Trends in Cross-State Origin and Destination Job Flows for Pennsylvania, 2002-2015

Center for Economic Development

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SUMMARY

Despite being bordered by or proximate to eight other states and Washington D.C., we find that Pennsylvania's employed workforce and jobs have remained fairly self-contained within the state since 2002. We also find that worker-to-job flows into and out of Pennsylvania vary substantially by state, not only in magnitudes in and out, but also by "net flow" (i.e. the number of PA workers that hold jobs in a given state minus the number of workers in that state that hold jobs in PA).

FINDINGS

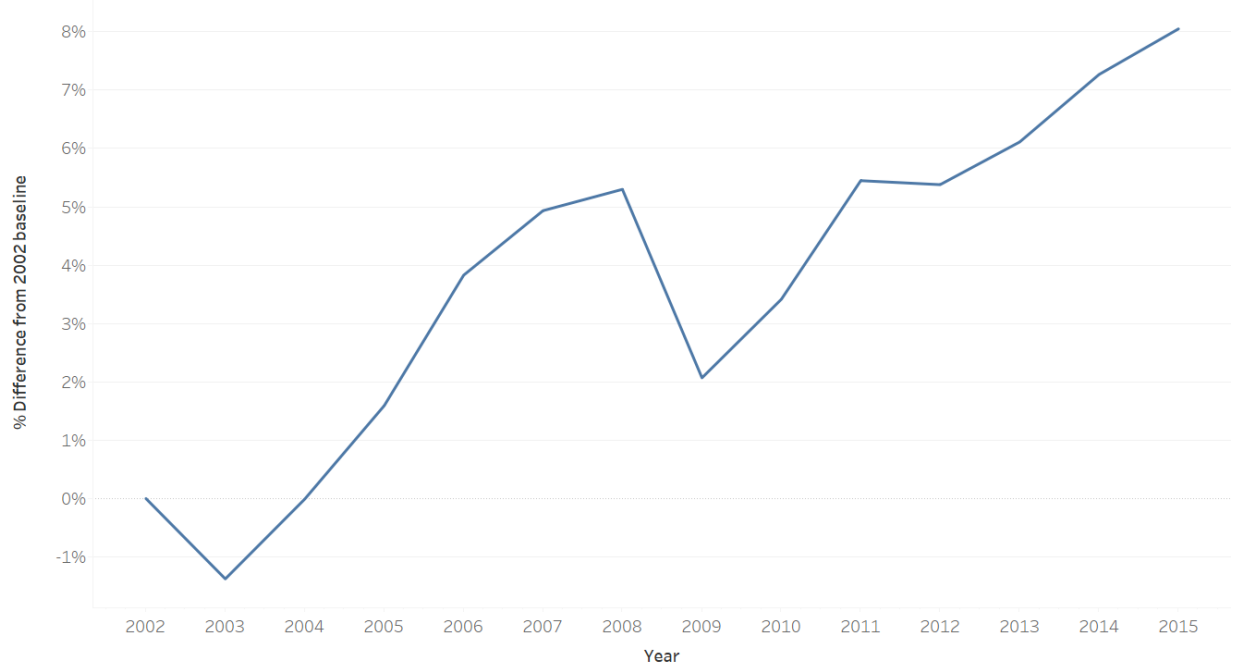
The following analysis uses data from the LODES program of the U.S. Census, the nature and limitations of which are described at the end of this report. Figures are limited to workers and jobs in Pennsylvania and surrounding states from 2002 to 2015. Jobs and workers from other states are ignored. The District of Columbia is ignored since data was only partially available for D.C. during the study period, but it is included in some tables for reference.

Pennsylvania workers work in Pennsylvania. The overwhelming majority of jobs held by PA workers are located in the Commonwealth. As of 2015, according to LODES, over 5.7M jobs in the study area were held by Pennsylvanians, over 5.3M of which were located in the Commonwealth. Just over 6% (370K) of these jobs were located in the adjacent (or nearby) states of New Jersey, New York, Maryland, Delaware, Connecticut, Delaware, Virginia, or West Virginia. Meanwhile, about 5.6M jobs in the study area were located in the Commonwealth, and about 5% of these were held by workers from these same nearby states.

At the state level the self-contained nature of the state's economy remained consistent over the study period. For example, by 2015 the LODES estimated number of jobs held by Pennsylvania workers in PA and surrounding states (again 5.7M) had increased by only 8% over 2002, the earliest year in the dataset, and the baseline year for this study. This growth was slow, and not steady, as significant year to year declines for recession years occurred in 2003 and 2009, with a slight decline in 2012.

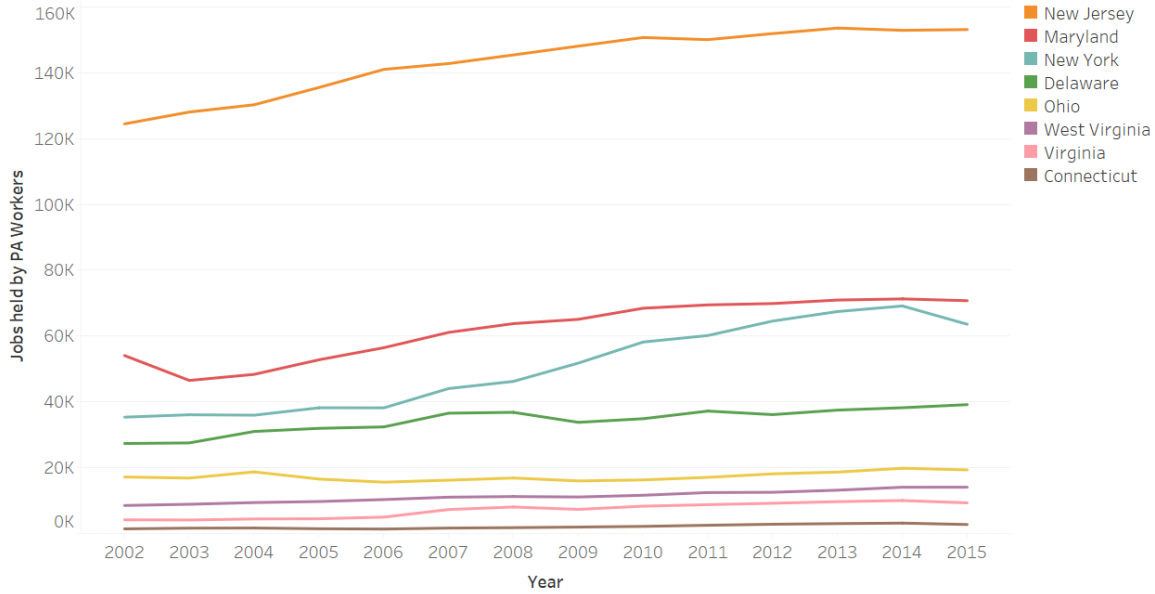
During this same period the share of jobs held by PA workers in other states stayed consistent, growing only minutely. In 2002, 5% of jobs held by Pennsylvanians were out of state, and while it grew slowly, by 2015 it was barely above 6%.

The number of jobs held by PA workers grew by 8% from 2002 to 2015, with declines in recession years, and 2012.



New Jersey, Maryland, and New York jobs hosted the most PA workers, in that order. However, New York's rate of influx of PA workers saw a relatively rapid increase from 2008 to 2014, followed by a noticeable drop off in 2015.

Out of state jobs held by PA residents state were most likely to be located in New Jersey, Maryland, New York, and Delaware vs. other nearby states. New Jersey employed the most PA workers. New York experienced the largest growth rate in jobs held by PA workers.



As already noted, there were slightly more "jobs held by Pennsylvanians" than "jobs located in Pennsylvania" in 2015. According to LODES the number of "jobs held by PA workers" very slightly but routinely exceeded the number of jobs located in Pennsylvania, for every year of the study period. The difference is sizeable in absolute terms but small as a share of the state's economy. In 2015 it was just over 79K (or 1.4% more jobs held by PA workers than PA located jobs).[1]

While largely self-contained the Commonwealth's labor market has consistently served as a slight "net exporter" of workers to surrounding states rather than a net importer...even if the numbers of involved are relatively small. As shown below, net exports to nearby states spiked in 2006 and peaked 2008 at 108K jobs, but have trended downwards thereafter, eventually stabilizing from 2011 on. As of 2015 the state held 76K more jobs in other states than those state's workers held in PA.

[1] The differential has been consistently small for other years in the study period, ranging from 1.3% to 2%.

These aggregate trends mask dynamics of interest between the Commonwealth and each state. The table below shows the number of jobs located in the surrounding states held by PA residents from 2002 to 2015, with shading indicating the percent difference from baseline (2002). Figures for the District of Columbia are included for reference only, as data on PA workers in DC jobs only became available in LODES from 2010 on.

Number of jobs held by PA workers in surrounding states and percent increase from 2002 baseline (2002 to 2015)

W State	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Connecticut	1,421	1,632	1,677	1,457	1,362	1,660	1,780	1,962	2,169	2,514	2,821	3,013	3,166	2,740
Delaware	27,357	27,536	31,007	31,962	32,401	36,571	36,819	33,784	34,887	37,210	36,132	37,506	38,222	39,162
Maryland	54,078	46,514	48,360	52,799	56,463	61,115	63,782	65,080	68,456	69,476	69,879	70,943	71,292	70,750
New Jersey	124,477	128,072	130,280	135,540	141,032	142,804	145,426	148,103	150,722	150,069	151,907	153,588	152,905	153,135
New York	35,360	36,087	35,960	38,211	38,188	44,050	46,226	51,794	58,185	60,170	64,562	67,454	69,146	63,584
Ohio	17,183	16,849	18,733	16,544	15,609	16,211	16,867	15,985	16,292	17,073	18,131	18,669	19,829	19,342
Virginia	4,168	4,115	4,426	4,483	4,981	7,292	8,056	7,339	8,317	8,771	9,194	9,687	10,026	9,316
West Virginia	8,518	8,893	9,406	9,722	10,320	11,043	11,233	11,100	11,625	12,449	12,532	13,169	14,067	14,079
District of Col..									3,401	3,885	3,736	4,253	4,414	3,889

% Difference fr..

-15.0% 150.0%

As previously noted, New Jersey, Maryland, and New York led the pack for all years in that order. However, the number of Pennsylvanians filling jobs in the Garden State has grown relatively modestly (23% by 2015).[2] This growth rate was surpassed by Maryland (30% by 2015), a figure which might have been larger if the flow of PA workers to Maryland had not retreated noticeably in 2003 and 2004. New York saw the third largest influx of PA workers, but starting in 2006, its rate of absorption increased markedly, such that by 2014 it held 96% more PA workers in NY jobs than it began with in 2002. However, 2015 also saw a noticeable decline in the flow of workers to NY, and the same measure stood at 80% that year. Turning to the remaining states, Delaware ranked fourth in the number of PA workers absorbed in 2015, but it ended this year with 43% more jobs filled by PA workers than it started with in 2002.

By the same measure West Virginia and Virginia also experienced relatively strong growth at 65% and 123% of the baseline year by 2015. The latter figure actually represents a decline from 140% in 2014, and in any case the influx to Virginia remained relatively modest at 9.3K jobs. The number of PA workers in Connecticut jobs was smaller still in absolute terms, and has experienced a relatively bumpy path. By 2015 the state absorbed only 2.7K workers, which represented a decline form 2014, but which was still 93% more than it began with in 2002.

Ohio is something of an outlier here, in that the growth of exported Keystone workers to the state clearly stalled from 2005 to 2009, and has grown relatively slowly since. As a result, as of 2015 it had only 13% more PA workers in OH jobs than it began with in 2002. For the record, although it is not shown on the table, the number of PA jobs held by PA workers grew as well, by about 7%.[3] Finally,

The following table shows the number of jobs *located in PA* that are held by residents of one of the aforementioned eight states. Here the numbers are comparable, but for most states smaller, which

[2] For ease of reading, growth rates reported here are typically rounded to the nearest percent.

[3] It is of note that the "flow" of workers to jobs in Connecticut, Maryland, New Jersey, and New York increased into 2009, a recession year, while it declined for all other states.

makes sense given that PA is a net exporter, rather than importer of workers. Here again for reference only we show the figures for D.C., which unlike the last table, were available in LODES since 2002.[4]

Number of jobs located in PA, held by workers from other nearby states, and percent change from 2002 baseline (2002-2015)

H State	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Connecticut	695	632	688	680	540	945	928	1,725	1,978	2,148	2,397	2,591	2,651	2,404
Delaware	22,255	23,769	23,475	24,160	24,468	25,656	26,421	29,506	29,916	31,287	32,071	32,301	33,274	32,898
Maryland	14,566	17,586	17,289	17,263	17,340	17,831	16,462	19,526	20,338	22,288	23,351	25,178	26,228	25,183
New Jersey	106,259	104,449	102,350	107,582	102,443	123,980	119,552	134,324	136,907	146,760	148,501	149,936	151,347	148,938
New York	19,371	19,901	20,265	20,866	22,066	25,204	22,680	26,119	29,152	32,233	34,045	34,444	36,134	35,486
Ohio	14,307	14,310	14,389	15,711	16,636	20,243	19,198	21,468	24,044	26,444	27,695	27,362	27,810	26,595
Virginia	2,210	2,289	2,266	2,297	2,269	2,964	3,165	3,746	4,221	4,690	4,866	5,517	5,869	5,395
West Virginia	10,434	10,294	10,529	10,870	11,154	13,457	13,696	14,460	17,025	18,278	19,039	19,569	19,763	18,991
District of Colum..	244	240	266	254	269	372	395	565	770	791	735	862	956	871

% Difference fr..
-15.0% 150.0%

First, one can note that there appears to be inflection points between 2006 and 2007 and 2008 and 2009. These appear previous table, although they are not as obvious. From 2007 on the influx of out of state workers to PA jobs seems to ratchet up.

At face value the relative magnitudes of the cross-border flows make sense. New Jersey hosts a dense set of employment centers right across the river from the Philadelphia region. New York and Maryland both share long border areas with PA, and both states host attractive, plausibly commutable (at least for some PA workers) employment centers (along with relatively job dense suburbs) of their own. West Virginia shares a smaller length of border with the state, but lacks comparable employment centers. Ohio shares a border and has large employment centers and job dense suburbs of its own, but much of this is not within a reasonable commuting distance from the Pennsylvania line.

The table below summarizes the net change between PA and each state in each direction from 2002 to 2015, and the rate of growth across the time period. New Jersey is of interest here. As noted in the previous tables, the number of NJ jobs held by PA workers exceeded the number of PA jobs held by PA workers (ex: 153K v. 149K in 2015). However, as shown below, the number of PA jobs held by NJ workers has grown faster and by more since 2002. Ohio, West Virginia, to a lesser extent Connecticut also experienced a "negative net flow" during this time.

2002-2015	Change in worker flow from PA	Change in worker flow to PA	Growth rate in flow from PA	Growth rate in flow to PA
Connecticut	1,319	1,709	93%	246%
Delaware	11,805	10,643	43%	48%
Maryland	16,672	10,617	30%	73%
New Jersey	28,658	42,679	23%	40%
New York	28,224	16,115	96%	83%
Ohio	2,159	12,288	13%	86%
Virginia	5,148	3,185	123%	144%
West Virginia	5,561	8,557	65%	82%

[4] Not surprisingly, few people appear to live in D.C. but work in Pennsylvania.

For reference the next table shows the net flow of workers between PA and each state. Each figure represents the number of jobs held by PA workers less the number of PA jobs held by workers from that state. Not surprisingly, most states started and remained net importers of PA workers, in that they hosted more jobs held by PA workers than they sent workers to PA jobs. West Virginia remained an exception, as it sent more workers to PA jobs than it received from 2002 on, particularly after 2009. The overage of WV workers continued through 2015 but seemed to recede after 2012. Ohio originally filled more PA jobs than it provided for PA workers in 2002, but from 2006 on the situation reversed. Both West Virginia and Ohio states saw net exports of their workers to PA jobs peak in 2012.

	Year													
Difference	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Connecticut	726	1,000	989	777	822	715	852	237	191	366	424	422	515	336
Delaware	5,102	3,767	7,532	7,802	7,933	10,915	10,398	4,278	4,971	5,923	4,061	5,205	4,948	6,264
Maryland	39,512	28,928	31,071	35,536	39,123	43,284	47,320	45,554	48,118	47,188	46,528	45,765	45,064	45,567
New Jersey	18,218	23,623	27,930	27,958	38,589	18,824	25,874	13,779	13,815	3,309	3,406	3,652	1,558	4,197
New York	15,989	16,186	15,695	17,345	16,122	18,846	23,546	25,675	29,033	27,937	30,517	33,010	33,012	28,098
Ohio	2,876	2,539	4,344	833	(1,027)	(4,032)	(2,331)	(5,483)	(7,752)	(9,371)	(9,564)	(8,693)	(7,981)	(7,253)
Virginia	1,958	1,826	2,160	2,186	2,712	4,328	4,891	3,593	4,096	4,081	4,328	4,170	4,157	3,921
West Virginia	(1,916)	(1,401)	(1,123)	(1,148)	(834)	(2,414)	(2,463)	(3,360)	(5,400)	(5,829)	(6,507)	(6,400)	(5,696)	(4,912)

While New Jersey steadily led Maryland in both the number of its jobs held by PA workers and the number of PA jobs held by its workers, the Garden State actually lags Maryland by net imports of PA workers…a lead that has increased over time. For example, in 2002 Maryland hosted 39.5K more PA workers in Maryland jobs than it sent MD workers to jobs in Pennsylvania. During that same year, New Jersey only received 18.2K more. While bumping around somewhat, Maryland's net inflow ultimately grew to and stayed over 45K. Meanwhile, after its net imports of workers from PA peaked in 2006, by 2015 New Jersey flirted with becoming a net exporter to PA in 2014, with only 4.1K net imports of PA workers.

One last way to look at these figures is the ratio of the number of PA workers employed in state "X" vs. the number of PA jobs held by workers from state "X". These ratios are shown in the table below. So for example, for every PA job held by a Connecticut resident in 2002, there were two jobs in Connecticut held by PA workers, but by 2015 this ratio had fallen to 1.1 jobs. Despite the fact that Pennsylvania still exported more workers than imported in 2015, there seems to be a striking difference in the "average ratio" from 2002 to 2008 and from 2009 onwards. Perhaps the sole outlier is New York, the only state that saw relatively higher ratios from 2009 onwards. As of 2015, five surrounding states were at, near, or under "parity", including New Jersey, the largest player. Only three (Maryland, New York, and Virginia) appeared to continue to be strong importers of PA workers.

	Year													
Jobs Ratio	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Connecticut	2.0	2.6	2.4	2.1	2.5	1.8	1.9	1.1	1.1	1.2	1.2	1.2	1.2	1.1
Delaware	1.2	1.2	1.3	1.3	1.3	1.4	1.4	1.1	1.2	1.2	1.1	1.2	1.1	1.2
Maryland	3.7	2.6	2.8	3.1	3.3	3.4	3.9	3.3	3.4	3.1	3.0	2.8	2.7	2.8
New Jersey	1.2	1.2	1.3	1.3	1.4	1.2	1.2	1.1	1.1	1.0	1.0	1.0	1.0	1.0
New York	1.8	1.8	1.8	1.8	1.7	1.7	2.0	2.0	2.0	1.9	1.9	2.0	1.9	1.8
Ohio	1.2	1.2	1.3	1.1	0.9	0.8	0.9	0.7	0.7	0.6	0.7	0.7	0.7	0.7
Virginia	1.9	1.8	2.0	2.0	2.2	2.5	2.5	2.0	2.0	1.9	1.9	1.8	1.7	1.7
West Virginia	0.8	0.9	0.9	0.9	0.9	0.8	0.8	0.8	0.7	0.7	0.7	0.7	0.7	0.7

To recap, only a relatively small and relatively consistent slice of PA workers hold jobs out of the state, and only small slice of PA jobs are held by out of state workers. But under the hood of these slices, striking dynamics of interest are apparent, and that suggest nontrivial ebbs and flows have

been taking place across the Commonwealth's borders. Our next report will examine these flows in more detail, including flows from county to county within Pennsylvania itself.

ABOUT LODES

Our analysis relies exclusively on data from the U.S. Census's Longitudinal Employer-Household Dynamics (LEHD) program, specifically a public use dataset called LEHD Origin Destination Employment Statistics, or LODES. The LEHD program relies on a federal state partnership called the Local Employment Dynamics partnership. Per the program's website:

> "Under the LED Partnership, states agree to share Unemployment Insurance earnings data and the Quarterly Census of Employment and Wages (QCEW) data with the Census Bureau. The LEHD program combines these administrative data, additional administrative data and data from censuses and surveys. From these data, the program creates statistics on employment, earnings, and job flows at detailed levels of geography and industry and for different demographic groups. In addition, the LEHD program uses these data to create partially synthetic data on workers' residential patterns."[5]

The essential value of the program is to match figures on jobs and associated earnings from the QCEW, which is a quarterly administrative census, with actual demographic data on the workers in those jobs. See https://lehd.ces.census.gov/ for more about the LEHD program and the LED partnership.

About Origin Destination Data from LODES

LODES is one of several data products produced by the LEHD program. LODES data is available in three forms: worker residence area characteristics, workplace area characteristics, and by origin destination pairs (ODs). Through LODES OD data is available at the Census block level for 49 participating states. LODES OD data also serves as the foundation of the "On The Map" tool from the U.S. Census.[6] We used OD data for this report. An example of an OD record is shown below.

w_geocode	h_geocode	SA0	SA01	SA02	SA03	SE01	SE02	SE03	SI01	SI02	SI03
420710004002010	420710122004020	5	1	4	0	1	2	2	0	0	5

The first two columns represent the workplace and residence involved in the OD pair, the latter being the "origin" and the former the "destination." They represent the location of the job, and the location of the residence of the worker that occupies that job, by block. In this case both the origin and destination are located in Lancaster County PA, although they are in different Census blocks (and tracts for that matter).

The remaining columns contain estimates of the number of jobs located in the workplace block group that are held by workers in the other block group, for a particular year, in this case 2009. The most important figure is SA0, which represents the annualized estimated number of jobs for the pair. SA01-SA03 (in green) breaks that estimate down by the age group of the workers in those jobs: SA01 indicates the number of jobs for workers 29 or younger, SA02 shows the number of jobs for workers 30-54, and SA03 for workers 55 or older. SE01-SE03 (in blue) breaks down the same

[5] https://lehd.ces.census.gov/ , "About Us", accessed 7/29/2018.

[6] See https://onthemap.ces.census.gov/ .

five jobs by earnings category: SE01 indicates the number of jobs that earned $1250 a month or less, SE02 shows the number that earned between $1,251 to $3,333 a month, and SE03 indicates the jobs that earned $3,333 or more, with categories set based on nominal, rather than real earnings. Finally SI01-SI03 (in peach) breaks the same five jobs down by aggregate industry sector, SIO1 shows the number of jobs in "goods producing" sectors, SI02 shows the number in "trade, transportation, and utility" sectors, and SIO3 includes jobs in "all other services" sectors. Subsets of these ODs are available for "all jobs", or for subsets of all jobs, including private, federal, or primary (as opposed to secondary). We used the "all jobs" dataset of ODs for this analysis, and for this report, relied mainly on the SAO "total jobs count".[7]

Employment coverage

LODES primary source of employment data is the Bureau of Labor Statistic's Quarterly Census of Employment and Wages (QCEW) program, which is itself based on the administrative records generated by employers for state unemployment insurance programs. Thus, QCEW is actually an administrative census of jobs and wages, and therefore its estimates of both indicate counts, rather than statistical estimates from samples. It is estimated to cover 95% of wage and salaried jobs, including private, federal civilian, state, and local government employment. Important exclusions of wage and salaried jobs include the employment armed forces, federal security agencies, most railroad workers, most student employment at schools, and some employment with religious and nonprofit organizations. Importantly, most self-employment is not covered by the QCEW or LODES. Exclusions include but are not limited to sole proprietors, independent contractors, small farmers, and gig workers (ex: drivers for Uber or Lyft) and other forms of self-employment.[8] While QCEW covers an estimated 95% of wage and salary employment, its exclusion of self-employed workers is nontrivial, in that by one recent estimate there were 15 million self-employed people in the United States, representing 10.1% of total employment.[9]

Employment size and location data

For private employment, LODES relies on data from QCEW for data on employer location and size (job count). This data is quite accurate overall, and is based on the same data that firms report to state unemployment insurance programs. By one estimate 97% of business addresses provided to the program are successfully located at a sub-county level.[10] Rarely, a firm may move and temporarily fail to update their address with the state. In some cases, the reported address may not be the place where a workers shows up to work most often (or at all, as in the case of a construction firm).[11]

But a larger issue for location accuracy is that for multi-establishment firms in the state, the data made available to LODES does not specify *where* workers report to work. By some estimates, 40-

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[7] Description of OD pair data derived mainly from "LEHD Origin-Destination Employment Statistics (LODES) Dataset Structure Format Version 7.3", at https://lehd.ces.census.gov/data/lodes/LODES7/LODESTechDoc7.3.pdf, accessed 07/29/2018. See this document for more on the OD file structure and data.

[8] Information on sources and limitation of coverage estimates derived from "Design Comparison of LODES and ACS Commuting Data Products", Graham, Kutzback, and Mackenzie, U.S. Census, CES 14-38, September 2014, page 3 at https://www2.census.gov/ces/wp/2014/CES-WP-14-38.pdf, accessed 7/29/2018; and "QCEW Frequently Asked Questions" at https://www.bls.gov/cew/#faq accessed 7/29/2018.

[9] "Self-Employment in the United States", Hipple and Hammond, U.S. Bureau of Labor Statistics, pages 1-2, https://www.bls.gov/spotlight/2016/self-employment-in-the-united-states/pdf/self-employment-in-the-united-states.pdf, accessed 7/29/2018

[10] Graham, et. al., page 7.

[11] Graham, et. al., page 6.

44% of jobs covered under the LEHD program are at such multi-site employers.[12] Multi-establishment data locates and specifies the number of jobs at each reported establishment, and information on the residence of workers, but does not specify which worker works (or works the most) at (or for) which establishment. In such cases, the given location and job count of the establishment are presumed to be accurate, but the question of who is employed in what job is unknown. The procedure by which LODES allocates workers to multi-establishment work sites is described further on.

A lesser but related problem are firms which *should* report employment as multi-site but do not. In this case a firm that actually has multiple work sites does not report them as such, and instead records all employment under one address. While a known problem this is also a relatively limited one, in that according to one estimate there is a "national [reporting] noncompliance rate of 5.61 percent of multiunit employers responsible for about 4.45 percent of multiunit employment."[13] This suggests that only 2% of LEHD reported employment could be potentially impacted by this problem, which, according the same source is particularly prevalent in reporting for school districts and state and local governments.

Worker residence data

By one estimate approximately 96% of the address information workers report to the LEHD program come with enough precision to be located at the sub-county level.[14] This link is achieved by comparing reported worker information to master file of several federal datasets that contain worker residence information. For a given year, inaccuracies can occur when a worker moves after the program's reference date of April 1, or when the address reported differs than the address contained in federal records.

Matching workers to multi-site establishments

As noted above, the data available to LODES does not link jobs at multi-site firms to worker residences. Instead these links are estimated through a modelling approach called Unit-to-Worker imputation. The process is complicated and probabilistic.[15] In assigning each worker observed to be employed at a multi-site firm to a worksite, it takes into account both the distribution of workplace sizes within the multi-site firm, and the distance between each worker residence and workplace. Thus, the closer a worksite is to a worker's residence, and the larger it is (proportionately) to other worksite candidates, the more likely that worker will be assigned to the location. This assignment is not assumed to be perfectly accurate, and since it is probabilistic, it can result in workers being assigned to something other than the nearest worksite location.

Confidentiality protection

LODES uses noise infusion to protect the confidentiality of employer job counts. This involves the injection of a randomly generated "fuzz factor" at the establishment level. This procedure is a method for protecting the confidentiality of job counts at the worksite level routinely used by many related employment statistics programs, including the QCEW. Finally, LODES generates synthetic data to represent the location of worker residences for each worksite. Thus, the residences

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[12] Green, Kutzbach, and Vilhuber, "Two Perspectives on Commuting: A Comparison of Home to Work Flows Across Job-Linked Survey and Administrative Files", CES 17-34, U.S. Census, April 2017, page 9. Link: https://www2.census.gov/ces/wp/2017/CES-WP-17-34.pdf accessed 8/5/2018.

[13] Graham et. al., page 6

[14] Graham et. al., page 7.

[15] For a description see Green et. al., page 9.

reflected in the "O" side of OD pairs for LODES do not actually represent observed residences, but synthetic data points that maintain the statistical properties of the underlying observed data geographically and demographically. This procedure can (very rarely) generate simulated block level OD pairs where no underlying observation exists, and fail to assign an OD where it does.

Known Methodological Discontinuities

LODES currently uses a master record file to "locate" observed worker residences, and for several other data procedures. This file draws address information from several sources, including but not limited to the IRS, HUD, HHS, and USPS. From 2012 on, the LEHD program used a new set of procedures to generate this file.

Implications

LODES OD data is subject to numerous sources of error. Within the universe of employment it covers, inaccurate workplace-residence pairs can result when employers report incorrect workplace addresses, or fail to report multiple workplaces, or when the LODES program assigns workers to the wrong workplace across multi-site employers. On the residence side, location error can occur when the worker moves during the reference period, or when federal residence records used to locate workers have obsolete addresses on file. Finally, confidentiality procedures also introduce error into the process.

Thus, it is important to note that not every block level OD pair reported under LODES necessarily represents a "real" commute flow. Some ODs are the result of employer misreporting, or erroneous program residence or workplace assignment, particularly for multi-site establishments. Even when the given residence and workplace OD locations are both accurate, they may still not represent an actual commute, given that workers may telecommute, work in construction etc.

All this said, the extent of these error depend on the geographical units of analysis involved. Once one moves from the census block level to county or state regions, the problems associated with employment type coverage and telecommuting remain, but the scope of error introduced by procedures such as noise infusion, multi-unit reporting, multi-unit assignment, and synthetic residence assignment fall off significantly. It is for these reasons we feel confident that patterns and trends shown in this report are the result of real economic activities across space rather than artifacts of LODES methodologies.

ABOUT THE CED

The Center for Economic Development at the College exists to help local institutions address challenges in the Pittsburgh region and the Commonwealth of Pennsylvania. Since its inception under the College in 1987, the Center has also followed an interdisciplinary approach to help the region and state confront problems and opportunities in economic, workforce, and community development. Through objective research and technical tools, the Center helps clients manage change through policy, strategy, and programming. Our toolkit includes economic, demographic, geographic, and institutional data analysis, economic and statistical modeling, survey design and analysis, performance measurement, and program design and evaluation. Since 2008, with the assistance of its EDO partners and C-level Executive Fellows, the CED has also provided a steady pipeline of academic, extracurricular, and experiential learning opportunities for master's students interested in economic development in the U.S. context. See www.cmu.edu/ced

About AESOP

The Annual Economic and Social Observatory of Pennsylvania (AESOP) was conceived in recognition of the fact that the CED's research could and should extend beyond the Allegheny County line. AESOP explores the local economic experience of the Commonwealth systematically by producing analysis and visualizations of economic and social indicators, patterns, and trends on a county basis for all of Pennsylvania. See https://www.heinz.cmu.edu/ced/visualizations-aesop. To find out more about AESOP contact Greg Lagana at glagana@andrew.cmu.edu.

About Heinz College

The CED is affiliated with the Heinz College of Information Systems and Public Policy at Carnegie Mellon University. Established in 1968 and renamed in 1992 in honor of the late U.S. Senator from Pennsylvania, Heinz College improves the ability of the public, private and nonprofit sectors to address important problems and issues facing society.

The College is home to two internationally recognized graduate-level institutions at Carnegie Mellon University: the School of Information Systems and Management and the School of Public Policy and Management. This unique colocation combined with its expertise in analytics set Heinz College apart in the areas of cybersecurity, health care, the future of work, smart cities, and arts & entertainment. See https://www.heinz.cmu.edu/.