**Estimação de taxas de migração por grupos etários com dados de última etapa e data fixa**
(POP/866 – Tópicos Avançados de Pesquisa em Migração)
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Fórmula original de Machado (1993) das Taxas Específicas de Emigração ($TEE_{x,ij}$):

$$TEE_{x,ij} = \frac{\sum_{t=0}^{4} K_{t,ij}}{K_{1,.i} + 2K_{2,.i} + 3K_{3,.i} + 4K_{4,.i} + 5K_{nm,i}}$$

Reformulação matemática das $TEE_{x,ij}$ (Amaral, Rodrigues e Fígoli 2004):

$$TEE_{x,ij} = \frac{\sum_{t=0}^{4} K_{t,ij}}{\begin{aligned} &0{,}5K_{0,.i} + 1{,}5K_{1,.i} + 2{,}5K_{2,.i} + 3{,}5K_{3,.i} + 4{,}5K_{4,.i} + \\ &4{,}5K_{0,i.} + 3{,}5K_{1,i.} + 2{,}5K_{2,i.} + 1{,}5K_{3,i.} + 0{,}5K_{4,i.} + \\ &5K_{nm,i} \end{aligned}}$$

onde:

$TEE_{x,ij}$ = Taxa Específica de Emigração da região $i$ para a região $j$, na faixa etária $x$;

$K_{t,ij}$ = população que migrou de $i$ para $j$, com tempo de residência atual igual a $t$. Sendo $t = 0$ para aqueles que migraram há menos de 1 ano; $t = 1$ para aqueles que migraram há um ano, e assim por diante;

$K_{t,.i}$ = somatório dos migrantes de todas as $k$ regiões ($k \neq i$) para a região $i$ que moram na residência atual há $t$ anos (número de pessoas-ano dos imigrantes que passam a ter o risco de migrar dessa nova região de destino);

$K_{t,i.}$ = somatório dos migrantes da região $i$ para todas as $k$ regiões ($k \neq i$), com tempo de residência igual a $t$ (número de pessoas-ano que esse migrante esteve exposto ao risco de emigrar de sua região de origem);

$K_{nm,i}$ = todos os residentes em $i$ no fim do período que já moravam em $i$ no início do período de análise ($nm$ = não-migrantes).

Em seguida, é estimada a Taxa de Não-Emigração Total (TNT):

$$TNT_{ij} = \exp\left[-\int_{0}^{x} TEE(u)\,du\right] = \exp\left(-\sum TEE_{x,ij}\right)$$

Por fim, é calculada a Taxa de Emigração Total (TET):

$$TET_{ij} = 1 - TNT_{ij}$$

A fórmula para a estimação das taxas de migração com dados de data fixa (Amaral, Rodrigues e Fígoli 2004) é a seguinte:

$$TEE_{x,ij} = \frac{\sum K_{ij}}{t * \sum\left[\dfrac{(K_{i.} + K_{ii}) + (K_i)}{2}\right]}$$

onde:

$TEE_{x,ij}$ = Taxa Específica de Emigração da região $i$ para a região $j$, na faixa etária $x$;

$K_{ij}$ = população que estava na localidade $i$ em 1º de setembro de 1986 e que residia na localidade $j$ na data de referência do censo;

$K_{i.}$ = população que estava na localidade $i$ em 1º de setembro de 1986 e que residia em uma outra localidade na data de referência do censo;

$K_{ii}$ = população que estava na localidade $i$ em 1º de setembro de 1986 e que continuava residindo em $i$ na data de referência do censo;

$K_i$ = toda população que reside em $i$ na data de referência do censo; e

$t$ = anos entre a data de referência do censo e a data de referência da pergunta de migração de data fixa.

**Improvements of Techniques to Estimate Migration Rates:**
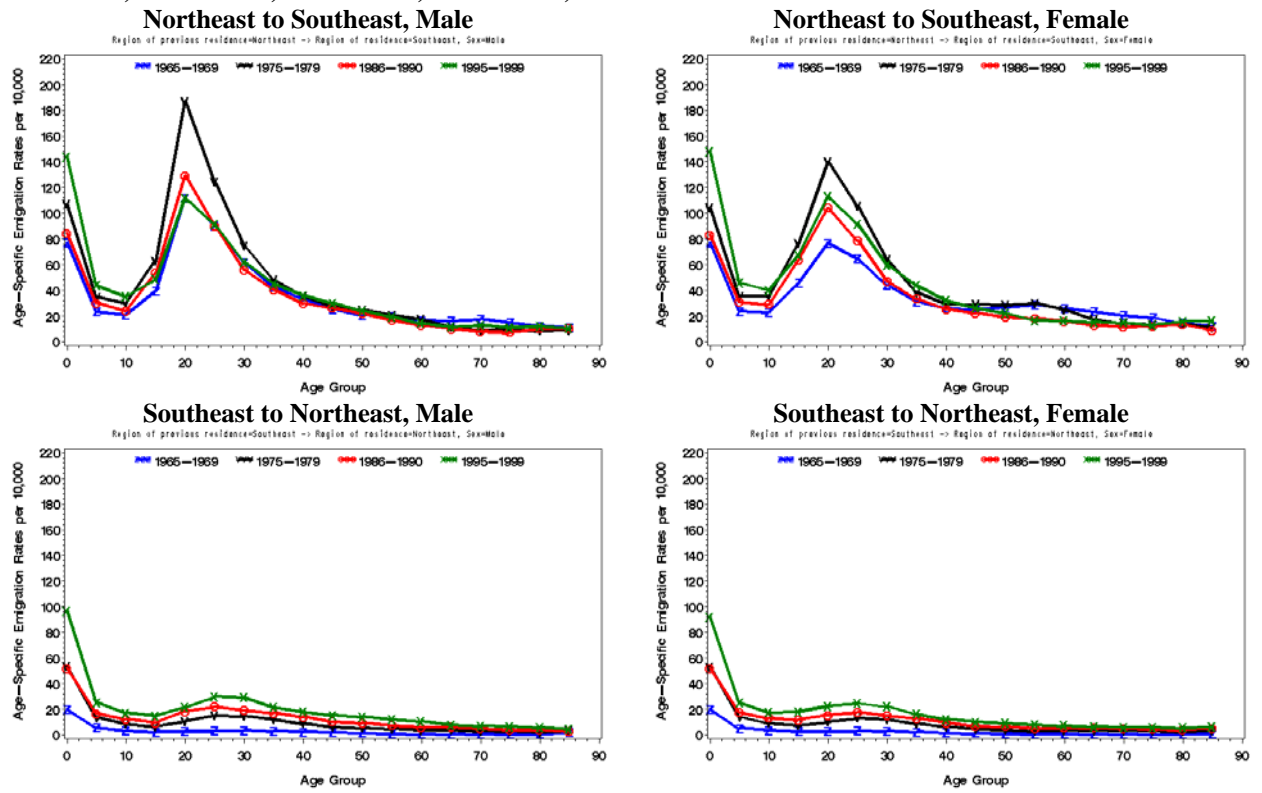**an Application with Brazilian Censuses Data**

Ernesto Friedrich de Lima Amaral

**Table 1: Emigration Descriptive Statistics by Sex for the Northeast and Southeast, 1965–1969, 1975–1979, 1986–1990, 1995–1999**

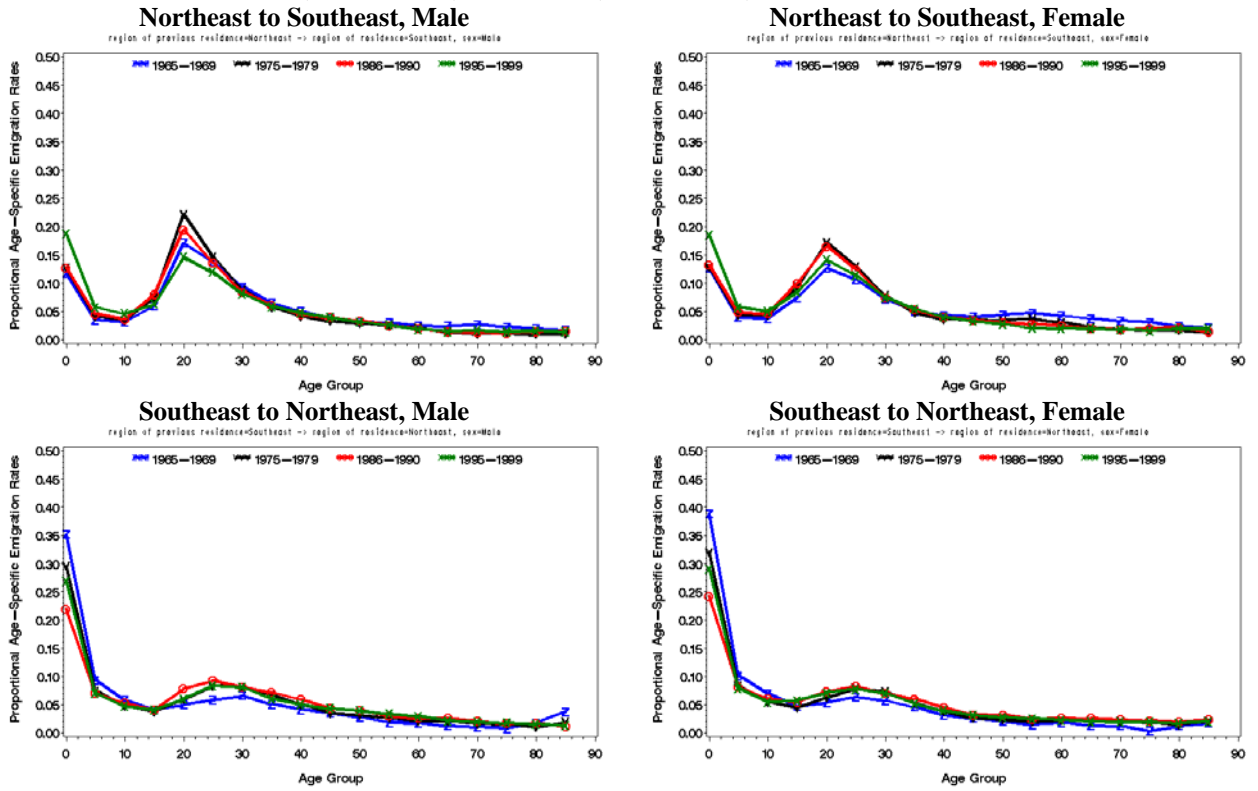| Region | 1965–1969 | | 1975–1979 | | 1986–1990 | | 1995–1999 | |
|---|---|---|---|---|---|---|---|---|
| | **Male** | **Female** | **Male** | **Female** | **Male** | **Female** | **Male** | **Female** |
| **Total Number of Emigrants** | | | | | | | | |
| Northeast to Southeast | 275,271 | 257,916 | 479,296 | 475,917 | 466,599 | 462,223 | 584,140 | 632,166 |
| Southeast to Northeast | 33,413 | 31,537 | 131,967 | 122,312 | 220,213 | 199,642 | 354,671 | 319,506 |
| **Population at the Beginning of the Period** | | | | | | | | |
| Northeast to Southeast | 15,231,876 | 15,647,004 | 17,922,897 | 18,661,136 | 21,386,107 | 22,347,267 | 24,125,153 | 25,153,124 |
| Southeast to Northeast | 19,356,335 | 19,433,996 | 24,854,997 | 25,082,990 | 30,494,899 | 31,387,211 | 34,533,615 | 35,955,314 |
| **Proportion of Emigrants on the Population of Origin** | | | | | | | | |
| Northeast to Southeast | 0.0181 | 0.0165 | 0.0267 | 0.0255 | 0.0218 | 0.0207 | 0.0242 | 0.0251 |
| Southeast to Northeast | 0.0017 | 0.0016 | 0.0053 | 0.0049 | 0.0072 | 0.0064 | 0.0103 | 0.0089 |
| **Total Emigration Rate ($TER_{ij}$)** | | | | | | | | |
| Northeast to Southeast | 0.0635 | 0.0591 | 0.0808 | 0.0780 | 0.0642 | 0.0611 | 0.0737 | 0.0768 |
| Southeast to Northeast | 0.0057 | 0.0051 | 0.0179 | 0.0165 | 0.0235 | 0.0212 | 0.0353 | 0.0310 |

*Source:* IBGE 1970, 1980, 1991, 2000.

**Figure 1: Age-specific Emigration Rates (*ASER*$_{x,ij}$) by Age Group and Sex for the Northeast and Southeast, 1965–1969, 1975–1979, 1986–1990, 1995–1999**
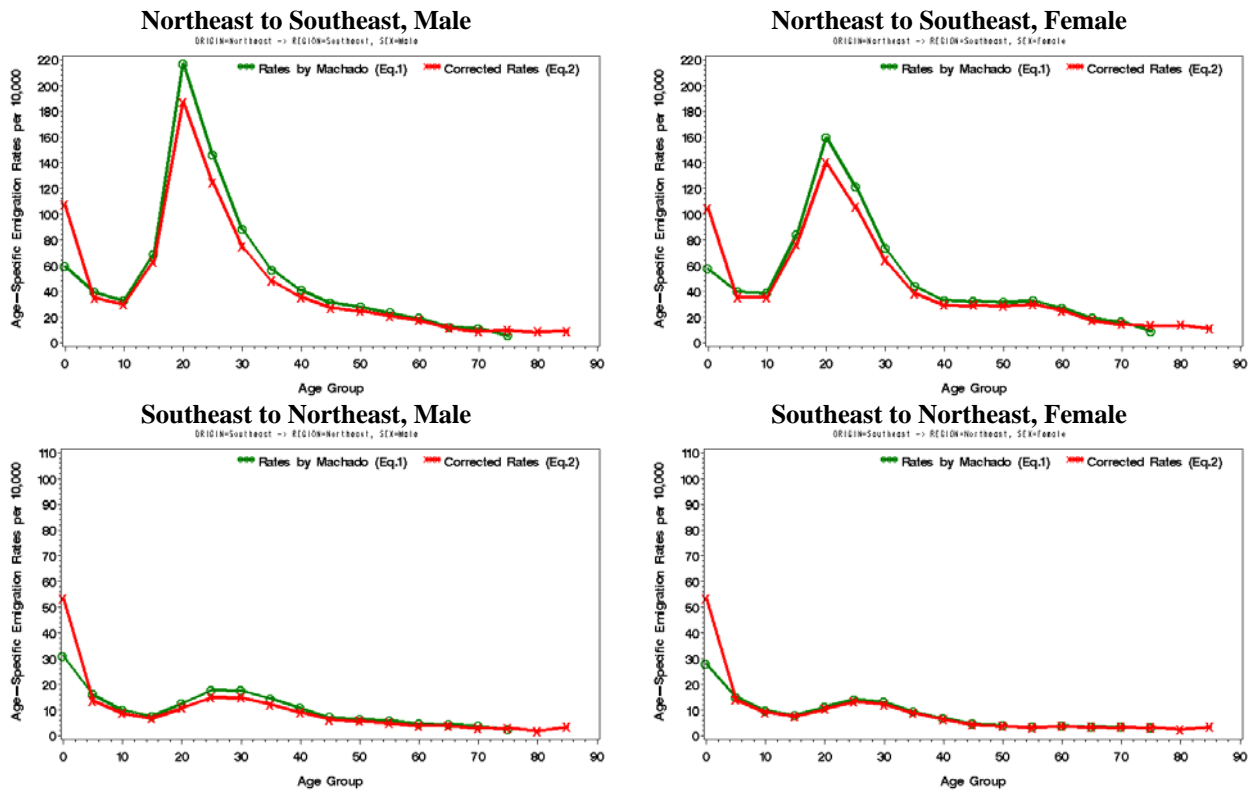


*Source:* IBGE 1970, 1980, 1991, 2000.

**Figure 2: Proportional Age-specific Emigration Rates ($ASER_{x,ij}$) by Age Group and Sex for the Northeast and Southeast, 1965–1969, 1975–1979, 1986–1990, 1995–1999**



*Source:* IBGE 1970, 1980, 1991, 2000.

**Figure 3: Age-specific Emigration Rates (*ASER*$_{x,ij}$) by Age Group and Sex for the Northeast and Southeast, Using Rates Estimated by Machado (Equation 1) and Corrected Rates (Equation 2), 1975–1979**

**Northeast to Southeast, Male**

**Northeast to Southeast, Female**

**Southeast to Northeast, Male**

**Southeast to Northeast, Female**

*Source:* Machado 1993; and IBGE 1980.
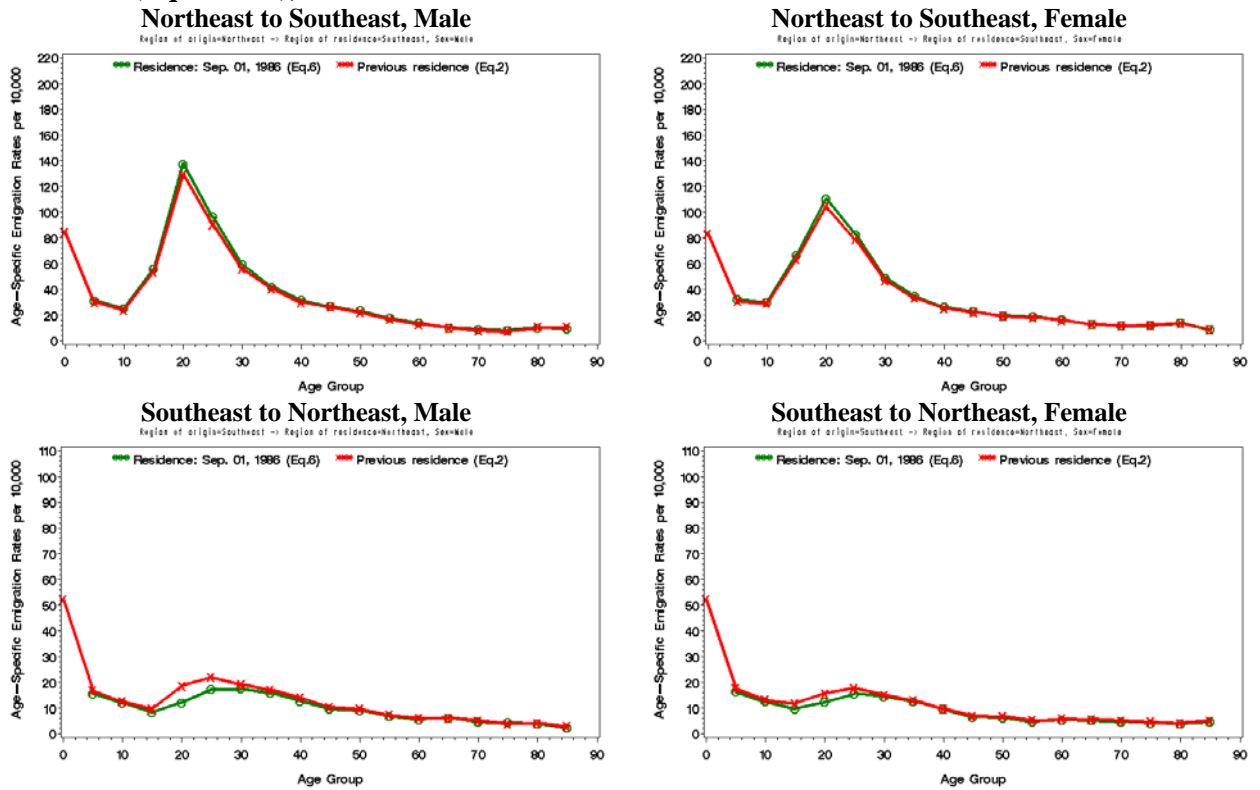
**Figure 4: Age-specific Emigration Rates (*ASER$_{x,ij}$*) by Age Group and Sex for the Northeast and Southeast, Using Data on Residence Five Years Before the Census (Equation 6) and Previous Residence (Equation 2), 1986–1990**

**Northeast to Southeast, Male**

**Northeast to Southeast, Female**

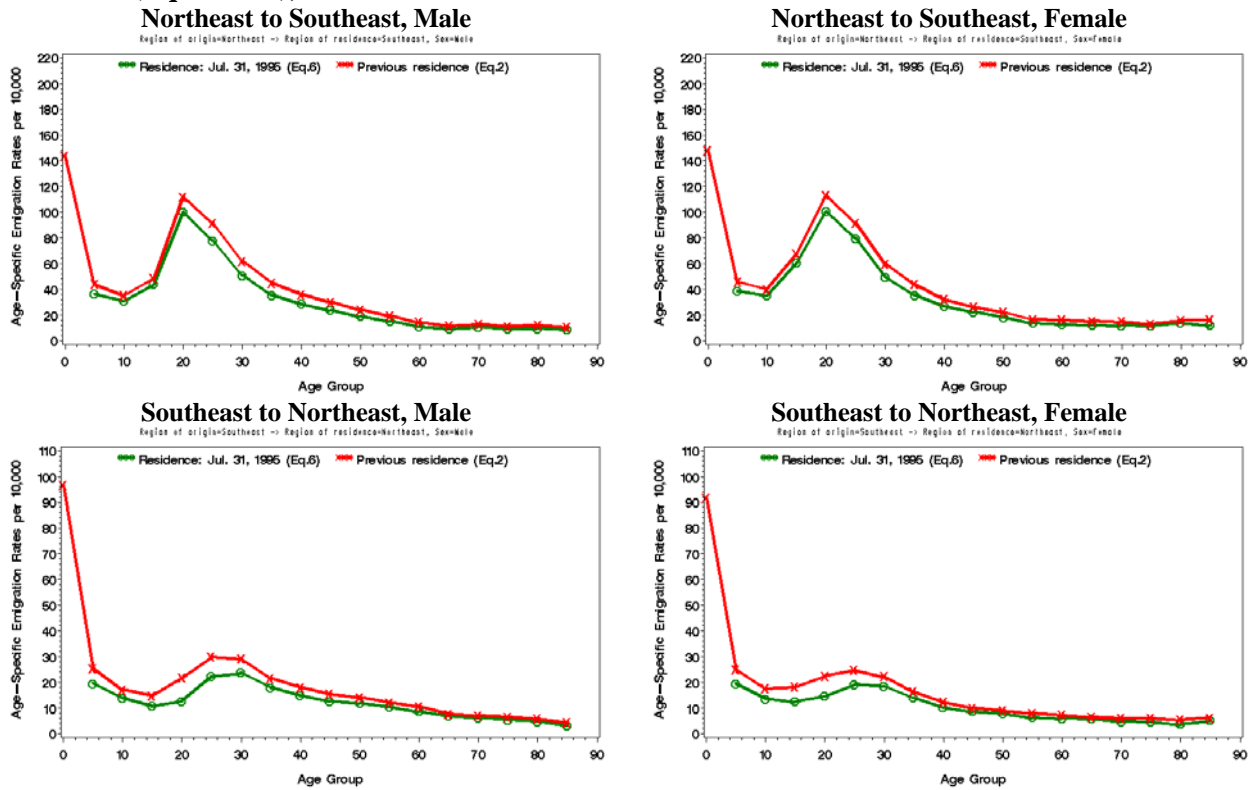**Southeast to Northeast, Male**

**Southeast to Northeast, Female**

*Source:* IBGE 1991.

**Figure 5: Age-specific Emigration Rates (*ASER$_{x,ij}$*) by Age Group and Sex for the Northeast and Southeast, Using Data on Residence Five Years Before the Census (Equation 6) and Previous Residence (Equation 2), 1995–1999**

**Northeast to Southeast, Male**

**Northeast to Southeast, Female**

**Southeast to Northeast, Male**

**Southeast to Northeast, Female**

*Source:* IBGE 2000.

**Appendix 1**

**Table 1: Age-specific Emigration Rates ($ASER_{x,ij}$) by Age Group and Sex from Northeast to Southeast, Estimated with Information on Place of Previous Residence (Last-Move Data) and Duration of Residence (Equation 2), 1965–1969, 1975–1979, 1986–1990, 1995–1999**

| Age group | Male | | | | Female | | | |
|---|---|---|---|---|---|---|---|---|
| | 1965–1969 | 1975–1979 | 1986–1990 | 1995–1999 | 1965–1969 | 1975–1979 | 1986–1990 | 1995–1999 |
| 0–4 | 0.007713 | 0.010679 | 0.008452 | 0.014370 | 0.007701 | 0.010449 | 0.008343 | 0.014788 |
| 5–9 | 0.002309 | 0.003478 | 0.003019 | 0.004388 | 0.002375 | 0.003533 | 0.003096 | 0.004587 |
| 10–14 | 0.002106 | 0.002991 | 0.002417 | 0.003534 | 0.002301 | 0.003543 | 0.002905 | 0.004033 |
| 15–19 | 0.003950 | 0.006305 | 0.005330 | 0.004851 | 0.004573 | 0.007662 | 0.006361 | 0.006740 |
| 20–24 | 0.011213 | 0.018697 | 0.012913 | 0.011203 | 0.007690 | 0.014007 | 0.010422 | 0.011309 |
| 25–29 | 0.009033 | 0.012445 | 0.009046 | 0.009142 | 0.006487 | 0.010558 | 0.007876 | 0.009130 |
| 30–34 | 0.006189 | 0.007497 | 0.005602 | 0.006213 | 0.004397 | 0.006416 | 0.004715 | 0.005989 |
| 35–39 | 0.004299 | 0.004824 | 0.004070 | 0.004509 | 0.003126 | 0.003848 | 0.003346 | 0.004372 |
| 40–44 | 0.003306 | 0.003557 | 0.002994 | 0.003629 | 0.002626 | 0.002935 | 0.002542 | 0.003205 |
| 45–49 | 0.002547 | 0.002741 | 0.002606 | 0.003032 | 0.002493 | 0.002908 | 0.002232 | 0.002631 |
| 50–54 | 0.002067 | 0.002468 | 0.002214 | 0.002441 | 0.002699 | 0.002868 | 0.001912 | 0.002228 |
| 55–59 | 0.001998 | 0.002069 | 0.001694 | 0.001964 | 0.002878 | 0.002999 | 0.001817 | 0.001678 |
| 60–64 | 0.001651 | 0.001739 | 0.001296 | 0.001429 | 0.002595 | 0.002486 | 0.001589 | 0.001626 |
| 65–69 | 0.001633 | 0.001158 | 0.001012 | 0.001137 | 0.002314 | 0.001741 | 0.001291 | 0.001560 |
| 70–74 | 0.001769 | 0.000898 | 0.000815 | 0.001301 | 0.002028 | 0.001424 | 0.001139 | 0.001498 |
| 75–79 | 0.001501 | 0.000984 | 0.000751 | 0.001110 | 0.001875 | 0.001343 | 0.001252 | 0.001299 |
| 80–84 | 0.001257 | 0.000836 | 0.001027 | 0.001216 | 0.001454 | 0.001389 | 0.001345 | 0.001589 |
| 85+ | 0.001103 | 0.000902 | 0.001052 | 0.001064 | 0.001253 | 0.001110 | 0.000899 | 0.001627 |
| $TER_{ij}$* | **0.063536** | **0.080816** | **0.064159** | **0.073679** | **0.059049** | **0.078006** | **0.061136** | **0.076781** |

* $TER_{ij}$ is the Total Emigration Rate.
*Source:* IBGE 1970, 1980, 1991, 2000.

**Table 2: Age-specific Emigration Rates ($ASER_{x,ij}$) by Age Group and Sex from Southeast to Northeast, Estimated with Information on Place of Previous Residence (Last-Move Data) and Duration of Residence (Equation 2), 1965–1969, 1975–1979, 1986–1990, 1995–1999**

| Age group | Male | | | | Female | | | |
|---|---|---|---|---|---|---|---|---|
| | 1965–1969 | 1975–1979 | 1986–1990 | 1995–1999 | 1965–1969 | 1975–1979 | 1986–1990 | 1995–1999 |
| 0–4 | 0.002004 | 0.005335 | 0.005208 | 0.009667 | 0.002004 | 0.005327 | 0.005193 | 0.009171 |
| 5–9 | 0.000536 | 0.001368 | 0.001677 | 0.002539 | 0.000525 | 0.001402 | 0.001749 | 0.002494 |
| 10–14 | 0.000332 | 0.000868 | 0.001254 | 0.001706 | 0.000360 | 0.000919 | 0.001314 | 0.001753 |
| 15–19 | 0.000239 | 0.000675 | 0.000973 | 0.001477 | 0.000244 | 0.000751 | 0.001181 | 0.001823 |
| 20–24 | 0.000284 | 0.001079 | 0.001862 | 0.002176 | 0.000276 | 0.001042 | 0.001566 | 0.002244 |
| 25–29 | 0.000332 | 0.001499 | 0.002202 | 0.003001 | 0.000326 | 0.001324 | 0.001773 | 0.002465 |
| 30–34 | 0.000377 | 0.001487 | 0.001923 | 0.002918 | 0.000296 | 0.001214 | 0.001512 | 0.002223 |
| 35–39 | 0.000292 | 0.001223 | 0.001710 | 0.002164 | 0.000236 | 0.000883 | 0.001297 | 0.001633 |
| 40–44 | 0.000239 | 0.000917 | 0.001407 | 0.001812 | 0.000163 | 0.000638 | 0.000972 | 0.001230 |
| 45–49 | 0.000203 | 0.000628 | 0.001027 | 0.001551 | 0.000133 | 0.000432 | 0.000689 | 0.000998 |
| 50–54 | 0.000159 | 0.000567 | 0.000950 | 0.001419 | 0.000106 | 0.000389 | 0.000687 | 0.000905 |
| 55–59 | 0.000106 | 0.000490 | 0.000723 | 0.001225 | 0.000076 | 0.000328 | 0.000519 | 0.000800 |
| 60–64 | 0.000101 | 0.000383 | 0.000608 | 0.001068 | 0.000096 | 0.000377 | 0.000564 | 0.000721 |
| 65–69 | 0.000070 | 0.000389 | 0.000616 | 0.000781 | 0.000066 | 0.000348 | 0.000556 | 0.000643 |
| 70–74 | 0.000061 | 0.000294 | 0.000499 | 0.000706 | 0.000064 | 0.000347 | 0.000500 | 0.000603 |
| 75–79 | 0.000047 | 0.000293 | 0.000389 | 0.000651 | 0.000019 | 0.000323 | 0.000458 | 0.000606 |
| 80–84 | 0.000099 | 0.000186 | 0.000415 | 0.000583 | 0.000067 | 0.000248 | 0.000410 | 0.000545 |
| 85+ | 0.000214 | 0.000350 | 0.000281 | 0.000451 | 0.000094 | 0.000346 | 0.000507 | 0.000636 |
| $TER_{ij}$* | **0.005681** | **0.017871** | **0.023445** | **0.035260** | **0.005140** | **0.016501** | **0.021220** | **0.031002** |

* $TER_{ij}$ is the Total Emigration Rate.
*Source:* IBGE 1970, 1980, 1991, 2000.

**Appendix 2**

**Table 1: Age-specific Emigration Rates ($ASER_{x,ij}$) by Age Group and Sex between Northeast and Southeast, Estimated by Machado (Equation 1), 1975–1979**

| Age group | Northeast–Southeast | | Southeast–Northeast | |
|---|---|---|---|---|
| | Male | Female | Male | Female |
| 0–4 | 0.005920 | 0.005743 | 0.003097 | 0.002798 |
| 5–9 | 0.003928 | 0.003976 | 0.001604 | 0.001509 |
| 10–14 | 0.003317 | 0.003903 | 0.000997 | 0.000975 |
| 15–19 | 0.006888 | 0.008424 | 0.000767 | 0.000797 |
| 20–24 | 0.021708 | 0.015960 | 0.001266 | 0.001117 |
| 25–29 | 0.014639 | 0.012145 | 0.001777 | 0.001423 |
| 30–34 | 0.008851 | 0.007368 | 0.001764 | 0.001310 |
| 35–39 | 0.005698 | 0.004405 | 0.001447 | 0.000938 |
| 40–44 | 0.004089 | 0.003314 | 0.001080 | 0.000674 |
| 45–49 | 0.003122 | 0.003249 | 0.000723 | 0.000454 |
| 50–54 | 0.002789 | 0.003174 | 0.000651 | 0.000406 |
| 55–59 | 0.002320 | 0.003285 | 0.000587 | 0.000344 |
| 60–64 | 0.001906 | 0.002711 | 0.000457 | 0.000392 |
| 65–69 | 0.001262 | 0.001911 | 0.000441 | 0.000356 |
| 70–74 | 0.001115 | 0.001663 | 0.000360 | 0.000347 |
| 75+ | 0.000548 | 0.000898 | 0.000257 | 0.000336 |

*Source:* Machado 1993.

**Appendix 3**

**Table 1: Age-specific Emigration Rates ($ASER_{x,ij}$) by Age Group and Sex between Northeast and Southeast, Estimated with Information on Place of Residence at a Fixed Prior Date (Equation 6), 1986–1990, 1995–1999**

| Age group | 1986–1990 | | | | 1995–1999 | | | |
|---|---|---|---|---|---|---|---|---|
| | Northeast–Southeast | | Southeast–Northeast | | Northeast–Southeast | | Southeast–Northeast | |
| | Male | Female | Male | Female | Male | Female | Male | Female |
| 0–4 | —— | —— | —— | —— | —— | —— | —— | —— |
| 5–9 | 0.003136 | 0.003217 | 0.001570 | 0.001634 | 0.003634 | 0.003858 | 0.001962 | 0.001949 |
| 10–14 | 0.002539 | 0.003029 | 0.001206 | 0.001250 | 0.003119 | 0.003519 | 0.001388 | 0.001373 |
| 15–19 | 0.005579 | 0.006688 | 0.000828 | 0.000971 | 0.004378 | 0.006038 | 0.001082 | 0.001248 |
| 20–24 | 0.013775 | 0.011043 | 0.001215 | 0.001228 | 0.010023 | 0.010074 | 0.001277 | 0.001467 |
| 25–29 | 0.009645 | 0.008278 | 0.001725 | 0.001563 | 0.007785 | 0.007955 | 0.002235 | 0.001916 |
| 30–34 | 0.005942 | 0.004899 | 0.001745 | 0.001447 | 0.005093 | 0.004950 | 0.002375 | 0.001853 |
| 35–39 | 0.004210 | 0.003469 | 0.001588 | 0.001267 | 0.003554 | 0.003546 | 0.001795 | 0.001392 |
| 40–44 | 0.003169 | 0.002607 | 0.001271 | 0.000952 | 0.002871 | 0.002686 | 0.001491 | 0.001024 |
| 45–49 | 0.002678 | 0.002283 | 0.000961 | 0.000655 | 0.002394 | 0.002231 | 0.001281 | 0.000858 |
| 50–54 | 0.002318 | 0.001966 | 0.000913 | 0.000626 | 0.001906 | 0.001857 | 0.001190 | 0.000786 |
| 55–59 | 0.001755 | 0.001885 | 0.000691 | 0.000469 | 0.001523 | 0.001384 | 0.001053 | 0.000637 |
| 60–64 | 0.001405 | 0.001609 | 0.000562 | 0.000533 | 0.001101 | 0.001276 | 0.000861 | 0.000599 |
| 65–69 | 0.001003 | 0.001307 | 0.000634 | 0.000514 | 0.000926 | 0.001220 | 0.000692 | 0.000574 |
| 70–74 | 0.000894 | 0.001156 | 0.000465 | 0.000470 | 0.001069 | 0.001173 | 0.000619 | 0.000475 |
| 75–79 | 0.000822 | 0.001214 | 0.000418 | 0.000412 | 0.000907 | 0.001144 | 0.000532 | 0.000459 |
| 80–84 | 0.001008 | 0.001384 | 0.000394 | 0.000393 | 0.000946 | 0.001384 | 0.000485 | 0.000366 |
| 85+ | 0.000959 | 0.000889 | 0.000227 | 0.000462 | 0.000863 | 0.001201 | 0.000334 | 0.000513 |

*Source:* IBGE 1991, 2000.

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