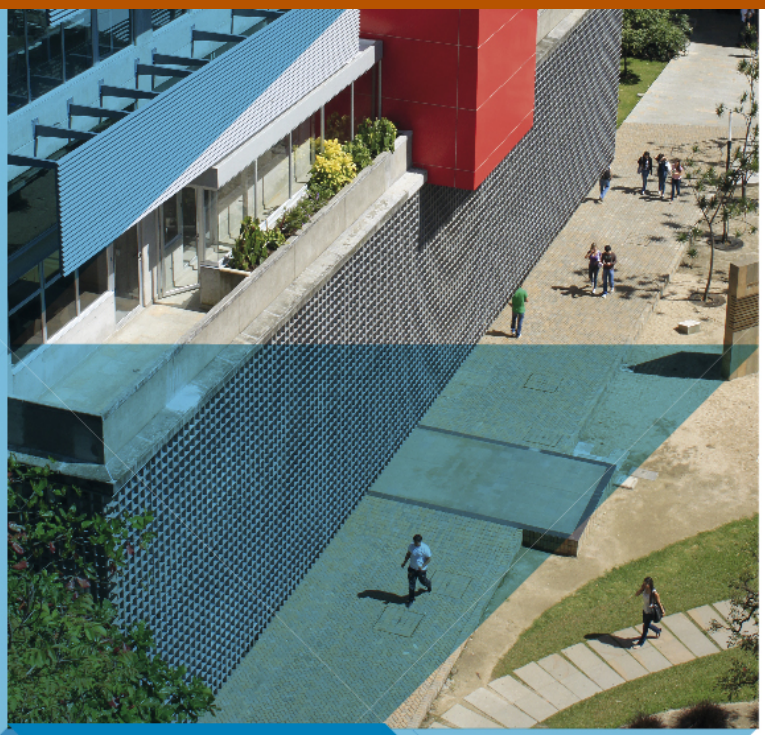

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The External Effect of Urban Schooling Attainment on Workers' Incomes in Ecuador

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Abstract

We estimate the direct and external effects of levels of schooling on personal income in Ecuador in 2011, using data for 69,653 individuals in 567 municipalities. Using a Mincerian model that includes municipal levels of schooling and the size of the municipality and controls for endogeneity, we find that each year of individual schooling raises individual income by 8.5 percent and each year of municipal schooling raises individual income by 2.2 percent. The external effect of an additional year of schooling is larger for workers with more schooling, for those with higher incomes, and for those in more educated municipalities.

JEL Codes: I25, R1, O15

Key Words: Ecuador; Schooling; External Effects; Regional Economics; Human Capital

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I. Introduction

In the 1950s Becker, Mincer, and Schultz began to study the effects of education on personal and national income. Since then hundreds of studies of the effect of a worker's schooling attainment on his/her earnings have demonstrated that this relationship is positive and relatively consistent across countries over time. On average each additional year of individual schooling raises an individual's income by 7 to 10 percent [Psacharopoulos and Patrinos, 2004].

Lucas [1988] hypothesized that a worker's level of schooling attainment may have positive external effects on income, either on the income accruing to physical capital or on the income of other workers. If a worker's schooling has external effects on the productivity of other workers, and if these effects are substantial, optimal public policy would require a major public role in the subsidization of schooling.

Determining whether a worker's level of schooling has external effects on the income of other workers and estimating their magnitude has turned out to be difficult. Simple OLS regression of workers' incomes on personal and regional levels of schooling yields estimated coefficients for the external effect of regional schooling that in some studies are as large, or larger than, the coefficient on the worker's own schooling. However, these large effects tend to disappear when other regional variables are added to the model or when the regional level of schooling is instrumented to control for its endogeneity.

Most of the existing studies of regional external effects of schooling estimate these effects in OECD countries where the data required for these estimates are more widely available. The most sophisticated studies have estimated the external effects in U.S. cities, metropolitan areas, and states. Some of these studies find evidence for the existence of external effects, and others do not. There are several recent studies of the external effects of schooling in Europe, but there are few for Latin America. Estimates for Latin America generally are not published in peer-reviewed, international journals, and they rarely control for the endogeneity of regional levels of schooling.

This paper contributes to the empirical literature by presenting the estimates of the direct and external effects of average schooling attainment in municipalities on workers´ incomes in Ecuador in 2011. We examine these effects using a modified Mincerian model that controls for the municipal level of schooling and other factors, including the size of the municipality and the interaction of individuals´ schooling and experience. The data base includes 69,653 individuals in 567 municipalities. The paper also examines the interaction of individual and regional levels of schooling attainment to determine whether the external effects are uniform across individuals with different levels of income and different levels of schooling.

Our estimate of the municipal level of schooling is the average level of attainment of the individuals within the municipality in the data sample, so the personal and municipal measures of schooling are not statistically independent. We utilize a two-level hierarchical model to determine whether the dependence between these levels of schooling noticeably biases the results. Separately, we use the average schooling attainment of males and females over 40 years of age as instruments to control for the endogeneity of municipal levels of schooling.

We find that in the standard Mincerian model each additional year of personal schooling raises a worker´s income by 9.3 percent. In the model that includes the municipal level of schooling and instruments for this schooling, each additional year of individual schooling raises income by 8.5 percent and each additional year of municipal schooling raises individual income by 3.9 percent. The effect of municipal schooling declines to 2.2 percent, but remains statistically significant, when a variable for the size of the municipality is added to the model. The estimated external effect varies among individuals, depending on their personal characteristics and the characteristics of the municipality. The effect is larger for workers with higher incomes, for workers who have higher levels of schooling, and for those living in more educated municipalities.

The remainder of the paper is organized as follows. Section II reviews the literature on the external effects of regional levels of schooling. Section III presents the estimation methodology and describes the data set. Section IV presents the results. Section V concludes.

II. Review of the Literature

Rauch [1993] provided one of the first studies of the external effect of regional levels of schooling on an individual's income. He estimated the effect of average levels of formal education in U.S. standard metropolitan statistical areas (SMSA's) on total factor productivity (TFP) in these areas in 1980, controlling for several regional characteristics other than education that could affect income. He found that an additional year of schooling raised an area's TFP by 2.8 percent.

The single most influential study in this literature is Acemoglu and Angrist [2000] analysis of the external effects of average schooling attainment in U.S. states on individual's salaries over the period 1950-90. Their study is particularly comprehensive in that it estimates effects for different time periods and controls for the endogeneity of both individual and state levels of schooling using several instruments, including compulsory schooling laws. They show that an OLS estimate of the external effect of 8 percent per additional year of state schooling largely disappears when they control for the endogeneity of state levels of schooling. In their many regressions the estimated external effect of an additional year of average schooling in the state on salaries varies, but on average it is only about 1%. The use of instruments did not change the estimated effect of the individual's level of schooling on his/her own income, but it completely changed the estimated external effect of the state level of schooling on this income.

Ciccone and Peri [2006] use a methodology examining wage differences between skilled and unskilled workers to estimate the effect of an additional year of schooling on workers' incomes in U.S. cities and states between 1970 and 1990. Using Acemoglu and Angrist's instruments, they find no external effects from schooling in cities and an external effect of 2% in states that is not statistically significant.

While these studies are methodologically important, their results are not definitive. Bils [2001] observes that the portion of Acemoglu and Angrist´s sample affected by their instrument is limited to the male students forced to remain in school, and that the external effects of increased schooling in this component of the sample could be smaller than in the rest of the sample. Rouse [2001] observes that the external effects of increases in post-secondary

schooling may be greater than the external effects of increases in average schooling attainment.

Moretti [2004] examines the effect of larger shares of college graduates on workers' incomes in cities in the 1980s. Using instruments for schooling, Moretti finds statistically significant effects of the level of schooling that vary depending on the worker´s level of schooling. He found that a 1% increase in the share of college graduates in a city raises the salaries of non-high school graduates by 1.9%, of high school graduates by 1.6%, and of college graduates by 0.4%. He also finds that OLS and 2SLS estimates are similar for individuals with less schooling, but that 2SLS estimates are smaller than OLS estimates for college graduates.

Iranzo and Peri [2009] attempt to reconcile Acemoglu and Angrist's [2000] small external effects of an additional year of schooling with Moretti's [2004] large effects of additional post-secondary schooling on workers with less schooling. They postulate that skilled and unskilled workers are not substitutes. Using the same instruments as Acemoglu and Angrist, they find that an additional year of post-secondary schooling raises state TFP by 6-9% over the 1960-2000 period, while an additional year of secondary schooling has little or no effect.

Rosenthal and Strange [2008] find that the share of college graduates in a region has a positive effect on wages but that this effect attenuates rapidly with distance from employment centers. In their analysis they control for regional characteristics and for the endogeneity of schooling. Their results can explain why studies find larger external effects in U.S. cities than in larger regions, such as states.

These empirical results for the U.S. support the hypothesis that a region's level of post-secondary schooling has external effects, but again they are not definitive. Sand [2013] utilizes Moretti's methodology to re-examine the effect of more college graduates in a city on the income of workers with a secondary school education. He finds that the large external effects of a higher share of college graduates on income in the 1980s largely disappeared in the 1990s.

Heuermann [2011] utilizes Moretti´s model without the physical capital input, using the number of schools and students in a region as instruments, to estimate the effect of regional levels of schooling on workers´ salaries in Germany during 1995-2001. He finds that an increase in the regional share of highly qualified workers by 1% raises wages of highly qualified workers by 1.8% and of non-highly qualified workers by 0.6%. He also finds that the external effects on wages are higher in the manufacturing sector than in the service sector. His results differ from Moretti´s results in that the external effects in Germany are larger for the more qualified workers. However, given the failure to control for other regional characteristics, his results may overestimate the external effects of regional schooling.

Rodríguez-Pose and Tselios [2012] examine the external effect of average levels of schooling during 1994-2001 in 14 countries in the European Union on individuals´ salaries at the household, region, and adjacent region levels of aggregation. They also control for certain other household, region, and adjacent region characteristics. They find large statistically-significant effects at all three levels of aggregation, which in the aggregate are as high as 14% for each additional year of schooling. However, given their failure to control for endogeneity, these effects may be overestimated.

This review of the most relevant literature suggests that regional levels of schooling have external effects on workers' incomes, but that the effect in highly educated countries is relatively small. Analyses that find large external effects generally lack controls for the endogeneity of regional schooling or fail to control for other regional characteristics. Sand's results suggest that the external effects of a higher share of college graduates may disappear when this share becomes large. This interpretation is consistent with Breton's [2013] findings. He shows that the external effect of investment in schooling on labor incomes across countries in 1990 exhibits diminishing returns. If the external effects of regional levels of schooling have diminishing returns, then these effects could be larger in Ecuador than in the U.S., since average schooling levels are considerably lower in Ecuador than in the U.S.

III. Methodology Used in the Study

The literature identifies several statistical problems that may bias the estimated effect of regional levels of schooling on individuals' incomes. The two most important problems appear to be the potential endogeneity of the regional level of schooling and the omission of regional characteristics other than schooling in the income model. A third potential problem is the lack of independence between the individual's level of schooling and the regional level of schooling when the regional level is calculated from the data on individuals' schooling.

In this study we use several estimation methodologies to identify and control for these types of bias in the estimates of the external effects of regional levels of schooling in Ecuador. We first use conventional OLS and 2SLS methods to estimate these effects. We then use two-level hierarchical modeling (2LHM) to separately treat the individual and municipal schooling data. And finally we use a proxy for the size of each municipality to control for other omitted variables that are likely to affect the level of individuals' incomes in a region.

Our basic model is a standard Mincerian model of workers' income as a function of individual schooling, experience, and experience^2, with two additional variables to represent average adult schooling in the municipality and the size of the municipality. In the model we measure income on an hourly basis:

1) $\text{Log(w/hr)}_i = \alpha_0 + \alpha_1\, \text{indsch}_i + \alpha_2\, \text{exp} + \alpha_3\, \text{exp}^2, + \beta_0\, \text{munsch}_j + \beta_1\, \text{munsize} + \mu_j + \varepsilon_i$

where i represents individuals, j represents municipalities, μ represents the random error related to municipalities, and ε represents the random error related to individuals within the municipalities. The two error terms are evaluated separately in the models that utilize a two-level hierarchical estimation procedure.

Hierarchical models are commonly used in studies of the effect of school characteristics on student achievement to control for the dependence of individual and school effects. They have not been used in studies of the external effects of regional levels of schooling, perhaps because there is no existing methodology to control for the endogeneity of regional levels of schooling in these models.

We control for the municipal level of infrastructure in some models by including the log of the number of individuals in each municipality in the data set. Since the data set is a representative sample of individuals in Ecuador, the number of individual's in a municipality is a proxy for the size of the municipality. Larger municipalities are likely to be denser and to have more infrastructure/individual than smaller municipalities.

While the Mincerian model is widely used to estimate the effect of schooling on a worker's income, its conceptual validity has been questioned. Heckman, Lochner, and Todd [2008] observe that Mincer created the model to estimate the marginal rate of return on investment in schooling. In deriving the model he assumed 1) schooling has no direct costs (i.e., only student time) 2) no income taxes, 3) no loss of working life with additional years of schooling, 4) independence in the effects of schooling and experience on income, and 5) marginal returns equal to average returns. They show that actual conditions are sufficiently different from these assumptions to invalidate the interpretation that the estimated coefficient on years of schooling in the Mincerian model is the marginal return.[1] Psacharopoulos and Patrinos [2004] observe that the estimated coefficient on years of schooling is actually an average effect of a year of schooling on a worker's income, rather than a marginal return on investment. Similarly, the estimated coefficient on (average) years of municipal schooling is an average effect.

Heckman, Lochner, and Todd show that an individual´s schooling and experience often are not independent in their effects on a worker's income. Experience can have a greater effect on workers' incomes at higher levels of schooling.

It is possible that an invalid assumption of independence between personal schooling and experience in the Mincerian model could bias the estimated effect of municipal levels of schooling. To control for this possibility, we create two interaction variables (sch*exp and sch*exp^2), which are the products of personal schooling and the experience variables, to

[1] In particular, tuition costs are substantial, and the effect of additional years of schooling is not continuous. There are large "sheepskin" effects, so that completion of a year of schooling with a degree has an effect on income that is much larger than completion of a year of schooling without a degree.

control for the interaction effect. We examine whether this change affects the estimate of the external effect of municipal schooling on personal income in a sensitivity analysis.

Acemoglu and Angrist [2000] present evidence that OLS estimates of the regional level of schooling are biased upward to a substantial degree due to endogeneity. We create two instruments for use with the municipal schooling variable to control for endogeneity. These instruments are the average schooling of females and of males over 40 years of age in each municipality. These measures are highly correlated with the average level of schooling of all workers in each municipality. Since the average schooling of these older residents is unlikely to be affected by the current income/hour of a worker in the municipality, these instruments meet the exclusion restriction.

We obtained the data in the study from the *Encuesta Nacional de Empleo, Desempleo y Subempleo* [2011] carried out in December 2011 by the Ecuadorian National Institute of Statistics and Censuses. The dependent variable in the study is log of income/hour, which we calculate from data in the survey on income and hours worked. The average schooling in each municipality is calculated from the level of schooling of the citizens between 15 and 65 years of age in the sample, without distinction of whether the person was working or not. The number of observations in each municipality varies, depending on the size of the municipality, from seven to 3,353. We calculate workers' years of experience in the labor force by subtracting their years of schooling plus six from their age.

Since the data used in the regressions are limited to those individuals that report income, they are unlikely to be a representative sample of the population. We control for this selection bias by applying the Inverse of Mills methodology created by Heckman [1979].

Subsequently, we perform two additional analyses. In the first we re-estimate the Mincerian model with an interaction term between individual schooling and municipal schooling (indsch*munsch) to see if the effect of municipal schooling on personal income varies by level of individual schooling. Subsequently, we use a quantile regression methodology to determine whether individual and external effects change across the wage distribution. Buchinsky [1994] shows that those individuals at the higher end of the distribution benefit

more from additional personal schooling, but as far as we know, estimates of the variation in the external effects of average regional schooling by income level have not previously been published.

IV. Results

The first set of results is shown in Table 1. Column 1 presents the OLS results for the standard Mincerian model. In this model each additional year of personal schooling raises workers' incomes by 9.3 percent. The magnitude of this effect is consistent with the literature. Psacharopolis and Patrinos [2004] report that the average effect of an additional year of schooling on income in Latin America is 8.2 percent. This average pertains to the available studies published prior to 2004.

Column 2 presents the OLS results with the addition of the municipal level of schooling to the model. In this regression each additional year of personal schooling raises workers' incomes by 8.5 percent, and each additional year of municipal schooling raises incomes by 3.9 percent. Column 3 presents the results adjusted using the Inverse of Mills methodology for selection bias. The effect of individual schooling increases to 9.1 percent, while the effect of municipal schooling declines to 3.5 percent.

Column 4 presents the 2SLS results using the average level of schooling of the workers over 40 in the municipality as instruments for the municipal level of schooling. In this model each additional year of personal schooling raises worker incomes by 8.8 percent and each additional year of municipal schooling raises workers' incomes by 4.2 percent. The F statistic indicates that the instruments are strong, and a Sargan test rejects the hypothesis that the instruments are endogenous. The results of these tests are shown in the appendix.

Colum 5 presents the results for a null model of the two-level hierarchical model (2LHM). The parameter sd(Residual) shows the amount of variance in individual income explained by the variation across individuals (0.8057) and sd(_cons) shows the variance explained by variation across municipalities (0.3851). These results indicate that 32 percent of the variance of hourly wages is explained by differences between municipalities and 68% is

explained by differences in individuals´ characteristics within municipalities.[2] These results indicate that an individual´s income is substantially affected by conditions in the municipality where he/she resides. The implication is that a correctly specified Mincerian model must include municipal characteristics, such as its average level of schooling and size.

Table 1
Effect of Individual and Municipal Schooling on Individuals' Incomes
[Dependent Variable is log(income/hour)]

	1	2	3	4	5	6	7	8	9
Method	**OLS**	**OLS**	**OLS**	**2SLS**	**2LHM**	**2LHM**	**OLS**	**2SLS**	**2LHM**
Constant	**-0.966**	**-1.262**	**-1.182**	**-1.247**		**-1.304**	**-1.257**	**-1.280**	**-1.470**
	0.023	*0.033*	*0.039*	*0.065*		*0.072*	*0.041*	*0.062*	*0.079*
Inverse of Mills			**-0.313**	**-0.240**		**-0.119**	**-0.039**	**-0.029**	**-0.075**
			0.086	*0.104*		*0.090*	*0.093*	*0.095*	*0.090*
Experience	**0.033**	**0.031**	**0.040**	**0.038**		**0.034**	**0.032**	**0.032**	**0.033**
	0.001	*0.001*	*0.003*	*0.003*		*0.003*	*0.003*	*0.003*	*0.003*
Experience^2	**0.000**	**0.000**	**-0.001**	**0.000**		**0.000**	**0.000**	**0.000**	**0.000**
	0.000	*0.000*	*0.000*	*0.000*		*0.000*	*0.000*	*0.000*	*0.000*
Ind. Schooling	**0.093**	**0.085**	**0.091**	**0.088**		**0.087**	**0.086**	**0.085**	**0.087**
	0.001	*0.001*	*0.002*	*0.003*		*0.002*	*0.002*	*0.003*	*0.002*
Mun. Schooling		**0.039**	**0.035**	**0.042**		**0.040**	**0.018**	**0.022**	**0.024**
		0.003	*0.003*	*0.007*		*0.008*	*0.004*	*0.010*	*0.008*
Log (Munic Size)							***0.036***	**0.033**	**0.069**
							0.004	*0.007*	*0.014*
sd(_cons)					**0.385**	**0.265**			**0.256**
					0.015	*0.012*			*0.012*
sd(Residual)					**0.806**	**0.726**			**0.726**
					0.004	*0.003*			*0.003*
F Statistic				***3857.2***				***2073.1***	
R^2	***0.22***	***0.23***	***0.23***	***0.23***		***0.17***	***0.23***	***0.23***	***0.18***
Total Effect of Schooling	***0.093***	***0.124***	***0.126***	***0.130***		***0.127***	***0.103***	***0.107***	***0.111***

Since individuals within the same municipality in Ecuador share common characteristics and aren't independent from each other, 2LHM should provide less biased estimates than OLS estimation. The limitation of hierarchical modeling is that it cannot control for endogeneity, so the results may exhibit endogeneity bias.

[2] For more information, see Snijders and Bosker [2012].

Column 6 presents the 2LHM results. A comparison of these results with the analogous OLS results in column 2 shows that the statistical dependence between the individual and municipal level schooling appears to bias the OLS results downward. The external effect of municipal schooling is 4.0 percent in the 2HLM results compared to 3.5 percent in the OLS results.

These initial results indicate that the municipal level of schooling has substantial external effects on workers' incomes, but it is possible that these effects are due to characteristics of the municipalities other than their average level of schooling. Column 7 presents OLS estimates of the model, including a variable for the size of the municipality. In these results the size of the municipality has a large statistically significant effect on individual income, and the estimated effect of an additional year of municipal schooling falls to 1.8 percent.

Column 8 presents the 2SLS results for the same model. In these results the effect of an additional year of schooling is 2.2 percent. This estimate is statistically significant at the five percent level. The F statistic indicates that the instruments continue to be strong, and the Sargan test continues to indicate that the instruments are exogenous. A Hausman test of the 2SLS results indicates that the OLS results are endogenous. The statistical results for these various tests are shown in the appendix.

Colum 9 shows the 2LHM results for the model that includes the size of the municipality. Again the inclusion of the proxy for municipal size is statistically significant and the estimated coefficient for the external effect of an additional year of municipal schooling is similar at 2.4 percent. Since both the 2SLS and 2HLM estimates are higher, we conclude that the OLS results are biased downward and that the 2SLS estimate of the effect of municipal schooling on personal income is a conservative estimate of this effect. As shown in column 8, the total direct and external effect of an additional year of schooling in the municipality is 10.7 percent.

An additional year of municipal schooling appears to raise individuals' salaries in Ecuador about 2.2 percent. Ideally the individual level of schooling also should have been instrumented in the 2SLS analysis to control for endogeneity, but an appropriate instrument

was not available. Since Acemoglu and Angrist [2000] found no evidence that OLS estimates of the effect of individual´s schooling are biased, we think it is unlikely that any bias in the estimated effect of individual's schooling is biasing the estimated effect of municipal schooling.

Table 2 presents a sensitivity analysis that estimates the effect of including interaction terms between individual schooling and the experience variables in the model. Column 1 shows the standard Mincerian model with the addition of this term. The other three columns

Table 2
Effect of Schooling on Individuals' Incomes with Interaction Terms
[Dependent Variable is log(income/hour)]

	1	2	3	4	5
Method	**OLS**	**OLS**	**2SLS**	**2LHM**	**OLS**
Constant	**-0.7275**	**-1.1123**	**-1.1367**	**-1.3415**	**-0.7652**
	0.051	*0.0591*	*0.0739*	*0.091*	*0.0657*
Inverse of Mills	**-0.672**	**-0.0393**	**-0.0272**	**-0.0761**	**-0.0330**
	0.085	*0.0935*	*0.0966*	*0.09*	*0.0917*
Experience	**0.0408**	**0.0225**	**0.0221**	**0.0231**	**0.0319**
	0.0037	*0.0038*	*0.0039*	*0.0036*	*0.0027*
Experience^2	**-0.0005**	**-0.0002**	**-0.0002**	**-0.0002**	**-0.0004**
	0.0000	*0.0000*	*0.0000*	*0.0000*	*0.0000*
Experience*Schooling	**0.0012**	**0.0013**	**0.0013**	**0.0012**	
	0.0003	*0.0003*	*0.0003*	*0.0002*	
Experience^2*Schooling	**-1.94E-05**	**-2.02E-05**	**-2.02E-05**	**-2.00E-05**	
	3.99E-06	*3.95E-06*	*3.96E-06*	*3.53E-06*	
Individual Schooling	**0.0870**	**0.0693**	**0.0684**	**0.0710**	**0.0228**
	0.0043	*0.0044*	*0.0048*	*0.0045*	*0.0070*
Municipal Schooling		**0.0177**	**0.0229**	**0.0245**	**-0.0297**
		0.004	*0.01*	*0.0082*	*0.0063*
Log (Municipal Size)		***0.0358***	**0.0326**	**0.0695**	**0.0685**
		0.0045	*0.0071*	*0.0142*	*0.0043*
Ind. School*Mun. School					**0.0060**
					0.0006
sd(_cons)				**0.2561**	
				0.0123	
sd(Residual)				**0.7257**	
				0.0033	
F Statistic			***1419.45***		
R^2	***0.23***	***0.23***	***0.23***	***0.18***	**0.23**

show the results from the full model estimated with OLS, 2SLS, and 2HLM. The results confirm the dependence of individual schooling and experience, since all the estimated coefficients on this term are statistically significant at the 1% level, but the estimates coefficients on municipal levels of schooling in these models is virtually identical to the estimates in Table 1. Again the 2SLS results indicate that each year of municipal schooling raises individuals' incomes by about 2.2 percent.

Column 5 examines whether the external effect of average schooling in the municipality is a function of the level of individual schooling by including an interaction term for the product of these two levels of schooling. The estimated coefficients on the individual and municipal schooling terms are very different, and the estimated coefficient on the interaction term is positive and statistically significant. The results strongly indicate that the external effect of the municipal level of schooling is considerably larger for individuals with more schooling, although the estimates could exhibit some endogeneity bias.

Table 3 illustrates the external effects of an additional year of schooling in a municipality for workers with various levels of schooling that correspond to the estimates in Column 5. An increase of one year in the average level of schooling from 10 to 11 years raises individual incomes by 0.6%, 4.3%, and 6.7% for individuals with these three levels of schooling. These results are consistent with Heuermann´s findings in Germany where the external effects of regional levels of schooling are greater for individuals with more schooling.

Table 3
Effect on Income of Moving to a Municipality with a Higher Level of Schooling

Schooling Completed	**Individual Schooling**	**Muncipal Schooling**	**Log(wage/hour)**	**Change in Income**
	(years)	(years)		(percent)
University	16	10	1.0316	
	16	11	1.0982	6.7
Secondary	12	10	0.6994	
	12	11	0.7420	4.3
Primary	6	10	0.2012	
	6	11	0.2076	0.6

Another way to examine the distribution of the external effects of more regional schooling is to estimate these effects for individuals with different levels of income. Table 4 shows the results from a quantile regression analysis, which shows how the individual and external effects of schooling vary with changes in individuals' income. The individual effects are the same as found by Buchinsky [1994]. Individuals with higher incomes benefit more from schooling that those with lower incomes, and the distribution of the external effects exhibits the same pattern.

Table 4
Effect of Schooling on Workers' Income in a Quantile Regression
[Dependent Variable is log(income/hour)]

Quantile	**10%**	**25%**	**50%**	**75%**	**90%**
Constant	**-2.32903**	**-1.53132**	**-1.10456**	**-0.81998**	**-0.26839**
	0.07844	*0.05013*	*0.04080*	*0.05050*	*0.10868*
Inverse of Mills	**0.44371**	**0.11743**	**-0.10727**	**-0.35742**	**-0.26839**
	0.19669	*0.10821*	*0.09190*	*0.14221*	*0.10868*
Experience	**0.01420**	**0.02513**	**0.03441**	**0.04599**	**0.04427**
	0.00568	*0.00312*	*0.00272*	*0.00381*	*0.00348*
Experience^2	**-0.00023**	**-0.00034**	**-0.00040**	**-0.00049**	**-0.00041**
	0.00007	*0.00004*	*0.00004*	*0.00005*	*0.00005*
Individual Schooling	**0.07092**	**0.07186**	**0.08024**	**0.09438**	**0.10155**
	0.00471	*0.00261*	*0.00219*	*0.00274*	*0.00278*
Municipal Schooling	**0.01520**	**0.01644**	**0.02591**	**0.02790**	**0.03043**
	0.00832	*0.00533*	*0.00374*	*0.00413*	*0.00561*
Log (Municipal Size)	**0.10458**	**0.05650**	**0.01871**	**-0.00206**	**-0.01482**
	0.00920	*0.00598*	*0.00441*	*0.00525*	*0.00622*
R^2	***0.11***	***0.12***	***0.13***	***0.17***	***0.19***
Total Effect of Schooling	**0.086**	**0.088**	**0.106**	**0.122**	**0.132**

The effect of an additional year of schooling on individual income is 7.1% in the lower 10% quantile of incomes, while at the 90% quantile the effect is 10.2%. The external effect of an additional year of schooling in the municipality in the lower 10% quantile of incomes is only 1.5%, while it is 3.0 percent in the 90% quantile. These results indicate that as individual

incomes rise from the 10% to the 90% quartile, the total effect of an additional year of schooling on incomes increases from 8.6% to 13.2%.

Table 5 shows results for a quantile model in which individual schooling interacts with the level of schooling in the municipality. The results indicate that there is a positive interaction effect between individual and municipal levels of schooling. More schooling consistently raises income, and individuals with higher incomes benefit more from the external effects of municipal levels of schooling.

Table 5
Effect of Schooling on Workers' Income in a Quantile Regression with Interaction Term
[Dependent Variable is log(income/hour)]

Quantile	10%	25%	50%	75%	90%
Constant	**-1.92733**	**-1.13237**	**-0.56400**	**-0.24220**	**0.01150**
	0.12859	*0.08695*	*0.07484*	*0.07207*	*0.09096*
Inverse of Mills	**0.40011**	**0.11165**	**-0.10141**	**-0.30560**	**-0.23388**
	0.19867	*0.10441*	*0.06613*	*0.16265*	*0.09767*
Experience	**0.01469**	**0.02447**	**0.03399**	**0.04386**	**0.04466**
	0.00543	*0.00303*	*0.00207*	*0.00441*	*0.00329*
Experience^2	**-0.00024**	**-0.00034**	**-0.00040**	**-0.00047**	**-0.00042**
	0.00007	*0.00004*	*0.00003*	*0.00006*	*0.00004*
Ind. Schooling	**0.02613**	**0.02510**	**0.01602**	**0.01797**	**0.02073**
	0.01257	*0.00876*	*0.00768*	*0.00810*	*0.01092*
Mun. Schooling	**-0.02167**	**-0.02074**	**-0.02680**	**-0.02890**	**-0.02633**
	0.01286	*0.00825*	*0.00802*	*0.00696*	*0.00887*
Interaction Effect	**0.00430**	**0.00452**	**0.00621**	**0.00721**	**0.00755**
	0.00113	*0.00075*	*0.00071*	*0.00067*	*0.00101*
Log (Munic Size)	**0.10519**	**0.05505**	**0.01814**	**-0.00031**	**-0.01624**
	0.00996	*0.00630*	*0.00500*	*0.00544*	*0.00480*
R^2	***0.11***	***0.12***	***0.13***	***0.17***	***0.19***

V. Conclusions

Numerous studies in the literature have estimated the external effect of regional levels of schooling on individual incomes in OECD countries. These studies generally find a small,

positive effect, although some studies find a large effect and others no effect. Few studies estimate these effects in Latin America, and these studies generally do not control for the endogeneity of regional levels of schooling.

This study examines the external effect of levels of schooling in municipalities on individual incomes in Ecuador, controlling for endogeneity, the size of the municipality, and possible interactive effects between individual schooling and regional schooling. The study also controls for the dependence of the schooling data between individuals and municipalities using a two-level hierarchical model.

The results for the null model in the two-level hierarchical estimate indicate that the income of an individual is affected by the context in which he lives. These results indicate that in Ecuador 32 percent of the variance in log(income/hour) are determined by the characteristics of the municipality. The implication is that a properly-specified Mincerian income model must include urban characteristics, such as the average size and average level of schooling in the municipality.

In all of the results we find that the level of schooling in the municipality has a positive effect on individuals´ income. The magnitude of the estimated effect of schooling on workers´ incomes declines when municipal characteristics are included in the model. In the complete model, an additional year of average schooling in the municipality raises income by 1.8 to 2.5 percent, depending on the estimation technique. The lower estimates are based on OLS estimation, which appear to be biased downward. A conservative estimate is that in 2011 on average an additional year of municipal schooling in Ecuador raised individual income by 2.2 percent.

We find that the effect of an additional year of municipal schooling varies depending on an individual´s level of schooling, with more educated individuals experiencing a larger effect. On average an additional year of schooling raises income by 0.6% for individuals with primary schooling, 4.3% for individuals with secondary schooling, and 6.7% for individuals with university schooling.

The effect of municipal schooling also varies depending on an individual's level of income. At the lower 10% quantile of income, an additional year of schooling raises income by 1.5% and at the 90% quantile by 3.0%. The effect of an additional year of schooling on individual income is 7.1% in the 10% quantile, while by the 90% quantile it is 10.2%. The associated total effect of an additional year of schooling in these quantiles rises from 8.6% to 13.2%, indicating that as incomes rise, the external effect of schooling on income increases from 21 to 29 percent of the direct effect.

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Appendix

Statistical Test Results

Table A-1 shows the first-stage regression for column 8 in Table 1. Table A-2 shows the results from an endogeneity test and a Sargan overidentifiyng restriction test, which indicate that the instruments are valid because they are correlated with the endogenous variable but not with the structural error term.

Table A-1 **First Stage** **Dependent variable Municipal Schooling**		
	Coef.	*Std. Err.*
Constant	**4.27661**	*0.06498*
Mills	**-1.98977**	*0.17727*
Experience	**0.06252**	*0.00499*
Expe2	**-0.00071**	*0.00007*
Log (Munic Size)	**0.48822**	*0.00687*
Schooling	**0.13143**	*0.00373*
Women 40> Mun. Schooling	**0.21170**	*0.00469*
Men 40> Mun. Schooling	**0.03266**	*0.00417*

Table A-2	
Tests of endogeneity	
Ho: variables are exogenous	
Durbin (score) chi2(1)	= .227053 (p = 0.6337)
Wu-Hausman F(1,24733)	= .226982 (p = 0.6338)
Test of overidentifying restrictions:	
Sargan (score) chi2(1)	= 2.19575 (p = 0.1384)
Basmann chi2(1)	= 2.19523 (p = 0.1384)

Table A-3 shows the results of a Hausman test indicating that the OLS estimates of the effect of municipal schooling in column 7 of Table 1 are biased.

Table A-3				
	Coefficients			
	2LSL (b)	MCO (B)	(b-B)	sqrt(diag(V_b-V_B))
Municipal Schooling	0.0221135	0.0176651	0.0044485	0.0093358
Mills	-0.0288855	-0.0394592	0.0105738	0.0221477
Experience	0.0319794	0.0323216	-0.0003422	0.0007171
Expe2	-0.0003557	-0.0003596	3.87E-06	8.11E-06
Schooling	0.0849821	0.0856789	-0.0006969	0.0014621
Log (Munic Size)	0.0328394	0.0355865	-0.0027471	0.0057649
Test: Ho: difference in coefficients not systematic				
chi2(5) = (b-B)'[(V_b-V_B)^(-1)](b-B)				
= 0.023				
Prob>chi2 = 0.9988				
(V_b-V_B is not positive definite)				