

1-Migration Tidy

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Preparing Migration Data

The Internal Revenue Service (IRS) maintains a [dataset of county-to-county level migration](#) from 1990 to 2013. Migration data for the United States are based on year-to-year address changes reported on individual income tax returns filed with the IRS. They present migration patterns by state or by county for the entire United States and are available for inflows—the number of new residents who moved to a state or county and where they migrated from, and outflows—the number of residents leaving a state or county and where they went. The data are available for filing years 1991 through 2013 and include:

- **Return_Num** - number of returns filed, which approximates the number of households that migrated.
- **Exmpt_Num** - number of personal exemptions claimed, which approximates the number of individuals.
- **Aggr_AGI** or **AGI** - total adjusted gross income, starting with filing year 1995.
- Aggregate migration flows at the state level, by the size of adjusted gross income (AGI) and age of the primary taxpayer, starting with filing year 2011.

Data have yet to be parsed for 1990 and 1991 because the `.txt` format is not easily readable. Further, because of data concerns with a large number of negative income flows of extremely unlikely negative values for income flows, the 1993 and 1994 years are omitted:

Table 1: Inflows

year	ofips	dfips	Return_Num	Exmpt_Num	Aggr_AGI
1994	63010	21137	71	164	-998560
1994	51059	51630	97	195	-995284
1994	48027	48201	263	546	-994258
1994	1	21137	475	1132	-990239
1994	53033	53011	519	976	-979406

Table 2: Outflows

year	ofips	dfips	Return_Num	Exmpt_Num	Aggr_AGI
1994	21001	63020	53	129	-999190
1994	21001	1	206	425	-996416
1994	51059	51630	97	195	-995284
1994	48027	48201	263	546	-994258
1994	53033	53011	519	976	-979406

where **Return_num** indicates aggregate tax returns between the origin county (*ofips*) and destination county (*dfips*) to proxy for number of households; **Exmpt-num** refers to the number of exemptions filed which proxies population; **Aggr_AGI** is the sum of Adjusted Gross Income for all filers and is in units of \$1,000s.

Note: I will document using the inflows data although the outflows data tells a similar story.

Further Analysis of Negative Values

The negative values undoubtedly are due to some sort of clerical or data conversion error. These may still be recoverable though seeing that summary statistics are still available. The first task is to try and detect these outliers through some sort of metric. A rudimentary way of detecting is by setting an arbitrary threshold of some unrealistic amount of average negative household AGI, say -\$100,000 per household, and checking which values exceed this.

year	Flagged	HH	Pop	AGI_Mean
1992	2	30	59	-7636
1993	3	2258	5340	-581550
1994	10	2662	6422	-918995
1995	3	23	41	-6644
1996	2	12	24	-1492
1997	13	25	50	-5320
1998	4	44	76	-7994
1999	9	28	53	-5932
2000	7	33	59	-4410
2001	9	32	61	-5582
2002	4	15	34	-2694
2003	8	16	33	-3956
2004	9	20	36	-6176
2005	9	22	46	-3354
2006	4	17	26	-3246
2007	11	32	58	-14916
2008	16	23	44	-5701
2009	14	29	50	-7762
2010	10	23	43	-7631
2011	62	76	158	-16837
2012	55	47	92	-12927

The flagged values appear to be minimal. If using AGI, then it is best to remove these flagged values. However, the `Return_Num` and `Exmpt_Num` do not appear to suffer. Using this data for population migration would be considered appropriate.

Correcting the AGI problem is left for future work, although there are a few notes I can give from analyzing these data:

1. Appears that the large negative values are clerical errors at the county level.
2. IRS also maintains data on county income, which give total AGI for all of the county filers for a given year. So these two datasets are related, although the county income data also has a problem with implausibly large negative values.
3. The AGI values for a county sum up. The migration data should match the income data, if not then this should be flagged.
4. If clerical error is not at the summed level for County A (i.e. a county-to-county node is the flagged value), then one can use a constraint to back out the flagged value.
5. If there are more than one flagged value for County A in a given year, then additional constraints are necessary. For County A, this implies there are flagged values to at least County B and County C (and potentially more). The first check should be to see the number of flagged values for County B, if there are no additional flagged values then this is identified. Continue to iterate through this process for additional flags.

Correcting for these implausible numbers should be possible, however the benefit is low for this project. If

income flows become a focal issue, then this will be picked up.

Suppression Issues

The IRS data are suppressed if there are fewer than 10 filers that migrate across regions. Sometimes these data are omitted completely while other times they are designated as suppressed with a -1 value, although the -1 distinction did not occur until 2004. To get an idea of how suppressed the data are, here is a quick table of suppressed values across years plus a column at the far side indicating the number of links containing the minimum number of filers (10):

year	Total	Suppressed	Pct_Suppressed	Minimum	Pct_Minimum
1992	97149	23	0.02	6931	7.13
1993	96746	0	0.00	6853	7.08
1994	98751	7	0.01	6915	7.00
1995	106981	6	0.01	6817	6.37
1996	108734	2	0.00	6878	6.33
1997	109319	1	0.00	6946	6.35
1998	110555	0	0.00	7177	6.49
1999	111201	0	0.00	7109	6.39
2000	111807	0	0.00	7017	6.28
2001	111581	0	0.00	7135	6.39
2002	109620	0	0.00	6918	6.31
2003	109820	0	0.00	6890	6.27
2004	114534	2278	1.99	7135	6.23
2005	118389	2276	1.92	7437	6.28
2006	116627	2288	1.96	7223	6.19
2007	118691	2256	1.90	7495	6.31
2008	116059	2331	2.01	7310	6.30
2009	110651	2549	2.30	6778	6.13
2010	113593	2525	2.22	7035	6.19
2011	130101	6433	4.94	7898	6.07
2012	131931	6373	4.83	8022	6.08

Suppression did not occur before 2004 although it is not clear what the reasoning behind this was. For data purposes, the best practice will be to change all values which are suppressed via the -1 value to NA to delineate that we know there is a connection but do not know the specific value. This will also be helpful with the above AGI problem of large, unrealistic negative values which should be coded as missing values.

While there may be some interesting research ideas with suppressed data, the easiest solution here is to simply drop the suppressed as there are no more than 5% of all values suppressed. We also see that the minimum threshold for reporting a migration connection (10 filers) has remained around 7,000 observations which is approximately 7% of all reported connections.

Corrections

The data are not clean or tidy, for one there is a concern of some malfunction on the IRS part because of the large negative AGI values above. There is no correction for potentially erroneously entered/calculated data except to flag outliers. But there are other problems which can be corrected. For instance, the FIPS codes for special flows changes across time. These special flows are used to indicate a county to larger region or larger region to county relationship (i.e. Total Migrants into Wake County). The IRS is not consistent across years or within years for this distinction. Cross-checks need to be performed to ensure that all data are consistent.

Working backwards a bit, in the 2011 and 2012 documentation we have the following special codes for each county:

Summary	Abbrev	State FIPS	County FIPS
Total Mig - US & For	US	96	000
Total Mig - US	US	97	000
Total Mig - Same St	US	97	001
Total Mig - Diff St	US	97	003
Total Mig - Foreign	US	98	000
Foreign - Overseas	FR	57	001
Foreign - Puerto Rico	FR	57	003
Foreign - APO/FPO ZIPs	FR	57	005
Foreign - Virgin Islands, U.S.	FR	57	007
Foreign - Other flows	FR	57	009
Other Flows - Same State	SS	58	000
Other Flows - Diff State	DS	59	000
Other Flows - Northeast	DS	59	001
Other Flows - Midwest	DS	59	003
Other Flows - South	DS	59	005
Other Flows - West	DS	59	007

And the region codes for the associated 59 State FIPS are as follows:

Northeast Region (59-001)	Midwest Region (59-003)	South Region (59-005)	West Region (59-007)
Connecticut (09-000)	Illinois (17-000)	Alabama (01-000)	Alaska (02-000)
Maine (23-000)	Indiana (18-000)	Arkansas (05-000)	Arizona (04-000)
Massachusetts (25-000)	Iowa (19-000)	Delaware (10-000)	California (06-000)
New Hampshire(33-000)	Kansas (20-000)	D.C. (11-000)	Colorado (08-000)
New Jersey (34-000)	Michigan (26-000)	Florida (12-000)	Hawaii (15-000)
New York (36-000)	Minnesota (27-000)	Georgia (13-000)	Idaho (16-000)
Pennsylvania (42-000)	Missouri (29-000)	Kentucky (21-000)	Montana (30-000)
Rhode Island (44-000)	Nebraska (31-000)	Louisiana (22-000)	Nevada (32-000)
Vermont (50-000)	North Dakota (38-000)	Maryland (24-000)	New Mexico (35-000)
	Ohio (39-000)	Mississippi (28-000)	Oregon (41-000)
	South Dakota (46-000)	North Carolina (37-000)	Utah (49-000)
	Wisconsin (55-000)	Oklahoma (40-000)	Washington (53-000)
		South Carolina (45-000)	Wyoming (56-000)
		Tennessee (47-000)	
		Texas (48-000)	
		Virginia (51-000)	
		West Virginia (54-000)	

A further note is that a county's non-migrant population is denoted by the FIPS codes being identical (the origin and destination are the same). Continuing to work backwards, documentation before 2005 does not exist, therefore one must manually go through the files to discern how the special flows are handled. In particular, we need to figure out the non-migrants and any special codes across state borders. From what I can tell, the above is consistent for all IRS data after 1995.

A first pass is to do a quick cross-tabulation of the special codes across years. This involves subsetting the data to use `State_Code_Origin` values which are not equal to the FIPS codes of US States. The following chart's columns indicate the `State_Code_Origin` across the rows of `year` where the value in each cell is the total count of that particular `State_Code_Origin`:

	0	57	58	59	63	96	97	98
1992	3145	1815	0	0	15606	0	0	0
1993	3135	1605	0	0	15564	0	0	0
1994	3137	1566	0	0	15672	0	0	0
1995	0	1634	3088	9001	0	3180	9460	1089
1996	0	1590	3075	9016	0	3180	9433	1055
1997	0	1562	3077	8954	0	3183	9441	1049
1998	0	1603	3076	8857	0	3186	9442	1057
1999	0	1570	3077	8874	0	3182	9440	1055
2000	0	1557	3077	8810	0	3182	9440	1043
2001	0	1603	3084	8977	0	3183	9455	1063
2002	0	1619	3076	8893	0	3183	9439	1073
2003	0	1621	3072	9009	0	3178	9426	1073
2004	0	1623	3073	9078	0	3193	9579	3193
2005	0	1637	3076	9253	0	3193	9579	3193
2006	0	1623	3075	9168	0	3193	9579	3193
2007	0	1681	3086	9243	0	3194	9582	3194
2008	0	1598	3082	9159	0	3195	9585	3195
2009	0	1215	3078	8911	0	3197	9591	3197
2010	0	1211	3091	9028	0	3197	9591	3197
2011	0	3590	3110	15450	0	3193	9576	2514
2012	0	3529	3107	15449	0	3193	9577	2475

Excellent. We can see a clear demarcation where, before 1995, the special codes appear to be designated with 0 and 63. Afterwards, it appears the special codes are as documented above except with three other clear changes in data patterns:

- In 2003, total values for the 98 FIPS (Total Foreign migration) were 1073 but then increased sharply to 3193 in 2004. This change likely demonstrates that the IRS now filled in a value of 0 (or suppressed) across all counties from 2004 and beyond where before the IRS would omit a value for the county if no (or suppressed) migration with foreign areas occurred.
- In 2010, total values for the 57 FIPS (Foreign flows) were 1211 but then increased to 3590 for 2011. I suspect the same implementation occurred as above: the IRS now replaces values with 0 (or suppressed) when before they may have simply omitted any value. This can be seen with the 98 FIPS (Total - Foreign) which changed from 3197 to 2514 across the same time.
- In 2010, total values for the 59 FIPS (Other flows - across regions) were 9028 but then increased to 15450 for 2011. This represents a 171% increase in values. I suspect the same implementation occurred as above: the IRS now replaces values with 0 (or suppressed) when before they may have simply omitted any value.

The necessary corrections for handling data before 1995 involve changing the special FIPS codes involving 0 (which represent total migrants) and 63 which are more complicated:

Table 8: Pre 1995 Special Codes

	10	11	12	13	14	15	20	21	22	30	50
COUNTY NON-MIGRANT	0	0	0	0	0	0	0	0	0	0	9417
DIFFERENT REGION	0	0	0	0	0	0	0	0	3402	0	0
FOREIGN	0	0	0	0	0	565	0	0	0	0	0
REGION 1: NORTHEAST	0	5172	0	0	0	0	0	0	0	0	0

	10	11	12	13	14	15	20	21	22	30	50
REGION 2: MIDWEST	0	0	5197	0	0	0	0	0	0	0	0
REGION 3: SOUTH	0	0	0	5196	0	0	0	0	0	0	0
REGION 4: WEST	0	0	0	0	5199	0	0	0	0	0	0
SAME REGION, DIFF. STATE	0	0	0	0	0	0	0	3402	0	0	0
SAME STATE	5090	0	0	0	0	0	3402	0	0	0	0
SUPPRESS ALL FLOWS	0	0	0	0	0	0	0	0	0	800	0

The biggest change is that we need to have consistent measures of Total-Migrants and Non-Migrants. I will choose to ignore all categories which can be calculated from other values (i.e. movement within state, movement within region, etc.). All ST 63 and CTY 50 values need to be converted to the respective home region. The ST 63 and CTY 15 is loosely classified as Foreign with around 200 observations each year with an average of 11.9787611 returns per observation. This indicates that the 63 “Foreign” is not likely to be movement to designated Foreign areas but rather observations that the IRS did not know what to do with and matches up well with a category called “Foreign - Other Flows.”

We also have ST 57 as a Foreign category that we need to inspect. Here is a chart with the column as the `County_Code_Origin` based upon being in the Foreign (57) category across all years:

	1	3	5	7	9
1992	571	63	1150	31	0
1993	594	52	922	37	0
1994	809	0	757	0	0
1995	23	68	510	3	1030
1996	14	61	511	3	1001
1997	19	63	483	1	996
1998	20	72	506	3	1002
1999	18	70	479	3	1000
2000	20	73	473	3	988
2001	25	85	484	3	1006
2002	22	94	484	4	1015
2003	13	94	492	2	1020
2004	31	88	483	3	1018
2005	18	96	503	3	1017
2006	30	117	475	4	997
2007	35	132	503	6	1005
2008	31	129	464	6	968
2009	17	111	323	5	759
2010	22	123	319	4	743
2011	390	146	622	9	2423
2012	408	138	586	7	2390

The foreign flows has a marked change of emphasis, from mainly classifying flows as 1 (Foreign - Overseas) before 1995 to 9 (Foreign - Other flows) for 1995 and beyond. All other maintain the same meaning and roughly the same proportions of classifications. A noted emphasis here with the 57 FIPS is that the summation of all of these equals the 98 + 000 classification (Total Migration - Foreign) that began in 1995.

As for the 58 category of “Other Flows”, these are defined as:

At the county level, counties with less than 10 returns have been aggregated into various “Other Flows” categories. The Other Flows categories are Same State, Different State, Foreign, as well as

by region (Northeast, Midwest, South, and West). See section E.6 for a list of the “Other Flows” categories and codes.

These serve the purpose of accounting up to the aggregate level. Without these miscellaneous values, then the summation across all counties for a given county may not add up to it’s Total Migrants.

The following are the equivalent changes to the pre-1995 data to best sync up data all the way through:

County Total Migration Flows:	ST	CTY	Pre-1995 Change
Non-Migrant (identical FIPS)	NA	NA	ST 63 + 50 to ST & CTY of interest
Total Migration – US+Foreign	96	000	ST 0 + CTY 1 to 96 + 0
Total Migration – Foreign	98	000	New Variable: SUM all 57 flows
Foreign - Overseas	57	001	Same.
Foreign - Puerto Rico	57	003	Same.
Foreign - APO/FPO ZIPs	57	005	Same.
Foreign - Virgin Islands, U.S	57	007	Same.
Foreign - Other flows (FR)	57	009	ST 63 + 15
Total Migration – US	97	000	97 + 0 = 96000 minus 98000
Other Flows - Same State (SS)	58	000	ST 63 + CTY 10 & 20
Other Flows - Different State (DS)	59	000	ST 63 + CTY 21 & 22
Other Flows - Northeast (DS)	59	001	ST 63 + 11
Other Flows - Midwest (DS)	59	003	ST 63 + 12
Other Flows - South (DS)	59	005	ST 63 + 13
Other Flows - West (DS)	59	007	ST 63 + 14
Total Migration – Same State	97	001	Sum across ST XX less its own + 58000
Total Migration – Different State	97	003	97000 minus 97001

For the purposes of this project, I do not have a substantial reason to have observations based upon different states or regions. The 97001, 97003, and all ST 58 and 59 are not important to me. Future research may dictate that I need to go back and calculate these values, but for the present time there are two structures that I need to calculate:

1. County Level statistics by year: Total In-migration, Total Out-migration, and Total Non-migrants. From those values, we can construct net-migration, total population (of filers), migration rates, etc. These are the typical variables in a migration study.
2. County-to-county: two separate dataframes which only contain the pairs between counties (the IN file and OUT file). Next, diagnostic checks are to be performed to ensure that **Return_num** and **Exmpt_num** are closely related. If given a year, these two values match for the IN and OUT then these values are OK. If different, or if one contains a value while the other does not, then there is a problem. Easiest solution is to simply average the two then move on, but if there are large differences then these values need to be flagged and checked. This data will contain the flow from County A to County B of households, people, and income (but not likely to be used).

Starting in 1995, the IRS data also provides summaries for the flows between a state and a county with a given 000 for County Code. Because of this, one needs to take care in making their own summary statistics in a county-to-county dataset. These values will be removed because the focus is on county-to-county only.

Inflow versus Outflow Merge

The IRS data contains two sets of files: one for the inflow between regions and one for the outflow between regions. I have looked across the IRS documentation in attempt to verify that the inflow from region A to

region B should also be the outflow from region B to region A. I have not found confirmation of this from documentation, so we need to attempt to figure this out through inspection of the data.

After combining the inflows and outflows files by year, origin FIPS code, and destination FIPS code, we can inspect to see how well these match. Below is a table which indicates **Total** as the number of county to county pairs; **Return**, **Exmpt** and **AGI** as the number of pairs which match for these categories; and **Match** which is the percentage of pairs which correctly match out of all the observed pairs:

There appears to be some change in the IRS procedure of reporting flows in 2004 as before the average percentage matching is greater than 97% but after this falls to below 95%. But the high percentage of match is a positive sign here. Next, we need to consider why there are values which do not match. To do so, I check to see the values where **IN** (or **OUT**) are suppressed but the **OUT** (or **IN**) are not suppressed:

year	Total	SupIN	SupOUT	BadMatch
1992	79631	1049	1286	2.9%
1993	79291	984	1113	2.6%
1994	81346	891	1127	2.5%
1995	80654	969	1109	2.6%
1996	82474	993	1051	2.5%
1997	83153	1010	1112	2.6%
1998	84330	961	1059	2.4%
1999	85030	984	1048	2.4%
2000	85716	1000	1055	2.4%
2001	85334	1058	1110	2.5%
2002	83430	1041	1158	2.6%
2003	83470	980	1083	2.5%
2004	90010	3185	3198	7.1%
2005	93653	3185	3202	6.8%
2006	92023	3174	3200	6.9%
2007	93928	3188	3206	6.8%
2008	91441	3192	3209	7%
2009	86708	3189	3212	7.4%
2010	89496	3178	3194	7.1%
2011	96572	2526	2440	5.1%
2012	98362	2472	2402	5%

As it turns out, the only values that do not match are due to a suppression on one side of the values but not the other. By combining the suppressed values of the inflows and outflows, we are able to get a fuller dataset for county-to-county level migration than if we only used one of these. The data are also symmetric in that the value of returns from County A to County B in the inflow and outflow are identical.

We can now move onto using these data for visualizations and modeling.