Preliminary draft

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On the Role of Structural Transformation in Demographic Change: Evidence from Multi-Generation Tracking Survey in the Philippines

by

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Abstract

This study investigates how improved connectivity to infrastructure affects demographic change of the population through transformation of industrial structure. Using the forty-year-long dynasty panel data from the Philippines, we find that higher exposure to newly constructed highway and industrial estates has led to extended longevity of the male heads among the household whose primary occupation transformed from agriculture to manufacturing. This indicates that structural transformation affects not only directly to the younger generations through occupational choice but also indirectly to their parents' generations presumably through resource transfer or better cares by the children's generations.

Keywords: Structural transformation; Aging; Demographic Change; Infrastructure; Impact Evaluation

Acknowledgements: We would like to thank late Professor Nobuhiko Fuwa for his critical contribution in initiating this joint research project. The Japan Society for the Promotion of Science provided funding (JSPS, Grant No. 26220502 and Grant No. 17H01653). We thank the residents of study villages and Agnes Chupungco and Elvie Dumayas of College of Public Affairs and Development, University of the Philippines Los Banos, for their cooperation in the tracking surveys. We appreciate supports by late Professor Robert Evenson who allowed us to use his datasets and Professor Barry M. Popkin who provided us with detailed information and data on the initial surveys. We are responsible for any errors in this article; the opinions expressed in this article are their own and do not reflect the views of affiliated organizations.

1. Introduction

Structural transformation and demographic changes are the two fundamental issues on economic development (ADB, 2020). Transformation of an economy from agriculture to industrialization and then services has been considered as the key driver of successful long-term economic development (Lewis, 1955; Ranis and Fei, 1961; Harris and Todaro, 1970; Hayami and Ruttan, 1985; Matsuyama, 1992; Hayashi and Prescott, 2008; Duarte and Restuccia, 2010; Bustos et al., 2021; and Gollin, et al., 2021). Demographic transition from a phase of high fertility and high mortality to a low birth and low death phase has been observed uniformly among high income economies which achieved economic development successfully (Bloom and Canning, 2004; Caldwell, 1981; Richerson, et al., 2009; Miles, 1999). Declines in birth and death rates can be attributed to an increase in income and resulting high opportunity costs of roaring children as well as a better access to medical services for which structural transformation of industries is the key element behind continuous enhancements in income. Yet, to the best of our knowledge, no study has investigated the nexus between structural transformation and demographic change using micro data. We bridge this important gap in the literature by examining how industrialization affects demographic change of the population using the forty-year-long family dynasty panel data from Laguna province in the Philippines, tracking households over more than 4 decades originally studied by Evenson (1980) and Popkin (2020). Ager et al. (2020) is an exceptional recent study that investigates how structural transformation changed fertility. Still, our dynasty-level panel data allows us to examine not only the fertility decisions of the affected generation but also the longevity of their parental generation.

To preview our analysis, we find that higher exposure to newly constructed highway and industrial estates has led to extended longevity of the male heads among the household whose primary occupation transformed from agriculture to manufacturing. To the best of our knowledge, this is the first study which employ a long-term household panel dataset to investigate long-term consequences of structural transformation on demographic change.

We believe our study has a novel contribution to the literature by combining the following two strands of the existing literature: First, there have been studies using long panel datasets such as Walker and Ryan (1990) and Lanjouw and Stern (2018) on India; Hayami and Kikuchi (2000) on the Philippines; Beegle, De Weerdt, and Dercon (2011) on Tanzania. We follow this tradition, combining it with the Rubin's framework of causal inference for industrialization (Imbens and Rubin, 2015). Second, we also use the cohort- and geography-specific identification strategy, following similar identification strategies to the existing studies which undertook impact assessments of roads and other transport infrastructure improvements on overall structural transformation of economies (Asher and Novosad, 2020 for India; Fajgelbaum and Schaal, 2020 for Europe; Proost and Thisse, 2019).

The paper proceeds as follows. Section 2 describes the research strategy, followed by the description of our survey, data, and identification strategy in Section 3. Section 4 presents empirical results followed by concluding remarks in Section 5.

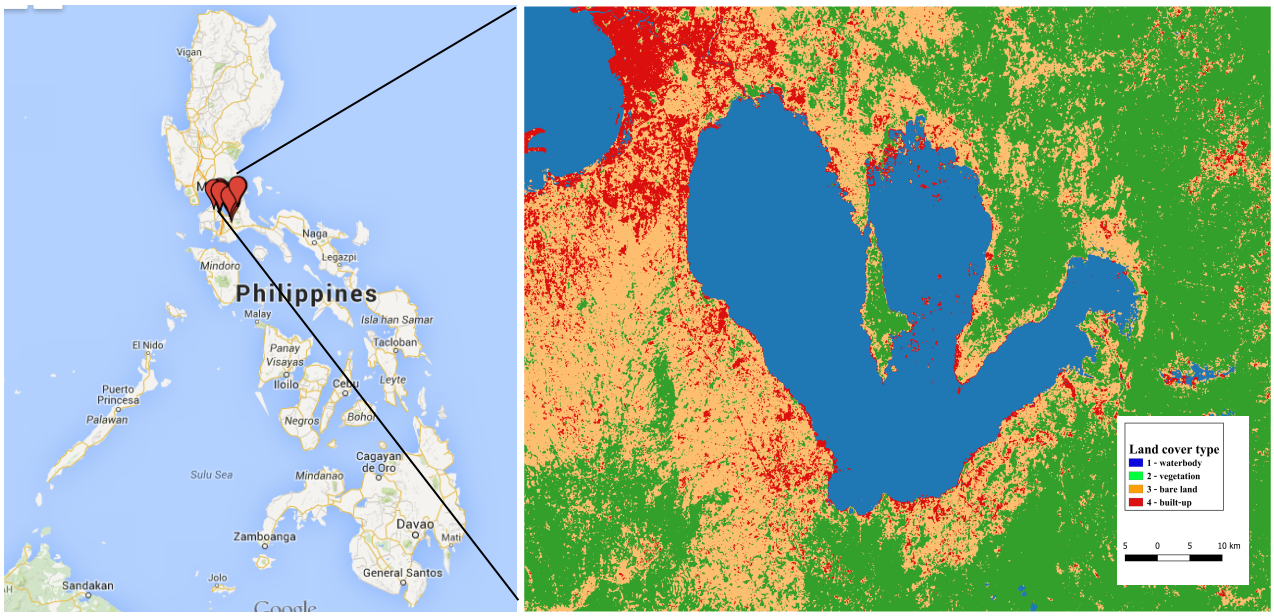
2. Research Strategy

Our study focuses on Laguna province in the Philippines, which provides ideal settings for our investigation. It is located to the south of Manila, the capital city, and is the third-largest province in the Philippines with the population of more than 3 million. The Lake Laguna, the largest lake in the Philippines, locates in the center of the province and agriculture and fishery has long been developed along the lake.

The unique characteristics of Laguna province is that the development has fairly even until the mid-1970s and the primary industry has been the center of the economy. The expressway, however, was constructed in 1978 and the western side of the province was connected to Manila. The improved connectivity to Manila attracted investment and a number of industrial parks were built since the late 1980s until the 2000s. As a consequence of the expressway and the industrial parks, the western side experienced a rapid industry development.

Figure 1 shows our study area in 1976, that is, just before the construction of the expressway. The map was based on the Landsat satellite imagery and the area was classified into four categories using a machine learning algorithm. The categories include waterbody (blue), vegetation (green), bare land (orange), and build-up (red). Manila is located to the Northwest of the lake and was already developed in 1976 as illustrated by the dominance of the build-ups. The Laguna province locates to the South of the Lake Laguna, and if we compare the South-west and South-east sides of the lake, the proportion of build-up is fairly similar. This suggests that the development was evenly-distributed in Laguna province before the expressway construction. Indeed, as we will see below, data from satellite imageries and population census support the baseline balance and pre-treatment parallel trend.

Figure 1
The Study Area in 1976



The expressway is called the Southern Luzon Expressway (SLEx). Figure 2(a) shows the current route of SLEx (A-B-C) with multiple lanes and Masapang Highway (C-D) with a single lane on each side, a network of these two roads connecting Metro Manila to the provinces of the CALABARZON region.[1] SLEx parallels with paved national highway (National Route 1) which was already over-loaded to accommodate increased transport demand. The Manila to Alabang portion of SLEx (A-B) was started in 1969 and the Alabang to Calamba

[1] CALABARZON is Region IV-A which is composed of Laguna province and other four provinces of Cavite, Batangas, Rizal, and Quezon.

part (B-C) opened in 1978 (Hayami and Kikuchi, 2000). The latter is one of the main targets of our study.

Since the opening of SLEx, industrial parks have emerged in the area, especially on the western and southern sides of Lake Laguna as can be seen in Figure 2(b). These industrial parks have established since the late 1980's until 2000's. The Laguna Technopark in Calamba, which was established in 1989, is the representative industrial park in the area, covering 460 hectares and having generated over 100,000 in direct employment according to the 2014 annual report of the Philippine Economic Zone Authority. Table 1 present the list of all the industrial parks constructed in our study area.

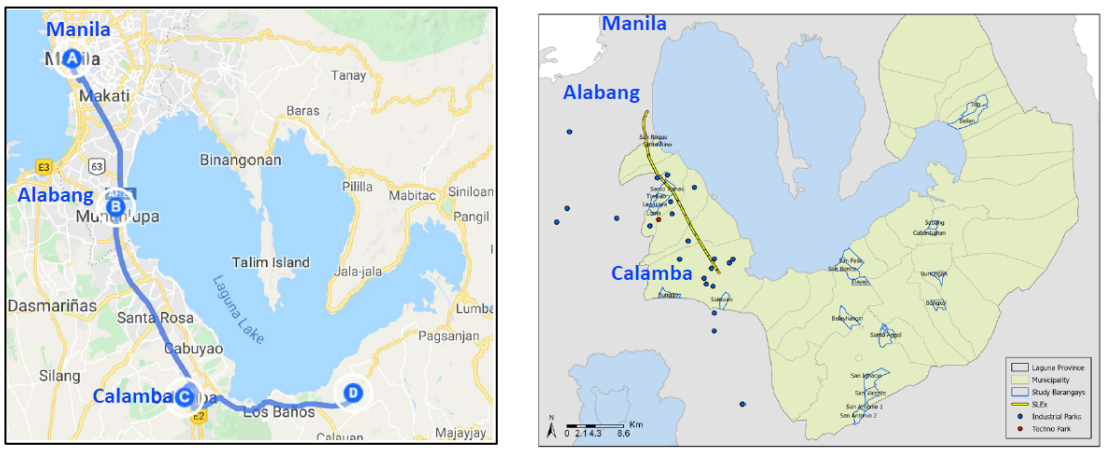
We employ the Rubin causal model and define "treatment" as year- and zone-specific "exposure to modernization" at village level. The modernization treatment includes the construction of the expressway and the openings of industrial parks. The modernization treatment captures reduced travel costs and enhanced job prospects. In addition, we collected the administrative information of the school construction in Laguna province and consider the school opening as another treatment capturing the improved access to human capital investment.

More specifically, our modernization-treated group includes those who were from a village ("barangay" in Tagalog) on the western side of Laguna province and were below the age of 10 in 1977 at the time of the SLEx construction. Their educational and occupational choices were most likely be affected by the openings of the SLEx and the industrial parks. We adopt difference-in-differences framework and compare the treated group with those who were from the treated barangays but were already decided on the education and the occupation (i.e., those above the age of 19) as well as those from the control barangays in the eastern side of Laguna province.

Similarly, we examine impact of school availability on education defining a school-treatment group of those who had a school in their barangay at the age of 6. Whether children had an access to school when they started schooling is a critical determinant of their lifetime educational attainment (Duflo, 2001).

Figure 2
Location of Highways and Industrial Parks

(a) SLEx (A-B-C) and Masapang Highway (C-D) **(b) Location of Industrial Parks**



Source) Authors' calculation based on Google Map.

Table 1. List of Industrial Parks

Code	Name	Established year	Land area (ha)	Number of companies	Filipino (%)
1	AG&P Special Economic Zone	N/A	40.3	N/A	96
2	Cocochem Agro-Industrial Park	2013	42.0	3	100
3	First Philippine Industrial Park	1997	331.9	13	70
4	First Philippine Industrial Park II	2013	91.8	N/A	70
5	Keppel Philippines Marine SEZ	2007	22.9	N/A	100
6	Light Industry & Science Park III	N/A	110.5	N/A	100
7	Lima Technology Center	1997	280.2	11	60
8	Philtown Technology Park	2006	66.6	N/A	100
9	Tabangao Special Economic Zone	N/A	86.0	1	100
10	Cavite Economic Zone	1980	278.5	382	100
11	Cavite Economic Zone II	N/A	53.7	N/A	60
12	Daiichi Industrial Park	1996	55.0	4	100
13	EMI Special Economic Zone	N/A	12.2	1	60
14	First Cavite Industrial Estate	1991	71.8	63	60
15	Gateway Business Park	1989	110.1	19	80
16	Golden Mile Business Park	2002	45.1	38	64
17	People's Technology Complex	2000	59.0	14	100
18	Suntrust Ecotown Tanza	2014	116.2	N/A	100
19	Calamba Premiere International Park	1999	65.6	18	60
20	Carmelray Industrial Park I	1992	80.0	22	100
21	Carmelray Industrial Park II	1999	143.0	36	100
22	Carmelray International Business Park	N/A	40.0	6	100
23	Filinvest Technology Park Calamba	2005	51.1	2	100
24	Greenfield Automotive Park	1998	65.9	2	100
25	Laguna International Industrial Park	1993	34.9	23	60
26	Laguna Technopark SEZ	1989	314.9	241	61
27	Laguna Technopark Annex	1989	29.0	N/A	61
28	Light Industry & Science Park I	1995	71.7	37	66
29	Light Industry & Science Park II	1997	68.0	19	66
30	SMPIC Special Economic Zone	1989	3.3	N/A	60
31	Toyota Sta. Rosa (Laguna) SEZ	1995	81.7	3	60
32	YTMI Realty Special Economic Zone	2014	20.7	4	60

Source) Authors' compilation

3. Survey, Data, and Identification Strategy

The data used in the analysis is the novel dataset combining the Laguna Multipurpose Household Survey and its tracking surveys to collect information over 40 years. Based on the survey conducted in 1977 in Laguna province, we conducted the tracking survey of all the original respondents as well as their descendants in 2017. The survey targeted all individuals in the family trees of the original 322 respondents surveyed in 1977, including those who already passed away at the time of our tracking survey. We collected information on the educational attainment and the lifetime occupation, among others. This unique data allows us to analyze their education and occupation choice of sample individuals in the period of dynamic modernization as well as rapid school openings.

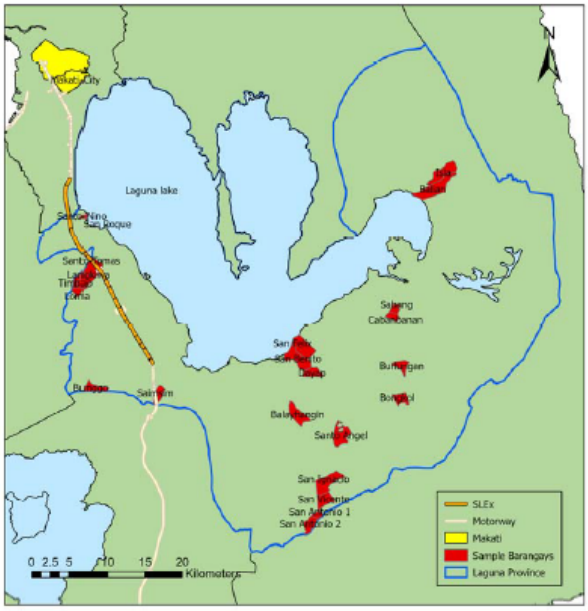
3.1. The Laguna Multipurpose Household Survey

The original survey of the Laguna Multipurpose Household Survey was designed and conducted by Professors Robert Evenson and Barry M. Popkin with 34 barangays and 576 households in Laguna province, the Philippines in 1975, covering the area of 1,795 km^2 and accommodating the population of 803,750 (Evenson et al., 1980). The original 34 sample barangays of the survey were selected by stratified random sampling. Thirteen sample barangays representing (i) lowland rice farming barangay were drawn from earlier survey, named Farm and Home Development Office survey, conducted by UPLB. With regard to the

other three categories of barangays, sample barangays were randomly selected from the list of all barangays in each category; six upland barangays, three fishing barangays, and 12 semi-urban barangays. The total of 34 sample barangays are selected to represent the socio-economic condition of entire Laguna province. In each of the 34 barangays, 16 households were randomly selected from the census of barangay households (except 27 households selected in each of the three fishing barangays). With such sampling framework, 576 households were surveyed in the 1975 survey (one household missing).

The survey has been continuously conducted in 1977, 1982, 1985, 1990, 1992, and 1998 (Ejrnæs and Pörtner, 2004). In each round, different subset was selected depending on the purpose of the survey, such as households with female in the reproductive age or households with children, and thus no comprehensive survey was conducted to cover all the sample households in 1975. The original data files and respondent lists for the first survey in 1975 was not available unfortunately, and thus, we used the data for the second round of Laguna Multipurpose Household Surveys conducted in 1977 as our baseline data, which was collected right before the completion of the SLEx. We believe that the sample households and barangays in 1977 survey represent the socio-economic condition of Laguna province fairly well. Accordingly, data from 322 households from the 23 barangays surveyed in 1977 were used as baseline information for the tracking survey. The 322 households consist our "original households." These 23 sample barangays are located along the Laguna Lake as presented in Figure 3.

Figure 3
The Study Barangays of the Laguna Multipurpose Household Survey in 1977



3.2 Individual Tracking Survey

We conducted a tracking survey in 2017 to cover all the 322 original households and their descendants. The tracking survey consists of two modules. First, in the individual module, we tracked all the descendants of the original households and collected their birth year, educational attainment, current and lifetime major occupation, agricultural land holdings and utilization,

and possessions of assets. Second, we conducted the village-level tracking survey in which the recall information on changes in access to infrastructure and large city like Manila and Calamba was collected in the 23 barangays studied in 1977.

Tracking Survey Protocol

First, we conducted a pilot individual tracking survey in one of the original 23 barangays. A sample barangay T is located in Binan municipality, Laguna province. Although 16 households were selected for survey in the 1975 survey, only 14 households were interviewed in 1977 in barangay T. Starting from the members of the 14 original households surveyed in 1977, we identified all the household members born in or joined the household after 1977. In addition, we identified and tracked all the descendants of the original household members, including the children, grandchildren, great grandchildren and great great grandchildren of the original household members. This sub-section explains the details of our tracking strategy.

Using the list of household members surveyed in 1977, we visited a barangay where a household resided in 1977. We asked a barangay captain, senior citizens and other knowledgeable persons in the barangay, whom we called "informants", about the current location of the original household. When the original household head and spouse were already deceased (as was often the case), we collected information on the residence of children of the original household. When the house of original household was still located in the same barangay and some of the original members lived in the household, the tracking was relatively easy. We tried to identify at least one and as many as possible members of and descended from the original household from the informants. In case no household member from the original household was identified from the informants, we visited the neighbors, land owners of the housing lot in 1977, current occupants of the lot, relatives, friends, schoolmates, or co-workers of the original household members to identify the current residence of the head, spouse and other existing members of the original household.

After identifying the members of the original households and their descendants, we visited some of them, whom we call "respondents," to collect data on the family tree of the original household using our tracking module. We used proxy interview to collect information on all the descendants as much as possible. We, then, asked the respondents to introduce other respondents who can account for missing information; we repeated such data collection procedure until we collected all the information on the members of the original households and their descendants. When we exhausted available respondents in the original barangay or its vicinity, we made a phone call to potential respondents living in remote area to collect information.[2]

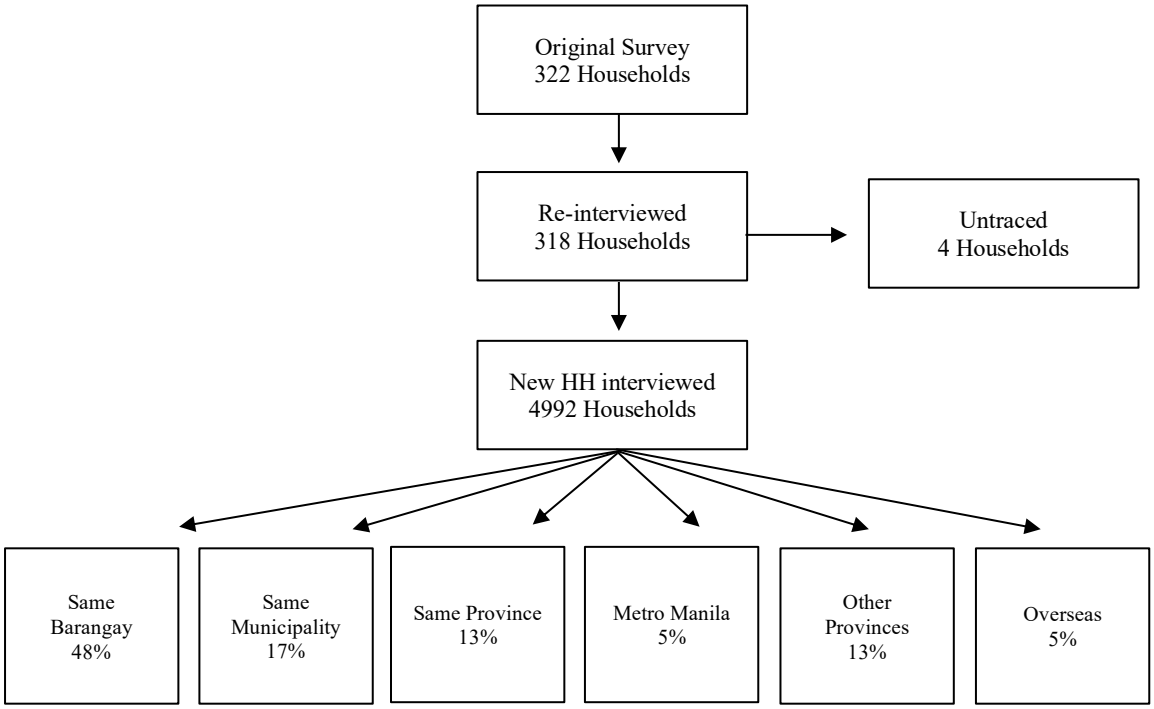
Data

Figure 4 presents the structure of the tracking survey in 2017 from the baseline survey in 1977. Using the list of household members surveyed in original survey, we visited the barangays where a household resided in 1977. Starting from the 322 original households surveyed in 1977, we could identify 318 households and their members born in or joined the household after 1977. To differentiate the original household and newly defined household, the original household was termed as a family tree or a family dynasty since the household in the new survey stems from its original family tree. The sample obtained from the tracking survey includes 4992 households with 23,650 individuals in 318 family dynasty. Almost half of the original

[2] Note that as facebook is widely used among Filipinos, some of the enumerators accessed facebook to collect information on birth year and educational attainment, among others.

households were still located in the same barangay and nearly two-thirds of them were in the same municipality (including the same barangay), we could reach 98.7 percent of tracking rates, which is a higher rate of recontact than other surveys. More detailed information about current location of household and migration is described in Section 5.

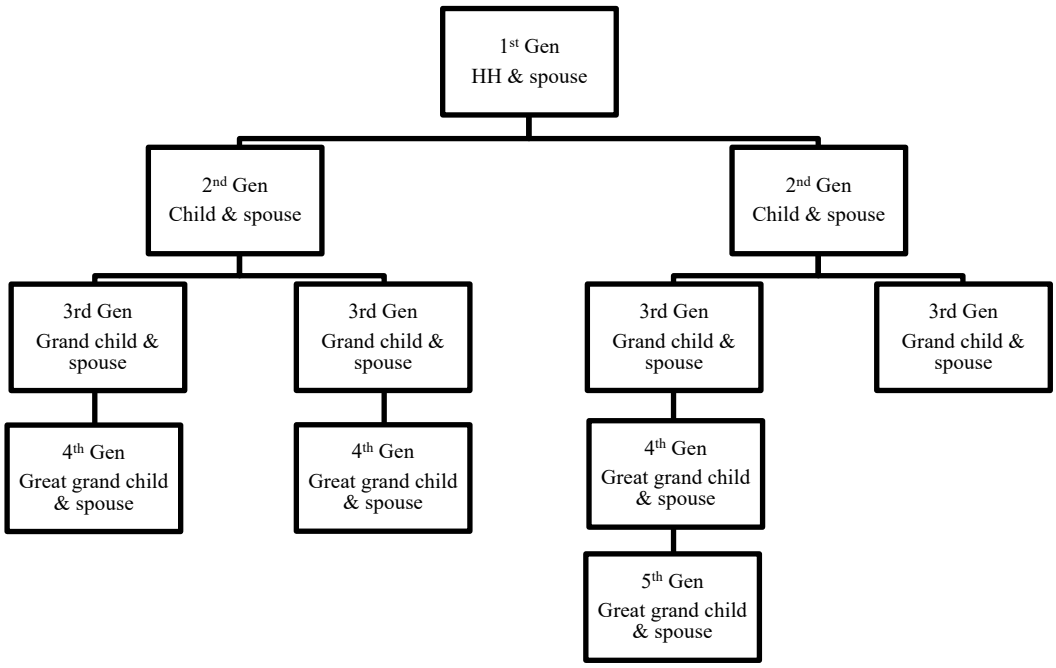
Figure 4. Tracking the households



The survey of family dynasty has a nested structure including four generations from the original household as seen in Figure 5. We surveyed the children (2nd generation), grandchildren (3rd generation), great grandchildren (4th generation), and great great grandchildren (5th generation) of the original household members and their spouses as the original household heads and their spouses has already deceased. Appendix A illustrates our survey results on tracking intergenerational information in one of the study villages.

The intergenerational dynamics is one of the intensively investigated topics in development economics (e.g., Solon, 1999; Black and Devereux, 2011). Although most of the existing studies analyze dynamics over few generations, i.e., from parents to children, or at most three generations, i.e., from grandparents to grandchildren, our tracking data covering five decades enable us to analyze even greater degree of intergenerational dynamics. In so doing, we expand the scope of a tracking survey by Beegle, De Weerdt, and Dercon (2011) to track not only the original households but also descendants of the original households to collect information of the 2nd to 5th generations from the original household head. By covering all the descendants, we can analyze transformation of occupation as well as the migration decision over generations, shedding light on sample selection issue in an ordinary household panel data, which focuses on residents of a specific location.

Figure 5. Nested Structure of the Survey



3.3. Barangay Tracking Survey

As a part of the Laguna Multipurpose Household Surveys, a barangay survey was conducted in 1977, 1979, 1982, 1985, 1990, 1992, and 1998. The collected data, however, is available in electronic form only for the 1982 survey. The 1982 survey covered 19 out of the 23 original barangays. We utilize this existing data in our newly conducted barangay survey to verify information.

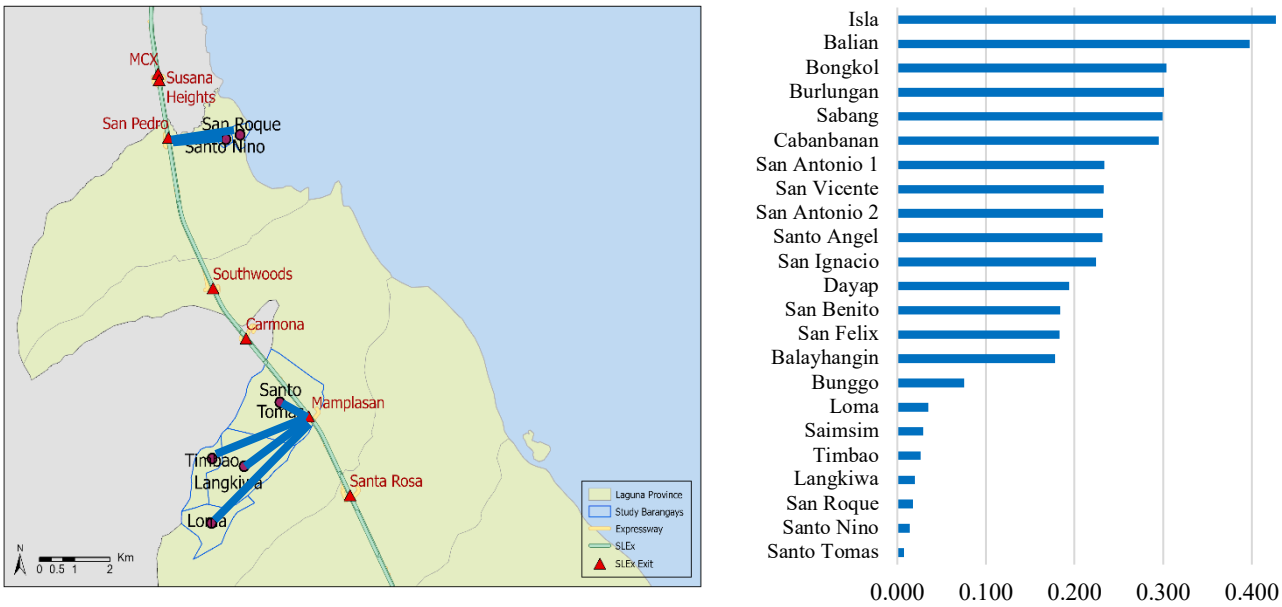
We conducted a barangay survey to collect retrospective information on the changes in access to infrastructure and public services. The survey protocol is as follows. Researchers visited barangay hall and senior citizen office to identify at least six (and as many as possible) respondents from different generations (including those who were born in 1940s, 1950s, 1960s, 1970s, 1980s, and 1990s) who can provide information at different time period, and record his/her age and telephone number. When memory of one respondent was not clear, information was collected from multiple sources to identify most credible one, and more respondents were added for data collection interview if necessary. In order to collect retrospective questions on travel time and fares going to Makati (center of Manila) or Calamba (large city in Laguna province and a stopping point to Manila), supplementary information was collected, as necessary, from bus/jeep conductors and drivers at major bus terminals utilized by the barangay residents.

3.4. Identification Strategy

In our study, we employ the Rubin causal model and define "treatment" as year- and zone-specific "exposure to modernization" at barangay level. There are multiple ways to disentangle the treatment and control zones separately. As a first way, we can utilize proximity of each barangay to the nearest entrance/exit of SLEx (Figures 5(a) and 5(b)) as well as industrial parks (Figure 5(c)) and the Laguna techno park (Figure 5(d)), the very first industrial park in Laguna province established in 1989. Based on historical as well as the latest information, we obtain

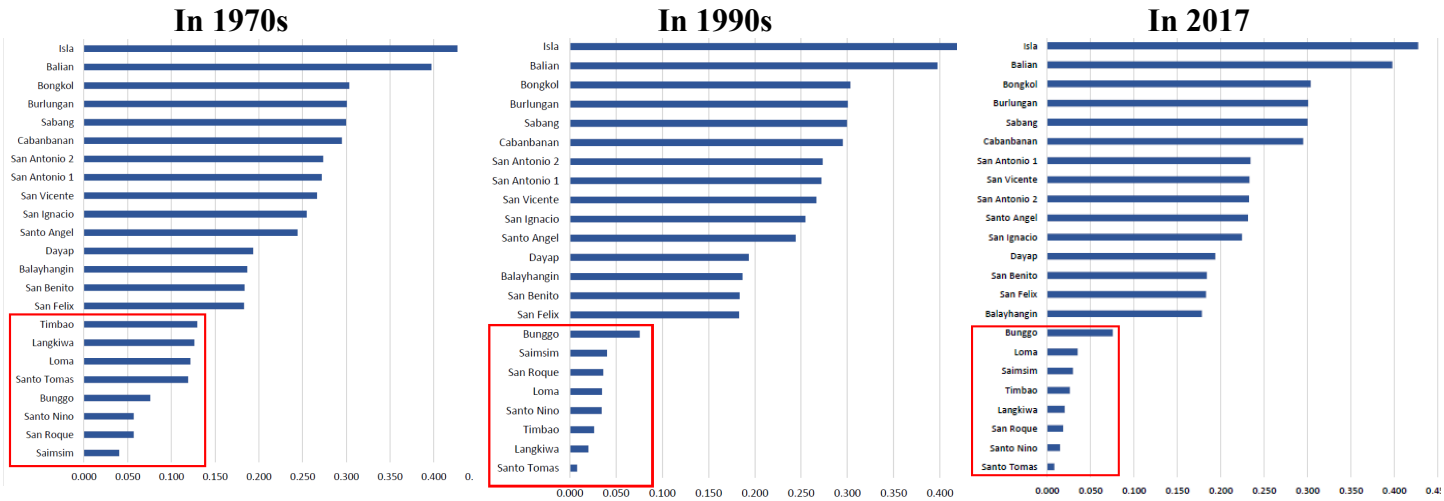
the distance rankings to the nearest entrance/exit.

Figure 5(a). Euclidean distance between barangay centroid and exit points in 2017



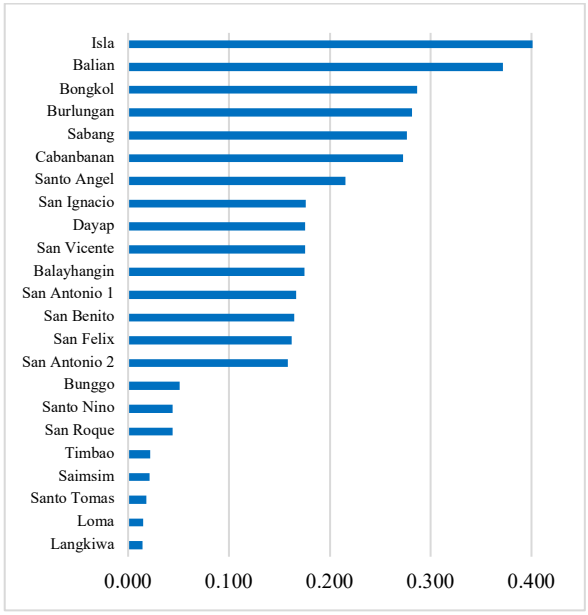
Source) Authors' calculation

Figure 5(b) Proximity of each barangay to the nearest entrance/exit of SLEx



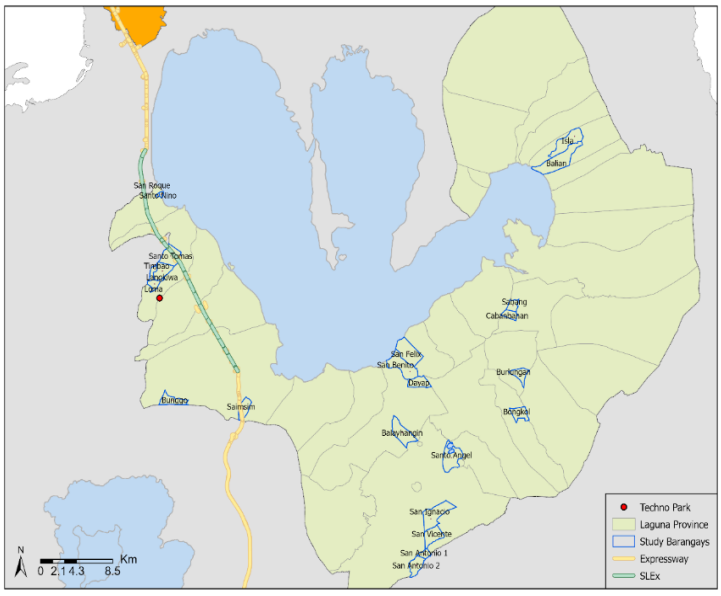
Source) Authors' calculation

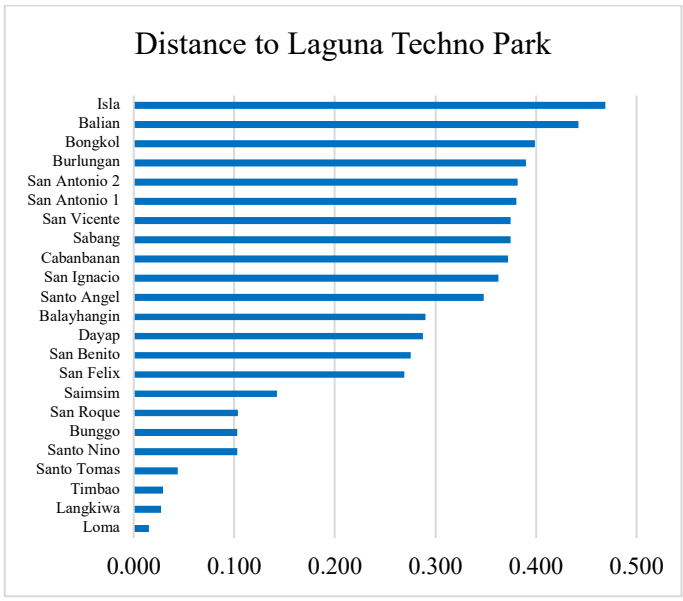
Figure 5(c). Nearest Industrial Parks in Laguna Province



Source) Authors' calculation

Figure 5(d). Laguna Techno Park with Study Barangays





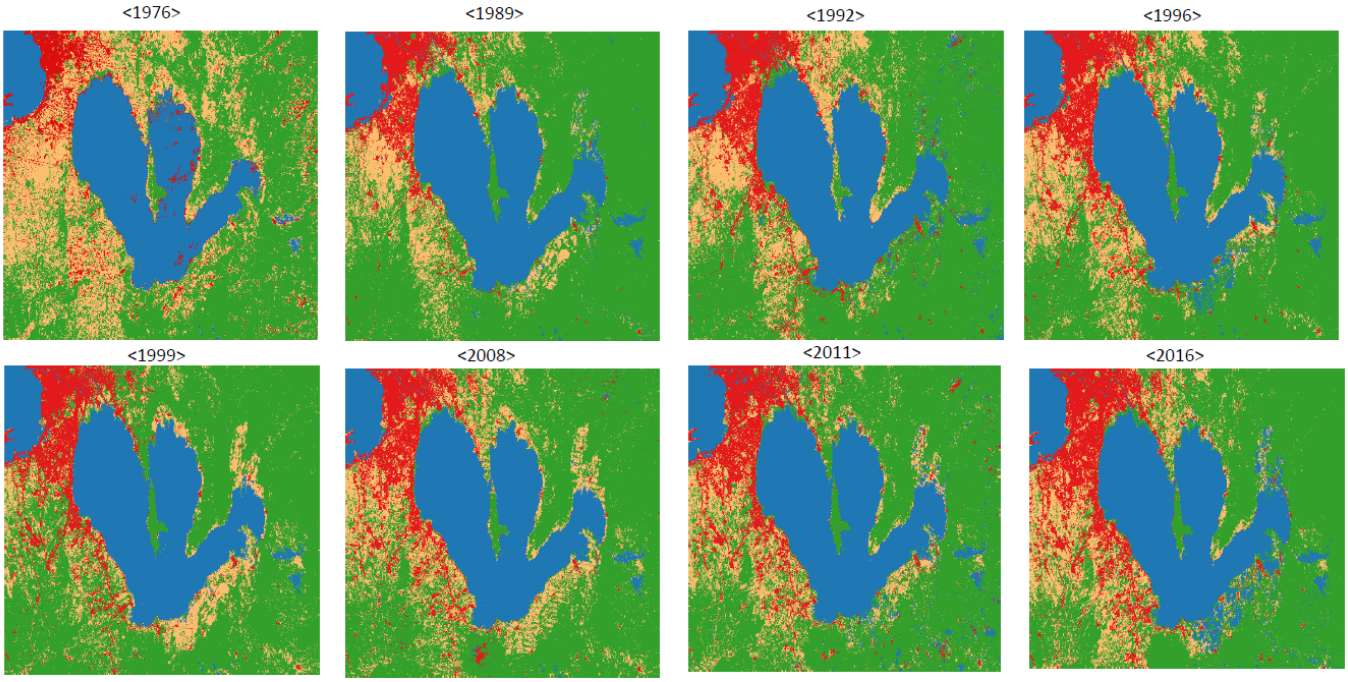
Source) Authors' calculation

Secondly, we can identify and postulate treatment and control zones geographically using information on land uses obtained from Landsat satellite imageries in the 1970s to the 2010s.[3] Figure 5(e) illustrates changes in land usage based on Landsat imageries in 1976, 1989,

[3] We construct land-use data with 269m*269m pixel size using these satellite imageries. While all the imageries are combined imageries of those in dry season and wet season, we are

1994, and 2009. We can observe overall land cover changes from agriculture (vegetation in red and barren in orange) to built-up (red) in Laguna province, especially in the area around SLEx circled in yellow on the map. This is the area of "Treatment group" defined by distance to SLEx from barangays and proportional changes in land cover to built-up.

Figure 5(e) Land Use Changes Observed by Satellite Imageries



Source) Landsat imageries, courtesy of NASA Goddard Space Flight Center and U.S. Geological Survey

Based on proximity to SLEx and industrial parks the satellite imageries, as well as expert opinions of the principal investigators of the original and tracking surveys, we set treatment group and control zones, respectively, as barangays located in the western side and eastern side of Lake Laguna (Figure 6.1). Since the group A barangays were already connected to Metro Manila even before the opening of SLEx, we set them as the always-treated group.

Considering that the Alabang-Calamba portion of SLEx was opened in 1978, we regard those who were below age 10 in 1977 (equivalently, age below 50 in 2017) as the group exposed to the treatment by which decisions on schooling and occupational choice were affected. The "before treatment" group is composed of those who were above age 19 in 1977. We also set an age restriction of above 19 years old in 2017 to exclude those who are still in post-secondary education and below 80 years old (top 5 percentile) in 2017 to rules out significant time trend before 1970s. Moreover, we impose a relationship restriction by excluding all the spouses of the original household heads and their families' descendants who were likely to spend their childhood in different barangay and entered the household after their completion of schooling. After all, our working data comprises 8,476 individuals in 4,256

undertaking refinements and quality control of low resolution of the old dataset from the 1970s, variations in seasons, and a mechanical failure 2000s.

households with 318 dynasties.

Using the satellite imageries from the Landsat, we compare the proportion of the build-up areas in treatment and control villages in which we can verify pre-treatment balance in 1976 (Figure 6.2(a)). Population growth trends during pre-treatment periods, in 1960-70 and 1970-80, also confirm data compliance with the parallel trend assumption as we can see from Figure 6.3(b). We believe these observations allow us to adopt the difference-in-difference framework to identify a causal impact of the modernization treatment.

Figure 6.1
Treatment and Control Zones

Group Dummies

Categorized into nine groups by Agnes Chupungco, a researcher in UPLB, who joined the Laguna Multipurpose Household Surveys project in 1977

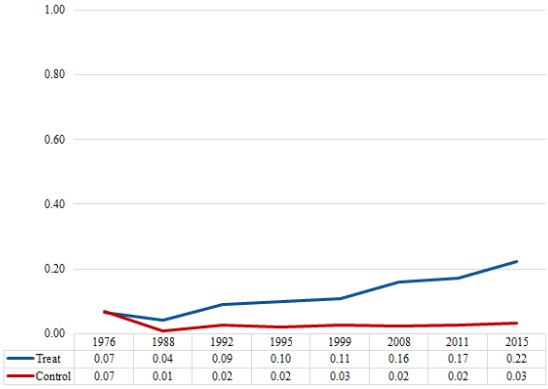
Treatment Dummy

Defined "Group A" as treatment group due to its enhanced access to Manila and Calamba through the SLEx

Source) Authors' compilation based on Google Map

Figure 6.2
Baseline Balance and Parallel Trend Checking

(a) Baseline Balance: Proportion of Build Up

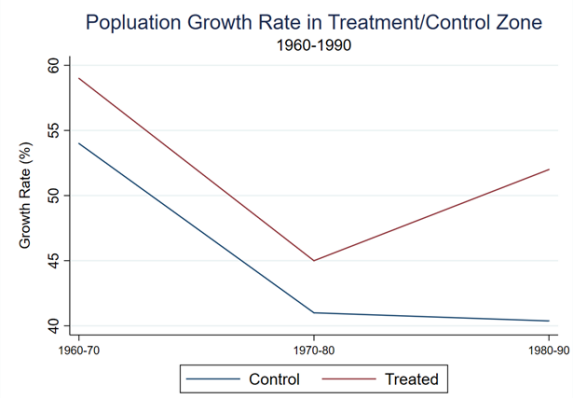


	1976	1988	1992	1995	1999	2008	2011	2015
Treat	0.07	0.04	0.09	0.10	0.11	0.16	0.17	0.22
Control	0.07	0.01	0.02	0.02	0.03	0.02	0.02	0.03

Note: The treatment villages include Santo Tomas, Langkiwa, Loma, Timbao, Bunggo, and Saisim and the control villages are San Roque, Santo Nino, Balayhagin, San Benito, San Felix, Dayap, San Antonio 1, San Antonio 2, San Ignacio, San Vicente, Santo Angel, Bongkol, Burlungan, Cabanbanan, Sabang, Balian, and Isla.

Source) Landsat imageries, courtesy of NASA Goddard Space Flight Center and U.S. Geological Survey

(b) Parallel Trend Checking: Population growth rates

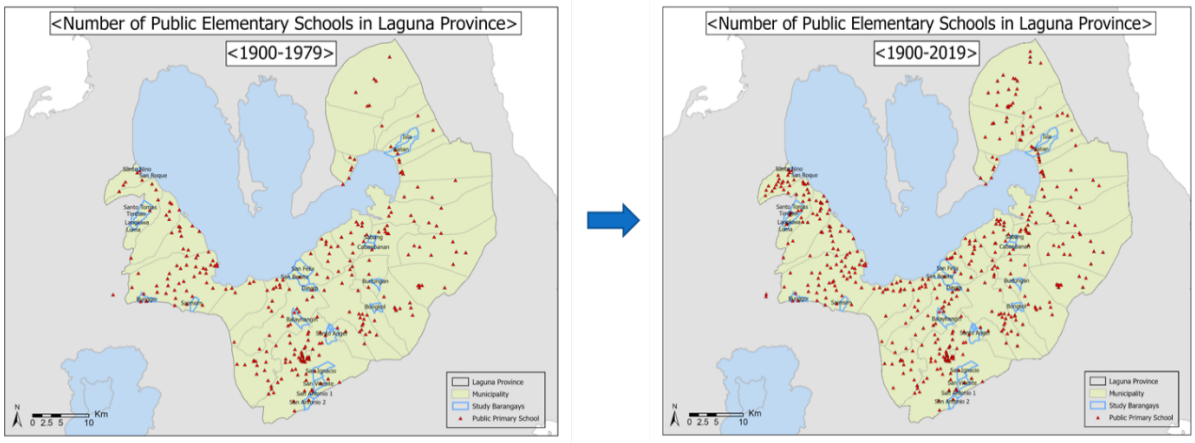


Note: The treatment municipalities include Binan and Calamba whereas the control municipalities are San Pedro, Victoria, Calauan, Magdalena, Liliw, San Pablo, Pagsanjan, and Pangil.

Source) Census of Population and Housing, National Economic Development Authority, the Republic of the Philippines, various years.

Another treatment we consider is school availability in each barangay. This school treatment is defined as the availability of public elementary schools within the residential barangay at age of 6 for each individual. The variable is constructed based on the administrative data from the Department of Education (DepEd). Figure 7 shows an increase in the number of public elementary schools during our survey period.

Figure 7
School Locations, 1900-79 and 1900-2019



Source) Authors' calculation based on administrative data from the Department of Education (DepEd).

We can see from Figure 4, 48% (55%) of the respondents stay at the same barangay

(municipality) of the original respondents and the rest 45% of the respondents migrated outside of the original municipality. Accordingly, our identification strategy is undermined by endogenous migration. To handle this identification challenge, we postulate a model of migration decision separately from an occupation choice model. Based on the canonical model of migration a la Harris and Todaro, it would be plausible to consider migration decision and occupational choice separately (Lall, Selod, and
Shalizi, 2006). Also, as Nakanishi (1991) describes, most of internal migration in the Philippines have been driven by push factors especially among the poor, supporting the separability between migration and occupational choice decisions. Following the existing literature on migration, we consider credit access (Lagakos, 2020; Estudillo, Sawada, and Otsuka, 2008) and social network (Munshi, 2003 and 2020) are the critical determinants of migration.

4. Empirical Analysis

4.1 Lifetime Primary Occupation

We follow the 24 industrial classifications in the 2000 Philippines Standard Industrial Classification (PSIC) to classify industry of life-time primary occupation, which are converted further into six sectors of: agriculture, manufacturing, industry, traditional services, modern services, and none (Table 2).

Based on this job classification framework, we examine age-specific distribution of primary (life-time) occupations by treatment or control zone (Figure 8). While, in both treatment and control zones, we observe dramatic decline in employment share of the agriculture sector over the generations, transformation in sector-specific employment structure from agriculture to traditional services and then manufacturing is more salient in the treatment zone than those in the control zone. In the treatment zone, the manufacturing sector becomes the dominant sector in labor market below 40-year-old age cohort, replacing the agricultural sector common in older cohorts above 60 years old and then the traditional service sector among the middle age groups in ages of 40s and 50s, whereas, in the control zone, traditional services has the highest share among those who are below 60 years old followed by the modern services.

Table 2. Sector Classification of Occupation

Code	Industry of Primary Occupation (Life-time)	Sector
A	Agriculture, forestry and fishing	Agriculture
C	Manufacturing	Manufacturing
B	Mining and quarrying	Industry
D	Electricity, gas, steam and air-conditioning supply	
E	Water supply, sewerage, waste management and remediation activities	
F	Construction	
G	Wholesale and retail trade; repair of motor vehicles and motorcycles	Traditional Services
H	Transportation and storage	
I	Accommodation and food service activities	
J	Information and communication	Modern Services
K	Financial and insurance activities	
M	Professional, scientific and technical services	
N	Administrative and support service activities	
P	Education	
Q	Human health and social work activities	
L	Real estate activities	
O	Public administrative and defense; compulsory social security	
R	Arts, entertainment and recreation	
S	Other service activities	
U	Activities of extraterritorial organization and bodies	
T	Activities of private households as employers and undifferentiated goods producing activities of households for own use	None
V	Full-time student	
W	Housewife/husband	
X	No job	

Note: The industry code in the survey questionnaire follows the classification of industry in the 2009 Philippine Standard Industrial Classification (PSIC).

4.2 Empirical Analysis

In order to examine the impact of structural transformation which has been driven by our industrialization "treatment," we postulate the following the male household head or "father" survival function. To highlight the role of structural transformation, we confine our analysis to the industry-specific subsamples in which "father" engaged in agriculture and "the eldest children" worked in sector *M*, i.e., agriculture, manufacturing, or traditional sector. Specifically, we postulate the following linear probability model (LPM) for survival function of "fathers":

$$S^M_{ihjt} = \gamma^M A_t + \eta^M_j + \theta^M (A_t d_j) + Z^M_{ihjt}\gamma^M + e^M_{ihjt}, \quad (1)$$

where S^M_{ihjt} is discrete variable representing survival status of "father" of individual i in family tree h of village j and born in cohort t. A_t takes one if the individual is in the after (younger) cohort aged 30-49 in 2017 (equivalently, below age 10 in 1977), and d_j is a modernization treatment indicator which takes one for treatment zone. Z^M_{ihjt} is vector of control variables, and e_i is unobserved individual-level component. Z^M_{ihjt} consit of access to school, father's education, mother's education, grandfather's education, grandmother's education, age and its squared

term, female dummy, father's age.

4.3. Estimation Results

We estimate equation (1) by residential location of the household to which individual *i* currently (in 2017) belongs to: (i) those living in the original village of family tree , (ii) those living in the original municipality (sub-sample (i) is encompassed), and (iii) those living outside the original municipality. The estimation results are reported in Table 3. We find that higher exposure to newly constructed highway and industrial estates has led to extended longevity of the male heads among the household whose primary occupation transformed from agriculture to manufacturing (columns 3 and 7). The point estimate of 0.273 reported in column 3 is economically large. It indicates that the fathers of the treated individuals are 27.3 percentage points more likely to survive at the time of our survey in 2017, even after controlling for the age of the individuals and that of the fathers themselves. A similar (or even larger) coefficient is obtained in column 7, focusing on the individuals living in the original municipality. Such a pattern, however, is not observed in column 11. This result may be regarded as placebo test because the individuals living outside the original municipalities are unlikely to be influenced by the treatment status based on their ancestor's (and thus, not their current) village. This result strengthens our finding of a positive impact of structural transformation on earlier generation's longevity.

Table 3 Linear Probability Model for Father's Survival

Table 1: Survival function of household head of the eldest child when father's lifetime occupation is agriculture

	Original Barangay				Original Municipality				Outside Original Municipality			
	Entire	Agriculture	Manufacturing	Traditional Services	Entire	Agriculture	Manufacturing	Traditional Services	Entire	Agriculture	Manufacturing	Traditional Services
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Dependent variable: Father is alive												
Access to school	0.076	0.099	-0.035	0.047	0.059	0.067	-0.103	0.067	0.036	0.196	0.136	0.017
	(0.053)	(0.147)	(0.105)	(0.090)	(0.042)	(0.125)	(0.093)	(0.068)	(0.056)	(0.182)	(0.119)	(0.128)
Father's education	0.008	0.005	-0.019	0.025**	0.006	0.008	-0.012	0.024**	0.006	-0.022	0.014	0.002
	(0.006)	(0.016)	(0.013)	(0.011)	(0.005)	(0.014)	(0.011)	(0.010)	(0.006)	(0.022)	(0.014)	(0.018)
Mother's education	0.002	0.010	0.008	-0.005	-0.006	0.009	-0.005	-0.010	-0.003	0.007	0.002	-0.002
	(0.006)	(0.022)	(0.013)	(0.011)	(0.005)	(0.018)	(0.010)	(0.009)	(0.006)	(0.017)	(0.012)	(0.017)
Grandfather's education	0.009	-0.007	0.007	0.045***	0.007	-0.009	0.010	0.041***	0.017**	0.040	0.010	0.009
	(0.009)	(0.029)	(0.019)	(0.017)	(0.007)	(0.022)	(0.013)	(0.013)	(0.008)	(0.034)	(0.018)	(0.022)
Grandmother's education	-0.057***	-0.061*	-0.024	-0.104***	-0.046***	-0.056**	-0.015	-0.092***	-0.041***	-0.091**	-0.042**	-0.024
	(0.010)	(0.032)	(0.020)	(0.018)	(0.007)	(0.025)	(0.015)	(0.015)	(0.009)	(0.035)	(0.018)	(0.024)
Age	0.022**	0.005	0.037*	0.024	0.027***	0.022	0.032**	0.023	0.028**	0.010	0.032	0.061
	(0.010)	(0.033)	(0.020)	(0.021)	(0.008)	(0.026)	(0.016)	(0.017)	(0.011)	(0.037)	(0.031)	(0.043)
Age^2	-0.000***	-0.000	-0.001**	-0.000*	0.000***	-0.000	0.001***	-0.000**	0.000***	-0.000	-0.001*	-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)
Female	0.008	0.039	-0.006	-0.020	-0.002	0.044	0.042	-0.037	-0.028	-0.020	0.025	-0.104
	(0.028)	(0.098)	(0.062)	(0.052)	(0.023)	(0.080)	(0.048)	(0.045)	(0.027)	(0.108)	(0.055)	(0.068)
Father's Age	-0.010***	-0.019***	-0.007**	-0.012***	-0.010***	-0.018***	-0.010***	-0.012***	-0.004*	-0.013*	0.006	-0.001
	(0.002)	(0.005)	(0.004)	(0.004)	(0.002)	(0.004)	(0.003)	(0.003)	(0.002)	(0.007)	(0.004)	(0.005)
Treat	-0.048	-0.115	-0.338**	0.128	-0.056	-0.093	-0.324***	0.076	-0.079	-0.212	0.174	-0.135

	(0.052)	(0.127)	(0.149)	(0.085)	(0.040)	(0.102)	(0.121)	(0.072)	(0.066)	(0.256)	(0.139)	(0.154)
Young	0.041	0.102	-0.079	0.043	-0.039	0.040	-0.356**	-0.063	0.050	-0.082	0.243	-0.139
	(0.057)	(0.165)	(0.185)	(0.100)	(0.047)	(0.139)	(0.148)	(0.085)	(0.057)	(0.194)	(0.166)	(0.137)
Treat*Young	-0.027	0.040	0.273*	-0.178	0.044	0.115	0.329**	-0.044	0.082	0.358	-0.133	0.134
	(0.063)	(0.183)	(0.163)	(0.109)	(0.049)	(0.142)	(0.133)	(0.089)	(0.073)	(0.307)	(0.150)	(0.175)
Intercept	1.308***	2.152**	1.138**	1.456**	1.405***	1.765**	1.770***	1.603***	0.800**	1.910	-0.148	0.282
	(0.312)	(1.021)	(0.543)	(0.618)	(0.251)	(0.841)	(0.443)	(0.485)	(0.316)	(1.123)	(0.802)	(1.072)
N	491	77	89	153	676	100	132	202	318	38	58	75
r2	0.418	0.534	0.469	0.491	0.423	0.532	0.455	0.469	0.368	0.527	0.705	0.326

5. Concluding Remarks

This study investigates how former agrarian villages have transformed their demographic characteristics in response to enhanced connectivity, focusing on the effects on the longevity of the male household head. We find significant and economically large impacts of their children's exposure to such modernization and resulting engagement to the manufacturing jobs on their fathers' longevity. Since we focus on the children's exposure, the effect is not through the change of their own occupation but expanded resource transfer to their parents or improved elderly care by their children. This finding suggests that structural transformation influences the demographics of various generations. It directly affects the exposed generation through occupation choice or income effect and, then, indirectly through fertility decisions of the exposed generation on their older generation, as we have shown in our analyses. Hence, a structural transformation has profound implications for the demographic change, and this nexus needs further investigation.

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