Demographic Analysis

Migration:
Estimation Using Residual Methods -
Internal and International Applications
Indirect Estimation of Migration Through Residual Methods

Outline of this session:

- Q - What is a residual method?
- A - An application of the demographic balancing equation on a broad scale.
  - Intercensal survival estimates for a sub-national area (CSRMig.xls or LTCSRMig.xls)
  - Life table survival estimates of net migration between two censuses (LTCSRMig.xls)
  - Estimation based on discrepancies with cohort component projections (Introduction to RUPCEN.xls and ResidualMigBetaZA.xls)

- Group activities
Indirect Estimation of Migration Through Residual Methods

The Basic Question: What is a residual method?

– As noted earlier, migration is very difficult to measure, and net migration is the component that it is hardest to measure among the components of the demographic balancing equation.

– Therefore, an indirect way of measuring net migration is to assume that all other components are correctly measured. If so, net migration will be the residual amount that allows the equation to balance …
Indirect Estimation of Migration Through Residual Methods

\[ \text{Pop.}_2 = \text{Pop.}_1 + \text{Births} - \text{Deaths} + \text{Net Migration} \]

\[ (T2) \quad (T1) \quad (B) \quad (D) \quad (NM) \]

Rearranging the demographic balancing equation allows us to estimate net migration as the residual difference of the other components

\[ \text{Net Migration} = \text{Pop.}_2 - \text{Pop.}_1 - \text{Births} + \text{Deaths} \]

\[ (NM) \quad (T2) \quad (T1) \quad (B) \quad (D) \]
Questions About the Reliability of Residual Methods

Net Migration = Pop.2 – Pop.1 – Births + Deaths
(NM) (T2) (T1) (B) (D)

• How complete are population counts in T2 and T1? (absolute and relative)

• How complete are estimates of births?

• How complete are estimates of deaths?
Further Challenges in Applying Residual Methods at the Sub-national level (rural, state, village, etc.)

Net Migration = Pop – Pop – Births + Deaths
(NM) (T2) (T1) (B) (D)

• Completeness of census counts may vary strongly across localities.
• Birth and death records may not be available (and if derived from surveys, there is statistical uncertainty).
• Such uncertainties are compounded by spatial sensitivity – the less populous the locality, the more sensitive it is to migration flows.
The Residual Method Can be Applied to Each Cohort

EXAMPLE – Use residual methods to estimate net migration of the cohort aged 0-4 in 2000 by the time they reach 10-14.

Net migration would be zero if the decline in that cohort counted between 2000 and 2010 was equal to the number of deaths reported for that cohort ...

\[
\text{Net migration} = \text{Pop.10-14} - \text{Pop.0-4} - \text{Births} + \text{Deaths} \\
\text{(2010)} - \text{(2000)} + \text{(2000-10)}
\]
Measuring Internal Migration (Indirect Estimation)

A variety of indirect methods that apply residual methods are available to estimate net internal migration. The following are based on results of two censuses:

- Census survival ratio method (CSRMIG.xls or LTCSRMig.xls) for one subnational area
- Life table survival ratios from two censuses (LTCSRMig.xls)
  - Forward survival from an earlier census
  - Reverse survival
  - Composite
- Formal cohort component projections
Using Residuals to Estimate Net Migration

Spreadsheets ranked based on increasing detail and complexity of assumptions

- Intercensal Survival (CSRmig.xls or LTCSRMig.xls)
- Life Table Survival (LTCSRMig.xls)
- Formal Cohort Component Projections (RUPCEN.xls or ResidualMigBetaZA.xls)
Estimating Net Migration in a Sub-National Area

Inter-Censal Survival (CSRmig or LTCSRmig) – Computes Net Migration in a Sub-National Area Using 2 Censuses

- Requires population distributions by sex and 5-year ages for the nation and one sub-area at 2 points in time.
- Mortality by age is *computed* based on survival probabilities of cohorts in the national counts.
- National survival probabilities are applied to sub-national counts (by age) at the time of the first census to estimate the cohort counts at the second census.
- Discrepancies between the actual and estimates counts at the second census are presumed to indicate net migration in the sub-national area.
## Census Survival Rate Method for Estimating Internal Migration

### A. Reported Populations by Age, Sex, and Residence

<table>
<thead>
<tr>
<th>Year and Age</th>
<th>Total</th>
<th>Subarea</th>
</tr>
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<tbody>
<tr>
<td>0-4</td>
<td>929,600</td>
<td>241,850</td>
</tr>
<tr>
<td>5-9</td>
<td>1,152,430</td>
<td>241,850</td>
</tr>
<tr>
<td>10-14</td>
<td>1,181,450</td>
<td>256,875</td>
</tr>
<tr>
<td>15-19</td>
<td>1,074,430</td>
<td>259,075</td>
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<tr>
<td>20-24</td>
<td>941,775</td>
<td>235,690</td>
</tr>
<tr>
<td>25-29</td>
<td>800,710</td>
<td>206,700</td>
</tr>
<tr>
<td>30-34</td>
<td>660,870</td>
<td>182,195</td>
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<tr>
<td>35-39</td>
<td>645,045</td>
<td>173,025</td>
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<tr>
<td>40-44</td>
<td>640,765</td>
<td>171,275</td>
</tr>
<tr>
<td>45-49</td>
<td>613,410</td>
<td>165,025</td>
</tr>
<tr>
<td>50-54</td>
<td>518,900</td>
<td>158,625</td>
</tr>
<tr>
<td>55-59</td>
<td>472,415</td>
<td>149,275</td>
</tr>
<tr>
<td>60-64</td>
<td>381,690</td>
<td>135,375</td>
</tr>
<tr>
<td>65-69</td>
<td>296,050</td>
<td>111,975</td>
</tr>
<tr>
<td>70-74</td>
<td>205,575</td>
<td>73,975</td>
</tr>
<tr>
<td>75+</td>
<td>280,150</td>
<td>92,025</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>10,795,265</td>
<td>2,690,730</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>Total</th>
<th>Subarea</th>
</tr>
</thead>
<tbody>
<tr>
<td>1981</td>
<td>12,068,290</td>
<td>3,054,625</td>
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</table>

Source: CSRMig – Enter Pop. By Age and Sex for 2 Points in Time; National and One Sub-area
2. Census Survival Rates, by Age/Sex
CSRMig – Output: Estimates of Net Migration for Sub-National Area Between the Census Dates

1. Net Number of Migrants, by Age/Sex

Graph showing net number of migrants by age and sex.
### Table 6. Estimates of Net Migration of Females for Manila, 1960-1970

<table>
<thead>
<tr>
<th></th>
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<td>0-4</td>
<td>2,218,377</td>
<td>1.1172</td>
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<td>2,871,594</td>
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<td>5-9</td>
<td>2,114,832</td>
<td>0.9915</td>
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<td>2,893,681</td>
<td>70,875</td>
<td>83,054</td>
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<td>10-14</td>
<td>1,669,435</td>
<td>0.9729</td>
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<td>2,478,426</td>
<td>63,250</td>
<td>79,489</td>
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<tr>
<td>15-19</td>
<td>1,429,547</td>
<td>0.8893</td>
<td></td>
<td>2,096,954</td>
<td>85,618</td>
<td>101,410</td>
<td>31,134</td>
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<tr>
<td>20-24</td>
<td>1,264,441</td>
<td>0.8413</td>
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<td>1,624,113</td>
<td>75,793</td>
<td>90,410</td>
<td>28,877</td>
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<tr>
<td>25-29</td>
<td>1,000,981</td>
<td>0.9571</td>
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<td>1,271,238</td>
<td>60,037</td>
<td>56,055</td>
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<tr>
<td>30-34</td>
<td>791,473</td>
<td>0.9513</td>
<td></td>
<td>1,063,783</td>
<td>34,813</td>
<td>44,648</td>
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<tr>
<td>35-39</td>
<td>725,906</td>
<td>0.9042</td>
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<td>938,013</td>
<td>31,927</td>
<td>36,963</td>
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<td>40-44</td>
<td>552,585</td>
<td>0.9295</td>
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<td>752,922</td>
<td>24,297</td>
<td>28,873</td>
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<tr>
<td>45-49</td>
<td>508,045</td>
<td>0.7966</td>
<td></td>
<td>656,332</td>
<td>20,207</td>
<td>23,678</td>
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<tr>
<td>50-54</td>
<td>344,745</td>
<td>0.8770</td>
<td></td>
<td>513,635</td>
<td>13,714</td>
<td>19,063</td>
<td>-5,251</td>
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<tr>
<td>55-59</td>
<td>235,536</td>
<td>0.8352</td>
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<td>404,713</td>
<td>9,366</td>
<td>14,484</td>
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<tr>
<td>60-64</td>
<td>199,118</td>
<td>0.7116</td>
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<td>302,336</td>
<td>7,921</td>
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<tr>
<td>65-69</td>
<td>369,795</td>
<td>0.5624</td>
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<td>196,716</td>
<td>11,114</td>
<td>6,405</td>
<td>-1,417</td>
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<tr>
<td>70-74</td>
<td>141,689</td>
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<td></td>
<td></td>
<td>3,746</td>
<td>5,636</td>
<td>-1,890</td>
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<tr>
<td>75+</td>
<td>207,990</td>
<td></td>
<td></td>
<td></td>
<td>4,779</td>
<td>6,251</td>
<td>-1,472</td>
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<tr>
<td>All ages</td>
<td>13,424,816</td>
<td>589,207</td>
<td></td>
<td>18,434,135</td>
<td>689,132</td>
<td>551,258</td>
<td>-40,224</td>
</tr>
</tbody>
</table>

**NOTES:** Column (3) = population 1970, age x divided by population 1960, age x-10; column (6) = column (4) (age - 10) times survival rate in column (3); column (7) = column (5) minus column (6)

For ages under 10, net-migration estimates are derived as follows: for age 0-4: 1/4 (ratio of population 0-4 to female population aged 15-44) times net migration for females aged 15-44; for age 5-9: 3/4 (ratio of population 5-9 to female population aged 20-49) times net migration for females aged 20-49.
Using Residuals to Estimate Net Migration

Spreadsheets ranked based on increasing detail and complexity of assumptions

- Inter-Censal Survival (CSRmig.xls or LTCSRMig.xls)
- Life Table Survival (LTCSRMig.xls)
- Formal Cohort Component Projections (RUPCEN.xls or ResidualMigBetaZA.xls)
Using Residuals to Estimate Net Migration

Life Table Survival – Computes Net Migration based on 2 Censuses and Life Table Values

- If life table survival probabilities are available, one can apply these to census data by sex and 5-year ages
- Calculate net migration by 1) surviving the 1st census population to time of the second or 2) reverse surviving the 2nd census population to time of the first
- Discrepancies between the actual and estimated counts are presumed to indicate net migration
- This method can be used to estimate net migration for the nation and local areas.
Measuring Internal Migration (Forward Survival)

First census
$P_{0-4}$
$P_{5-9}$
$\ldots$
$P_{75-79}$
$P_{80+}$

Life table survival ratios $S_{x,x+10}$
\[S_{x,x+10} = \frac{L_{x+10}}{L_x}\]

Equivalent to

Expected population
$P_{10-14}$
$P_{15-19}$
$\ldots$
$P_{80+}$ at second census

=  

Expected population
$P_{10-14}$
$P_{15-19}$
$\ldots$
$P_{80+}$ at second census

-  

Second census
$P_{10-14}$
$P_{15-19}$
$\ldots$
$P_{80+}$, ages at second census

=  

Implied migrants
Measuring Internal Migration
(Reverse Survival)

Second census
P$_{10-14}$
P$_{15-19}$
... 
P$_{80+}$

Life table survival ratios $1/(S_x)$
i.e.,
$L_x / L_{x+10}$

Expected population
P$_{0-4}$
P$_{5-9}$
... 
P$_{70+}$ at first census

Expected population
P$_{0-4}$
P$_{5-9}$
... 
P$_{70+}$ at first census

First census
P$_{0-4}$
P$_{5-9}$
... 
P$_{75-79}$
P$_{70+}$

Implied migrants
P$_{0-4}$
P$_{5-9}$
... 
P$_{70+}$, ages at first census
Measuring Internal Migration (Composite)

Successive census counts typically differ in their completeness. Thus, for cohorts common to two censuses, forward survival estimates of migration from an earlier census will differ from backward survival estimates from a later census.

If one census is more fully reported, migration estimates based on survival to/from that census should be more accurate.

If relative census completeness is unknown, one may take a composite of the above estimates.
Measuring Internal Migration (Composite)

Implied migrants
\[ P_{0-4} \]
\[ P_{5-9} \]
\[ \ldots \]
\[ P_{70+} \], ages at first census

\[ P_{10-14} \]
\[ P_{15-19} \]
\[ \ldots \]
\[ P_{80+} \], ages at second census

\[ + \]

\[ = \]

\[ 2 \]

Implied migrants for cohort aged \( P_x \) ages at mid-intercensal period
These methods estimate net migration for a cohort that has been counted at two points in time.

Such cohorts, however, typically pass through several age groups, across which migration rates may differ. These cohort-based estimates of net migration are consistent with any number of period-based rates for the age groups the cohort passes through.

Consider the lexis diagram ....
Lexis Diagram Dissection of Cohort Migrants

Cohort migrants age 10-14 in 2015
Lexis Diagram Disection of Cohort Migrants

Migrants ages 10-15
Lexis Diagram Dissection of Cohort Migrants

Age

0 5 10 15

Time


Migrants ages 5-9
Lexis Diagram Dissection of Cohort Migrants

Migrants ages 5-9

Cohort migrants age 5-9 in 2015
Using Residuals to Estimate Net Migration

Spreadsheets ranked based on increasing detail and complexity of assumptions

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- Formal Cohort Component Projections (RUPCEN.xls or ResidualMigBetaZA.xls)
Using Residuals to Estimate Net Migration

RUPCEN

More refined estimates of net migration by age and sex can be produced through cohort-component projections. Mean net migration by age/sex can be estimated using residual techniques:

1. When a new census is available, estimate the counts by projecting forward from an earlier census (assuming zero migration)
2. Determine the residual between the expected count and the projected count
3. Estimate the migration implied by that residual
Using Residuals to Estimate Net Migration

RUPCEN

Compared to other methods, the main advantage of the cohort component approach is flexibility. For instance,

- Cohort projections generate annual cohorts of births, so net migration can also be estimated for young children
- Some projections software allow life table probabilities to change over time
- Other refinements and customization are available through ResidualMigBetaZA, which allows annual patterns of migration to vary
RUPCEN Output –
Implied Net International Migration

Population by Age

Projected to 2000 from 1990 Census with no migration

Counted in Census, 2000

Would use of residual methods here imply net in-migration or net out-migration 1990-2000?
## Summary Features of Methods to Measure Net Migration Using Two Censuses

<table>
<thead>
<tr>
<th>Method</th>
<th>Application</th>
<th>Survival based on</th>
<th>Flexibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSRMig.xls (PAS) or LTCSRMIg.xls (SPToolkit)</td>
<td>Internal Cohort survival</td>
<td>Lower</td>
<td></td>
</tr>
<tr>
<td>LTCSRMIg.xls (SPToolkit)</td>
<td>Internal Life Tables</td>
<td>Medium</td>
<td></td>
</tr>
<tr>
<td>RUPCEN.xls or ResidualMigBetaZA.xls (NewPAS)</td>
<td>Internal Life Tables (cohort International component)</td>
<td>Highest</td>
<td></td>
</tr>
</tbody>
</table>
Exercises

• Estimate net migration as a residual based on the demographic balancing equation.

• Based on the components of the balancing equation in your country, what is your estimate of net intercensal migration (or internal migration for a subarea)? If you are uncertain about those components, what is a reasonable range of estimates?