighted in Behrman (1996) by providing a useful “statistical procedure to control for choices in the presence of unobserved variables.”

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2 This concise description of our objectives is due to an anonymous referee.

3 See for instance Partido Revolucionario Institucional (1976) and Secretaría de Educación Pública (1989) for official policy statements relevant to the two time periods studied.

4 In using this ‘as if’ statement we follow a long tradition in political economics, reviewed excellently in Inman (1987).

5 Mexico is a federation of 31 states and the Federal District (DF). Our study deals strictly with the states, largely because the DF has a different and complex institutional education structure.

6 For instance, Morales-Gómez and Torres (1990) (p. 51) assert: “Educational financing in general has been used to counteract radical trends emerging from the political conflict permeating society. In this sense, educational policies and programs are used as powerful tools for the political cooptation of leaders, and to eliminate sources of dissatisfaction and conflict in certain social sectors.” These same authors state (p. 173) that: “although education is expected to produce human capital, in practice it is designed to produce political capital for the [Mexican] State and the elites.” See also Dresser (1994).
in the sector. In 1978, the Ministry of Education (Secretaría de Educación Pública; SEP) instituted a deconcentration program and established federal, state-level delegations in each state to handle the duties of service provision as well as sub-state resource distribution and budgeting. SEP has continued to allocate funds centrally, deciding the strategy with which to meet educational demand nationally. Hiring and distribution of personnel also continued until 1992 as a function carried out in a highly centralized manner through both SEP’s own decisions and those made through negotiation with the teacher’s union, which is in turn highly centralized.

In May of 1992 the Federal Government, together with all 31 states, signed a major accord supposedly decentralizing responsibility for educational services to the states. Called the Agreement for the Modernization of Basic Education, this transfers all federal educational infrastructure as well as teachers and administrative personnel to the states. Most of the financing, however, will continue to have a federal source. Funds will be transferred annually to the states in much the same manner they had previously been transferred to the federal delegations. The states will then have considerable freedom to use those funds, and one imagines that the Federal Government will not be able to hold them as accountable as it did its own delegations. This point immediately begs the following question about educational service provision in the decade preceding the agreement: How has the Federal Government performed as a centralized provider of education? Have federal allocation patterns, for instance, exhibited an attempt to fulfill the functional responsibility of Federal Government, outlined in Peterson (1995), to redistribute educational outcomes from relatively well-performing states to relatively poor performing states? What are the other determinants of federal educational expenditures? These questions provide the motivation of our study.

Perhaps the most consequential point for this study is that while the Federal Government must respond to budget requests from states as well as to basic salary needs for teachers and administrative personnel in each state, SEP has considerable discretionary leeway in the way in which it allocates resources to states. In addition, priorities are almost surely set in part at a level higher than SEP, by the Mexican president himself. These priorities would address both development and political needs as perceived by the Institutional Revolutionary Party (PRI), the ruling party. This study gives some indication of how the Federal Government has chosen to pursue its policies.

The central government maximizes a social welfare function that considers the outputs in each state from the two public sectors: schooling and roads. This welfare function is additively separable and linear in the two sectors:

\[ W = U(S;N) + V(R,M) \]  

and is maximized subject to the following budget constraints

\[ \sum_{i=1}^{ns} E_{i}^{S} N_{i} \geq G^{S} \quad \sum_{i=1}^{ns} E_{i}^{R} M_{i} \geq G^{R} \]  

where \( S \) is the vector of per capita state outputs from schooling (literacy); \( R \) is the vector of per capita state outputs from roads (miles of roads); \( N \) is the vector of state school-age populations; \( M \) is the vector of state total population; \( G^{S} \) and \( G^{R} \) are the total national expenditure in education and roads, respectively, for the time period; \( ns \) is the number of states in Mexico; \( E_{i}^{S} \) is the per (school age) capita educational expenditure and \( E_{i}^{R} \) the per capita road expenditure in each state; \( N_{i} \) is the state school-age population, and \( M_{i} \) is the state total population.

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\[ \text{9 We thank Tony Smith for noting that, if it seems unreasonable (or counter-intuitive) to conceive of the government maximizing a social welfare function, the problem may be re-written as a government maximizing its own utility function. The results would not change. Thus, the analysis yields information on the government’s preferences that is not otherwise observable.} \]

\[ \text{10 As we shall see in Section 3, the inclusion of roads as a second sector is motivated by the necessity of finding a good instrument for the estimation of the schooling expenditure equation. We may use another public service, such as the provision of drinking water, instead of roads, without losing the flavor of the model. For the sake of clarity, we wish to emphasize that our concern in this study is to explore the efficiency-equity trade-off and other determinants of expenditures inherent in the federal education allocation to states. We are not concerned with the determinants of federal road allocations. We will include roads formally in the model merely to extract a clear instrument.} \]
The notion behind the different population variables is simply that roads are consumed by everyone, whereas education (generally) only by those of appropriate age. While the Government implicitly wishes to maximize schooling and road output (S and R), it has no direct control over them. The Government does, however, control spending, and it thus impacts outcomes indirectly through production. The schooling and road production functions are assumed to have partial log-linear form:

\[
\ln S_i = \delta^S \ln E_i^S + h(\frac{S_i}{R_i}) + \varepsilon_{S_i}
\]

\[
\ln R_i = \delta^R \ln E_i^R + g(\frac{S_i}{R_i}) + \varepsilon_{R_i},
\]

where \( \delta^S \) is a production function elasticity for sector j, \( \varepsilon_{S_i} \) and \( \varepsilon_{R_i} \) are sector-specific error terms which may include unobservables, and \( h \) and \( g \) can be any functional form(s) as long as it exhibits positive marginal productivities over the input vector \( \zeta \), albeit with diminishing returns. A more detailed discussion of the production behavior can be found in Section 3 where we assume the production functions to be log-linear.

Following Craig (1987) and Behrman and Craig (1987), we specify a Kohm–Pollak welfare function for Eq. (1) and note that doing so “allows a test of whether the [government] is concerned only with aggregate output, or whether there is some distributional concern over absolute differences” in outcomes from the service being provided (Craig, 1987, p. 300). In our analysis, we test whether the Federal Government has distributional concerns for outcomes from schooling expressed in the way it allocates educational funding to states. Outputs are, after all, what planners should be interested in, and the model specified shows how the distribution of outputs by the central authority could occur in the opposite direction from inputs because of the inherent characteristics of the states’ residents involved.

The Kohm–Pollak welfare function tests for two kinds of distributional concern: the first, inequality aversion, reveals the extent to which the Federal Government attempts to trade efficiency for equity; the second, unequal concern, reveals the extent to which particular state characteristics influence the Federal Government’s allocation of resources (based upon the resulting outcome it expects from those resources). It takes the following form:

\[
W = \frac{1}{q} \ln \left[ \sum_{i=1}^{n} \alpha_j N_i e^{55S_i} \right] + \frac{1}{q} \ln \left[ \sum_{i=1}^{m} \alpha_j M_i e^{55R_i} \right]
\]

where

\[
N = \sum_{i=1}^{n} \alpha_j N_i, M = \sum_{i=1}^{m} \alpha_j M_i.
\]

The parameter \( q \) is the measure of inequality aversion (which grows stronger the smaller, or more negative, the value for the parameter) for sector j, and the \( \alpha_j \) are the parameters of unequal concern. Specifically, \( q \in (-\infty, 0) \) such that as \( q \) approaches zero, the government has no inequality concern and is purely concerned with efficiency (the utilitarian outcome); thus the government simply sums productivity over weighted individual outcomes. Likewise, as \( q \) approaches negative infinity, the government is purely concerned with equity (the Rawlsian outcome).

The government maximizes Eq. (4) subject to Eqs. (2) and (3) by choice of \( E_i^S \) and \( E_i^R \). Without loss of generality, we will exhibit the constrained optimization problem for the schooling sector only. We start with the first-order condition:

\[
\frac{\partial W}{\partial S_i} \frac{\partial S_i}{\partial E_i^S} - \lambda N_i \leq 0,
\]

where \( \lambda \) is the Lagrange multiplier associated with the sectoral budget constraint. In the case of the Kohm–Pollak welfare function and the partially log-linear production function, the first-order conditions take on the following form:

\[\text{Geometrically, inequality aversion is reflected by the degree of curvature (concavity) of the welfare surface: the more sharply curved, the higher the degree of inequality aversion. Unequal concern is reflected by the degree of asymmetry of the welfare surface about the 45° ray from the origin.}\]

\[\text{Note that the } \alpha_j \text{ are the same up to a factor of proportionality for the two sectors; a set of state characteristics should affect each sector the same.}\]

\[\text{For a proof of this proposition, please see Appendix A. Behrman and Craig (1987) found the Kohm–Pollak welfare function to dominate empirically a generalized CES form, while Behrman and Birdsall (1988) found CES to weakly dominate Kohm–Pollak. Considering that the Kohm–Pollak welfare function, through the parameter } q, \text{ already allows for a broad range of functional shapes (see Appendix A and footnote 14), we choose instead to focus our modeling efforts on proper instrumentation.}\]

\[\text{Note that this assumes that national amounts of educational and road expenditures are fixed in the time period, and that the central government simply allocates these resources among states according to the social welfare function.}\]

\[\text{We do not wish to imply, here or elsewhere in the study, that the Federal Government is a single entity with clearly definable goals. Of course, the process of allocating resources across states is a contentious fiscal and political process that results from complex interplay between the President, the Finance Ministry, the Ministry of Education and each state governor. No matter what the intention of the Government, however, this approach has the capacity to identify key policy parameters.}\]
\[ K^s\alpha_i\epsilon_i e^{\delta_S} = \lambda N, \]  
where
\[ K^s = \left[ \sum_j \alpha_j N_j e^{\delta_S} \right]^{-1}. \]

Canceling \( N_i \) and \( M_i \) on both sides and taking logs we get:
\[ \ln [K^s\alpha_i e^{\delta_S}] + \ln \delta_S = \ln \lambda. \]

Rearranging terms yields an equation that can be readily estimated:
\[ \ln \left( \frac{E_S^i}{S_i} \right) = \ln K^s - \ln \lambda + \ln \delta^s + \ln \alpha_i + q^s S_i. \]

The first three terms make up the intercept in the regression equation and are therefore not individually identifiable.

Collecting all unobservables in Eq. (10) into a constant, we can rewrite the expenditure equation as
\[ \ln \left( \frac{E_S^i}{S_i} \right) = \beta_0 + \ln \alpha_i + q^s S_i, \]
where the unequal concern parameter \( \alpha_i \) depends in logarithmic form on the state characteristics and some unobservables:
\[ \ln \alpha_i = \sum_{i=1}^p \beta_i \ln x_i + v_i. \]

Those state characteristics should affect each sector the same (up to a factor of proportionality). In fact, we shall make use of this assumption later when trying to find an instrument for expenditure in the schooling production function.

The expenditure equation is now stochastic.\(^{18}\)

\[ 17 \text{ Note that the unobservables are assumed to be independent of instruments used for } S \text{ in Eq. (11).} \]

\[ 18 \text{ Note that this is not the completed solution to the maximization problem. Rather, we assume the government acts in the manner described (as if to maximize the described social welfare function) and test for the factors that influence its action within the given framework. We can do so because both } S \text{ and } E \text{ are observable, as are the variables of unequal concern. In this sense, the equation should not be construed as a cost function. In fact it can be rewritten as} \]
\[ \ln \left( \frac{E_S}{S} \right) = \beta_0 + \sum_{i=1}^p \beta_i \ln x_i + q^S S_i + \ln (S_i) + v_i \]
which is unambiguously an expenditure equation.

\[ \text{ln} \left( \frac{E_S}{S} \right) = \beta_0 + \sum_{i=1}^p \beta_i \ln x_i + q^S S_i + v_i \]

This is the form of the equation we finally wish to estimate to obtain values for \( q \) and \( \alpha_i \).

3. Stochastic structure and estimation problems

In order to understand fully the behavior of the central government in relation to the states, one needs to consider the production of the outcome (e.g. literacy in a given state). Such a production function would clearly depend upon educational expenditures themselves, thus forcing the implementation of a simultaneous equation system. If states are treated unequally, then the timing of expenditure outlays would make a difference on educational outcomes. For instance, states where heavy federal expenditure on education started earlier would presumably have a higher literacy rate today. First-differencing in the outcome production equation would control for endogenous educational expenditure allocation.\(^{19}\) While we engage in a two-period comparison in this study, we do not have each regressor used in 1980 available for 1990 and are hence unable to estimate a first-differenced model. A detailed discussion of the regressors is found in Section 4.

Schooling outcomes are assumed to depend on educational expenditure, the amount (or quality) of schooling that the parents received, some returns to scale effects (in our case captured by the degree of urbanization) and the endowment of the student. A fundamental problem encountered in the estimation process is that student endowments are not observable.

Consider the following log-linear production equation:
\[ \ln S_n = \gamma_n + \delta_S \ln E_n + \gamma_S \ln PS_n + \gamma_U \ln U_n + \mu_n + \epsilon_n. \]
where \( PS \) is the parental schooling variable, \( U \) the degree of urbanization, and \( \mu \) the 4th state’s deviation from average student endowment. Factors other than \( PS \) and \( U \) may be considered relevant, but the spirit of the discussion will remain unaltered. We have added time subscripts in this equation with the notable exception of the endowment variable. The estimation problem comes from two sources: (1) it is very likely that schooling expenditures \( E_n \) and state endowments \( \mu_i \) are correlated over time; (2) in addition, matters are complicated by the unobservability of \( \mu_i \), meaning that in a regression exercise the endowments will simply be captured by the error term \( \epsilon_n \).

We could get a noisy estimate of \( \mu_i \) from Eq. (14),
but only if we contend with the correlation of expenditure and endowments. For this we need an instrument for \( E_i^S \) and we turn to the road sector for such an instrument. Road and schooling expenditure will be correlated because we assumed earlier that the unequal treatment parameter is the same in both sectors. Why is this so?

If we consider the expenditure formula (Eq. (11)), we see that shocks to schooling expenditure come from \( v_i \). This shock term was defined earlier in Eq. (12) as the error term for the unequal treatment parameter (stemming, for example, from measurement error or omitted variables). If we therefore make the reasonable assumption that the unequal treatment parameter \( \alpha \) is the same for both sectors, a shock to \( E_i^S \) will affect \( E_i^R \) proportionately the same.

Before proceeding, we need to make one further identifying assumption: shocks in unequal treatment (from \( v \)) are uncorrelated with student endowments (\( \mu \)). Since endowments determine schooling which appears on the right hand side of the expenditure equation (Eq. (13)), correlation between \( \mu \) and \( v \) needs to be zero in order to obtain unbiased estimates. Since these endowments are invisible even to the government (whereas factors yielding unequal treatment by the government, such as income, are not), this identifying assumption seems quite reasonable.

A final assumption is that (only partially observable) endowments in the road sector are uncorrelated with schooling endowments. We see no reason why this assumption should be violated. However, if it is, road expenditure will serve as a worse instrument for schooling expenditure.

4. Data and estimations

We will now describe each of the variables we have chosen for estimating the schooling production and expenditure equations. The dependent variable for the expenditure equation, \( E_i^S/S_i \), is federal expenditure in each state divided by one of two educational outcome variables, which will be explained below. Each of these variables is divided, in turn, by that state’s population aged 4 to 17. This gives the per capita school expenditure for the school-aged population. The federal expenditure is adjusted according to a regional wage index.\(^{20}\) In the estimation of schooling production, it will be instrumented by \( E_i^R \), the per capita expenditure on roads.\(^{21}\) For educational outcomes (\( S_i \)) we consider two variables with relative merits: (1) the state literacy rate for the school-age population\(^{22}\) (YOUNGLIT) and (2) the percentage of state population with at least some post-primary education (POSTPRIM).\(^{23}\)

We consider four variables which describe state characteristics relevant to unequal concern. We have chosen these variables based on over 100 interviews with

\(^{20}\) Data source for 1980: Secretaria de Educacion Publica (1982) (p. 499). Note that these data are for 1981 while all other data in this study are for 1980. Summary statistics for all data are available from the authors.


\(^{22}\) Data source for 1980: constructed from INEGI (1988) (pp. 221–230). The age range for which the literacy rate is constructed is 6–19 years.

\(^{23}\) For the purposes of this study, it is important to note that the schooling data and goals used by SEP usually have referred to coverage rather than quality. That is, they have been much more likely to refer to the proportion of the population being served than to the quality of the schooling they receive. But the above point is significant because our empirical work uses criteria such as the proportion of the population receiving secondary schooling and the literacy rate as education outputs. Of course, we would prefer to use standardized test results. In fact, it would be interesting to test the different effects of increasing quality versus increasing the quantity of schooling through various forms of expenditure, much like Behrman and Birdsall (1983) have done. However, they knew the average years of schooling for teachers in each of the regions they were studying, and this information is not available presently for Mexican states. It remains well guarded by the National Teachers’ Union. While literacy does, to some extent, measure the quality of the education provided, it is simply a minimum quality requirement. While it is thus less of a pure quantity measure than the portion of the population with some post-primary schooling, it is a rough measure of the quantity of schooling provided.

Clearly, the variable chosen as an educational outcome is of critical importance. One might note that the proportion of student-aged population with some secondary schooling is a strong reflection of the quality of education of the educational system in the state since better educational systems will often prove more effective in keeping their pupils longer. Second, the measure also provides a yardstick for the quality of education, in that higher quality education will inspire more students to stay in school longer, given that the returns they expect to reap from doing so will be higher.

It is important to add that the Mexican Federal Government uses measures such as POSTPRIM as an evaluation measure for states. While one might argue that the outcome measure ought not depend on the preferences of a government, such consideration is justified in the specific context of the model employed. Since the model is a social welfare function, it is indeed important that the Government (which is maximizing social welfare) perceives the output measure as a component of social welfare. We are, after all, interested in analyzing how the Government acts. POSTPRIM should, then, provide a reasonably accurate measure of the Government’s attempt to trade efficiency for equity. Finally, with the exception of literacy rates for 1990, other available measures of educational output yielded similar results as those presented below using POSTPRIM.

a wide range of Mexican governmental officials, most in
the Ministry of Education, at both the federal and state
levels. We have also interviewed prominent Mexican
education analysts and academics. Finally, we have
reviewed much of the official rhetoric of the Government
and the Ministry of Education (for example, Secretaria
de Educacion Publica, 1989; Partido Revolucionario
Institucional, 1976).

For 1980 the variables of unequal concern are as follows.

1. (MEDIAN): a state’s median monthly income. 24
2. (MIGRATION1): the proportion of a state’s popu-
lation that migrated to the Federal District (DF) from
1976 to 1980. 25
3. (INDIG): a dummy for states with large indigenous 26
populations. It is difficult to determine the exact per-
centage of a state’s indigenous population. However,
the indigenous (as opposed to Mestizo) population is
poorly connected to the PRI. Since almost 96% of the
indigenous population resides in one of only 10 states,
a dummy variable is sufficient. 27
4. (PRI): the percentage of votes cast for PRI candidates
for the state’s deputies to the national assembly (from
the 1979 federal elections). 28

The fourth state characteristic, the political variable,
deserves closer analysis. Mexico had de facto a one party
system for six decades, where elections are manipulated
and political opposition found little real tolerance. 29 It
would be surprising to find that states which demonstrate
some form of opposition in the form of low support for
the PRI would be treated the same as states where
the PRI enjoys an unchallenged status. The question
remains, would the (PRI controlled) Federal Government
reward well-behaved states and punish the deviants or
try to ‘buy back’ those opposition states instead?

We repeat the analysis for 1990 using variables that
match as closely as possible those chosen for 1980.
They are:

(1a) (GDP_pc): GDP per capita for 1989; 1990
was unavailable. 30
(2a) (MIGRATION2): the proportion of total
migrants to the DF from 1985 to 1989 that came from
state I. We believe this to be a better measure of
migrants than for 1980 because it is a measure of a
state’s relative contribution to the number of
migrants. 31
(3a) (INDIG2): the proportion of state I’s population
over the age of 5 that speaks an indigenous language,
and it is a measure for the percent of the population
that is considered indigenous.

(4a) (PRI_PRES): the percentage of votes cast in the
1988 presidential elections for Carlos Salinas, the
candidate for the ruling Partido de la Revolucion
Institucional (PRI). In 1980 we did not use presiden-
tial election results because the previous presidential
election was in 1976. 32

Since we are explicitly modeling the endogeneity of
schooling outcomes via a production function, we must
justify the supposition of exogeneity on the part of the
state characteristics. For both MEDIAN and INDIG, we
do not believe that either wealthy people or those classi-
fied as indigenous are likely to move to states with high
educational expenditure. For MEDIAN, however, it is
possible that through the production function, the greater
level of educational funds yields higher levels of school-
ing outcomes and therefore increases student earning
potential. Considering the migration variable
MIGRATION1, since we are examining migration from
state I to the DF and not migration from I to j, we believe
the exogeneity assumption on this variable is justified.
Finally, with respect to our political variable, it is indeed
possible that PRI votes in a given state are determined
by educational expenditure to that state, but it seems
improbable that such expenditures would heavily or

26 The term ‘indigenous’ is not so much racial as it is cultural.
Those citizens who consider themselves indigenous (almost all
the population has some pre-Columbian heritage) distinguish
themselves through their lifestyle and language.
27 We construct the dummy based on information in Ryan
(1984) (p. 89). States with large indigenous populations include
Chiapas, Guerrero, Hidalgo, Mexico, Michoacan, Oaxaca, Pue-
bla, San Luis Potosi, Veracruz, and Yucatan.
29 This also raises questions about the accuracy of electoral
data, which is likely to be controlled by the PRI. The researcher
who compiled the data we use recognizes this fact in discussing
how she compiled them (Gomez Tagle, 1990: Chapter 1); how-
ever, we believe (as does Gomez Tagle) that her data do reflect
the relative if not the absolute strength of the vote for the PRI
in each state. Thus, we are more concerned with the sign on
the coefficient on the electoral variable than in interpreting the
coefficient as an elasticity.
30 We would have preferred to use median income, but unfor-
tunately this was not available. Data source: Professor Miguel
Seikely, El Colegio de Mexico (unpublished data).
31 Data sources for (2a) and (3a) are the 1990 Mexican popu-
lation census by INEGI (1990).
decisively influence the voting outcome. We are investigating how 1988 elections influenced 1990 expenditure decisions; clearly the reverse could not have happened.

For the production equation, we consider four explanatory variables in addition to expenditure per student-aged population, EDUCEXP. (Note that we will run two versions: one for each of the two educational outcomes. This, of course, means that there will be two corresponding parental schooling variables for \( P_\text{S_i} \) in Eq. (11): parental literacy and parental post-primary schooling.) For 1980 we use:

1. (URBAN): the percentage of the state’s population residing in an urban area.\(^33\)
2. (ROADEXP): per capita road expenditure per state for 1981. 1981 was chosen because we use schooling expenditure data for 1981, for which this variable is an instrument in the production equation, because of the reliability of the data for this year.\(^34\)
3. (OLD_LIT): per cent literacy of the age group 30–39 (considered the potential parental group for the age group 7–14).\(^35\)
4. (OLD_SCH): per cent of age group 30–39 that have more than 6 years of schooling.

For 1990, all the variables are the same except for the instrument for schooling expenditure. Rather than using road-specific expenditure, which was unavailable, we use:

(2a) (TRANSEXP): per capita federal expenditure in the transportation and communication sector; instrument for 1990.\(^36\)

Before turning to the expenditure function to address the issues of equity–efficiency trade-offs and unequal treatment, we consider the results in schooling production. All estimation is done by 2SLS.

Table 1(a) and (b) give the results for the production equation regressions for both possible outcomes: column 1 is for literacy, column 2 for post-primary schooling. Although a good overall fit was obtained, the lack of any significant coefficient in the 1980 production equation for post-primary schooling is unsatisfactory. Road expenditure may indeed be a poor instrument for educational expenditure.\(^37\)

We also considered possible urban effects in the production of schooling. Do more urban areas make more productive use of educational monies? For either outcome in both 1980 and 1990, the answer appears to be no (the coefficient on URBAN is not significant). Upon careful reflection this is not surprising, however. More highly educated people tend to live in cities, and there may be few economies of scale effects for population density in the production of schooling. Or, at least, federal efforts in targeting rural areas may offset any urban or scale effects.

The only significant difference between the 1980 and 1990 estimations may be in the significance of the parent...
ental schooling variable for the post-primary schooling outcome. Whereas in 1980 a parent’s having some post-primary schooling seemed to have no effect on his/her children’s educational outcome, this is no longer true in 1990. However, by and large the results for 1980 and 1990 are qualitatively very similar.

We can now turn our attention to the results of the expenditure equation (Eq. (13)). How is one to interpret this regression equation intuitively? First, let us examine the dependent variable $E_i/S_i$. It is clear that a government would want this measure to be lower rather than higher. That is, it would want either to spend as little money as possible, for a given level of schooling, or to raise the level of schooling, holding the level of expenditure fixed. However, a government has no direct control over schooling outcomes. It only has control over expenditure, which affects outcomes through the production technology.\(^38\) So, we are testing for an inverse relationship between level of schooling and expenditure. In other words, all else being equal, for a high $S_i$ (a well-educated state), does a government lower $E_i$ in order to lower $E_i/S_i$?

The measure of inequality aversion, $q$, is the means by which we can determine if in fact a government is willing get less bang for its buck, so to speak. If $q$ is zero, then $qS_i$ drops out, and the government simply tries to get the largest schooling output for the smallest possible expenditure. This result would indicate that the government tries to get the most bang for its buck — and it is interested only in efficiency. If $q$ is negative, however, then a higher level of schooling output in a state causes the government to lower expenditure in that state, thus lowering $E_i/S_i$. Intuitively, we can think of this as $E_i$ going down faster than $S_i$.\(^39\) Concomitantly, for a state with low schooling output, $E_i$ would go down proportionally less than $S_i$, or up proportionally more. Thus, the government trades efficiency for equity. Or, to put it another way, aggregate schooling output is not maximized and some additional aggregate illiteracy is tolerated nationally to achieve the distributional aims of the Federal Government with respect to the states. Given two states equal in all other respects, the one with a lower level of schooling output would receive more funding.

Including the characteristics of unequal concern means that we believe the government also acts by looking at these factors when it invests. An instinctive way of conceiving this concept might be: how does the government spend money and also redistribute? The log form of the regression equation allows us to interpret the coefficients of unequal concern as elasticities. Thus, a negative coefficient would mean that, all else being equal, the characteristic causes the government to spend less in a state because $E_i/S_i$ will be smaller, and the government only has control over expenditure. The fact that the coefficients are elasticities means that we can relate the magnitude of the coefficient directly to a percentage change in $E_i/S_i$.

In contrast to the production equation, there is a qualitative change from 1980 to 1990 in the modeling of educational expenditure. The first thing we notice is the deterioration in the goodness of fit, as measured by the adjusted $R^2$. Columns 1 and 2 of Table 2(a) and (b) present the results of the regression of the expenditure equation in the paper using the instrument constructed from the production equation, assuming equal treatment of states by the Federal Government (equal concern). By equal treatment we mean that $\alpha_i=\alpha \gamma I$, or that $\alpha$ cannot be separately identified from the intercept. For columns 3 and 4 we model unequal treatment explicitly; more precisely, the $\alpha_i$ are allowed to vary log-linearly with four state characteristics. $F$ tests for joint insignificance of the unequal concern variables were soundly rejected.

The most striking difference between 1980 and 1990 results are the insignificance of literacy as an outcome that the Federal Government targets with educational expenditure. Whereas for 1980, under the equal treatment formulation (column 1), the coefficient on YOUNGLIT $q$ is negative and significant, this is no longer the case for 1990. Recall that a negative $q$ indicates that the Federal Government is willing to trade off some efficiency for equity in educational resource allocation. The fact that the coefficient is insignificantly different from zero may mean that the government has efficient resource allocation as its primary objective (a utilitarian government). However, it turns out that the data exhibit little variation across states. In other words, nearly all states had achieved high levels of literacy (in the school-aged population) by 1990. Therefore, it is hardly surprising that the government no longer finds it necessary to target school-age literacy with educational monies. This is in accord with other educational analyses of Latin America which conclude that in the decade of the 1980s, most countries made the transition from strategies aimed at literacy to strategies that adopted so-called ‘post-literacy’ goals.

This conclusion is substantiated by the results on post-primary schooling. Looking at column 2, $q$ is still negative and significant, but has increased in magnitude dramatically (from $-0.07$ in 1980 to $-1.83$ in 1990). We hesitate to put much weight on the absolute value of this coefficient and only wish to point out that the concern on the part of the Federal Government seems indeed to

---

\(^{38}\) Remember, we have assumed that our inputs to the production function, including expenditure, exhibit positive marginal productivities.

\(^{39}\) Again, note that $q>0$ makes no sense in our context, for it would mean that the marginal benefit of expenditure would be negative. Spending more would get the Government less.

Table 2
School expenditure 1980 and 1990

<table>
<thead>
<tr>
<th></th>
<th>(1)</th>
<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>(a)</strong> School expenditure, 1980: dependent variable=$E_i/S_i$, YOUNGLIT ($q$) efficiency–equity trade-off</td>
<td>-0.04**</td>
<td>0.06</td>
<td>-0.02</td>
<td>-0.02</td>
</tr>
<tr>
<td></td>
<td>(0.015)</td>
<td>(0.03)</td>
<td>(0.02)</td>
<td>(0.02)</td>
</tr>
<tr>
<td>POSTPRIM ($q$) efficiency–equity trade-off</td>
<td>-0.07**</td>
<td>(0.009)</td>
<td>-1.14**</td>
<td>-1.26**</td>
</tr>
<tr>
<td></td>
<td>(0.044)</td>
<td>(0.44)</td>
<td>(0.44)</td>
<td>(0.44)</td>
</tr>
<tr>
<td>MEDIAN</td>
<td>2.10**</td>
<td>1.46*</td>
<td>(0.86)</td>
<td>(0.73)</td>
</tr>
<tr>
<td></td>
<td>(0.13)</td>
<td>(0.17)</td>
<td>(0.17)</td>
<td>(0.17)</td>
</tr>
<tr>
<td>PRI</td>
<td>0.27**</td>
<td>0.20*</td>
<td>0.06</td>
<td>-0.34</td>
</tr>
<tr>
<td></td>
<td>(0.13)</td>
<td>(0.17)</td>
<td>(0.27)</td>
<td>(0.17)</td>
</tr>
<tr>
<td>MIGRATION1</td>
<td>1.14**</td>
<td>1.26**</td>
<td>-6.06</td>
<td>3.97</td>
</tr>
<tr>
<td></td>
<td>(0.44)</td>
<td>(0.44)</td>
<td>(7.19)</td>
<td>(4.69)</td>
</tr>
<tr>
<td>INDIG</td>
<td>0.06</td>
<td>0.34</td>
<td>-0.06</td>
<td>-0.34</td>
</tr>
<tr>
<td></td>
<td>(0.27)</td>
<td>(0.17)</td>
<td>(0.27)</td>
<td>(0.17)</td>
</tr>
<tr>
<td>CONSTANT</td>
<td>-0.25</td>
<td>-0.16</td>
<td>-6.06</td>
<td>3.97</td>
</tr>
<tr>
<td></td>
<td>(1.26)</td>
<td>(0.20)</td>
<td>(7.19)</td>
<td>(4.69)</td>
</tr>
<tr>
<td>Adj. $R^2$</td>
<td>0.17</td>
<td>0.67</td>
<td>0.46</td>
<td>0.76</td>
</tr>
</tbody>
</table>

| **(b)** School expenditure, 1990: dependent variable=$E_i/S_i$, YOUNGLIT ($q$) efficiency–equity trade-off | -0.41          | 4.55           | -1.35          | -1.35          |
|                        | (1.52)         | (2.73)         | (0.88)         | (0.88)         |
| POSTPRIM ($q$) efficiency–equity trade-off | -1.83**        | (0.57)         | -0.51**        | -0.28          |
|                        | (0.57)         | (0.23)         | (0.22)         | (0.23)         |
| GDP_PC                 | 0.07           | -0.03          | -0.15**        | -0.15**        |
|                        | (0.20)         | (0.18)         | (0.05)         | (0.04)         |
| PRL_PRES               | 0.08**         | 0.05           | 0.08**         | 0.05           |
|                        | (0.04)         | (0.03)         | (0.04)         | (0.03)         |
| MIGRATION2             | 6.17**         | 7.31**         | 6.95**         | 9.55**         |
|                        | (1.38)         | (0.35)         | (1.88)         | (2.11)         |
| INDIG2                 | 0.33           | 0.52           | 0.33           | 0.52           |
| CONSTANT               | 6.17**         | 7.31**         | 6.95**         | 9.55**         |
|                        | (1.38)         | (0.35)         | (1.88)         | (2.11)         |
| Adj. $R^2$             | 0.03           | 0.24           | 0.03           | 0.52           |

* indicates significance at the 90% level of confidence, ** indicates significance at the 95% level of confidence; figures in parentheses are standard errors. N=31.

have shifted from literacy for the young to post-primary schooling, a post-literacy goal.

Columns 3 and 4 in Table 2(a) and (b) present the results of the regressions on Eq. (14) in which the $a_i$ are allowed to vary log-linearly with the four state characteristics mentioned above. All variables, except the outcome variable, are in natural logs, which allows for interpretation of the coefficients as elasticities.

The results support the existence of unequal concern with respect to states. In other words, two states with the same level of outcome will receive different levels of per capita expenditure if they are different in any of the state characteristics. For example, given two states with equal literacy rates, the poorer state, in terms of median income, will receive a higher level of per capita expendi-

ture from the Federal Government. However, we can no longer assert with confidence that the Government sacrifices some efficiency for equity as evidenced by the lack of significance of $q$ for both educational outcomes.

There are some interesting changes in the relative importance of state characteristics. First, please note that for 1990 we no longer use a dummy variable to denote a state that has a high proportion of indigenous population. Given the lack of consistent significance across all estimations for both outcomes for both time periods, the results are inconclusive at best. We may be able to say that the Federal Government does not seem to treat states with significant indigenous populations (whether measured by a dummy for 1980 or as a percentage for 1990) less favorably. During the 1980s, the plight of indigen-
ous populations gained more attention, and President Carlos Salinas’ 1988 presidential campaign specifically promised to target them. Even though we no longer were able to find median income data for 1990, the Federal Government still seems to allocate more educational resources to relatively poor states.

A large qualitative change occurred with the migration variable: a complete reversal. Whereas in 1980 the Federal Government had a policy to bribe potential migrants with educational money (and funds in other sectors) to stay at home, the opposite seems to be in effect in 1990. The population in Mexico City, which grew dramatically in the 1970s due to migration, remained constant since the early 1980s. However, it is hard to believe that a negative and significant coefficient on MIGRATION2 indicates a conscious policy of punishing states that have large migration rates. The results may come from the Government’s decision to support disadvantaged groups, but among them to support those with higher expected returns. Migrants tend to fit this description. Thus, if the Government is ignoring 1985–1990 migration altogether and is simply looking at what segments of the population are located where in 1990, an attempt to target the disadvantaged groups with high enough expected returns to avoid a very high efficiency cost could very well yield a negative coefficient on the migration variable. In addition, if the Government is targeting areas with high population growth, we could obtain the same result. Also, contrary to 1980 when migration to Mexico City presented a grave problem, the capital’s population growth rate slowed considerably in the late 1980s, and the Government would no longer seem to have a specific policy of paying migrants to stay put as the 1990 results show.

The positive and significant coefficient on PRI for 1980 is indeed salient. This provides some evidence that the Federal Government may indeed have tried, in effect, to reward those states in which it received support during the 1979 legislative elections. In fact, the coefficient on PRI is one of the largest in magnitude, indicating that the effect of voting behavior on expenditure is quite strong. It is then not surprising that the election variable loses its significance for 1990. Though for decades the PRI rewarded supportive areas, a very poor showing in the 1988 presidential elections caused it to try to buy back some areas that had voted against it.40 The probable net result, some ‘rewarding’ and some ‘buying back’ leaves our results insignificant for PRLPRES. Basically, state level data are not specific enough. Gershberg (1995) has found robust results using municipal level data for one state where q is significant, negative, and of a magnitude (−2.20) larger than we find for the state-level data here. In addition, in this one state Gershberg (1995) finds a significant and negative relationship between opposition voting and expenditure.

Finally, it is instructive to consider how sensitive these results are to the use of the instrumentation we employ. In this case, use of the non-instrumented model for the same expenditure equations presented in Table 2(a) and (b) revealed no substantive differences in the magnitude, sign, or statistical significance of any of the coefficients. This of course does not mean that future research in this area is absolved of the need to use an instrumental variable approach, as long as the data are available. For empirical explorations of the determinants of resource allocation to have policy impact, they must be defensible as the soundest method available. Importantly, only having done the instrumentation can we correctly understand the effect of schooling expenditure on outcomes, recognizing correlations between state-level student endowments and federal educational allocations to states.

5. Summary and conclusions

We have presented an adaptation of a model in which a government with central authority allocates resources and outcomes in a public service sector as if to maximize a social welfare function. This function is increasing in its two arguments, population and public service outcome; however, the central authority cannot directly choose the levels of these outcomes and must use its indirect control through both public service inputs (expenditures) and its impression of the public good technology. Employing a Kohm–Pollak welfare function allows us to measure the extent of the efficiency–equity trade-off (inequality aversion) and unequal concern among sub-central jurisdictions on the part of the central authority.

Few studies of this kind have been performed on LDCs, even though this particular methodology seems readily adaptable to many developing economies. We perform estimations on two cross-sectional Mexican data sets of the central Government’s state level allocations in the education sector for 1980 and 1990, while providing a non-data-intensive means for dealing with the exogeneity problems that arise. This kind of analysis is important because it could potentially yield knowledge unavailable through other means, since many LDC governments, including Mexico’s, are secretive and non-transparent about the manner in which they allocate education funds.41 We wish also to emphasize that we per-

40 See Dresser (1994) and Molinar Horcasitas and Welden (1994) for further political analysis.

41 In addition, the performance of this kind of analysis, including the instrumentation, can play an important, if indirect, role in the policy-making arena. High-level Mexican officials are often highly-trained technically. Current President Ernesto Zedillo, for instance, was formerly the Secretary of Education. He has a PhD in economics from Yale University. Conver-
formed this analysis primarily with data that are generally available in published form in most countries.

For both years we find that the Federal Government does in fact display some inequality aversion nationally, and that this result holds for two different measures of educational service outcomes. However, we cannot say that the level of inequality aversion is strong or, more importantly, consistent across various measures and time periods. In addition, we find that unequal concern among states exists with respect to certain specific state characteristics, but the Government’s behavior vis-à-vis these characteristics did in fact change from 1980 to 1990.

This study may serve as a benchmark for developing policies for the decentralization of finance in the educational sector in Mexico. Specifically, any means by which resources were to be decentralized to the state’s discretion (e.g. matching grants) ought to consider the effects, both positive and negative, on redistribution with respect both to (public service) outcomes and the median incomes in the state. Meanwhile, some of the results with respect to unequal concern among states indicate the possibility for fiscal decentralization to eliminate some of the factors involved in resource allocation that pertain little to the supposed goal of financing the sector: increased educational performance. With respect to educational investments, this study points out that the Federal Government’s maintaining the purse strings for most investments, this study points out that the Federal Government’s maintaining the purse strings for most educational allocations may indeed allow it to redistribute resources among regions, and that it may indeed do so. However, the practice also retains the possibility of using educational investment for political leverage, and inconsistent, at best, equity enhancement. Formula-driven allocations to states is one obvious solution.42

Acknowledgements

The authors owe thanks to Steve Craig, Don Winkler, Bob Inman, Tony Smith, Andrew Haughwout, Hector Salazar, Robert Kaestner, Ted Joyce, Pablo Latapí, two anonymous referees, and especially Andrew Foster and Jere Behrman. The usual caveat applies.

42 For a more extensive discussion of policy recommendations, see Gershberg (1996, 1998).

Appendix A

In the Kohm–Pollack specification of the welfare function, the inequality aversion parameter \( q \) determines the shape of the welfare surface. More specifically, as \( q \) approaches zero, the welfare function exhibits no inequality aversion and is reduced to pure additivity of schooling outcomes (the utilitarian result); as \( q \) approaches \(-\infty\), the welfare function assumes the maximum form and the iso-welfare curves become L-shaped (the Rawlsian result). For the purposes of simplifying the notation of this proof, and without loss of generality, we shall assume equal treatment across states. Following Blackorby and Donaldson (1980), the welfare function thus takes on this form:

\[
W = \frac{1}{q} \ln \left[ \sum_{i=1}^{n} \frac{1}{n} Z_i^{q} \right] = \ln \left[ \left( \sum_{i=1}^{n} \frac{1}{n} Z_i^{q} \right)^{1/q} \right] \quad (A1)
\]

\[
= \ln \left[ \left( \sum_{i=1}^{n} Z_i^{q/n} \right)^{1/q} \right], \text{ for } Z_i = e^{x_i} \forall i
\]

which is just the log of a CES welfare function. Without loss of generality we consider the case for \( n=2 \).

A.1. Case 1: \( q \to 0 \)

\[
W = \ln \left[ \frac{1}{2} Z_1 + \frac{1}{2} Z_2 \right]^{1/q} = -\frac{1}{q} \ln \left[ \frac{1}{2} Z_1 + \frac{1}{2} Z_2 \right]
\]

\[
\lim_{q \to 0} W_2 = \frac{1}{2} Z_1 \ln Z_1 + \frac{1}{2} Z_2 \ln Z_2 \quad (A3)
\]

Following Varian (1984), we want to find the limit of \( W \) as \( q \to 0 \). Evaluating this expression at \( q=0 \) we find:

\[
\lim_{q \to 0} W_2 = \frac{1}{2} \ln Z_1 + \frac{1}{2} \ln Z_2
\]

which is pure additivity of schooling outcomes (pure efficiency concern).

A.2. Case 2: \( q \to -\infty \)

Assume, without loss of generality, that \( n=2 \) and that the weights attached to \( Z_i \) equal one. Suppose further that \( Z_i = \min(Z_1, Z_2) \). We can then assert the following:

if \( Z_i = \lim_{q \to -\infty} (Z_1 + Z_2)^{1/q} \), then \( Z_i = \ln \left[ \lim_{q \to -\infty} (Z_1 + Z_2)^{1/q} \right] \).

Following Varian (1984), we note the following:

\[
Z_i \leq Z_1^{1/q} + Z_2^{1/q} \Rightarrow Z_i \geq (Z_1 + Z_2)^{1/q} \quad (A5)
\]
Table 3
Summary statistics for 1980 data*

<table>
<thead>
<tr>
<th>Variable name</th>
<th>Mean</th>
<th>SD</th>
<th>Min–max</th>
</tr>
</thead>
<tbody>
<tr>
<td>EDUCEXP (E&lt;sub&gt;S&lt;/sub&gt;) (1000s of 1980 pesos)</td>
<td>4.13</td>
<td>1.79</td>
<td>1.33–8.14</td>
</tr>
<tr>
<td>YOUNGLIT (S&lt;sub&gt;i&lt;/sub&gt;) (%)</td>
<td>82.11</td>
<td>5.58</td>
<td>66.7–90.9</td>
</tr>
<tr>
<td>POSTPRIM (S&lt;sub&gt;i&lt;/sub&gt;) (%)</td>
<td>21.42</td>
<td>8.07</td>
<td>11.1–48.7</td>
</tr>
<tr>
<td>ROADEXP E&lt;sub&gt;R&lt;/sub&gt;&lt;sub&gt;i&lt;/sub&gt; (1000s of 1980 pesos)</td>
<td>0.224</td>
<td>0.162</td>
<td>0.038–0.767</td>
</tr>
<tr>
<td>MEDIAN (1980 pesos)</td>
<td>3722.66</td>
<td>976.61</td>
<td>291.90–5957.90</td>
</tr>
<tr>
<td>MIGRATION1 (%)</td>
<td>0.57</td>
<td>0.42</td>
<td>0.19–1.89</td>
</tr>
<tr>
<td>PRI (%)</td>
<td>77.94</td>
<td>10.24</td>
<td>55.49–95.30</td>
</tr>
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<td>URBAN (%)</td>
<td>43.02</td>
<td>18.32</td>
<td>15.10–80.30</td>
</tr>
<tr>
<td>OLD_LIT (PS&lt;sub&gt;i&lt;/sub&gt;) (%)</td>
<td>82.37</td>
<td>10.19</td>
<td>58.29–94.12</td>
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<tr>
<td>OLD_SCH (PS&lt;sub&gt;i&lt;/sub&gt;) (%)</td>
<td>31.17</td>
<td>7.33</td>
<td>12.96–52.50</td>
</tr>
</tbody>
</table>

* States considered indigenous: Chiapas, Guerrero, Hidalgo, Mexico, Michoacan, Oaxaca, Puebla, San Luis Potosi, Veracruz, and Yucatan. There are 31 states in our sample.

Table 4
Summary statistics for 1990 data

<table>
<thead>
<tr>
<th>Variable names</th>
<th>Mean</th>
<th>SD</th>
<th>Min–max</th>
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<td>EDUCEXP (E&lt;sub&gt;i&lt;/sub&gt;) (1000s of 1990 pesos)</td>
<td>306.90</td>
<td>86.19</td>
<td>161.73–588.68</td>
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<td>YOUNGLIT (S&lt;sub&gt;i&lt;/sub&gt;) (%)</td>
<td>90.0</td>
<td>3.76</td>
<td>77.10–95.61</td>
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<tr>
<td>POSTPRIM (S&lt;sub&gt;i&lt;/sub&gt;) (%)</td>
<td>40.84</td>
<td>8.05</td>
<td>25.15–56.65</td>
</tr>
<tr>
<td>TRANSEXPER (E&lt;sub&gt;R&lt;/sub&gt;) (1000s of 1990 pesos)</td>
<td>0.018</td>
<td>0.012</td>
<td>0.003–0.055</td>
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<tr>
<td>GDP_PC (1000s of 1989 pesos)</td>
<td>4868.05</td>
<td>1688.03</td>
<td>2445.12–9626.87</td>
</tr>
<tr>
<td>MIGRATION2 (%)</td>
<td>3.23</td>
<td>5.32</td>
<td>0.26–27.13</td>
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<tr>
<td>INDIG2 (%)</td>
<td>8.58</td>
<td>12.12</td>
<td>0.10–44.20</td>
</tr>
<tr>
<td>PRI_PRES (%)</td>
<td>57.78</td>
<td>14.35</td>
<td>23.21–89.91</td>
</tr>
<tr>
<td>URBAN (%)</td>
<td>68.14</td>
<td>15.29</td>
<td>39.50–92.00</td>
</tr>
<tr>
<td>OLD_LIT (PS&lt;sub&gt;i&lt;/sub&gt;) (%)</td>
<td>87.86</td>
<td>7.86</td>
<td>66.08–96.69</td>
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<tr>
<td>OLD_SCH (PS&lt;sub&gt;i&lt;/sub&gt;) (%)</td>
<td>35.36</td>
<td>8.30</td>
<td>20.31–52.59</td>
</tr>
</tbody>
</table>

Since q<0 and Z<sub>i</sub>=min(Z<sub>i</sub>,Z<sub>j</sub>),

\[ Z_i + Z_j \leq Z_i + Z_j = 2Z_i \Rightarrow [Z_i + Z_j]^{1/q} \geq 2^{1/q}Z_i \]  \hspace{1cm} (A6)

Combining the inequalities appearing second in Eqs. (A5) and (A6) we get:

\[ Z_i^{1/q} \geq [Z_i + Z_j]^{1/q} \geq 2^{1/q}Z_i \]  \hspace{1cm} (A7)

Letting \( q \to -\infty \), we establish that

\[ \lim_{q \to -\infty} [Z_i + Z_j]^{1/q} = Z_i. \]  \hspace{1cm} (A8)

We have shown that, as \( q \to -\infty \), the welfare function assumes the maximum form yielding L-shaped iso-welfare curves. The welfare function thus exhibits pure equity concern (Rawlsian outcome).

Appendix B

Tables 3 and 4

References


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