JOLTS Reporting, Item Imputation, and Sample Rotation: Impact on JOLTS-CES Divergence October 2013

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Abstract
The Bureau of Labor Statistic's Job Opening and Labor Turnover survey (JOLTS) attempts to measure US labor market dynamics on a monthly basis. The JOLTS survey estimates both the flow of employment into business establishments (hires) and the flow of employment out of business establishments (separations). In theory, it is assumed that the levels of these two types of flow should relate directly and proportionately to the trend in the overall employment level. A number of factors prevent the employment trend and the net flow of hires and separations from equilibrating on a monthly basis. However, it is expected in theory that *over time* this equilibration should eventually occur.

We will present evidence that *even over time*, for reported JOLTS data, the net flow of hires minus separations greatly exceeds reported employment trend and that this disequilibrium is the result of a significant deficiency in reported separations or excess of reported hires. Finally, we will present the corrective action adopted by JOLTS to account for the divergence between Current Employment Survey (CES) employment and JOLTS hires minus separations.

Key Words: Item Imputation, synthetic estimates

1. Introduction

The Job Opening and Labor Turnover survey (JOLTS) is designed to measure US labor market dynamics on a monthly basis. The JOLTS survey estimates monthly employment and both the flow of employment into business establishments (hires) and the flow of employment out of business establishments (separations). In theory, it is assumed that the levels of these two types of flow should relate directly and proportionately to the trend in the overall employment level. When employment is trending up it is expected that the flow of hires should proportionately exceed the flow of separations. Conversely, when employment is trending downwards it is expected that the flow of separations should proportionately exceed the flow of hires. A number of factors prevent the employment trend and the net flow of hires and separations from equilibrating on a monthly basis. However, it is expected in theory that *over time* this equilibration will eventually occur. The purpose of this paper is to empirically compare the theory outlined above with actual reported JOLTS data to show that theory does not match empirical practice. We will present evidence that *even over time*, for reported JOLTS data, the net

flow of hires minus separations greatly exceeds the un-benchmarked employment trend and that this disequilibrium is likely the result of a significant deficiency in reported separations or excess of reported hires by approximately 1.6 million over the course of the survey.

The current JOLTS item imputation algorithm is a nearest neighbor approach. Imputed records are paired with their nearest neighbor, that is, the reported record with the closest level of employment. The current imputation approach provides comparable levels of hires and separations relative to reporters. However, it does not provide a satisfactory relationship between the imputed records' employment trend and imputed levels of hires and separations. This paper will detail why this is true and provide an alternative imputation approach that maintains the satisfactory levels of hires and separations while providing a better relationship between recipient employment trend and imputed levels of hires and separations. In addition, the effect of sample rotation on the disparity between estimated employment trend and estimated flow (hires and separations) will be discussed. Finally, it will be shown that the corrective action adopted by JOLTS to account for the divergence between CES employment and JOLTS hires minus separations (that is, the alignment procedure) is a reasonable approach.

2. Methodology

To make the case that *even over time* the net flow of reported hires and separations greatly exceeds the reported un-benchmarked employment trend a comprehensive dataset of JOLTS micro data was constructed. All reported JOLTS micro data establishment records over the entire existence of the survey (December 2000 to December 2012) were included provided the following two criteria were met; those which did not meet these criteria were not included in this analysis:

1. The establishment had two consecutive months of reported employment (that is, current month and prior months reported employment)
2. The establishment had reported both hires and total separations in the current month (that is, current month imputed hires and total separations values were ignored)

Each micro record contained the reported employment, hires and total separations values as well as the sampling weight, non-response adjustment factor (NRAF), and CES benchmark factor (BMK) used in estimation.

This data set allows for a direct comparison between reported employment trend and net flow of hires and separations for each JOLTS respondent and this comparison can be made over any length of time (such as annually or over the life of any respondent in survey) to assess how frequently any given respondent reported an employment trend equal to its hires and separation flow. More importantly, this respondent-level data can be summarized by industry and over any time period.

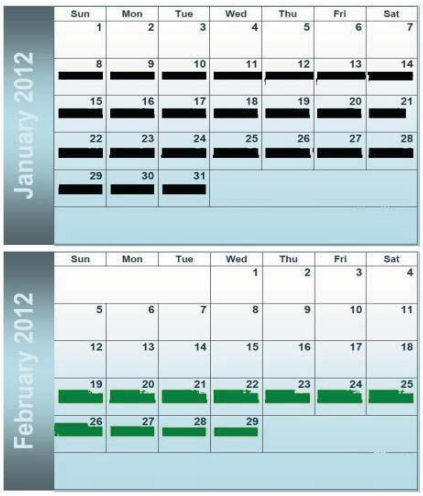
3. Why doesn't employment trend equal hires and separations flow on a monthly basis?

As stated in the introduction, there a number of factors that prevents the employment trend and the net flow of hires and separations from equilibrating on a monthly basis. This section will attempt to elaborate upon what those factors are and why the equilibration will not occur.

Employment in JOLTS is a stock measure taken during the pay period that includes the 12th of the month. The employment trend is, therefore, the difference between two stock measures. The figure below illustrates an example of the specific time points used to measure employment trend: the employment trend is the employment from January 8th to January 14th subtracted from the employment from Feb 12th to Feb 18th.

In contrast, JOLTS hires and separations data is a flow measure over the course of a given month. The figure below illustrates the specific time points used to measure hires (or separations) flow: the hires (or separations) flow is measured from February 1st to February 29th.

Thus employment trend and hires and separations flow do not occur over precisely the same time period. The employment trend in this example can be accounted for by hires and separations that occur over the time period of January 8th to February 18th. However, the actual hires and separations monthly estimates are measured from February 1st to February 29th: the hires and separations that contribute to the employment trend from January 8th to January 31st (period in black below) are not included in the current hires and separations estimate. Those hires and separations that occur during the period February 19th to February 29th (the period in green below) are included in the current hires and separations estimate but do not contribute to the employment trend in question.



On a monthly basis, the time period of employment trend for a given respondent is not the same time period for hires and separations flow, with the exception of establishments with monthly payrolls. Consequently, these two measures may diverge during that time

period. In addition, the JOLTS hires and separations concept is qualitatively different from employment. The employment data represents the number of employees that were employed during the pay period of the 12th of the month. If the employee is not on the payroll *even in the case that relationship between employee and employer remains unchanged*, then that employee may not be included in the employment total. Employment is not dependent on the relationship between employer and employee but rather depends on whether the employee is paid. In contrast, hires and separations as measured by JOLTS are based exclusively on the relationship between employer and employee. The initiation of the relationship between employer and employee is termed a hire and the termination of the relationship between employer and employee is termed a separation.

The classic example of where this qualitative difference between employment and hires and separations regularly occurs is in public schools. During the summer recess there are many educational support staff personnel (bus drivers, cafeteria workers, janitors, etc.) who are dropped from the school payroll in June (and consequently are not included in the monthly employment reported by the school during the recess period) and then return to the payroll in the fall. However, the relationship between the support staff and school remains unchanged, that is, there has not been a hire or separation. Thus there is a reported decrease in employment by the school in June and an offsetting increase in employment in September. This creates disequilibrium between employment trend and hires and separations flow during the summer that is only resolved with the end of summer recess in September.

Thus it is likely that macro-level employment trend will not equilibrate with macro-level hires and separations flow on a monthly basis. Only *over time*, at the micro and macro level, should employment trend equilibrate with hires and separations trend. Stated in another way, there is an expectation that the monthly disequilibrium should be symmetric about zero: from the example alluded to above, the disequilibrium brought about when educational support staff drop from the payroll in June should be symmetrically offset by the disequilibrium brought about when the same educational support staff returns to the payroll in September.

4. JOLTS reported data

There were over 1 million JOLTS records that meet the criteria as laid out in the Methodology section. Below is a summary (Total Non- Farm) of the un-weighted reported JOLTS data with respect to employment change, hires and separations:

Table 1. JOLTS Reported Data (Total Non Farm, Dec 2000 to Dec 2012)

N Reporters:	1,075,180
Net Reported Employment Change:	-321,065
Total Reported Hires:	14,434,044
Total Reported Separations:	13,187,632
Total Reported (Hires – Separations):	+1,246,412

It can be seen from the data above that the reported employment trend is in disequilibrium with hires and separations flow during the period of December 2000 to December 2012: the net reported employment change is negative (-321,065) while reported hires minus separations is positive (+1,246,412). There are three major possible logical explanations for this disequilibrium:

1) An excessive number of reported hires have been reported by JOLTS respondents relative to reported employment change.
2) An insufficient number of reported separations have been reported by JOLTS respondents relative to employment change.
3) A combination of the two explanations above.

The internal divergence of a given establishment or group of establishments (i) at time t is defined as:

$$\text{Internal Divergence}_{it} = (\text{Hires}_{it} - \text{Seps}_{it}) - (\text{Emp}_{it} - \text{Emp}_{it-12})$$

Positive internal divergence occurs when and is consistent with the logical explanations above:

$$(\text{Hires}_{it} - \text{Seps}_{it}) > (\text{Emp}_{it} - \text{Emp}_{it-12})$$

Below is the analysis of un-weighted reported JOLTS data with respect to employment change, hires and separations at the major industry level.

Table 2. JOLTS Reported Data (Industry Detail, Dec 2000 to Dec 2012)

ID	Industry	N	EMP CHANGE	HIRES	SEPS	H-S	Int_Div
21	Nat Res & Mining	26,541	-8,998	107,394	103,986	3,408	12,406
23	Construction	56,215	-29,584	294,856	268,010	26,846	56,430
31	Nondurable MFG	50,054	-38,187	337,441	359,092	-21,651	16,536
33	Durable MFG	80,277	-91,164	547,825	635,737	-87,912	3,253
42	Wholesale Trade	47,112	-21,943	138,144	146,515	-8,371	13,572
44	Retail Trade	101,519	-4,491	455,139	444,629	10 ,510	15,001
48	Transport & Utilities	39,028	-81,082	614,484	594,174	20,310	101,392
51	Information	22,938	-9,600	145,984	162,842	-16,858	-7,258
52	Finance & Insurance	35,726	-48,566	286,443	298,918	-12,475	36,091
53	Real Estate & Rental	24,052	-4,824	78,620	77,476	1,144	5,968
55	Professional Business Services	91,909	-36,245	536,897	512,847	24,051	60,296
56	Temp Help	12,993	-31,636	321,635	321,066	569	32,205
61	Educational Services	31,939	50,618	490,601	377,731	112,870	62,252
62	Health Care and Social	115,435	112,891	1,771,285	1,361,734	409,551	296,660
71	Arts & Entertainment	29,276	-15,440	637,419	596,256	41,163	56,603
72	Accommodation & Free	77,015	-28,197	487,615	461,753	25,862	54,059
81	Other Services	38,536	1,344	173,238	137,019	36,219	34,875
91	Federal Government	24,047	-50,900	1,718,156	1,682,904	35,252	86,152
92	State & Local Government	82,508	131,779	3,522,804	3,151,609	371,195	239,416
93	State & Local Education	88,060	-116,841	1,768,063	1,493,336	274,727	391,568
TNF	**Total Non Farm**	**1,075,180**	**-321,065**	**14,434,044**	**13,187,632**	**1,246,412**	**1,567,477**

At the industry level, with one minor exception, internal divergence is positive.

Below is the analysis of un-weighted reported JOLTS data with respect to employment change, hires and separations by reported employment size:

Table 3. JOLTS Reported Data (Size Detail, Dec 2000 to Dec 2012)

SIZE	REPORTED EMPLOYMENT	N	EMP CHANGE	HIRES	SEPS	H-S	Int_Div
1	0-19 Employees	191,131	-10,836	113,560	123,283	-9,723	1,114
2	20-49 Employees	294,003	53,478	500,595	438,547	62,048	8,570
3	50-249 Employees	280,316	-120,951	991,904	959,329	32,575	153,526
4	250-999 Employees	156,984	-93,826	1,837,867	1,734,209	103,658	197,484
5	1000-4999 Employees	106,434	-141,735	4,213,277	3,770,348	442,929	584,664
6	5000+ Employees	46,312	-7,194	6,776,841	6,161,917	614,924	622,118

For every reported employment size class internal divergence is positive.

Below is the analysis of un-weighted reported JOLTS data with respect to employment change, hires and separations by reporting year:

Table 4. JOLTS Reported Data (Annual Detail, Dec 2000 to Dec 2012)

YEAR	N	EMP CHANGE	HIRES	SEPS	H-S	Diff
2001	49,137	17,191	1,035,341	983,864	51,477	34,285
2002	90,582	161,865	1,452,707	1,242,511	210,196	48,331
2003	80,159	-248,572	1,213,868	1,179,581	34,287	282,859
2004	92,204	-8,021	1,361,148	1,267,760	93,388	101,409
2005	91,842	23,001	1,442,657	1,256,144	186,513	163,512
2006	88,235	37,358	1,293,501	1,118,382	175,119	137,761
2007	89,440	44,351	1,326,321	1,132,499	193,822	149,471
2008	85,711	-50,241	1,058,964	987,208	71,756	121,997
2009	88,467	-238,546	864,225	924,827	-60,602	177,944
2010	99,379	4,194	994,304	932,231	62,073	57,879
2011	107,579	-86,692	1,119,557	1,037,108	82,449	166,141
2012	112,445	20,045	1,271,450	1,125,518	145,932	125,887

Once again, for every year of the survey, internal divergence is positive. The tables above all demonstrate that in the overwhelming number of cases that the net reported employment change is less than reported hires minus separations—as it would be if an insufficient number of reported separations or an excess of hires have been reported by JOLTS respondents relative to employment change. JOLTS reporters have under-reported separations or over-reported hires by approximately 1.6 million over the course of the JOLTS survey thus severely compromising the ability of JOLTS hires minus separations to equilibrate to JOLTS reported employment. This lack internal "internal consistency" within JOLTS in turn compromises the ability of JOLTS hires minus

separations to track CES employment change. Internally inconsistent reported JOLTS hires and separations data is a prime cause of the JOLTS-CES divergence.

Further study of respondents is needed to determine to what extent under-reporting of separations occurs relative to over-reporting of hires. Further study is also necessary to pinpoint the reasons for the respondents to systematically report data without internal consistency.

5. JOLTS Imputation

The JOLTS is based on a multivariate sample $(x_1, y_1) \ldots (x_n, y_n)$ with observed item values (such as hires, separations, etc.) $y_1,...,y_r$ (survey respondents), missing $y_{r+1},..., y_n$ (item non-respondents), and observed reported employments $x_1,...,x_n$. JOLTS uses a Nearest Neighbor Imputation (NNI) algorithm that imputes missing y_j by $(\frac{y_i}{x_i}) * x_j$, where $1 :: i :: r$ and i is the missing neighbor of j as measured by the x variable, such that i satisfies $|x - x_j| = \min_{1::k::r} |x_k - x_j|$ within imputation class. That is, what is borrowed from the nearest donor within the imputation class is the ratio of the nearest donor item to nearest donor employment multiplied by the non-responding recipient employment. Imputation recipients use the same donor for all missing item values. If we consider hires as y and separations as z then the NNI imputes missing y_j by $(\frac{y_i}{x_i}) * x_j$ and imputes missing z_j by $(\frac{z_i}{x_i}) * x_j$.

In this approach, it is reported employment (x) that is being used to determine the nearest neighbor. However, is the mere *level of employment* of a donor or recipient appropriate for imputing hires or separations (or both) of the recipient? Consider the case of a donor establishment with a reported employment of 50 with that of a recipient within the same imputation class with a reported employment of 50. The fact that both the donor and recipient have similar static employment does not carry any information about the dynamics of that employment for either recipient or donor. The donor may be sharply contracting while the recipient could be sharply expanding. In such a situation, would the sharply contracting donors' hires to employment ratio and separations to employment ratio be a good fit for the expanding recipient? It likely would not be.

A direct comparison may be made between reported and imputed records with respect to employment trend and hires and separations. The internal divergence will again be used for illustrative purposes: a 0 value for internal divergence for a reporting unit indicates that the employment change and hires minus separations value are equivalent. The larger the magnitude of the internal divergence, the less the reported employment change fits hires and separations. Below is a comparison between reported records (employment change reported, hires and separations reported) and imputed records (employment change reported, hires and/or separations imputed):

Table 5. Internal Divergence: Reported vs. Imputed

Internal Divergence (n=143,389)	**Percent Reported (n=1,075,180)**	**Percent Imputed**
0	51%	7%
± 1	58%	18%
± 5	79%	39%
±10	88%	52%

Irrespective of size, over 50% of reported records have a 0 internal divergence indicating a perfect match between employment change and reported hires minus separations. The imputed records fit poorly in comparison with the reported.

This paper suggests a hybrid approach that retains elements of the current approach while incorporating the fact that, in a large number of cases, reported employment change equals reported hires minus reported separations. The suggestion, where both hires and separations need to be imputed and the reported employment change is known of an imputation recipient, is to use the current approach to impute one element (hires or separations) and to solve for the other using the reported employment change. More precisely, if the employment changes were negative: then impute hires as usual and solve for separations. If the employment change were positive: then impute for separations and solve for hires.

If we consider hires as *y* and separations as *z* and the reported JOLTS employment change ($emp_t - emp_{t-1}$) = φ then:

when φ :: 0

NNI would impute missing y_j by $(\frac{y_i}{x_i}) * x_j$ and imputes missing z_j by $y_j +$ ⟨

When φ > 0

NNI would impute missing z_j by $(\frac{z_i}{x_i}) * x_j$ and imputes missing y_j by $z_j +$ ⟨

Whenever reported employment change is unknown or the recipient record is a partial imputation, then the current approach would still be used. This would enable the imputed records to more closely resemble reported records with respect to the relationship between reported employment change and hires minus separations.

6. JOLTS Sample Rotation

The preceding sections of this paper have demonstrated that JOLTS reported employment change fails to equilibrate to reported hires minus separations due to insufficient

reporting of separations or a surplus of hires. In addition, the current JOLTS imputation algorithm has a tendency to provide imputed hires and separations that are not likely to match the employment change of imputation recipients. There is one further aspect of JOLTS estimation that is likely to add to the disequilibrium between employment change and hires minus separations: sample rotation. Each month, a non-certainty segment of the JOLTS sample is rotated out of estimation while an equally sized sample segment is rotated in. However, there is no way of insuring that the employment changes of the sample being rotated out is identical or approximates the employment changes of the sample being rotated in.

To quantify the extent of sample rotation, the following graph details the number of respondent records from Dec 2000 to December 2012 that were imputed, non-imputed but reported consecutive months, and non-imputed but did not report in consecutive months:

Table 6. JOLTS Record Types

Type of Record	Percentage of Records
Imputed	12.12%
Non-Imputed Consecutive	82.30%
Non-Imputed Non-Consecutive	5.58%

The number of records affected by sample rotation is not large (approximately 5% since the non-imputed, non-consecutive also includes intermittent respondents). However, the fact that there is nothing methodologically that can be done to ensure that the employment change profile of sample rotated out approximates the employment change profile of sample rotated in suggests that some non-trivial amount of disequilibrium may occur as a result of sample rotation.

7. Using CES Employment Change as a JOLTS Hires minus Separations Benchmark

The employment analyzed in the previous sections was JOLTS reported employment. In JOLTS estimation, this reported employment estimate is ratio-adjusted to the Current Employment Survey (CES) employment estimate. This is done since the CES employment estimate is estimated using a substantially larger sample than is the JOLTS employment estimate. The CES estimate, as a consequence, has a substantially lower employment variance than does its JOLTS counterpart. To help quantify the magnitude of the effect of the difference in employment variance between CES employment and JOLTS un-benchmarked employment, the mean monthly absolute employment change of CES Employment at the Total Non Farm level was approximately 899,000 from December 2000 to December 2012 while for the JOLTS un-benchmarked employment estimate the mean monthly absolute employment change was approximately 1,362,000 (or about 52% greater).

Since the CES provides a lower monthly employment variance than does JOLTS then it stands to reason that the CES provides a superior estimate for employment change. Since JOLTS hires and separations flow should approximate employment change in the long run and CES provides the superior estimate of employment change, then it follows that JOLTS hires and separations flow in the long run should be benchmarked to CES employment change. Consequently, JOLTS has adopted an alignment procedure that does, in effect, precisely that.

The alignment procedure developed by JOLTS to correct the divergence between CES employment change and JOLTS hires and separation trend benchmarks JOLTS hires and separations to CES employment change estimates by manipulating hires and separations levels such that the annual seasonally adjusted CES employment trend approximates the annual JOLTS hires and separation trend. Seasonal factors are removed from the aligned seasonal series to create a non-seasonal aligned series. This allows for the preservation of JOLTS seasonal patterns in the JOLTS hires and separations non-seasonal series. Although, as seen in this paper, JOLTS reported employment change does not equilibrate with reported hires and separations flow due to reporting, imputation, and sample rotation this deficiency is reasonably removed by benchmarking JOLTS hires and separations to CES employment change through the alignment procedure.

8. Conclusion

This paper empirically compared the theory that reported employment trend in the JOLTS series should equilibrate over time with JOLTS hires and separations trend with actual reported JOLTS data and has shown conclusively that theory does not match empirical practice. There is strong evidence to conclude that JOLTS reporters systematically under-report separations or over-report hires and that this lack of internal consistency is a prime causal factor in the JOLTS-CES divergence. The current JOLTS imputation approach and the level of monthly sample rotation contribute to the disequilibrium as well. This paper suggests an improvement to the JOLTS imputation approach and concludes that the JOLTS alignment procedure is an adequate and reasonable approach that mitigates the disequilibrium.

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