Impact of Hydroelectric Dams on Indigenous Language Retention:

A Case Study at Chixoy Dam

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May 2013

I. Introduction

I.A Dams

Large hydroelectric dams are a highly controversial energy infrastructure in the developing world. Often hailed as a reliable and cost-effective source of renewable energy, hydroelectric dams are also widely criticized for the damage they inflict on local ecosystems, and on the (often poor and politically marginalized) human populations that live near them. As the world's pioneer of hydroelectricity—the United States—begins tearing down dams to restore fisheries, renew ecosystems and recover sacred indigenous lands, countries throughout the developing world are rapidly erecting new dams in pursuit of low-cost energy. Large and fast-growing economies like China and Brazil are building the largest dams the world has ever seen. While benefits of electrification are well established, measuring the full environmental and social costs of dams has proven more challenging.

Hydropower accounts for 16% of the world's electricity (International Energy Agency), generates relatively few greenhouse gas emissions compared with fossil fuels, and is renewable as long as river flows are maintained. Dams provide an astounding 85% of electrical use in Brazil (Barham et. al. 2011), the world's sixth largest economy, and continue to be built at a rapid pace in fast-developing countries like China and India—countries that would likely burn low-grade coal as an alternative. They are also a popular energy source in other developing countries—particularly in parts of Latin America and Southeast Asia—pursuing badly needed economic growth, but with few affordable

energy alternatives. Yet critics maintain that the benefits of energy development and economic growth, distributed largely to industry and urban dwellers far from the dams themselves, do not justify the costs imposed on indigenous communities and other poor, rural populations that live near the dams. Large dams flood vast tracts of forest, destroy fisheries, interrupt natural flooding cycles that fertilize riverbanks, and disrupt river ecosystems. Their reservoirs have displaced 40-80 million people globally by flooding their lands, and have displaced many millions more by destroying livelihoods, depleting water sources and creating new disease vectors (WCD 2000).

Given a growing global demand for electricity as hundreds of millions of people begin to rise out of poverty and into the middle class, and given an international imperative on low-carbon energy production, dams are unlikely to fall out of favor any time soon. Yet valid cost-benefit analyses of dams demand a complete understanding of costs; policy makers would be well advised to incorporate the full range of potential dam impacts into their decision-making frameworks. This paper offers an econometric strategy for measuring impacts on communities displaced by dams, primarily by exploiting a quasi-experimental setting in which dam and reservoir placement is plausibly orthogonal to potential development outcomes for surrounding villages. That is, once a dam is constructed, communities in the reservoir area become displaced by flooding and comprise a "treatment" group of displaced people, while similar communities nearby but outside of the reservoir are not displaced, and serve as a valid counterfactual or control group. Specifically, this paper studies the impact of Guatemala's largest hydroelectric dam on the indigenous language retention of displaced Mayan communities, thereby

measuring a *cultural* impact—one of the profound yet least studied impacts of dam displacement.

I.B Culture

The World Commission on Dams[1] (WCD) reports that up to 80 million people have been displaced by dams globally (Dams and Development 2000, 104), and that those people have paid an "unacceptable and often unnecessary price…in social and environmental terms (Dams and Development 2000, xxviii)." These social and environmental costs are increasingly considered in policy papers—including WCD's landmark report—but discussion of *cultural* costs is rare and generally limited to impacts on World Heritage sites or physical assets such as cemeteries or temples. In reality, cultural impacts are far greater and broader: communities that are forced off of the land that they have inhabited for generations face difficulty retaining cultural practices that are intimately tied to their environment, including traditional livelihoods, foods, medicines, dress, spiritual practice, language, and forms of community organization and governance (Informe de Identificación 2009; Colchester 2000; Steenstra 2010). Loss of culture inflicts negative consequences on the displaced: it is detrimental to their psychosocial well-being, which in turn carries social and economic consequences (Cernea 1998); it entails loss of cultural diversity, which is an asset that is valued by societies globally; and it is a violation of human rights laid out in international agreements such as the UN Declaration on the Rights of Indigenous Peoples and the UN Covenant on Economic, Social and Cultural Rights.

[1] The World Commission on Dams is a group of experts established in 1998 by the World Bank, mandated to assess the effectiveness of large dams and provide standards for future dam development.

The research described here looks specifically at the impact of dam displacement on indigenous language retention. Language fluency is chosen as an outcome variable as it is relatively easy to measure compared with other cultural assets, and because language is a fundamental element of cultural identity (Yoshioka 2010; Valenzuela 2010; Everett 2012), making it a good proxy for cultural health and continuity.

I.C Contributions

This paper makes two major contributions to the literature. First, it applies a difference-in-differences approach to measure the impacts of dams on displaced communities. To the best of my knowledge, the economic literature has not presented any case in which an econometric approach is taken to measuring the impacts of individual dams, or to measuring the impact of dams on displaced people specifically. The few impact evaluations that have examined distributional impacts of dams focus on the dichotomy between upstream and downstream impacts at the country or sub-country level. Duflo and Pande (2007) use a dataset that includes every large irrigation dam in India to show that districts downstream from irrigation dams benefit from increased agricultural productivity and reduced vulnerability to rainfall shocks, while districts in the vicinity of dams experience heightened poverty and volatility with no significant impact on agricultural output. Strobl and Strobl (2011) demonstrate similar distributional effects for the African continent. This line of research, however, only tangentially considers impacts on displaced communities themselves. A large body of qualitative research does focus on displaced communities, and presents the many-faceted economic, social and cultural

impacts of dams on those communities. These studies have informed the thinking and decisions of development practitioners, but their qualitative nature places them somewhat out of sync with—and perhaps, in the policy realm, at a disadvantage to—the quantitative models used to assess economic and financial feasibility of dams. By applying an econometric approach to measuring impacts of one dam on the communities it displaced, I introduce an empirical design that can quantify multi-dimensional impacts on displaced people in specific cases. Replication of such research can help us measure the true short- and long-term impacts that displaced communities experience, and can help us understand the mechanisms through which these impacts occur and therefore strategies for minimizing adverse effects.

Second, this paper focuses on language retention as the primary outcome of interest, making it the first econometric paper that measures a *cultural* impact on people displaced by dams. As discussed above, cultural impacts of dams—and of any infrastructure that displaces traditional communities—are among the most important yet least understood determinates of a people's well-being. Again, a large body of qualitative research elucidates impacts of dams and displacement on the cultural health and continuity of indigenous and other traditional societies, but the qualitative and anecdotal nature of their findings make them difficult to situate within quantitative cost-benefit analyses. By providing a preliminary quantitative measure of cultural impacts, this paper contributes to the inclusion of cultural considerations in policy decisions regarding dams. Measurement of cultural outcomes gives us a more complete understanding of dam impacts, and how

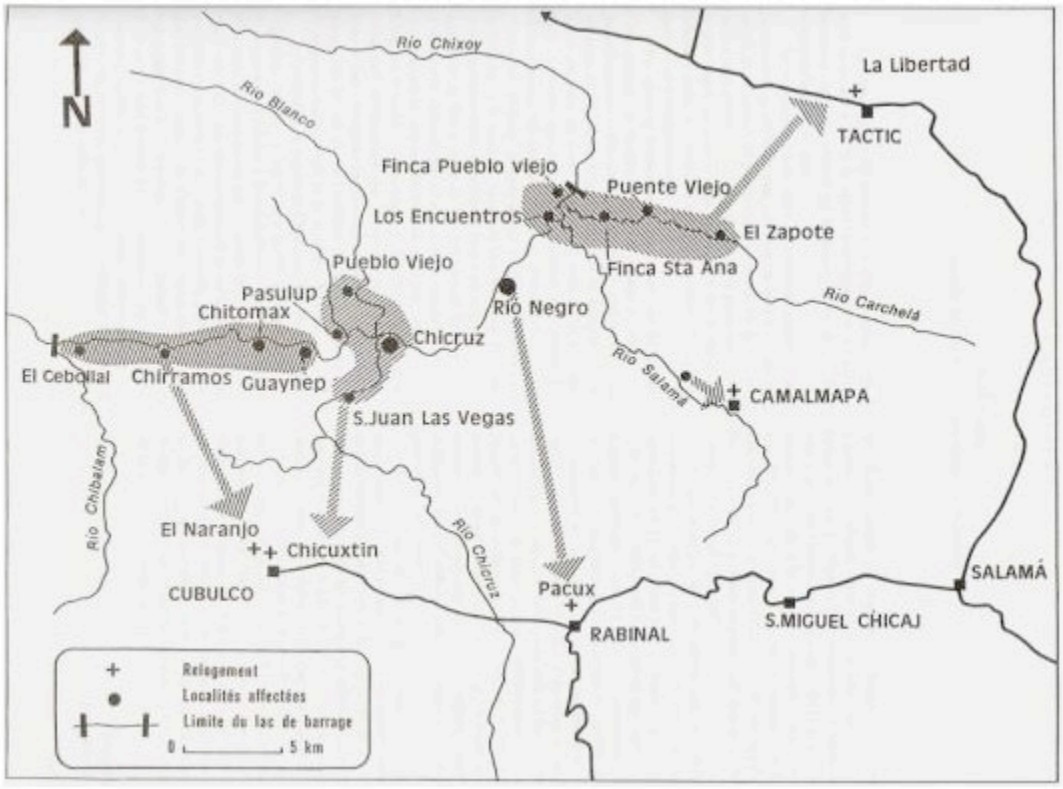
those impacts are distributed between “winners” and “losers” in energy and agricultural development.

II. Background

II.A Chixoy Dam

The Chixoy Dam sits on the Rio Negro River in the highlands of central Guatemala. With 275 MW of installed capacity, it accounts for approximately 15% of Guatemala’s electricity potential. Dam construction took place primarily in the 1980s; by 1982 nearly 3,500 people from Maya Achí communities on the Rio Negro River had been displaced. Nine villages were completely inundated by the reservoir, and over twenty were partially displaced or otherwise affected. Most displaced families were resettled into four government-built “model villages” close to existing towns and paved roads, while some 40 families settled in an existing town. Figure 1 illustrates this process (though some names have changed since the map was drawn). In 1994 a fifth settlement was built to accommodate families from one of the original settlements that had become exceptionally overcrowded. Apart from the movement into this settlement, almost no in- or out-migration has occurred since the original resettlement. Maya Achí communities that were beyond the reach of the reservoir and were therefore not displaced continue to reside along the Rio Negro River, both upstream and downstream from the reservoir.

Figure 1



Communities in the shaded areas above were displaced to army-built settlements, marked by the plus signs (+) on this map. These settlements sit at the edges of larger towns and are close to roads.
Source: Douzant Rosenfeld, via Barbara Rose Johnston, Chixoy Dam Legacy Issues Study.

II.B Communities

Displaced communities comprise five villages in the provinces Alta and Baja Verapaz in central Guatemala, and make up a portion of a sixth town. In Baja Verapaz, the community[2] of Pacux is approximately nine miles (along a slow highway) from El Naranjo and Chicustin, which are adjacent. San Francisco—the town that predated the dam and absorbed 40 displaced families—is eight miles to the south. In Alta Verapaz, Rosario Italia and San Antonio Panec are nearby each other and about 17 miles north of

[2] I use the term "communities" throughout this paper to refer to each resettled group. Locals more commonly use the terms "colonies" or "settlements".

Pacux (though traveling these 17 miles requires most of a day due to the quality of roads and the mountainous terrain). Pacux, El Naranjo and Chicustin are immediately adjacent to established towns, while the other three cities are a 20-40 minute bus ride from established towns. In Baja Verapaz province, these adjacent towns are comprised of Spanish and Achí speakers, while in Alta Verapaz pre-existing towns include Spanish, Q'eqchi and Poqomchí speakers[3]. The six communities range from 120 to 200 households in size and are comprised almost entirely of the families of villages that were inundated by the reservoir in 1982, with the exception of the 700 household town of San Francisco, which predated the dam and absorbed approximately 40 displaced households.[4]

Prior to displacement, the Maya Achí communities living along Rio Negro River lived in relative isolation, growing the food they ate, raising livestock and catching fish. Some traveled occasionally into established towns to buy and sell at markets, which entailed a several hours walk in each direction. The median household in my sample owned 2 *manzanas* of land—approximately 3.4 acres—before being displaced. All households report having grown their own grain to eat, while 97% grew beans and 69% grew vegetables to eat. All households raised animals for food consumption purposes and 97% caught fish to eat. 48% owned radios, though none had electrical connections. The median household owned 36 chickens (with all households owning at least four), one horse, three cows and three pigs. 21% of households had a literate male head of

[3] There are 21 recognized Mayan languages in Guatemala, broken down into branches, sub-branches and sub-families. Q'eqchi and Poqomchí are Mayan language distinct from Achí but of the same sub-branch.
[4] Regression estimates presented in this paper include data from 36 households in San Francisco. These estimates are robust to regressions not shown here that exclude the San Francisco sample.

household, and 5% had a literate female head. The average household sent someone to sell food at a market twice per month, and to buy food three times per month—the difference is explained by 40% of households that did not sell food at all, whereas nearly all households purchased food items at least once per month.

The ideal control group in this study would be other Maya Achí communities living just beyond the reservoir, so as not to have been displaced, who we would expect to have very similar characteristics to the displaced groups at baseline. However, a constraint in data collection, described in detail in the following section, limited the control group to a set of villages closer to established towns and highways. For this reason their baseline characteristics are slightly different. The average household in the control group looked the same as in the treatment group in terms of amount of land owned, and percent of families growing grain and raising animals. However, 11 percent of these households had electricity, only 20% grew vegetables and only 46% caught fish. Only 13 percent of households had literate male heads, but 12 percent had literate female heads. The average household sold food only once per month, but purchased food about 3.4 times per month. The median household owned 20 chickens, one horse, 1.5 cows and four pigs.

In the treatment group about 94% of individuals were fluent in Achí immediately prior to dam construction, compared with 83% in the control group. In the treatment group 7.5% could read Achí, compared with 5.6% in the control group. Descriptive statistics for the treatment group prior to dam construction are presented in Table 1.

Table 1

Descriptive statistics for treatment communities prior to displacement

Variable	Mean	S.D.	Min	Max	n
Households					
Has electricity	0	0	0	0	97
Owns radio	0.48	0.50	0	1	97
Amount of land owned (manzanas)[a]	3	2.11	1	12	94
Grows grain	1	0	1	1	97
Grows beans	0.97	0.17	0	1	97
Grows vegetables	0.69	0.46	0	1	97
Raises animals	1	0	1	1	97
Catches fish	0.97	0.17	0	1	97
Male HOH can read	0.19	0.39	0	1	91
Female HOH can read	0.06	0.23	0	1	89
# Chickens owned	48.95	49.99	4	300	95
# Horses owned	1.72	3.07	0	17	97
# Cows owned	6.31	8.28	0	42	96
# Pigs owned	4.21	3.47	0	20	95
Individuals					
Age[b]	29.49	10.63	15	59	107
Male	0.52	0.50	0	1	107
Travels to a town/city to earn income	0.55	0.50	0	1	105
Travels to a town/city for work	0.35	0.48	0	1	107
# of times travels to a town/city per month	2.39	2.3	0	12	103
Fluent in Achi	0.93	0.25	0	1	107
Reads Achi	0.08	0.27	0	1	106

[a] 1 manzana = 1.73 acres

[b] Data was not collected on individuals under 15 years old

III. Data

All datasets were compiled via household surveys in Baja Verapaz and Alta Verapaz provinces in Guatemala. Enumerators collected data from as many households as possible in treatment villages and in purposefully selected control villages. Treatment villages were defined as those housing communities that were physically displaced by the Chixoy Dam reservoir. Control villages were defined as villages that were predominately

ethnically Maya Achí and close to the reservoir, but far enough not to have been displaced. Village leaders, NGO staff members and other key informants were interviewed on village characteristics such as access to infrastructure and presence of NGOs.

A team of enumerators surveyed households in Spanish and in Achí, depending on respondents' ability and comfort, along a series of questions on geographic movement, socioeconomic status and language ability and preference. Between one and five individuals were interviewed in each household; all interviewed individuals were asked to provide data on their present status, and all individuals at least 45 years old (and therefore at least 15 years old at the time of displacement) were asked to provide information pertaining to their status before being displaced. There is some evidence in the literature indicating that retrospective self-reporting can be subject to recall bias, in which subjects do not accurately remember details from the past. I have two reasons for believing that this problem is minimal. First, individuals in these communities experience very little change in their livelihoods, travel or other routines over the course of their lives; the displacement for most people was the singular transformative event in their lives, and the "before" and "after" periods are very well defined and marked in their minds. Conditions before the dam was built, which remained fairly consistent, should therefore be easily recalled and contrasted against conditions after dam construction. Second, at least for the displaced communities, NGOs have worked continually over the past twenty years to seek reparations and other forms of compensation through litigation on behalf of the displaced communities, which has involved working directly with the

communities and asking them to recall pre-displacement conditions on a regular basis. In light of these factors, any measurement error that does occur should be classical, and if anything should increase variance and/or attenuate estimates of impact.

Data collection involved one substantial constraint, which influenced the empirical strategy described below. Due to limited time and resources, household surveys were not possible in the most remote villages near the reservoir, which represent the ideal control villages. Instead, data was collected from control villages closer to established towns, roads and markets. Because of their location, the assumption of parallel trends between treatment and control villages is violated and the integrity of control villages as a true counterfactual is undermined, diminishing the validity of difference-in-difference estimates. I account for this by using a triple difference model to exploit time trends within each group; this is explained further in the next section. The following section also presents the ideal estimation strategy—using a simple double difference model to estimate unbiased results—which is recommended for future impact evaluations for displaced people in which data collection from communities near the reservoir is possible.

IV. Empirical Strategy

In many cases, displacement caused by dam construction creates a quasi-experimental setting that can be exploited to generate unbiased estimates of impacts on displaced people. Large dams tend to be built on rivers in rural areas, where river valleys are often

populated by villages that subsist on water, fish, fertile soil and other resources provided by the river. When a dam is built, it creates a reservoir by blocking up the river valley. Villages in close proximity are physically flooded by the reservoir, and thereby displaced. Villages upstream from the reservoir's edge are not displaced. If displaced and non-displaced villages throughout the river valley share characteristics, as they often do—ethnicity, language, custom, socioeconomic status, livelihoods, access to education and health service, proximity to road infrastructure, etc.—then an assumption of parallel trends can plausibly be made and a difference-in-differences strategy can estimate impacts caused by the dam. (Parallel trends is less plausible for communities immediately downstream from the reservoir, who tend to experience different impacts on their well-being due to changes the dam imposes on the downstream riverine ecosystem.)

In this case, any dam impact of interest can be measured by:

$$Y_{ivt} = \beta_0 + \beta_1 Displaced_v + \beta_2 Post_t + \beta_3 Displaced_v * Post_t + X' + u_{it}$$

Displaced is equal to one for individuals or households from a village displaced by the dam, *Post* is equal to one in the period after displacement (specifically, in the current period, 2012), and β_3 is the difference-in-differences estimator. *X'* represents a vector of individual and household control variables including frequency of travel outside of the home village, ownership of television and radio, amount of land owned, and a number of socioeconomic indicators.

This paper applies this estimation strategy to measure the impact of displacement on the retention of Achí language—a critical element of cultural continuity and a proxy for other cultural factors, which are not rigorously measured in cost-benefit analyses used for dam-building. In particular, it examines two different dependent variables: an indicator variable for Achí fluency and an indicator variable for ability to read Achí.

As mentioned in the data section, geographic constraints prevented enumerators from accessing ideal counterfactual villages. I therefore amend the empirical strategy to a triple difference model that helps to account for different language use time trends within each cohort. The third difference is between a "young" vs. "old" cohort. The old cohort can refer to those who were above school age and/or well into adulthood when the dam was displaced, and had therefore already had formed their language preferences. The young cohort can refer to those in an early childhood development phase up to secondary school age, who may still be forming language preferences. Any major changes in language use over time for each community as a whole should be picked up by the old cohort, and differencing out this time trend theoretically removes time effects on language use attributable to non-dam related differences between the communities. This strategy is only useful if the old cohorts' language use does change over time, and changes in a way that is representative of its respective community as a whole. While this assumption is not formally tested here, the analysis does show markedly different results for double difference and triple difference estimates, suggesting that including the third difference is relevant. In the analysis presented in the following section and in Table 2 below, the old

cohort are defined as individuals who were over 30 years old at the time of displacement, and the young cohort are individuals under the age of 15 at the time of displacement.

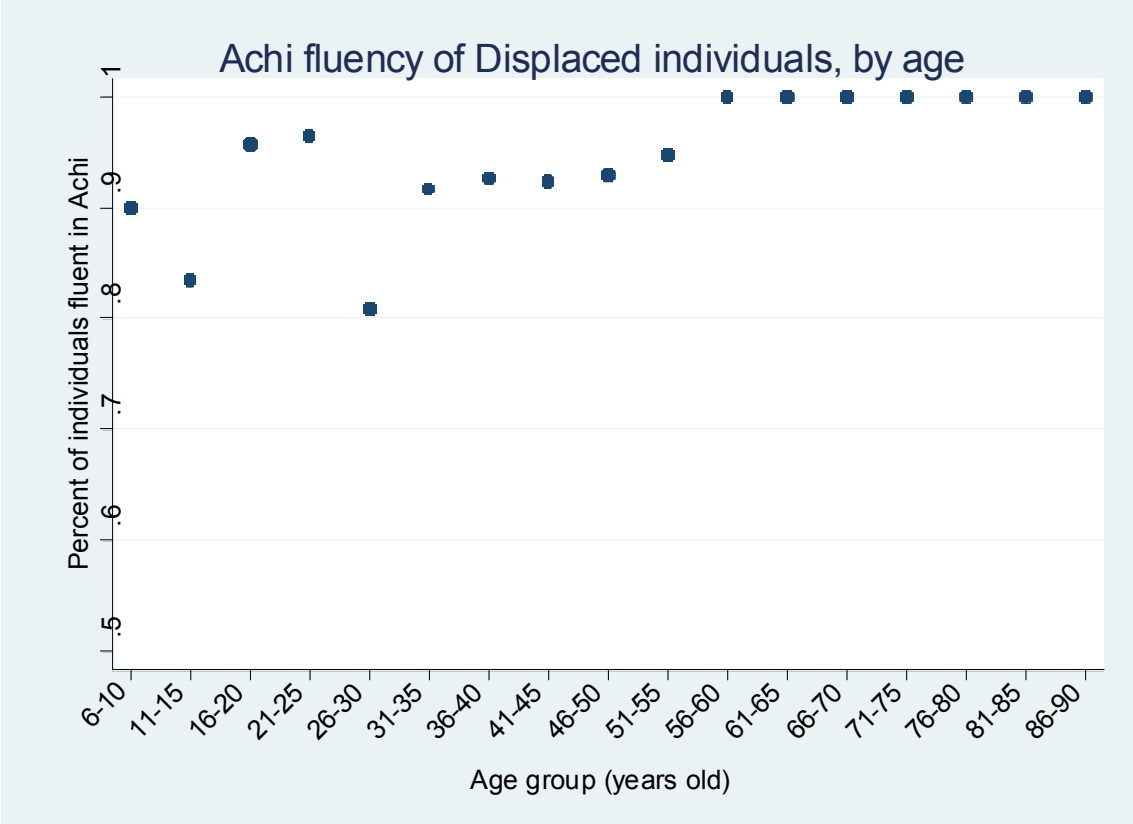
V. Results

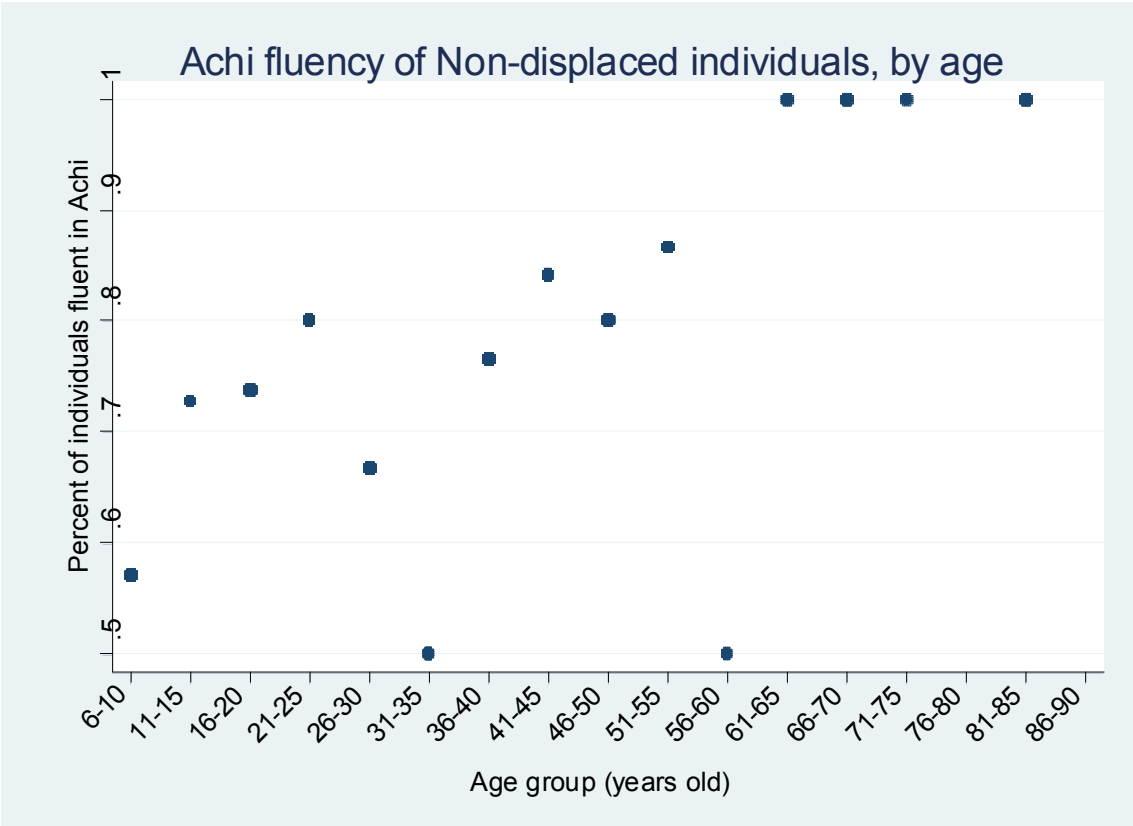
Two graphs below show current Achí fluency rates by age intervals—separate graphs for displaced and non-displaced communities. Each dot on the graph represents the average number of Achí-fluent people in each corresponding five year interval.[5] The graphs show 100% Achí fluency for the oldest individuals in both the treatment and control groups, and decreasing rates of fluency for younger individuals in both groups. When comparing the two groups, we see initial evidence that displaced communities did *not* lose Achí fluency at a higher rate than non-displaced communities—in fact, the opposite appears to be the case. This is, again, unsurprising, as control villages were located in a more "mainstream" or connected context than treatment groups before displacement, and are expected to have faster assimilation trends. A similar graph for control villages closer to the dam would potentially look quite different.

The graphs do highlight a more surprising trend: in displaced communities, the decrease in Achí fluency rates appear to begin among the 51-55 year old age group—individuals who were 21-25 years old at the time of displacement. Control communities begin to see fluency rates fall around the same time. People of this age should already have established their language fluency before dam construction—it seems unlikely that they

[5] The graphs are organized by five-year intervals because there are too few data points to generate smooth trends across individual years.

would lose fluency of a language that they had been fluent in at the age of 21-25, even after 30 years, especially if they are continuing to live in areas in which Achí is spoken frequently. This suggests that some other trend in the region emerged that drove some loss of Achí fluency. This could be the beginning of the country's civil war, an introduction of radio into communities, or a government policy. Further research and analysis would be needed to address this issue.


Achi fluency of Displaced individuals, by age
Percent of individuals fluent in Achi
.5
.6
.7
.8
.9
1
6-10
11-15
16-20
21-25
26-30
31-35
36-40
41-45
46-50
51-55
56-60
61-65
66-70
71-75
76-80
81-85
86-90
Age group (years old)


Achi fluency of Non-displaced individuals, by age
Percent of individuals fluent in Achi
.5
.6
.7
.8
.9
1
6-10
11-15
16-20
21-25
26-30
31-35
36-40
41-45
46-50
51-55
56-60
61-65
66-70
71-75
76-80
81-85
86-90
Age group (years old)

In Table 2 I present double difference and triple difference estimates for Achí fluency and ability to read Achí. The double difference point estimates in the first three columns indicate that individuals in displaced communities were 3.0 to 4.8 percentage points *more* likely to be fluent in Achí than individuals in control communities as a result of the dam. This is an unsurprising result since control communities, as discussed above, were villages that existed close to larger towns and highways before dam construction, and not a true counterfactual. It is plausible that time trends in these villages would include much faster language loss than in the isolated treatment villages even after displacement of treatment villages. The triple difference point estimate in column 4, which accounts for some of the difference in time trends between treatment and control areas as discussed above, suggests that displaced communities were 4.2 percentage points less likely to be fluent in Achí. This evidence supports the theory that displaced communities lose indigenous language retention at a faster rate than non-displaced communities. However, none of these four estimates are statistically significantly different from zero. Moreover, the triple difference point estimate is sensitive to variations in the age range used to define "old" and "young" cohorts, and becomes positive under some definitions.

Somewhat more informative are the estimates of impact on ability to read Achí, reported in columns 5 through 8. Double difference estimates significant at the 10 percent level indicate that ability to read Achí in displaced communities increased only slightly, and 10.4 to 11.7 percentage points more slowly than in control communities. This finding is interesting even when using the non-counterfactual control villages included in this study. One plausible explanation for this is that the increase in ability to read among control

communities is due to a general increase in literacy, as Spanish and Achí are written with the same characters. This hypothesis has some support from trends in ability to read Spanish: similar regressions (not shown here) using a dichotomous outcome variable for ability to read Spanish also yield negative (though statistically insignificant) estimates, providing some evidence that control communities learned to read Spanish at a faster rate that displaced communities. This suggests that even though displaced communities were resettled in areas in close geographic proximity to control communities, they lack equivalent access to education resources or are otherwise impeded in their educational attainment.

The triple difference regression yields an estimate indicating a 17.9 percentage point decrease in ability to read Achí for the displaced group, compared with the control group, significant at the 5 percent level. This would suggest that since being resettled, young people in displaced communities have learned to read Achí at a much slower rate than in the pre-established communities, even after controlling for differences in time trends. Again, this most likely reflects a general increase in literacy among control communities that has been more rapid than in displaced communities; the triple difference point estimate on ability to read Spanish (not shown here) is -0.155, roughly equivalent to the estimate on ability to read Achí and significant at the 5% level.

Table 2

VARIABLES	(1) achifluent	(2) achifluent	(3) achifluent	(4) achifluent	(5) achiread	(6) achiread	(7) achiread	(8) achiread
post	-0.0578**	-0.0813***	-0.0920**	-0.0152	0.206***	0.191***	0.202***	-0
	(0.0267)	(0.0288)	(0.0387)	(0.0277)	(0.0424)	(0.0396)	(0.0412)	(1.52e-08)
displaced	0.130***	0.128***	0.110***	0.122	0.0246	0.0257	0.0314	0.0227
	(0.0252)	(0.0255)	(0.0262)	(0.0993)	(0.0261)	(0.0249)	(0.0349)	(0.0216)
post_displaced	**0.0299**	**0.0482**	**0.0399**	0.0596	**-0.117***	**-0.107***	**-0.104***	0.0261
	(0.0499)	(0.0469)	(0.0515)	(0.0403)	(0.0628)	(0.0567)	(0.0565)	(0.0346)
young				-1.99e-08				-0
				(0.0949)				(1.63e-08)
young_post				-0.0621				0.268***
				(0.0630)				(0.0460)
young_displaced				0.000966				-0.000505
				(0.0993)				(0.0216)
y_p_d				**-0.0423**				**-0.179****
				(0.0809)				(0.0840)
Constant	0.824***	0.833***	0.929***	0.833***	0.0274*	0.0241	-0.0621	0
	(0.0212)	(0.0268)	(0.0365)	(0.0949)	(0.0143)	(0.0189)	(0.0377)	(1.22e-08)
Individual controls	No	Yes	Yes	No	No	Yes	Yes	No
Household controls	No	No	Yes	No	No	No	Yes	No
Observations	701	667	550	365	699	665	549	364
R-squared	0.062	0.077	0.114	0.087	0.046	0.052	0.107	0.110

Robust standard errors in parentheses
Coefficients of interest are in bold
*** p<0.01, ** p<0.05, * p<0.1

VI. Discussion and Conclusion

This paper introduces a difference-in-differences methodology for generating unbiased estimates of the impact that dams have on the communities they displace. Treating dam displacement as a natural experiment, it measures before-after differences for the outcome variable of interest, controlling for time trends by comparing displaced groups to similar but non-displaced groups that live beyond the edge of the reservoir. This

strategy can be applied to a range of outcomes including, but not limited to, measures of wealth, education, health, food production, psychological well-being, or social organization. Utilizing this estimation strategy should have high value for policy makers, since impacts on displaced communities are a central issue in dam-related policy debates but have not been rigorously quantitatively measured. Applying an economic method that can be replicated gives us useful information about the true impacts on displaced communities. Numerous opportunities exist to undertake such analysis, as many large dams that displace local populations are constructed every year.

Future studies that employ this method should refrain from only measuring common development indicators such as income, education and health. While these are important tenets of development and well-being, less tangible impacts on the social and cultural fabric of communities are highly relevant for indigenous communities in particular, and are deeply impacted by displacement. These, in turn, have implications for economic, social and psychological well-being in the long run. In this paper, I use impact on language use as a proxy for cultural continuity. Other measures of cultural continuity could include frequency of traditional ceremonies, knowledge of heritage or oral stories, consumption of traditional foods, application of customary law, use of indigenous agricultural techniques, or more nuanced measures of language use (beyond a binary indicator for pure fluency).

The difference-in-differences results presented in this paper are undermined by limitations in the sample such that the comparison group used does not provide a true

counterfactual. I modify the strategy to a triple-differences model that helps to account for differential time trends in each group, but my analysis under this model does not produce statistically significant estimates of the impact of displacement on language use.

I do find significant effects of displacement on the ability to read Achí. The interpretation of the regression results is that the control group improved their ability to read Achí at a much higher rate than the treatment group. This is probably a function of a general increase in literacy, rather than a specific cultural development. Because the treatment group was displaced to an area close to the comparison group, this finding suggests that individuals in established villages have better access to education than resettled villages, even though they have the same proximity to infrastructure and the same rights to education under the law. While beyond the scope of this paper's intended research, this is an interesting finding. It suggests that stark inequalities exist between resettled communities and "host" communities, and appears to contradict a commonly made argument that resettling indigenous groups in areas with improved infrastructure is beneficial for them. Further analysis of how resettled communities develop over time as compared with host communities would be enlightening.

Finally, two recommendations for further econometric analysis of dam impacts are to estimate impacts across multiple time periods, and to explore the mechanisms that account for measured changes. Impacts on displaced communities are manifold and dynamic; they should be measured immediately following displacement, and at multiple points in time for many years following resettlement. Some economic indicators may

improve over time if communities do in fact have access to improved infrastructure, health and education services, and employment opportunities. Social and cultural impacts may emerge slowly, and their full extent or consequences may not become clear for years or decades. Analysis of panel data or repeated cross-sectional data across multiple time periods could reveal valuable information about the evolution of impacts on displaced people—and in doing so inform holistic interventions to mitigate negative impacts.

The analysis presented in this paper stops short of exploring mechanisms that may lead to deterioration of language use. If comparison to a true counterfactual does produce evidence of language loss, it would be useful to examine the specific mechanisms that account for that loss. Some possibilities include transition from a sustenance agriculture or hunting/gathering economy to trade-based economy that entails more interaction with "mainstream" society, enrollment in schools in Spanish-speaking areas, utilization of markets in Spanish-speaking areas or increase in engagement in migrant labor. With data on these variables, analysis could explore heterogeneous impacts between different types of people (i.e. those who engage in migrant labor and those who do not, or those who attend market frequently and those who do not), and generate evidence about the mechanisms through which language use is influenced.

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