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On June 11, 2018, the article was republished to correct the following sentence regarding the analysis of earnings changes in table 9b:

Conversely, average hourly earnings may increase at the lower level industries, but decline in the aggregate.



An average mystery in hours and earnings data entails a weighty explanation

By Angela Clinton

A total average goes up while all the averages at the component level go down. Is that possible? Yes—and understanding the statistical method involved is the key to explaining this seeming mystery.

Employment, hours, and earnings data from the [Current Employment Statistics](#) (CES) survey, also known as the establishment or payroll survey, are among the most highly anticipated economic statistics published each month by the Bureau of Labor Statistics. National CES estimates, along with labor force data from the [Current Population Survey](#) (household survey), are available with the [Employment Situation](#) news release, typically on the first Friday of the month following the reference month. The data in this release provide a broad view of current economic conditions in the U.S. labor market.

Policymakers and other data users look to CES series of average weekly hours for signs of potential economic slowing or acceleration. The workweek for manufacturing, in particular, serves as a leading economic indicator. Surges or declines in demand may be temporary; thus, businesses often adjust their employees' hours before deciding whether to hire or lay off workers. Data users also closely follow average hourly and weekly earnings. Earnings provide information on the buying power of workers. Rapidly rising earnings also may signal wage-push inflation, whereby employers raise the prices of goods and services to offset higher wages and salaries paid to employees.¹

The mystery

The over-the-month change in any hours or earnings series is the most important characteristic in the analysis of trends, and data users often look to the highest industrial level—total private—for insight. However, looking at the hours and earnings of industry components that make up the private sector may lead some data users to question changes at the total private level that intuitively do not make sense. The change in average weekly earnings from July to August 2017 serves as an example. How could average weekly earnings increase at the total private level when they decreased for its two components—goods-producing and private service-providing? (See table 1.)

Table 1. Average weekly earnings of all employees, July–August 2017, seasonally adjusted

Sector	July	August	Change
Total private	\$906.10	\$907.82	\$1.72
Goods-producing	1,119.02	1,112.68	-6.34
Private service-providing	867.13	866.52	-0.61

Source: U.S. Bureau of Labor Statistics.

To understand how changes at the total private level can differ in direction from changes at the lower industry levels, one must consider how BLS aggregates the series. Employment estimation is straightforward: employment at lower levels of industry detail, such as goods-producing and private service-providing, is simply summed to yield employment at the next higher level, total private.² The aggregation procedures for hours and earnings are not as straightforward. Changes in the aggregate are determined not only by each component industry's average, but in how those averages are weighted. Average weekly hours are weighted by employment of the lower level industries, average hourly earnings are weighted by total hours for which workers are paid, and the product of average weekly hours and average hourly earnings equals average weekly earnings. The aggregated estimates must also be calculated in a specific order beginning with employment, followed by weekly hours, hourly earnings, and finally weekly earnings.

Weighting the workweek

Simple examples can show how changes in employment and the average workweek affect average weekly hours at aggregate levels. Tables 2a and 2b show two basic industries, A and B, with their corresponding estimates of employment and average weekly hours. Month 1 serves as the baseline employment and hours. Consider this baseline as the month prior to the reference month and month 2 as the reference month.

Table 2a. Month 1: baseline weekly hours and employment levels

Industry	Employment level	Percentage of summary industry employment	Average weekly hours per worker	Total hours per week
Industry A	5	33.3	40.0	200
Industry B	10	66.7	30.0	300
Summary industry	15	100.0	33.3	500

Table 2b. Month 2: employment increases for industry B

Industry	Employment level	Percentage of summary industry employment	Average weekly hours per worker	Total hours per week
Industry A	5	20.0	40.0	200
Industry B	20	80.0	30.0	600
Summary industry	25	100.0	32.0	800

Employment in industries A and B is summed to obtain employment for the summary industry. Total hours (the product of employment and average weekly hours) are calculated for each basic industry and then summed. Divide the 500 total hours by summary employment to obtain average weekly hours for the summary industry. The workweek is then rounded to the nearest tenth of an hour. In the month 1 estimates, one can see that the average for the summary industry (33.3 hours) falls between the range of average hours for industries A and B and is closer to the average of industry B, which makes up a larger share of employment.

Month 2 (reference month) in table 2b shows the same estimates of average weekly hours for the basic industries, but industry B employment increases. While the average workweek did not change for the basic industries, it did for the summary industry. Industry B represents an even greater share of total employment, thus the summary average is pulled down toward the average of industry B.

In tables 3a and 3b, employment holds steady from month 1 to month 2, but the workweek increases for industry B. The average workweek for the summary industry increases but is still closer to average weekly hours of industry B.

Table 3a. Month 1: baseline weekly hours and employment levels

Industry	Employment level	Percentage of summary industry employment	Average weekly hours per worker	Total hours per week
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Table 3a. Month 1: baseline weekly hours and employment levels

Industry	Employment level	Percentage of summary industry employment	Average weekly hours per worker	Total hours per week
Industry A	5	33.3	40.0	200
Industry B	10	66.7	30.0	300
Summary industry	15	100.0	33.3	500

Table 3b. Month 2: average weekly hours increase in industry B, employment unchanged in industries A and B

Industry	Employment level	Percentage of summary industry employment	Average weekly hours per worker	Total hours per week
Industry A	5	33.3	40.0	200
Industry B	10	66.7	32.0	320
Summary industry	15	100.0	34.7	520

The conundrum arises when, from baseline to month 2, average weekly hours increase for both basic industries but decline in the summary industry. (See tables 4a and 4b.) One must look to the shift in employment. Industry B, with below-average hours, increased its employment share, which, in turn, pulled the summary average down and more than outweighed the positive impacts of the increases in the average weekly hours series for industries A and B.

Table 4a. Month 1: baseline weekly hours and employment levels

Industry	Employment level	Percentage of summary industry employment	Average weekly hours per worker	Total hours per week
Industry A	5	33.3	40.0	200
Industry B	10	66.7	30.0	300
Summary industry	15	100.0	33.3	500

Table 4b. Month 2: average weekly hours increase in industries A and B, employment increases in industry B

Industry	Employment level	Percentage of summary industry employment	Average weekly hours per worker	Total hours per week
Industry A	5	14.3	41.0	205
Industry B	30	85.7	31.0	930

Table 4b. Month 2: average weekly hours increase in industries A and B, employment increases in industry B

Industry	Employment level	Percentage of summary industry employment	Average weekly hours per worker	Total hours per week
Summary industry	35	100.0	32.4	1,135

Tables 5a and 5b show the opposite effect, whereby the workweek falls for both industries A and B, however employment rises in industry A. The positive impact of the job gain in industry A, with its longer workweek, more than outweighed the downward effects of declines in the component industries' workweeks, resulting in an increase in average weekly hours for the summary industry.

Table 5a. Month 1: baseline weekly hours and employment levels

Industry	Employment level	Percentage of summary industry employment	Average weekly hours per worker	Total hours per week
Industry A	5	33.3	40.0	200
Industry B	10	66.7	30.0	300
Summary industry	15	100.0	33.3	500

Table 5b. Month 2: average weekly hours decrease in industries A and B, employment increases in industry A

Industry	Employment level	Percentage of summary industry employment	Average weekly hours per worker	Total hours per week
Industry A	15	60.0	39.9	599
Industry B	10	40.0	29.9	299
Summary industry	25	100.0	35.9	898

These results illustrate how changes in average weekly hours are dependent on the changes in the workweek of component industries and on the change in mix of employment between industries with higher and lower average hours.

Conflicting signals in dollars and sense

Average hourly earnings at summary levels are weighted by total weekly hours of each basic industry. Thus, changes in employment and average weekly hours (through total hours) and changes in average hourly earnings of basic industries affect average hourly earnings at aggregate levels.

Tables 6a and 6b show two basic industries, A and B, with their corresponding estimates of total weekly hours and average hourly earnings. The month-1 baseline represents estimates before changes are applied (the month prior to the reference month). The sum of total weekly hours for industries A and B equals total hours for the summary industry. The product of total hours and average hourly earnings represents total payroll for each basic industry. Total payroll dollars of industries A and B are summed and then divided by the sum of total hours to obtain

average hourly earnings for the summary industry. The distribution of total hours are evenly split in the baseline data; therefore, average hourly earnings for the summary results in a simple average of hourly earnings from the two basic industries.

Table 6a. Month 1: baseline weekly hours and earnings

Industry	Total hours per week	Percentage of summary industry hours	Average hourly earnings	Total weekly payroll
Industry A	300	50.0	\$25.00	\$7,500
Industry B	300	50.0	10.00	3,000
Summary industry	600	100.0	17.50	10,500

Table 6b. Month 2: total hours increase in industry A, average hourly earnings unchanged in industries A and B

Industry	Total hours per week	Percentage of summary industry hours	Average hourly earnings	Total weekly payroll
Industry A	400	57.1	\$25.00	\$10,000
Industry B	300	42.9	10.00	3,000
Summary industry	700	100.0	18.57	13,000

When total hours increase for industry A and average hourly earnings of the component industries remain unchanged, then hourly earnings for the summary industry move closer to industry A's hourly earnings, because it now carries more weight.

If the weights of total hours do not change, then any change in average hourly earnings at the basic industry level pulls average earnings at the summary level in the same direction. In tables 7a and 7b, average hourly earnings rose in industry A and pulled the summary average upward also.

Table 7a. Month 1: baseline weekly hours and earnings

Industry	Total hours per week	Percentage of summary industry hours	Average hourly earnings	Total weekly payroll
Industry A	300	50.0	\$25.00	\$7,500
Industry B	300	50.0	10.00	3,000
Summary industry	600	100.0	17.50	10,500

Table 7b. Month 2: average hourly earnings increase in industry A, hours unchanged in industries A and B

Industry	Total hours per week	Percentage of summary industry hours	Average hourly earnings	Total weekly payroll
Industry A	300	50.0	\$30.00	\$9,000
Industry B	300	50.0	10.00	3,000
Summary industry	600	100.0	20.00	12,000

Just as average weekly hours of component industries can move counter to the average workweek for a summary industry, one can observe similar types of movements in average hourly earnings. Suppose that average hourly earnings decrease in both industries A and B. (See tables 8a and 8b.) It might seem that average hourly earnings

at the summary level should also decrease. However, if total hours for the higher paying industry A rises enough, then average hourly earnings for the summary industry can actually rise.

Table 8a. Month 1: baseline weekly hours and earnings

Industry	Total hours per week	Percentage of summary industry hours	Average hourly earnings	Total weekly payroll
Industry A	300	50.0	\$25.00	\$7,500
Industry B	300	50.0	10.00	3,000
Summary industry	600	100.0	17.50	10,500

Table 8b. Month 2: total hours increase in industry A, average hourly earnings decrease in industries A and B

Industry	Total hours per week	Percentage of summary industry hours	Average hourly earnings	Total weekly payroll
Industry A	600	66.7	\$24.00	\$14,400
Industry B	300	33.3	9.00	2,700
Summary industry	900	100.0	19.00	17,100

Conversely, average hourly earnings may increase at the lower level industries, but decline in the aggregate. Tables 9a and 9b illustrate how these changes can occur. The greater weight of total hours in industry B pulled average hourly earnings at the summary level lower and more than offset increases in the basic industries' hourly earnings.

Table 9a. Month 1: baseline weekly hours and earnings

Industry	Total hours per week	Percentage of summary industry hours	Average hourly earnings	Total weekly payroll
Industry A	300	50.0	\$25.00	\$7,500
Industry B	300	50.0	10.00	3,000
Summary industry	600	100.0	17.50	10,500

Table 9b. Month 2: total hours increase in industry B, average hourly earnings increase in industries A and B

Industry	Total hours per week	Percentage of summary industry hours	Average hourly earnings	Total weekly payroll
Industry A	300	33.3	\$26.00	\$7,800
Industry B	600	66.7	11.00	6,600
Summary industry	900	100.0	16.00	14,000

Mystery solved

So, what forces drove those average weekly earnings changes in August 2017? When aggregating average weekly hours up from basic to summary levels, one must consider both employment and average weekly hours of all the basic series that feed into the summary. Employment rose relatively faster in goods-producing industries than in private service-providing industries, giving added weight to the goods-producing component for calculating average weekly hours of all private-sector workers. Because the average workweek in goods-producing is above

the total private average, the increase in employment share placed upward pressure on total private average weekly hours. The positive influence created by the change in employment mix offset declines in the average workweeks for both goods-producing and private service-providing industry groups, leaving average weekly hours unchanged at the total private level. (See tables 10a through 10f.)

Between July and August, total weekly hours were down slightly in both goods-producing and private service-providing industries and resulted in a small weight shift (.01 percentage point) toward the above-average earnings in goods-producing industries. The weight shift toward the higher average earnings combined with a 6-cent gain in average hourly earnings of private service-providing industries more than offset the 2-cent decrease in hourly earnings of goods-producing industries, thus producing a gain in average hourly earnings at the total-private level.

Table 10a. Employment (thousands): over-the-month changes, July to August 2017

Industry	July		August		Change
	Level	Percent of total	Level	Percent of total	
Goods-producing	20,040	16.11	20,115	16.14	75
Private service-providing	104,362	83.89	104,495	83.86	133
Total private	124,402	100	124,610	100	208

Source: U.S. Bureau of Labor Statistics.

Table 10b. Average weekly hours: over-the-month changes, July to August 2017

Industry	July	August	Change
Goods-producing	40.5	40.3	-0.2
Private service-providing	33.3	33.2	-0.1
Total private	34.4	34.4	0

Source: U.S. Bureau of Labor Statistics.

Table 10c. Total weekly hours (thousands): over-the-month changes, July to August 2017

Industry	July		August		Change
	Level	Percent of total	Level	Percent of total	
Goods-producing	811,620	18.93	810,635	18.94	-986
Private service-providing	3,475,255	81.07	3,469,234	81.06	-6,021
Total private	4,286,875	100	4,279,869	100	-7,006

Source: U.S. Bureau of Labor Statistics.

Table 10d. Average hourly earnings (dollars): over-the-month changes, July to August 2017

Industry	July	August	Change
Goods-producing	\$27.63	\$27.61	-\$0.02
Private service-providing	26.04	26.10	0.06
Total private	26.34	26.39	0.05

See footnotes at end of table.

Source: U.S. Bureau of Labor Statistics.

Table 10e. Total weekly payroll (thousands of dollars): over-the-month changes, July to August 2017

Industry	July		August		Change
	Level	Percent of total	Level	Percent of total	
Goods-producing	\$22,425,061	19.86	\$22,381,619	19.82	-\$43,442
Private service-providing	90,495,630	80.14	90,547,007	80.18	51,378
Total private	112,920,690	100	112,928,626	100	7,936

Source: U.S. Bureau of Labor Statistics.

Table 10f. Average weekly earnings (dollars): over-the-month changes, July to August 2017

Industry	July	August	Change
Goods-producing	\$1,119.02	\$1,112.68	-\$6.34
Private service-providing	867.13	866.52	-0.61
Total private	906.10	907.82	1.72

Source: U.S. Bureau of Labor Statistics.

Average weekly hours equal total hours divided by employment, and average hourly earnings equal total payroll divided by total hours. For any industry, the product of average weekly hours and average hourly earnings represents average weekly earnings. Canceling out total hours from the equation shows that average weekly earnings, when aggregated up, are simply weighted by employment of the lower level industries. (See figure 1.)

Figure 1.

Average weekly earnings = Average weekly hours × Average hourly earnings

$$\begin{aligned}
 &= \frac{\text{Total hours}}{\text{Employment}} \times \frac{\text{Total payroll}}{\text{Total hours}} \\
 &= \frac{\text{Total payroll}}{\text{Employment}}
 \end{aligned}$$

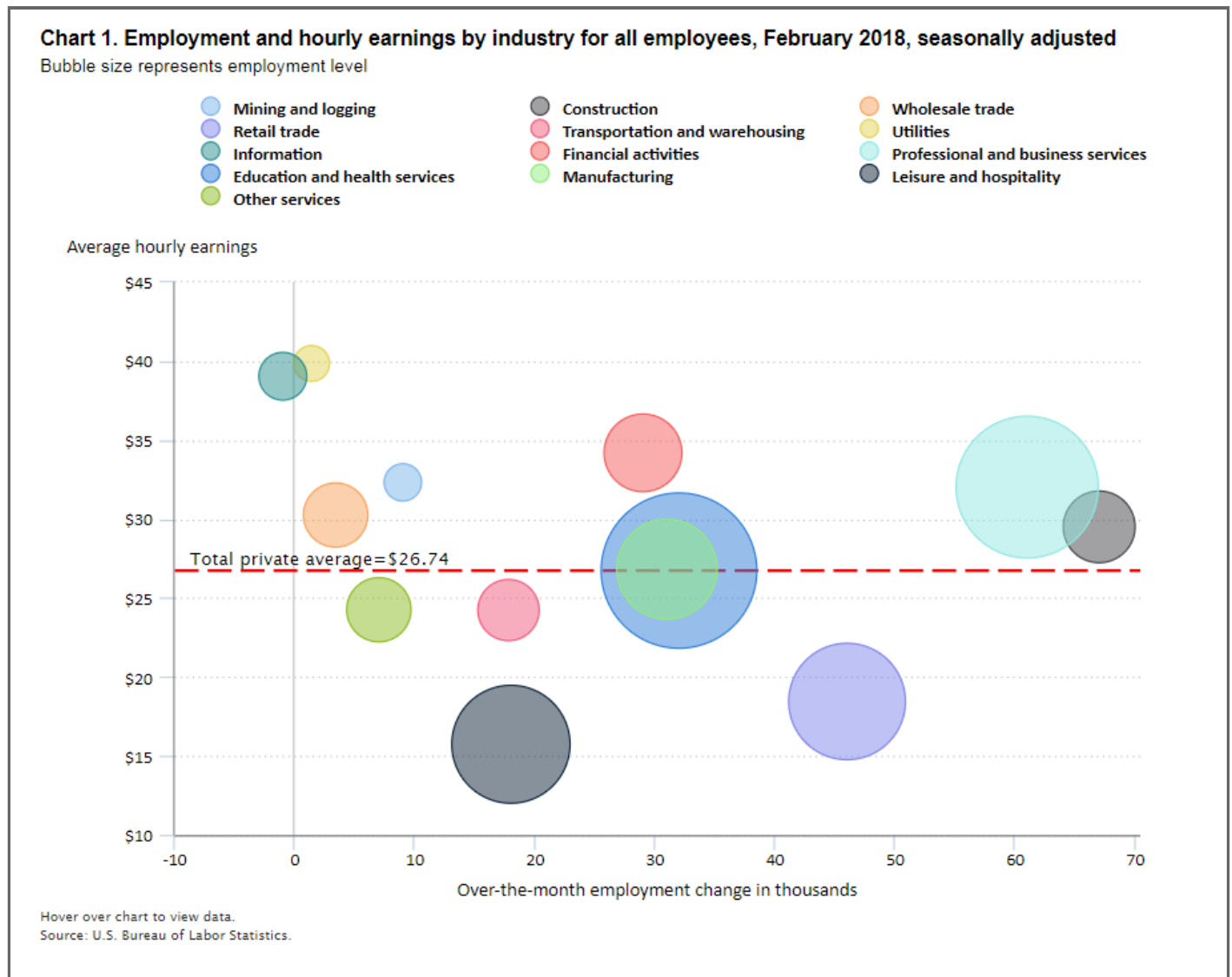
In August 2017, both the weight shift in employment to goods-producing with above-average earnings and the increase in average hourly earnings for private service-providing industries contributed to the increase in average weekly earnings at the total private level.

Visualizing the details

Visual tools can help demonstrate how weights affect the averages. Each month with the Employment Situation news release, BLS publishes a bubble chart showing average hourly earnings, employment change, and relative employment size by industry. For instance, chart 1 shows the data for February 2018 with average hourly earnings on the y-axis and the employment change on the x-axis. The bubble size corresponds to the industries' relative employment size—the larger bubble implies greater employment weight. Education and health care represent the largest share of employment (19 percent), but with its average hourly earnings equal to the total private average, any employment change in the sector would not move the total earnings average. Professional and business services represents about 17 percent of employment and pays above average earnings, and thus the employment

gain would pull the average up. In contrast, retail trade at 13 percent of employment has below-average earnings, so its job gain pulls the total private average down. Now consider the utilities industry, which has the highest hourly earnings among all industries, its 0.4-percent share of employment is so small, that its 1,400 employment change along with a 26-cent earnings increase had a negligible effect, less than one-half cent, on the total private average.

(For a chart of the most recent month's data, see <https://www.bls.gov/charts/employment-situation/employment-and-average-hourly-earnings-by-industry-bubble.htm>.)



Conclusion

Although at first glance it may seem illogical for a summary average, such as average weekly earnings of all private-sector employees, to increase or decrease while the component industry-level averages move in the opposite direction, the puzzle can be explained by observing how weights operate in the calculation. Average weekly hours may increase or decrease for all of the basic industries, but changes in the share of employment in basic industries may offset those changes. Industries with greater employment weights pull the average workweek

at the summary level towards its own average. Likewise, changes in employment, average weekly hours, and average hourly earnings can affect how both average hourly and weekly earnings change at the summary level.

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NOTES

¹ Estimates of hours and earnings are produced for two private-sector employment groups—all employees and production and nonsupervisory employees, a subset of all employees. Calculations of hours and earnings are the same for each group of employees, using the hours and earnings for each group. For more information on the Current Employment Statistics survey, see www.bls.gov/ces/.

² Seasonally adjusted CES data published in the Employment Situation are aggregated from the lowest industry levels shown in the [Employment Situation B tables](#). Data at lower levels that are released one month later are independently seasonally adjusted and do not aggregate precisely. All not-seasonally-adjusted data are aggregated from the lowest industry detail, regardless of when released, up to total private (and total nonfarm for all employees).

SUGGESTED CITATION

Angela Clinton, “An average mystery in hours and earnings data entails a weighty explanation,” *Beyond the Numbers: Employment and Unemployment*, vol. 7, no. 9 (U.S. Bureau of Labor Statistics, June 2018), <https://www.bls.gov/opub/btn/volume-7/mystery-in-average-of-hours-and-earnings.htm>