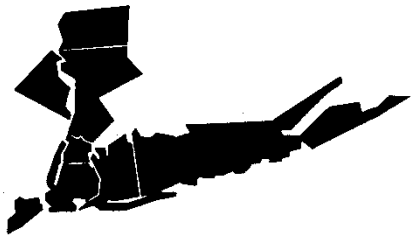

New York Metropolitan Transportation Council

The Metropolitan Planning Organization

Demographic and Socioeconomic Forecasting

Technical Memorandum
2040 Forecasts Modeling Methodology
TAZ Allocation

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D E M O G R A P H I C A N D
S O C I O E C O N O M I C F O R E C A S T I N G

2040 FORECASTS TAZ ALLOCATION METHODOLOGY

By NYMTC and NYCDCP

2040 Forecasts TAZ Allocation Methodology

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1. Introduction

This technical report explains the methodology and data sources used to disaggregate county level 2040 Socioeconomic and Demographic (SED) forecasts to transportation analysis zone (TAZ) level forecasts. The disaggregated SED forecasts consist of sixteen data variables for 3,586 TAZ's within the twenty-eight county region.

The 2040 county level forecasts for population and employment were produced by New York Metropolitan Transportation Council (NYMTC) and were adopted by the Program, Finance and Administration Committee (PFAC) on September 15, 2011.

The adopted SED forecasts established county level controls for the variables which were disaggregated to TAZ level. Those TAZ level SED forecasts are used as one of the inputs for the New York Best Practice Model (NYBPM), the travel demand forecasting tool. NYBPM outputs are used for conformity report, 2040 Regional Transportation Plan (RTP) report, and other purposes.

The TAZ disaggregation was a collaborative process between NYMTC and the New York City Department of City Planning Population Division (NYCDCP). During the entire process NYMTC's Forecast Working Group (FWG) provided important insight and valuable feedback which was incorporated into the forecasting process.

NYMTC produced disaggregated SED forecast data for twenty-three (23) counties, while NYCDCP disaggregated data for the five counties of New York City. Both agencies worked closely together to come up with very similar methodologies for the TAZ disaggregation process. **Table 1** provides a list of counties with the corresponding number of MCD's (minor civil divisions/local governments), census tracts and TAZ's.

1.1 TAZ-Level Socioeconomic and Demographic Variables

The method presented in this report is used to disaggregate the SED variables from the county-level to the TAZ geographic level as required by NYBPM. County-level variables are adopted by PFAC and in most cases represent controls to which TAZ-level variables must conform. In addition, forecasts are required for a number of variables for which no county-level totals exist. Variables can be conceptually divided between residence-based variables, workplace-based variables, and school enrollment variables. Residence-based variables are related to characteristics of the population in the areas where people live. Workplace-based variables are related to characteristics of workers at their place of employment. Enrollment variables are related to school locations.

Table 1. Number of MCD's, Census Tracts and TAZ's by Region, Subregion and County

Area Name	MCD's	Census Tracts	TAZ's
New York Regional Total	**99**	**3,240**	**2,449**
New York City Total	**1**	**2,168**	**1,622**
Bronx	-	339	273
Kings	-	761	513
New York	-	288	318
Queens	-	669	434
Richmond	-	111	84
Long Island Total	**17**	**607**	**474**
Nassau	5	284	238
Suffolk	12	323	236
Lower Hudson Valley Total	**81**	**465**	**353**
Dutchess	22	79	66
Orange	23	79	66
Putnam	6	19	14
Rockland	5	65	38
Westchester	25	223	169
New Jersey Total	**397**	**1,543**	**740**
Bergen	70	179	70
Essex	22	210	218
Hudson	12	166	158
Hunterdon	26	26	26
Mercer	13	77	13
Middlesex	25	175	25
Monmouth	53	144	53
Morris	39	100	39
Ocean	33	126	33
Passaic	16	100	16
Somerset	21	68	21
Sussex	24	41	24
Union	21	108	21
Warren	22	23	23
Connecticut Total	**50**	**399**	**397**
Fairfield	23	210	213
New Haven	27	189	184
NYMTC 28 County Totals	**546**	**5,182**	**3,586**

Note: MCD's = Minor civil divisions are general purpose local governments

Residence-based variables are as follows:

- Total Population
- Household Population
- Group Quarters Population – Total
- Group Quarters Population – In Institutions
- Group Quarters Population – Homeless/Streets
- Group Quarters Population – Other
- Number of Households – Total
- Average Household Size
- Mean Household Income
- Employed Labor Force

Workplace-based variables are as follows:

- Employment – Total (Census 2000 CTPP Basis)
- Employment – Office (Census 2000 CTPP Basis)
- Employment – Retail (Census 2000 CTPP Basis)
- Mean Earnings per Worker

School enrollment variables are as follows:

- K-12 Enrollment
- University Enrollment

1.2 Transportation Analysis Zones and Other Geographies

TAZ-level variables are required for 28 counties within five sub-regions. **Table 1** lists counties by sub-region.

The population and employment forecasts are generated at the county level. For residence-based variables (e.g., household and group quarters (GQ) population, households, and employed labor force) the adopted forecasts act as controls to TAZs, while for employment-related forecasts they are used to establish rates of change for TAZs.

TAZs are defined based on Census tracts or block groups for some areas and on MCDs for others. Block groups are among the smallest Census geographic units, generally corresponding to several city blocks; MCDs correspond to larger units such as entire towns.

Because input data are typically available for Census geographies rather than TAZs, the SED forecasts are developed on a Census Tract or MCD basis first and then converted to a TAZ basis using a correspondence table. For simplicity's sake, these lower Census geographies may be referred to as TAZs in the discussion that follows. In many cases there is a one-to-one relationship with TAZ geographies (i.e., one tract or MCD equals a single TAZ). In other cases, a TAZ comprises a group of two or more tracts. Finally, in some cases tract-level data must be allocated between TAZs. Based on the correspondence table, these conversions are carried out automatically in the database using SQL queries.

For areas where TAZs are based on block groups and thus represent quite small areas, or where there are several hundred TAZs within one county, it can be useful to carry out the TAZ distribution in a two-stage process, going first from the county level to a larger sub-county unit—such as the Public Use Microdata Area (PUMA)—and then to the TAZ level. In this way, broader sub-county growth patterns and exogenous town-level forecasts may be reflected. PUMAs were used as an interim geography for NYCDCP's variable disaggregation for NYC TAZs.

2. Overview of the TAZ Disaggregation Methodology

As indicated earlier, TAZ-level variables can be divided into three sets: residence-based variables, workplace-based variables, and enrollment variables. Residence-based and workplace-based variables each represent a logically related group whose values are interdependent and are therefore calculated together. For example, within the residence-based group, household population and group quarters population together must equal the total population, and average household size must equal the quotient of household population and number of households.

In the case of the residence-based group, several variables correspond to county-level forecast variables, which serve as controls. Other residence-based variables do not correspond directly to county-level forecasts; they are generally calculated based on the controlled variables.

For the workplace-based variables, there is no direct equivalency between the variables adopted at the county level and those required at the TAZ level. For example, while county-level employment forecasts represent all employees for a given area, TAZ level forecasts represent only workers actually present at their workplace on a given day (excluding, for instance, workers absent due to illness or vacation). Therefore, for workplace-based variables, county-level variables do not serve as a direct control on TAZ level variables, but rather are used to establish rates of change by counties.

Within the residence-based controlled variables, household population, group quarters population and households are treated as primary variables from which other secondary variables are derived. In addition to corresponding to county-level forecasts, these variables are related to the units in which major development data are expressed, as discussed below. For the primary variables, the distribution method is used to allocate increments of growth from county forecasts to TAZs. For example, based on adopted forecasts, a given county might be projected to grow by an increment of 5000 households between the years 2005 and 2010. The distribution method would allocate this growth to individual TAZs so that the total growth increment for all TAZs located within a given county is equal to the original increment for the county as a whole. A similar distribution would be carried out for other primary variables; secondary variables, such as employed labor force, would then be derived and controlled to county forecasts where necessary.

The top-down distribution can be carried out in two stages in which forecasted increments of growth are distributed. In the first stage, county-level growth increments

are distributed to the zones with major developments. Information on these projects and their timelines come from project pipeline data submitted by county representatives which is usually updated once a year. The threshold for major developments is a minimum of 50 residential units or 15,000 square feet for commercial developments. The second stage involves distribution of the rest of projected county growth to the TAZ level. The distribution is based on two factors: existing share of the 2010, and a growth factor from 2000 to 2010.

Maps showing the 2040 TAZ distribution and growth from 2010 to 2040 were sent to the county planners for comments. Extensive comments were received and changes have been made accordingly.

3. Methodology – NYMTC

3.1 Total Population, Household Population and Group Quarters (GQ) Population

Total, household and group quarters population data for county subdivisions and census tracts were collected for 2010 from the 2010 decennial census. Total population was calculated as the sum of household and group quarters population. Since the NYBPM transportation zones are based on 2000 Census tracts, a relationship file between Census 2000 tracts and 2010 tracts provided by Census Bureau were used to transform 2010 population data into 2000 census tracts.

Household population and group quarter population were distributed to the TAZ level based on two factors: existing weight of 2010 and growth factor from 2000 to 2010. Before the top down process began, growth was first assigned to zones with major development projects. Future major projects were submitted by counties and were geo-coded by NYMTC staff. Information such as development units were converted to number of household and household population based on county specific household size forecasts.

For Rockland County, the model also includes the build out analysis explicitly. Rockland County specified the residential capacity for each zone within the county and shared the information with NYMTC. If the allocation exceeds the capacity defined by the county, the surplus will be redistributed to other zones based on available capacity.

Group Quarters Population: Total, Institutional, Homeless, and Other GQ
The methodology adopted by NYMTC for group quarters population is the same as applied by NYCDCP. Please refer to section 4.0 on page 9 for details.

Households and Household Size
Household formation characteristics pertain to the number of households, population in households, and average household size.

Number of households in the year 2010 was collected from the Decennial 2010 Census at tract level. The growth into the future for each tract was carried out in a similar fashion to

household and group quarter population. Growth was first assigned to the tracts with new major development projects, and then to the rest of the tracts within the county based on the 2010 share and growth factor from 2000 to 2010.

Household size was derived from household population and number of households, as shown in the formula below.

Household Size = Household Population / Number of Households

3.2 Employed Labor Force

Employed labor force was derived from population by age/sex/race/ethnicity based on estimates of labor force participation and unemployment rates and controlled to county-level increments of growth. The number of persons in the employed civilian labor force in 2000 was available at the census tract level. A TAZ's share of the 2000 borough total of the employed civilian labor force was applied to the projected borough employed civilian labor force to derive the TAZ-level employed civilian labor force. This was done for each 5-year interval for the 2010-2040 period.

Total, Retail and Office Employment

Unlike residence-based variables, workplace-based variables for employment do not use county level forecasts directly as control totals. This is because the employment concept used for county forecasts differs from that used for TAZ forecasts. The employment forecasts at county level are the real number of jobs, while the employment at TAZ level really means number of work trips generated at a specific working day. Not 100 percent of the workforce goes to work everyday, since there are people on vacation, sick leave and working from home. However, for modeling purposes, the primary concern is actually how many work trips there are on a typical working day. For this purpose, Census Transportation Planning Package (CTPP) data were used to set a baseline, and county forecasts of payroll employment were used to establish rates of employment change for component of TAZs.

CTPP is a set of special tabulations from the decennial census calculated for transportation planners. The data were tabulated from answers to the Census 2000 long form questionnaire. Because of the large sample size, the data are precise. CTPP provides complete and efficient data, in a traditional format, across the United States.

The next update of CTPP is expected to be available in late 2012. Therefore, there is, as yet, no current employment by working place at census tract level. The ACS 5-year data set (2006-2010) provides complete information on employment by workplace at county subdivisions, but is not detailed enough at census tract level. Therefore, for county and county subdivision controls, ACS table B08526 from the 2006-2010 data set was used, and the share of each census tract of county subdivisions was gathered from the CTPP 2000 dataset.

NYMTC collected detailed information on further major development projects for each jurisdictional county. The project listings submitted by counties contain detailed

information, such as the location of the project, the scale, and the phasing plan, which tells when each phase of the project is expected to be finished. Using this detailed information, NYMTC staff first geo-coded the projects to individual census tracts, and converted the scale of the projects into number of employees using industry standards.

Growth was first assigned to the tracts with new major development projects, and then to the rest of the tracts within the county, based on the 2010 share and growth factor from 2000 to 2010.

3.3 Household Income and Earnings

Earnings data are critical in determining the supply and demand for all transportation projects. As with the employment data, CTPP data were used to collect earning data. As mentioned before, the next update of CTPP will only be available in fall 2012, and CTPP 2000 is the only current available dataset. The CTPP 2000 provided earnings data at the census tract level data for both number of earners and aggregate earnings (Tables P2-006 and P2-063). Earnings at the census tract level were inflated to 2010 dollars by applying the county growth in earnings for the 2000-2010 periods as shown in the Department of Labor's Quarterly Census of Employment and Wages data.

Aggregate household income per census tract was taken from the 2005-2009 ACS (Table B19025), and then divided by the number of households within that census tract to derive mean household income.

3.4 K12 School Enrollment and University Enrollment

For the projected population enrolled in school (K-12), the population ages 5 to 19 were used as a proxy. To obtain the TAZ level population of those in this age group, the 2010 TAZ share of the total population that was from 5 to 19 years of age was applied to the projected TAZ population.

With respect to university enrollment, original source data was gathered from Connecticut's offices of Financial & Academic Affairs for Higher Education and Department of Higher Education (now closed), New Jersey's Office of Higher Education and New York's State Education Department. From each state a list of colleges and universities and the Fall 2010 enrollment was collected.

The enrollment data provided was limited to total enrollment, while some institutions have multiple campus locations and in some cases the enrollment figures were linked only to a single campus location. An effort was made to separate student enrollment associated with the various institutions campuses, by contacting and checking (website) the individual college and university to obtain student enrollment at these separate locations.

For the 23 counties (not including the five counties of New York City), 139 locations were geo-coded to the TAZ level and the student population were assigned. Enrollment was indexed to growth in total employment at the county level base year (2010), and for each of the 5-year intervals for the 2015-2040 projected years.

Source of enrollment data (accessed November 2011):
-Connecticut Office of Financial & Academic Affairs for Higher Education; list of college and universities (w/ city/town names), and Connecticut Department of Higher Education (This department was closed effective July 1, 2011); enrollment data.

- http://www.ctohe.org/HEWeb/CollegesList.asp
- http://www.ctdhe.org/dheweb/enrollmentftesearch1.asp

-New Jersey Office of Higher Education; list of college and universities by education type (w/ city/town names), and statistical tables for enrollment data.

- http://www.nj.gov/highereducation/colleges/index.html
- http://www.nj.gov/highereducation/colleges/index.html

-New York State Education Department – Office of Higher Education: Office of Research and Information Systems (NYSED-ORIS); enrollment for college and universities by county.

- http://eservices.nysed.gov/orisre/

4. Methodology – NYCDCP

In this section of the technical report, NYCDCP presents the data sources employed and explains the methodology used for the 2040 socioeconomic and demographic inputs at the TAZ level for use with the NYBPM. The discussion will encompass each of the required 16 data inputs for the five boroughs of New York City. These include population variables (total population, household population, group quarters population, institutional group quarters population, homeless group quarters, other group quarters), household variables (number of households, average household size, and average household income), employment (employed civilian labor force, workers who commute, retail employment, office employment), earnings per worker, university enrollment, and school enrollment. The data source used for each of the above variables and the methodology employed to allocate them to the 1622 TAZs in New York City is discussed in the following sections.

4.1 Population in Households

NYMTC provided the NYCDCP with New York City's population by borough projected at 5-year intervals to 2040 and NYCDCP was responsible for allocating each borough's 2010-2040 population down to the TAZ level.

Before allocating the projected population at the TAZ level, NYCDCP first independently projected the population at a sub-borough level of geography – to the Public Use Microdata (PUMA) level (see **Appendix** for detailed definition.)

These population projections were created using standard demographic techniques that take existing male and female living in households in different age groups ("age/sex cohorts") and move them forward through time using assumptions on future births,

deaths, and migration. This "cohort component model" projects not only total household population but creates a new age/sex distribution for 2020, 2030, and 2040. (As noted later, the projected group-quarters population was then added on to get the total population.)

These projections were then examined by planners at NYCDCP to see whether the projected growth in the population at a sub-borough level was consistent with current land use and changes in the city's zoning.

4.2 Projecting Population at a PUMA level using a Cohort Component Model

The Cohort Component Model is based on the premise that population growth can be broken down into three main components of change: births, deaths, and migration. While births increase the base population and deaths reduce it, migration results in an addition or diminution depending on whether there is overall positive or negative migration. Therefore:

Projected Population (P_1) = Base Population (P_0) + Births – Deaths + Net Migration

The fundamental difficulty in using the cohort component model rests in identifying appropriate fertility, mortality, and migration rates to apply to different age groups. In general, most *baseline* projections assume that the future will be in line with historical patterns. Of course, no pattern can be expected to continue without alteration, as when population decline in one era produces opportunities for growth in future periods. Thus, baseline assumptions are modified using scenarios that demographers believe may be likely in the future, including assumptions about increased longevity and new housing development – which could result in lower losses to migration as more people stay in the area. Of course, the degree to which such future patterns hold is directly related to the ultimate success of a projection.

The following were the stages in the creation of these projections:

I. Adjusting the base population for undercount and removing the group quarters population;
II. Creating the baseline PUMA household population based on a series of fertility and mortality rates for the 2007-2009 period, and migration rates by age/sex for the period 1990-2010;
III. Examining the projected PUMA population for reasonability, and adjusting it in the context of the city's land use and the effects of projected zoning changes;
IV. Calibrating the projections to independent 2040 projections provided by NYMTC, and allocating PUMA projections down to the TAZ level; and
V. Adjusting the TAZ level population based on land use/zoning considerations

See **Appendix** for more detailed data analysis.

4.3 Average Household Size and Number of Households

In 2010, the household population and the number of households were available at the census block level, which were converted into 2000 TAZs. The average household size in each TAZ was then calculated (household population/number of households). NYCDCP projected the population by TAZ at 5-year intervals for the period 2015-2040. NYMTC provided projected average household size for each borough for this period. The borough change in average household size during each 5-year interval was applied to TAZs within the borough.[i] With projected household population and average household size now available, the number of households was derived for each 5-year interval at the TAZ level (household population/average household size). Households at the TAZ level were fitted to the projected number of households for each borough provided by NYMTC. The TAZ level distribution of households for each 5-year interval was applied to the borough control, which resulted in TAZ-level household numbers that summed to the borough control.

4.4 Group Quarters Population: Total, Institutional, Homeless, and Other GQ

The GQ population can be either in an institutional or a non-institutional setting – the difference being that those in an institutional setting experience a high degree of supervision. Within these settings, the 2010 decennial census divides the GQ population into seven broad categories, with the Institutionalized GQ population divided into four categories: *correctional facilities for adults, juvenile facilities, nursing/skilled care facilities, and other institutional facilities*. The non-institutionalized GQ population is broken down into three broad categories: those in *college/university student housing, military quarters, and other non-institutional facilities*. These seven broad categories and their sub-categories are shown below.

Total

Institutional population

Correctional facilities for adults

Federal detention centers

Federal prisons

State prisons

Local jails and other municipal confinement facilities

Correctional residential facilities

Military disciplinary barracks and jails

Juvenile facilities

Group homes for juveniles (non-correctional)

Residential treatment centers for juveniles (non-correctional)

Correctional facilities intended for juveniles

Nursing facilities/Skilled-nursing facilities

Other institutional facilities

Mental (Psychiatric) hospitals and psychiatric units in other hospitals
Hospitals with patients who have no usual home elsewhere
In-patient hospice facilities
Military treatment facilities with assigned patients
Residential schools for people with disabilities

Non-institutional population

College/University student housing

Military quarters

Military barracks and dormitories (non-disciplinary)
Military ships

Other non-institutional facilities

Emergency and transitional shelters for people experiencing homelessness
Group homes intended for adults
Residential treatment centers for adults
Maritime/merchant vessels
Workers' group living quarters and Job Corps centers
Other non-institutional facilities

Besides the Total GQ population, there were three subsets of the GQ population that were of interest: the Institutional GQ population, Homeless GQ, and Other GQ. In 2010, the "Emergency and transitional shelters for people experiencing homelessness" was combined with a portion of the Other non- institutional population[ii] (which included the count of street homeless and those using facilities such as soup kitchen and mobile food vans) to obtain the Homeless GQ population, while the Other GQ population was the difference between the overall Non-institutional population and the derived Homeless GQ population.

In 2010, the Total GQ population, the Institutional GQ population, and the Non-Institutional GQ were available at the census block level, while the derived Homeless GQ and Other GQ were available at the census tract level. The block-level data allowed for a more accurate conversion to 2000 TAZs, while the derived Homeless GQ and Other GQ were then put into TAZs using the 2000 census tract to TAZ equivalency provided by NYMTC.

NYMTC provided NYCDCP with the projected Total GQ population by borough in 5-year intervals for the period 2015-2040. For each of these 5-year intervals, each TAZ's 2010 share of its borough's Total GQ population was calculated and applied to the borough's projected Total GQ population to obtain the TAZ-level counts of these populations. The Total GQ population at the TAZ level was then split into its Institutional vs. Non-institutional components based on their 2010 TAZ-level shares. Finally, the Non-institutional population at the TAZ level was divided into its Homeless GQ and Other GQ components using the 2010 split of these populations. This gave us TAZ level Total GQ, Institutional GQ, Homeless GQ, and Other GQ for each 5-year interval in the 2010-2040 period.

4.5 Total Population

The household population at the TAZ level was added to the GQ population at the TAZ level to obtain the Total Population by TAZ. This was done for each 5-year interval for the 2010-2040 period.

4.6 Employed Civilian Labor Force

The total number of persons in the employed civilian labor force was provided by NYMTC at the borough level at 5-year intervals for the 2010-2040 period.

The number of persons in the employed civilian labor force in 2000 was available at the census tract level and was put into TAZs using the 2000 census tract to TAZ equivalency from NYMTC.[iii] A TAZ's share of the 2000 borough total of the employed civilian labor force was applied to the projected borough employed civilian labor force to derive the TAZ-level employed civilian labor force. This was done for each 5-year interval for the 2010-2040 period.

4.7 Workers with Trips

The total number of jobs was provided by NYMTC at the borough level at 5-year intervals for the period 2000-2040. The number of *workers with trips* (EmpTot) had to be projected for the 2010-2040 period and allocated down to the TAZ level.

The 2000 Census Transportation Planning Package (CTPP) provided total workers at their workplace and persons who worked at home at the borough level. The difference between these two populations is the number of workers with trips. This borough population was first projected at 10-year intervals for the 2010-2040 period using the growth rates in the Payroll Employment Forecast provided by NYMTC. Each borough's projected population of workers with trips was then allocated to the PUMA level based on the 2000 PUMA to borough distribution of workers with trips.

For each borough, planners examined PUMAs in terms of potential for high job growth – in light of the city's current and projected zoning changes – and adjusted worker trips accordingly.

See appendix for more detailed data analysis.

4.8 Retail Employment and Office Employment

Along with establishing the overall number of workers with trips by borough and TAZ for the 2000-2040 periods (as discussed earlier), the total number of retail and office workers with trips had to be projected at 5-year intervals for the 2010-2040 period down to the TAZ level.

The 2000 CTPP provided the number of workers at the census tract level as well as the number of these workers in retail and in office employment. These data were put into TAZs using the 2000 census tract to TAZ equivalency provided by NYMTC, and the percent of workers in each TAZ who were in retail and office employment was

calculated. This was then applied to the projected borough workers with trips for the 2010-2040 period to obtain the projected number of workers in retail and office employment with trips at the TAZ level.

4.9 Earnings and Household Income

The 2000 CTPP provided earnings data at the census tract level data for both number of earners and aggregate earnings (Tables P2-006 and P2-063). These tract level data were then put into TAZs using the equivalency provided by NYMTC and earnings per worker were calculated at the TAZ level. Earnings at the census tract level were inflated to $2010 by applying the borough growth in earnings for the 2000-2010 periods as shown in the Department of Labor's Quarterly Census of Employment and Wages data.

Household income at the census tract level were from the 2005-2009 ACS (Table B19025). Both number of households and aggregate household income were available in 2000 tracts; these data were put into TAZs and the average household earnings was calculated.

4.10 School Enrollment and University Enrollment

As described earlier, the population projections conducted by NYCDCP provided the projected overall population at the TAZ level in 5-year intervals for the 2010-2040 periods. In addition, these projections provided detailed age data for each PUMA for these time points. For the projected population enrolled in school (K-12), we used the population ages 5 to 19 as a proxy. To obtain the TAZ level population of those in this age group, the 2010 TAZ share of the total population that was within the same group was applied to the projected TAZ population. The TAZ-level population was then summed to the borough level and calibrated to the NYCDCP projected borough population of those ages 5 to 19.[iv]

With respect to university enrollment, NYCDCP maintains the *Selected Facilities and Program Sites Database,* which provides a listing of major facilities in the City of New York and detailed information on the populations associated with these institutions. A subset of these facilities, namely Post-Secondary Degree Granting Institutions and their respective enrollments, was selected. This included major university facilities, as well as post-secondary technical schools and the satellite locations of larger institutions. The original source of these data was the New York State Education Department Office of Research and Information Systems (ORIS), which manages a comprehensive higher education data system that collects and distributes information on the quality and status of higher education in New York State. ORIS collects and analyzes data from all degree granting postsecondary institutions except federal units, and from 250 non-degree granting proprietary schools, on major indicators of the quality of higher education in New York State, including enrollment, degrees conferred, admissions, finances and a variety of performance measures.

A limitation of these data is that some institutions have multiple buildings in a variety of locations throughout the city but, in some instances, a single student enrollment figure is associated with one main building or campus location. Whenever possible, we made an

effort to separate student enrollment associated with different divisions of a school, (e.g. college or arts and sciences, school of medicine, school of engineering), when these data were available. In the case of satellite locations of larger institutions (e.g. satellite campuses of a college in different boroughs), we contacted institutions to obtain student enrollment at these separate locations.

Each facility was geo-coded to 2000 census tracts and then put into TAZs, where the student population was assigned. To derive increases in university enrollment, we examined NYCDCP projected borough growth in the population ages 20 to 34 at 5-year intervals for the period 2010-2040. While university enrollment – especially in Manhattan – is more likely to be correlated with growth in this population nationwide, we felt that borough-specific increases in this age group would also likely affect growth in university enrollment. Thus, borough level growth was applied to each TAZ in the borough at 5-year intervals for the 2010-2040 periods.

APPENDIX

What is a PUMA

A PUMA is a census geographic designation that is largely coterminous with New York City's community districts. New York City's government structure includes 59 community districts, each with a board, whose members are charged with identifying needs in their district and articulating local neighborhood concerns as part of the local planning process. Since a PUMA requires a minimum population of 100,000, some community districts that did not meet the threshold had to be combined with an adjacent district, resulting in 55 PUMAs.

Projecting Population at a PUMA level using a Cohort Component Model

I. Adjusting for Population Undercount and Removing the Group Quarters Population

Adjusting for Undercount

Reasonable estimates of population change can only be obtained when errors in census coverage (i.e., undercounts and over counts) are relatively constant from one census time point to the next. Therefore, before assessing change from 1990 to 2010, NYCDCP had to evaluate census undercount for all time points. And, indeed, since the undercount for 1990 was high (245,000 persons or 3.2 percent), compared to a negligible number for 2000, reported growth over the period related to migration was likely to be overstated. In order to determine the real contribution of the components of change, it was necessary to adjust the 1990 population upward to correct for the undercount.[v] At this point, NYCDCP were not able to adjust the 2010 decennial census counts, as the Census Bureau's Census Coverage Measurement (CCM) survey results have not yet been released. Instead, migration rates were adjusted using local knowledge of areas where we suspect an undercount occurred (southern Brooklyn and northeast Queens).

Removing the Group Quarters Population

When considering those who live in a dormitory, nursing home, or even a prison – defined as populations living in "group quarters" – it is obvious that their mortality, fertility, and migration patterns are different from those living in households. Therefore, NYCDCP followed the common practice of initially removing those in group quarters from the general population and placing them back in after the household population projection was completed.

II. Creating the Baseline

This section examines how the three components of population change were calculated and how they were employed in the projection model.

Fertility

So as not to subject births to any one-year anomaly, NYCDCP averaged births in 2007, 2008, and 2009, and calculated age-specific rates based on the 2010 population. Birth data were obtained from the New York City Department of Health and Mental Hygiene,

while population data by age were from the decennial census. The age-specific fertility rates determine how births are distributed by age of the mother.

Generally speaking, New York City had a conventional pattern of age-specific fertility: Rates peaked at ages 20-24, declined slightly for ages 25-29 and 30-34, and then fell steeply thereafter. The two boroughs that had the highest overall fertility, the Bronx and Brooklyn, also had the highest age-specific fertility rates for those ages 20-24. Alternatively, many PUMAs in Queens and Staten Island followed a more "suburban" fertility pattern, with moderate overall levels, and rates peaking at ages 25-29 for Queens and at 30-34 for Staten Island. Manhattan had remarkably low overall fertility, especially for those under age 30. Unlike the case with other boroughs, women in many Manhattan PUMAs ages 35 to 39 had fertility rates higher than for those in their 20s, usually the prime child-bearing ages.

Since fertility rates are relatively low and given the difficulty in projecting fertility, these rates were kept constant for the entire 2010-2040 period.

Mortality

In order to project deaths into the future, NYCDCP averaged deaths occurring in 2007, 2008, and 2009 to calculate age-specific death rates based on the 2010 population. Data on deaths were obtained from the New York City Department of Health and Mental Hygiene, while population data by age were from the decennial census. These age-specific death rates were then used as the foundation for a life table that calculated survival rates by age for each PUMA. These rates represent the percentage of persons who are likely to survive to the next five year time point.[vi] Naturally, younger age groups have much higher survival rates than older ones, but no age group is immune from death over a five year period.

These survival rates, which were employed for the 2010-2040 period, follow a very traditional pattern of high probability of survival for the younger ages, with very little attrition until ages 55-59. Thereafter, the probability of survival begins to fall, declining steeply for the older age groups. While our focus is on age-specific survival rates, the cohort component model used in this analysis actually uses rates that are age *and* sex-specific. This permitted us to project the population by age and sex. The Total Fertility Rate and life expectancy used for each PUMA are in **Table 2**.

Migration

Migration is the most volatile component in a cohort component model. Age-specific and crude migration rates (CMRs) were calculated using decennial census data from 1990-2000 and 2000-2010. Age-specific migration rates for each period were calculated by applying survival rates to the initial decennial census household population for five-year intervals, then subtracting that result from the mid-year estimate (the average population of the two decennial years). The difference between the two is the total number of net migrants by age for that five-year interval. Assume, for example, a 1990 population of 20-24 year olds totaling 5,000 and a mid-decade estimate of 25-29 year olds totaling 5,500. If the population of 20-24 years olds was survived 5 years resulting in a population

of 4,900 25-29 year olds in 1995, this would imply a net inflow of 600 from 1990-1995. Net migrants were divided by the initial population to create age-specific migration rates for each 5-year period, and then averaged to arrive at the rate for the entire decade.[vii] The overall migration dynamic is captured by the CMR, which was calculated by totaling net migrants in each 5-year period and dividing that by the mid-decade population.[viii] A positive CMR implies that those who move into a PUMA outnumber those who leave, while the reverse is true if the rate is negative. In general, migration trends from 1990-2010 for most New York City PUMAs are negative. Staten Island was the only borough with its entire three PUMAs showing positive migration.

III. Examining the projected total population for reasonability and adjusting it in the context of the city's zoning and projected zoning changes.

The resulting projections of the total population by PUMA for the years 2020, 2030, and 2040 were then examined for reasonableness and in the context of the city's projected zoning changes. This step is needed because past history is not necessarily a good indication about the future, which in some cases, may be almost the opposite of the past – "back-filling" areas depleted of population, being a good example.

For each borough, planners ranked each PUMA in terms of potential for growth – High, Medium, and Low Growth. The projected borough household population change was allocated to each PUMA based on whether current and projected zoning changes would allow for high, medium, or low growth. **Figure 1** shows PUMAs with their respective growth classifications.

Crude migration rates were adjusted to hit the projected PUMA growth as envisioned by city planners. This also provided projected population at the PUMA level by age, which is used in K12 enrollment at the TAZ level.

Since the fertility component is reasonably accurate (and since we do not expect mortality to be very different), we adjusted only the crude migration rate. While it was possible to change the age-structure of migration by altering age-specific rates, no such changes were made in this projection since age patterns of migration tend to be stable over time. Instead, the overall CMR was adjusted, which changes migration across all age groups, but maintains the overall age-specific migration pattern. Adjustments were made to the PUMA household population only – the GQ population was left unchanged. The final crude migration rates that were used for each decade are in **Table 3**.

IV. Calibrating the NYCDCP projections to independent projections provided by NYMTC, and allocating PUMA projections down to the TAZ level

After the PUMA projections produced by the baseline rates were adjusted to reflect the city's projected zoning changes, the PUMA populations in each borough were then calibrated against the 2020, 2030, and 2040 borough projections provided by NYMTC. This was done separately for each borough, by applying the PUMA distribution of

NYCDCP's projected household population to the population controls provided by NYMTC to derive the new PUMA household population.

Allocation of PUMA projections down to the TAZ level was based on the distribution of the 2010 household population. The 2010 decennial census household population was available by 2010 census block, which was used to put the data into PUMA and TAZ geography. Projected PUMA populations for 2020, 2030, and 2040 were then put into TAZs based on the 2010 TAZ to PUMA distribution.[ix]

V. Adjusting the TAZ level population based on land use/zoning considerations

The final step was to examine high and medium growth PUMAs to make sure that household population growth was allocated to specific TAZs that were in areas that have had or are projected to have major changes in land use/zoning. In addition, some TAZs are unable to accept growth proportionate to their current distributions, and future growth in these areas was curbed.

Figure 2 highlights TAZs where higher or lower than average growth is expected. Overall, 61 TAZs were adjusted taking into account potential for future growth—fifty-eight TAZs expected to experience a higher than average share of growth and three TAZs expected to experience lower growth. Select TAZs were adjusted in the Bronx in Williamsbridge (PUMA 3702), Morrisania and Tremont-Bathgate (PUMA 3705), Norwood (PUMA 3706), West Concourse (PUMA 3708), and Mott Haven (PUMA 3710). In Brooklyn, adjustments were made in Greenpoint-Williamsburg along the waterfront (PUMA 4001), Downtown Brooklyn (PUMA 4004), Park Slope and Carroll Gardens-Gowanus (PUMA 4005), Prospect Heights (PUMA 4006), East New York (PUMA 4008), and Coney Island (PUMA 4018). Adjustments in Manhattan were in TAZs in Central Harlem (PUMA 3803), East Harlem (PUMA 3804), Roosevelt Island (PUMA 3805), Lincoln Square (PUMA 3806), Hudson Yards (PUMA 3807), Turtle Bay and Stuyvesant Town (PUMA 3808), and in Lower Manhattan (PUMA 3810). Adjustments in Queens were made in Ravenswood and Dutch Kills (PUMA 4101), Downtown Flushing (PUMA 4103), Long Island City (PUMA 4109), and Jamaica (PUMA 4112). In Staten Island, one TAZ was adjusted along the North Shore (PUMA 3903).

The above steps gave us TAZ-level household population for the years 2010, 2020, 2030, and 2040. For the mid-decade years 2015, 2025, and 2035, NYCDCP TAZ level projections were obtained by averaging populations at the start and the end of that decade. For example, the projected 2025 population was an average of the projected populations in 2020 and 2030. NYCDCP's projected populations by TAZ for 2015, 2025, and 2035 were calibrated to the borough controls provided by NYMTC: TAZ-to-borough proportions for each of these years were applied to the borough controls provided by NYMTC to derive TAZ level populations for these years that added up to the borough populations provided by NYMTC.

Workers with Trips – (EMPTot)
PUMAs with anticipated above-average job growth resulting in a higher number of worker trips are highlighted in **Figure 3**. With respect to PUMA adjustments by borough, the South Bronx (PUMA 3710), downtown Brooklyn (PUMA 4004), and Hudson Yards (PUMA 3807) in Manhattan, were allotted higher than average growth. In Queens, La Guardia Airport (PUMA 4102), Flushing (PUMA 4103), JFK (PUMA 4105), Long Island City (PUMA 4109), and Jamaica (PUMA 4112) were allotted higher than average growth. No adjustments were made for any Staten Island PUMA.

PUMA-level growth – both unadjusted and adjusted – was then allocated to the TAZ level based on the TAZ to PUMA distribution of workers with trips in 2000. Further adjustments were made here as well, with specific TAZs in the above PUMAs being allotted higher than average growth. **Figure 4** shows TAZs where adjustments were made. Areas where adjustments occurred include TAZs that encompassed Hudson Yards and Jamaica.

This gave us the final TAZ level data for workers with trips in 2010, 2020, 2030, and 2040. Data for the years 2015, 2025, and 2035 were obtained by averaging TAZs in the adjacent periods. TAZ level data for these years were then calibrated to the borough controls provided by NYMTC based on each year's TAZ to borough distribution of workers with trips.

Table 2. Total Fertility Rate and Life Expectancy by PUMA

PUMA	Total Fertility Rate (Births per female)	Life Expectancy (yrs)
3701	1.94	80.12
3702	2	80.14
3703	1.62	80.21
3704	1.93	79.42
3705	2.17	77.06
3706	2.18	78.96
3707	2.4	79.84
3708	2.46	77.25
3709	2.11	79.11
3710	2.49	77.64
4001	1.92	80.83
4002	1.93	78.82
4003	2.08	75.64
4004	1.44	79.1
4005	1.57	80.96
4006	1.71	77.27
4007	2.07	75.74
4008	2.02	78.36
4009	1.9	81.31
4010	1.9	82.2
4011	2.13	80.35
4012	3.06	81.82
4013	1.83	81.34
4014	3.85	83.17
4015	2.24	81.76
4016	1.96	82.13
4017	1.78	82.32
4018	1.93	80.33
3801	1.83	83
3802	1.56	80.41
3803	1.82	75.28
3804	1.97	75.99
3805	1.34	85.06
3806	1.62	83.96
3807	1.03	81.97
3808	1.03	84.89
3809	1.61	81.01
3810	1.2	84.26
4101	1.29	81.38
4102	2.32	83.79
4103	1.83	83.39
4104	1.43	84.27
4105	1.72	82.23
4106	1.94	82.87
4107	2.16	84.4
4108	1.6	83.74
4109	1.6	83.5
4110	1.81	80.95
4111	1.94	82.08
4112	2.01	79.63
4113	1.91	81.16
4114	2.35	76.33
3901	1.71	81.42
3902	1.79	80.94
3903	2.1	78.45

Table 3. Ten-Year Crude Migration Rates by PUMA

PUMA	Baseline (Avg 1990-2010)	2010-2020	2020-2030	2030-2040
3701	-32.89	-45.91	-42.69	-33.21
3702	-41.83	-88.12	-72.52	-75.89
3703	41.36	-0.04	12.39	17.02
3704	10.98	-69.46	-60.8	-56.32
3705	-39.96	-117.13	-83.69	-73.99
3706	-130.51	-124.92	-97.43	-93.08
3707	-173.17	-128.84	-78.48	-62.48
3708	-102.96	-113.37	-69.72	-53.82
3709	-77.66	-95.99	-71.77	-65.91
3710	-86.62	-119.52	-65.39	-55
4001	-106.47	-93.01	-32.58	-36.75
4002	-153.93	-75.33	-0.92	-0.28
4003	-65.84	-69.58	-11.8	-27.37
4004	-63.51	-43.32	26.89	20.94
4005	-89.95	-79.86	-25.25	-24.36
4006	-143.26	-60.54	-11.71	2.53
4007	-141.08	-82.12	-36.76	-26.35
4008	-78.57	-57.53	-3.71	-8.68
4009	15.23	-69.68	-69.53	-70.84
4010	-162.14	-62.79	-19.05	-7.73
4011	-211.28	-75.08	-16.29	-3.58
4012	-72.69	-161.7	-94.9	-123.61
4013	14.93	-49.03	-47.11	-50.32
4014	-84.73	-178.95	-158.68	-194.66
4015	-129.38	-91.21	-61.55	-51.75
4016	19.32	-26.01	-13.76	-23.52
4017	52.18	-44.03	-41.76	-41.24
4018	-4.79	51.24	115.85	108.29
3801	-161.48	-64.43	-30.69	-5.69
3802	-126.12	-53.41	-26.77	-7.53
3803	-28.66	-11.36	33.15	43.2
3804	-83.69	0.55	54.68	62.04
3805	-36.5	-32.04	-10.32	-36.94
3806	-73.61	-27.99	1.83	-9.22
3807	78.36	29.93	53.98	40.73
3808	2.71	-9.22	-18.02	-16.8
3809	-82.21	-41.97	-3.39	18.92
3810	66.78	-16.55	-7.26	-26.74
4101	-70.72	45.03	80.91	69.54
4102	-0.92	-86.3	-79.38	-95
4103	-2.83	25.98	56.73	55.29
4104	14.24	14.8	23.81	26.95
4105	-41.51	-35.02	-18.79	-6.48
4106	-27.01	-74.1	-76.64	-75.66
4107	-43.35	-72.59	-57.98	-69.8
4108	4.56	-5.65	3.17	-10.77
4109	-9.07	41.58	65.86	27.86
4110	6.9	-52.27	-52.55	-59.77
4111	16.75	-44.71	-38.42	-50.8
4112	-51.19	-42.92	-21.83	-16.17
4113	-16.29	-43.59	-35.32	-30.99
4114	-13.59	3.66	41.01	43.08
3901	50.72	25.98	65.99	70.62
3902	24.97	1.67	29.36	40.52
3903	29.23	-28.73	-4.4	-11.14

Figure 4. Traffic Analysis Zones (TAZs) with Above-Average Shares of Growth

Bronx			Manhattan		
TAZ	**PUMA**	**Neighborhood**	**TAZ**	**PUMA**	**Neighborhood**
998	3702	Williamsbridge	234	3803	Central Harlem
1000	3702	Williamsbridge	236	3803	Central Harlem
1003	3702	Williamsbridge	271	3804	East Harlem
787	3705	Morrisania	272	3804	East Harlem
789	3705	Morrisania	317	3805	Roosevelt Island
854	3705	Tremont-Bathgate	143	3806	Lincoln Square
856	3705	Tremont-Bathgate	77	3807	Hudson Yards
861	3705	Tremont-Bathgate	79	3807	Hudson Yards
879	3706	Norwood	80	3807	Hudson Yards
883	3706	Norwood	309	3807	Hudson Yards
760	3708	West Concourse	124*	3808	Stuyvesant Town
805	3708	West Concourse	139	3808	Turtle Bay
753	3710	Mott Haven	4	3810	Lower Manhattan
754	3710	Mott Haven	5	3810	Lower Manhattan
761	3710	Mott Haven	6	3810	Lower Manhattan
762	3710	Mott Haven	12	3810	Lower Manhattan
763	3710	Mott Haven	13	3810	Lower Manhattan
Brooklyn			**Queens**		
TAZ	**PUMA**	**Neighborhood**	**TAZ**	**PUMA**	**Neighborhood**
1032	4001	Greenpoint-Williamsburg	352	4101	Dutch Kills
1075	4004	Downtown Brooklyn	355	4101	Ravenswood
1078	4004	Downtown Brooklyn	494	4103	Downtown Flushing
1079	4004	Downtown Brooklyn	495	4103	Downtown Flushing
1080	4004	Downtown Brooklyn	496	4103	Downtown Flushing
1088	4004	Downtown Brooklyn	363	4109	Long Island City
1213*	4005	Park Slope	643	4112	Jamaica
1218*	4005	Park Slope	644	4112	Jamaica
1227	4005	Gowanus-Carroll Gardens	645	4112	Jamaica
1214	4006	Prospect Heights	646	4112	Jamaica
1215	4006	Prospect Heights	683	4112	Jamaica
1178	4008	East New York	684	4112	Jamaica
1385	4018	Coney Island			
1386	4018	Coney Island	**Staten Island**		
			TAZ	**PUMA**	**Neighborhood**
			1574	3903	North Shore

*TAZ with expected lower than average share of growth

Figure 1. Projected Population Growth by PUMA

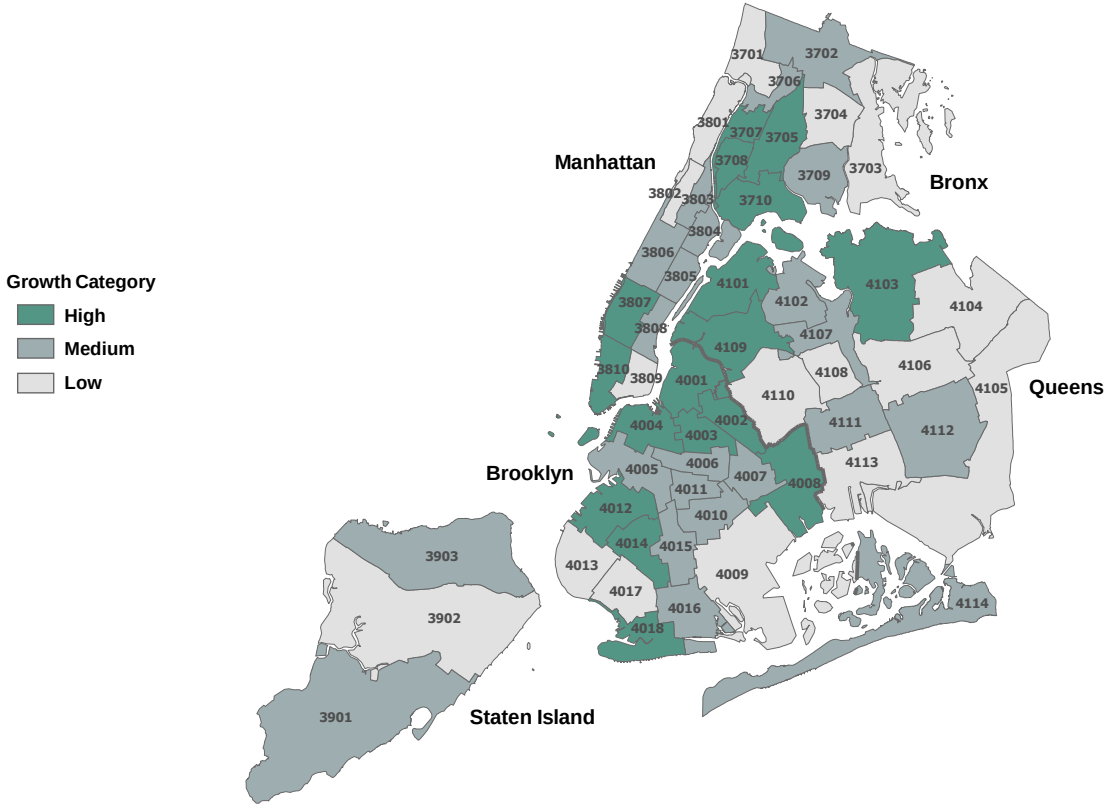

Figure 2. Traffic Analysis Zones (TAZs) with TAZ-PUMA Population Distribution Adjustments

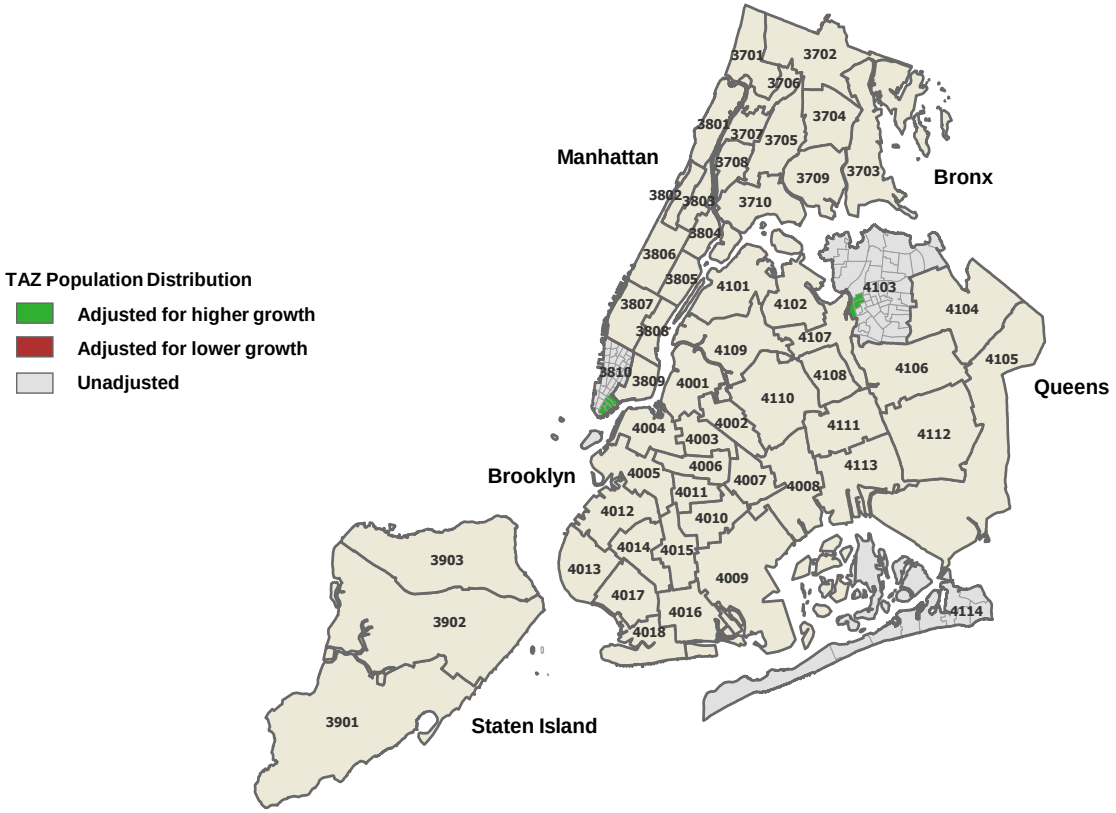

Figure 3. New York City PUMAs with Zoning Initiatives that will Result in Above-Average Job Growth

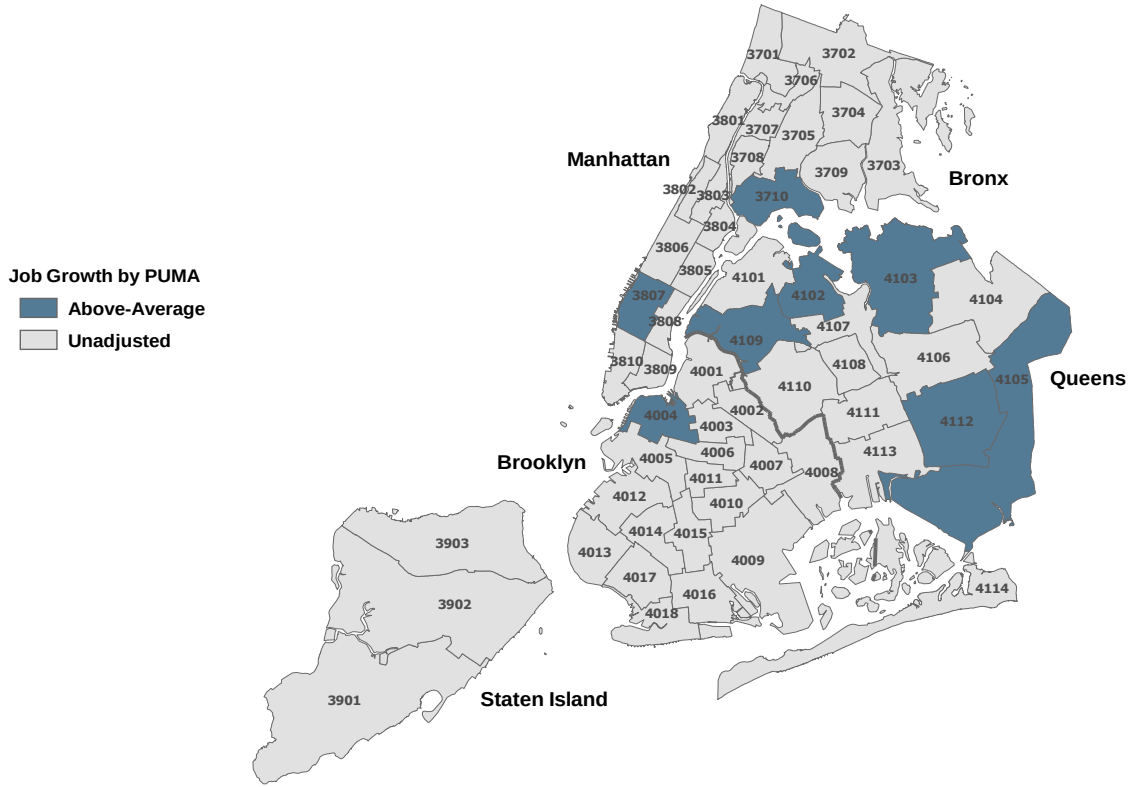

Figure 4. Traffic Analysis Zones (TAZs) with TAZ-PUMA Employment Distribution Adjustments

ENDNOTES

[i] We also had the choice of applying the 5 year increases in borough households provided by NYMTC to come up with projected households at the TAZ level, and then computing average household size. But we chose to project average household size at the TAZ level since average household size is much more stable.

[ii] In 2010, we had to estimate the share of the "Other non-institutional facilities" that were comprised of street homeless and those using facilities such as soup kitchen and mobile food vans. This was done indirectly by first examining GQ data for 2000. In order to make Group Quarters tables comparable between 2000 and 2010, the following subcategories had to be combined for 2000 and 2010:

2000 (from PCT 16):	2010 (from PCT 20):
-Groups homes for the mentally ill	-Group homes intended for adults
-Group homes for the mentally retarded	
-Group homes for the physically handicapped	
-Other group homes	
-Dormitories	-Workers' group living quarters and Job Corps centers
-Religious GQ	
	-Emergency and transitional shelters (with sleeping facilities) for people experiencing homelessness
-Others non-institutional GQ	-Other non-institutional facilities

In 2000, the homeless population was included in "Others non-institutional GQ." In 2010, the portion of the homeless population in emergency and transitional shelters was shown separately, but religious GQ, the street homeless, and those using soup kitchens and mobile food vans were included in "Other non-institutional facilities" and had to be estimated. The 2000 religious GQ component was calculated on the above aggregated subcategories, and this percentage was applied to the 2010 aggregated subcategories to create a religious GQ number for 2010. The estimated religious GQ was then removed from the 2010 "Other non-institutional facilities" subcategory to calculate an estimated street homeless population. This population was added to the "Emergency and transitional shelters" population to obtain an estimated Homeless GQ population. (The 2010 "Other non-institutional facilities" category also included the population in shelters for victims of domestic violence and the population in natural disaster shelters, These addition elements were not able to be extracted from the total, but the numbers are likely to be a small portion of the total.)

[iii] The 2000 decennial census underestimated the number of people in the civilian labor force which led NYMTC to use Local Area Unemployment Statistics (LAUS) from the Bureau of Labor Statistics as the data source for borough level projections. Despite the overall census underestimate in 2000, the 2000 *distribution* of the civilian labor force population by TAZ was deemed appropriate to allocation the 2010-2040 projected civilian labor force populations to the TAZ level.

[iv] One shortcoming of this approach is that not all 5 to 19 year old residents are enrolled in a school located in the same TAZ of residence. This is particularly true for high school students.

[v] The age/sex distribution of the undercounted population in New York City was not available. At the national level, undercount rates by age/sex were available through demographic analysis, so we employed this distribution to make adjustments to the city's population.

[vi] Survival rates are not precisely the proportion surviving to the next age group. Instead, they are calculated

through a life table, which determines survival in terms of life expectancy and person years lived within an interval against all remaining intervals. This is because each age group is not subject to the exact same chances of dying, since people are distributed evenly throughout the age group. For instance, the 0-4 year old age group is not merely comprised of infants at the beginning of the projection. Rather, it includes infants, 1, 2, 3, and 4 year olds alike. This is why a simple proportion cannot be applied to each age group -- people are moving to the next age group before the five year period has concluded and are thus subject to a different probability of dying.

[vii] For each decade, migration rates were calculated for a 5 year period and then averaged to create the rate for the entire decade. The rates for 1990-2000 and 2000-2010 were then averaged to create a rate for the entire 1990-2010 period

[viii] The crude migration rate (CMR) is calculated by adding the estimated number of net migrants in the first portion of the relevant historical period to the net migrants in the second portion of the period, dividing by 2, then dividing that figure by the mid year population of the same period. For example, to obtain the CMR for 1990-2000, 1990-1995 net migrants would be added to the 1995-2000 net migrants, then divided by two, then divided once again by the 1995 population. A rate for 2000-2010 would be calculated in a similar manner and the rates for the two decades would then be averaged.

While the age-structure of migration can be altered by changing age-specific rates, adjusting the overall CMR changes migration rates across all age groups while maintaining the overall pattern of migration by age.

[ix] 18 TAZs crossed PUMA boundaries. For each split, TAZ to PUMA proportions were calculated.