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ABSTRACT

The paper considers age-sex patterns of fluctuation of employment, unemployment, labour force participation, hours worked per employee, and hours worked per capita. The patterns are extracted (by regression) from annual data for the period 1976-2011 and expressed in the form of group-to-aggregate elasticities. An additive relationship among the elasticities is noted and used to decompose the variation of per capita hours worked into source contributions. On that basis, participation and employee hours are found to be significant contributors generally over the working age range, but especially among young workers. The results suggest a considerable amount of "hidden" unemployment during cyclical downturns.

Key words: cyclical labour force behaviour, age-sex unemployment and employment rates, hidden unemployment

JEL Classification: J21, J20

1. INTRODUCTION

We are concerned in this paper with age-sex patterns of employment and unemployment fluctuations in Canada, as extracted from Labour Force Survey data covering the period 1976 to 2011. More specifically, we are concerned with what happens to male and female workers of different ages when aggregate rates of employment and unemployment change. A plot of Canadian unemployment rates indicates two major cycles over the period (1980s, 1990s), two minor cycles (1970s, early years of the 2000-2010 decade), and a "medium" but (as of 2011) incomplete cycle; the aggregate rate varied from a low of 6.0 percent in 2007 to a high of 12.0 percent in 1983. (See Figure 1.) Men and women of different ages reflected these aggregate fluctuations in different ways and different degrees; details can vary with circumstances from one cycle to another but the broad patterns of labour force behaviour are relatively stable – and it is the broad patterns that this paper is about. (Hoynes, Miller, and Schaller, 2012, did a comparative study of patterns of this type in the U.S. during the "Great Recession" of 2007 and the recession of the 1980s, and found the patterns of different demographic groups to be "remarkably stable across three decades of time.")

We begin by establishing a framework in which the fluctuations of employment groups can be related to fluctuations at the aggregate level. We define the unemployment relationships in terms of elasticities – elasticities of the group rates with respect to the aggregate rate. We then observe that average hours worked per member of the population – "work intensity", as we call it – can be decomposed into three components: labour force participation, the employment rate, and average hours per employee. We show how this relationship can be used to decompose work intensity elasticities into corresponding component elasticities, and to assess their relative contributions. We describe the data we use, discuss the methods for calculating the elasticities, and present and interpret the results. A final summing-up section highlights what we think are the most important of the results.

2. SETTING UP THE ANALYSIS

The unemployment rate, as conventionally defined, is $u = U/L$, where U is the number unemployed and $L = E + U$ is the number in the labour force, E being the number employed. Attaching subscripts s for sex, x for age, and letting the unsubscripted symbols refer to aggregate-level variables, we can ask how the u_{sx} variables vary when there is a change in u. That is the first question of interest in this paper. However, there is an issue to be dealt with: the u_{sx} rates are components of u, in that $u = \sum_{s,x} a_{sx} u_{sx}$, where $a_{sx} = L_{sx}/L$, the s,x labour force share. Our data period is 1976-2011 and there have been long-run changes in labour force composition over that period, most notably increases in the shares of women. One might expect therefore that the relationships between the u_{sx} and u rates would have changed over the three and a half decades, for that reason, and it is desirable to replace u with a standardized rate from which the labour force share changes have been removed. We define the standardized rate (in any year) as $\bar{u} = \sum_{s,x} \bar{a}_{sx} u_{sx}$, where $\bar{a}_{sx}$ is the average s,x labour force share over the 36 years. The modified first question of interest is then how the age-sex unemployment rates vary when there is a change in the aggregate rate *after the effects of changes in labour force composition have been removed from that rate*. (The s,x rates are still components of $\bar{u}$, of course; we discuss that below.) To make the question more specific we rephrase it in terms of elasticities: What are the proportional changes in the u_{sx} rates when there is a change of one percent in the $\bar{u}$ rate?

The second question of interest to us is how the "work intensity" of the population is affected when there is a change in the aggregate employment rate. Let $w = H/N$ be work intensity, the annual average number of hours worked (H) per member of the population (N), let $p = L/N$ be the labour force participation rate, let $e = E/L = 1 - u$ be the employment rate, and let $h = H/E$ be the number of hours worked per person employed. The variables are connected by the identity $w = peh$. Using the same subscripting convention as before, and taking logs on both sides, we may write

$$lnw_{sx} = lnp_{sx} + lne_{sx} + lnh_{sx} \qquad (1)$$

Now consider how each of the variables in this equation is affected when the aggregate employment rate changes, or rather the standardized aggregate employment rate, since again we wish to eliminate the effects of changes in labour force composition. The standardized aggregate employment rate is $\bar{e} = 1 - \bar{u}$, as we define it (for consistency with the standardized unemployment rate), and taking the derivative of each term with respect to $\bar{e}$ yields the equation

$$\eta(w_{sx}, \bar{e}) = \eta(p_{sx}, \bar{e}) + \eta(e_{sx}, \bar{e}) + \eta(h_{sx}, \bar{e}) \qquad (2)$$

where $\eta(w_{sx}, \bar{e}) = \partial lnw_{sx}/\partial ln\bar{e}$ is our symbol for the elasticity of w_{sx} with respect to $\bar{e}$, and similarly for the other terms in the equation. The convenience of equation (2) is that it allows the elasticity of work intensity to be additively decomposed into participation rate, employment rate, and hours-per-employee component elasticities.

It is informative, before moving on, to compare the series of standardized aggregate unemployment rates with the unstandardized series. Figure 1 make the comparison. Standardization does not alter the general time profile but it does have some effect, and at least gives the satisfaction of knowing that one type of possible distortion has been removed.

3. THE DATA

The data set on which our calculations of elasticities are based is drawn from the Canadian Labour Force Survey master files, available at the Statistics Canada Research Data Centre at McMaster University. The set includes annual average estimates of population, labour force, employment, unemployment, and hours of employment for the period 1976 to 2011, by age and sex. There are two forms of hours reported by the survey, actual and usual. We experimented with both, found little difference in results, and eventually chose actual hours as the more appropriate definition for our purposes. (For an analysis and reconciliation of the alternative definitions, see Galarneau, Mayard, and Lee, 2005.)

The data reflect the coverage restrictions of the Labour Force Survey: institutional population, full-time members of the Canadian Armed Forces, and persons living on reserves and other aboriginal settlements in the provinces are excluded. Also excluded from national survey estimates are persons living in the Territories. (For additional information about the Labour Force Survey, see Statistics Canada, 2008.) The various ratios used in our analysis are calculated by us.

4. ESTIMATING THE ELASTICITIES

A generic form of the equations used to estimate the unemployment elasticities is the following:

$$f(u_{sx}) = g(\bar{u}) + \gamma t + \delta t^2 \qquad (3)$$

where $f(.)$ and $g(.)$ are selected functions and time and time squared are included to capture longer-term trends. We tried a variety of function combinations, calculating elasticities for each: linear, log/log, log/linear, linear/logit, and others. Our interest is in general patterns (the signs of the elasticities, whether they are less than or greater than one, comparisons across age groups and between the sexes) and the patterns were essentially similar, regardless of the function combination. Our final choice was the simplest convenient one, log/log:

$$lnu_{sx} = \alpha + \beta ln\bar{u} + \gamma t + \delta t^2 \qquad (4)$$

The elasticities are then given directly by the β coefficients.

A similar choice was made for the effects of the standardized aggregate employment rate. Using the same coefficient symbols as in equation (4),

$$\ln y_{sx} = \alpha + \beta ln\bar{e} + \gamma t + \delta t^2 \qquad (5)$$

where $y = w, p, e, h$, with s,x subscripts attached. Again the elasticities are the β coefficients.

Initial calculations indicated autocorrelation of residuals as a common feature of the regression estimates of equations (4) and (5). At least one reason for that is likely the two-stage Labour Force Survey sample design. Primary sampling units (PSUs) are selected randomly at the first stage and dwellings within the PSUs are then selected by a further random procedure. A dwelling, once selected, remains in the sample for six consecutive months, and is then replaced. Even though our data are annual averages there is some overlap of respondent dwellings from one year to the next; residents of a dwelling entering the sample in October of one year, for example, will be surveyed in October, November, and December of that year, and again in January, February, and March of the next. Moreover, once a PSU has been selected, it remains in the sample; dwellings rotated out after six months are replaced by other randomly selected dwellings in the same PSU until the PSU has been exhausted and another PSU selected to replace it. A PSU stays in the sample for a considerable length of time and its effects on sample estimates persist. Both the six-month rotation of dwellings and the longer-period rotation of PSUs can thus contribute to autocorrelation in the sampling error of the survey estimates, and hence in the regression residuals. There may be other reasons for the autocorrelation in the residuals but this is likely one of them.

There were 12 age groups identified initially in our analysis for each of the two sexes, 24 groups in all, and five separate types of series (u, w, p, e, h) for each group. In total there were then 120 individual series and 120 regression equations. Some of the series of regression residuals gave clear evidence of second-order autocorrelation and for convenience we adopted a uniform estimation procedure to allow for that. The procedure is the iterated form of the second-order Prais-Winsten estimator, a variant of the Cochrane-Orcutt estimator. (The second-order Prais-Winsten estimator preserves the first two observations, whereas the Cochrane-Orcutt method would drop them. The estimator is implemented in SHAZAM, Version 11; see Whistler et al., 2011.) We experimented also with ordinary least squares and the first-order P-W estimator; the estimated coefficients were quite similar to the second-order P-W estimates but the latter were preferred because of the autocorrelation properties of the residuals, and the results reported below are based on them.

The sex-age specific unemployment rates, u_{sx}, are components of the aggregate standardized unemployment rate, $\bar{u}$, implying that the dependent variable in equation (4) for a particular group is regressed on an independent variable of which it is a part. A similar observation applies to the e_{sx} dependent variables in equation (5): each is itself a component of $\bar{e}$. In both cases, though, each of the s,x groups is only one out of the 24 from which the overall standardized variables are constructed so that the direct connection is necessarily slight. Also, one might imagine these two sets of equations as constituting blocks within a larger (unspecified) block-recursive macro model; aggregate employment and unemployment could be thought of as having been generated at a higher level in the block recursive sequence in this hypothetical model and then fed (in standardized form) to the lower-level sex-age equation blocks, with no feedback to the aggregates in the model, thus avoiding endogenous connections. Whether or not one likes that way of looking at the situation the components-to-aggregate links are weak. We like the idea of regressing the components on the aggregates because we think that is a straightforward way of looking at the issues of interest: one considers a change in the aggregate unemployment rate, for example, and asks what that implies for the unemployment rates of young workers, older workers, etc.

Equation (5) involves regressing all of the dependent variables on a common set of independent variables. Given equation (1) that implies that a total (lnw_{sx}) and each of its three components ($lnp_{sx}, lne_{sx}, lnh_{sx}$) are regressed on the same set of variables. A well-known result from regression theory is that the adding-up restriction would hold exactly if the estimator were linear (ordinary least squares); in particular, it would hold for the β coefficients and equation (2) would then be satisfied exactly. Our estimator is nonlinear though, and so the elasticity estimates will satisfy equation (2) only approximately. There are two ways of estimating $\eta(w_{sx}, \bar{e})$: (a) the direct way, by carrying out the regression for lnw_{sx}, as in equation (4), and using the β coefficient; (b) the indirect way, by adding up the β coefficients from the separate regressions for lnp_{sx}, lne_{sx}, and lnh_{sx}. We have calculated the estimates in both ways (the estimates are similar) but show here the indirect ones, thus preserving the theoretically exact adding-up property in the reported results. (We show also t-ratios based on the direct method.)

5. RESULTS

Results for unemployment rates are provided in Table 1, separately for males and females. The table shows the mean unemployment rates over the 36 years of the data period for 10 age groups from 15-19 to 60-64. (The groups 65-69 and 70 and over are omitted from this table and the later ones; results for those groups were deemed unreliable because of the small numbers involved.) The table shows also the calculated elasticities based on equation (4), and two sets of t-ratios, relating to two alternative null hypotheses: H_0:0, representing elasticity = 0, and H_0:1, representing elasticity = 1. (The latter null is the relevant one for a test of whether a group unemployment rate moves in proportion to the aggregate rate, vs. the alternative hypothesis of less than or more than in proportion.)

It is important not to overinterpret the results: the t-ratios do not have the t or normal distribution probabilities, except asymptotically, so caution in their interpretation is indicated. Having said that, the table does suggest some interesting patterns. One is that the elasticities for female unemployment rates are, in every age group, lower than the corresponding male elasticities, even though the average unemployment rates for females are higher in half of the age groups. Moreover, the male elasticities are greater than one in all of the age groups over 20 while the female elasticities are, without exception, less than one. The t-ratios for tests of proportionality are relatively low at older ages but overall the male/female patterns are consistent. When the aggregate unemployment rate rises, rates for males over 20 rise more than proportionally, female rates less than proportionally.

The elasticities for 15-19-year-olds are especially interesting. Males in that age range have by far the highest average unemployment rate of any group (19.1 percent) but the lowest of all the response elasticities when the aggregate rate changes. Females 15-19 also have the highest mean unemployment rate for their sex and the lowest elasticity. The reasons for these (perhaps surprising) results become clearer below.

We turn now to Tables 2 and 3, showing results based on equation (5). The elasticities in these tables are with respect to the (standardized) aggregate employment rate. The elasticities for work intensity are shown in the final column of each table and their component elasticities in the earlier columns – elasticities of participation rates, employment rates, and hours per employee. H_0:0 t-ratios are shown for all three components, as well as H_0:1 ratios for the employment rate elasticities.

A decrease in the aggregate employment rate is the obverse of an increase in the aggregate unemployment rate. When the aggregate unemployment rate rises and the employment rate falls there are three effects for males (Table 2): the employment rate in every age group falls too (the elasticities are positive) but participation rates and average hours worked also fall, at least for ages under 60. The declines in participation can be interpreted as widespread net “discouraged worker” effects – net of any “additional worker” effects, that is, to use those time-honoured labels. The declines in average hours worked per employee can be interpreted as the net effects of reductions of hours for those still employed and a possible shift in the full time/part time worker distribution if full time workers were to be laid off in greater proportions than part time workers. The declines in its three components means that work intensity declines by more than the decline in the aggregate employment rate alone, in all cases , and much more so among younger groups. Work intensity falls by 6.0 times the proportional decrease in the aggregate employment rate, for males 15-19, and 3.3 times for males 20-24. Reduced participation no doubt reflects in part decisions to stay in school longer, or return to school, when the labour market offers fewer job possibilities.

The results for females (Table 3) are broadly similar but different in detail. As with males, the participation rate effects appear strong for 15-19-year-olds. For ages older than that they lack any statistical significance although the fact that the elasticities are positive for every age group under 60 does tempt us with an informal suggestion of consistency with the male rates. The effects on hours per employee are generally significant (by conventional standards) and the elasticities are uniformly positive for all age groups, implying again consistency with the male results. An elasticity of 4.7 for 15-19-year-old females indicates strongly that the effect on work intensity for that group goes well beyond the direct effect of the reduced employment rate.

Another way of looking at the results in Tables 2 and 3 is to rework them to show the proportional contribution of each component elasticity to the overall elasticity of work intensity in an age group. We do that in Table 4, showing the contributions in percentage form – component elasticities as percentages of intensity elasticities. For males under 20, employment fluctuations account for 40 percent of the fluctuations in work intensity, a full 60 percent thus being attributable to fluctuations in participation and hours of employment (in roughly equal proportions). For males 20 and over, the direct employment effect accounts (very roughly) for 60 to 70 percent among the age groups. For females under 20, the direct employment effect is an even smaller proportion than for males under 20, only 27 percent; almost three quarters of work intensity fluctuations are attributable to fluctuations in participation and hours (again, in roughly equal proportions). For females 20 and over, direct employment fluctuations account for some 55 to 65 percent of work intensity fluctuations, the balance being the result mostly of variations in average hours of employment.

6. SUMMING UP

Changes in employment and unemployment at the aggregate level are distributed unevenly among workers of different ages and sexes, based on calculated elasticities. Male employment and unemployment rates are more elastic than female rates with respect to the aggregates; a one percent change at the aggregate level has a greater effect on male rates than on female rates at all ages. The male unemployment elasticity exceeds one in every age group except the youngest while the female elasticity is less than one in every group, and this holds even though the *level* of the unemployment rate is higher for females in five out of ten age groups. (In general, levels and elasticities have little connection.) The male work force is simply more sensitive to changes over the employment cycle than the female work force.

Teenage responses stand out in the tables. The average unemployment rate for teenage males was by far the highest rate for any male group over the period 1976-2011 but the elasticity with respect to the aggregate rate was the lowest of any group. For females of the same age the average unemployment rate was again the highest, the elasticity the lowest. In a period of high cyclical unemployment the recorded unemployment rates for the youngest workers would mask a considerable amount of "hidden" unemployment, as represented by withdrawals from the labour force and reductions of average hours for those still employed.

The work intensity of the population (our term for average hours per capita) reflects not only changes in employment but also changes in labour force participation and average hours per employee. It is therefore more elastic than employment alone at all ages, and especially at younger ages. For males 20 and over, employment variation accounts directly for only about 60 or 70 percent of the variation in work intensity, depending on the age group, and for males under 20 it accounts for only 40 percent; a full three-fifths of the variation in intensity for this group is thus attributable to changes in participation and employee hours. For females the situation is generally similar for ages over 20 but even more extreme for the under-20s: only about a quarter of the variation in intensity is attributable to changes in employment, three-quarters to changes in participation and employee hours. Overall, the implications of the employment cycle for average hours worked by the population (and hence average income) exceed by a wide margin the direct effects of the changes in rates of employment and unemployment. There is much more going on behind the scenes than the employment and unemployment rates alone would indicate.

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Figure 1: The Aggregate Unemployment Rate,
Standardized and Unstandardized, 1976-2011

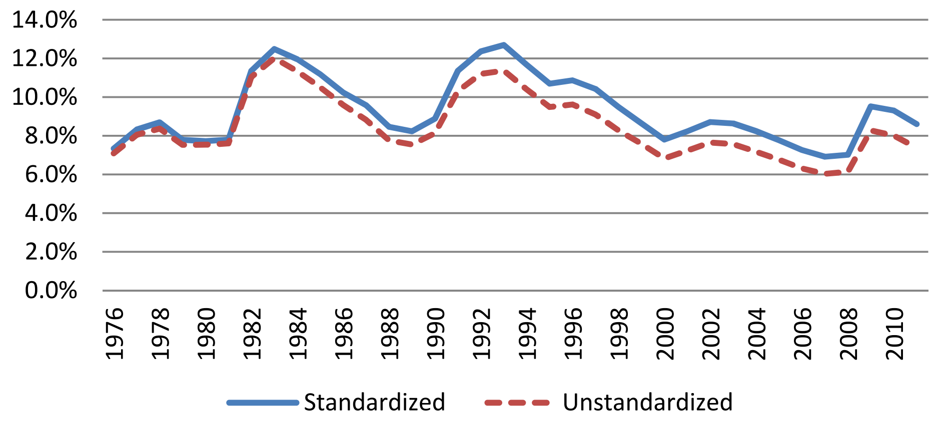

Table 1: Age Group Mean Unemployment Rates and Elasticities with Respect to the Standardized Aggregate Unemployment Rate ($\bar{u}$)

	Males				Females			
Age group	Mean unemployment rate (%)	Elasticity	$t-$ratio $H_0: 0$	$t-$ratio $H_0: 1$	Mean unemployment rate (%)	Elasticity	$t-$ratio $H_0: 0$	$t-$ratio $H_0: 1$
15-19	19.1	0.93	14.0	-1.0	15.9	0.59	6.8	-4.6
20-24	13.5	1.14	18.3	2.3	10.3	0.86	14.6	-2.5
25-29	9.5	1.29	17.0	3.8	8.6	0.74	9.1	-3.3
30-34	7.5	1.37	19.5	5.3	8.0	0.89	14.3	-1.9
35-39	6.7	1.18	23.0	3.5	7.5	0.82	13.8	-2.9
40-44	6.3	1.15	19.9	2.5	6.8	0.74	15.4	-5.3
45-49	5.9	1.20	38.6	6.6	6.4	0.79	9.4	-2.4
50-54	6.0	1.16	21.0	2.8	6.3	0.87	11.6	-1.7
55-59	6.7	1.25	15.5	3.1	6.5	0.91	10.3	-1.0
60-64	7.1	1.13	10.3	1.2	6.1	0.95	7.2	-0.4

Table 2: Age Group Elasticities with Respect to the Standardized Employment Rate ($\bar{e} = 1 - \bar{u}$): Work Intensity and its Components, Males

	Participation rate (p)		Employment rate (e)			Hours per employee (h)		Work intensity (w)	
Age group	Elasticity	t – ratio $H_0: 0$	Elasticity	t – ratio $H_0: 0$	t – ratio $H_0: 1$	Elasticity	t – ratio $H_0: 0$	Elasticity	t – ratio $H_0: 0$
15-19	1.68	4.3	2.41	11.9	6.9	1.93	7.7	6.02	9.7
20-24	0.49	3.3	2.04	15.7	8.0	0.74	4.0	3.27	10.8
25-29	0.31	4.3	1.51	17.5	5.9	0.47	4.2	2.29	14.8
30-34	0.32	4.9	1.21	20.7	3.5	0.51	3.8	2.04	16.5
35-39	0.20	3.2	0.92	21.6	-1.9	0.50	3.1	1.62	12.7
40-44	0.18	2.9	0.83	17.3	-3.6	0.38	3.0	1.39	12.4
45-49	0.16	2.7	0.81	27.6	-6.6	0.29	2.0	1.26	8.6
50-54	0.06	0.5	0.79	23.3	-6.0	0.23	1.4	1.08	7.2
55-59	0.19	1.1	0.93	13.8	-1.1	0.34	1.9	1.46	6.4
60-64	-0.05	-0.1	0.91	10.9	-1.0	0.53	3.1	1.39	2.4

Note: Elasticities for work intensity are obtained by summation, which preserves the theoretical adding-up restriction; t-ratios are based on the direct elasticity estimates.

Table 3: Age Group Elasticities with Respect to the Standardized Employment Rate ($\bar{e} = 1 - \bar{u}$): Work Intensity and its Components, Females

	Participation rate (p)		Employment rate (e)			Hours per employee (h)		Work intensity (w)	
Age group	Elasticity	t – ratio $H_0: 0$	Elasticity	t – ratio $H_0: 0$	t – ratio $H_0: 1$	Elasticity	t – ratio $H_0: 0$	Elasticity	t – ratio $H_0: 0$
15-19	1.72	4.9	1.24	6.6	1.3	1.71	5.6	4.67	7.0
20-24	0.16	0.8	1.07	14.3	1.0	0.44	2.1	1.67	5.8
25-29	0.24	1.2	0.78	10.5	-2.9	0.37	1.9	1.39	2.9
30-34	0.17	0.8	0.82	15.2	-3.4	0.37	2.3	1.36	4.7
35-39	0.10	0.6	0.72	14.2	-5.5	0.41	2.8	1.23	4.8
40-44	0.04	0.2	0.59	16.5	-11.6	0.33	2.0	0.96	4.3
45-49	0.03	0.2	0.58	9.1	-6.6	0.44	2.9	1.05	4.7
50-54	0.12	0.5	0.63	11.5	-6.6	0.40	2.0	1.15	3.3
55-59	0.16	0.5	0.68	9.7	-4.6	0.46	2.9	1.30	4.2
60-64	-0.14	-0.2	0.67	7.7	-3.8	0.63	3.0	1.16	1.6

Note: Elasticities for work intensity are obtained by summation, which preserves the theoretical adding-up restriction; t-ratios are based on the direct elasticity estimates.

Table 4: Work Intensity Elasticities with Respect to the Standardized Aggregate Employment Rate ($\bar{e} = 1 - \bar{u}$): Percentage Distributions Among Component Elasticities

	Males				Females			
Age group	Participation rate (p)	Employment rate (e)	Hours per employee (h)	Work intensity (w)	Participation rate (p)	Employment rate (e)	Hours per employee (h)	Work intensity (w)
15-19	27.9	40.0	32.1	100.0	36.8	26.6	36.6	100.0
20-24	15.0	62.4	22.6	100.0	9.6	64.1	26.3	100.0
25-29	13.5	65.9	20.5	100.0	17.3	56.1	26.6	100.0
30-34	15.7	59.3	25.0	100.0	12.5	60.3	27.2	100.0
35-39	12.3	56.8	30.9	100.0	8.1	58.5	33.3	100.0
40-44	12.9	59.7	27.3	100.0	4.2	61.5	34.4	100.0
45-49	12.7	64.3	23.0	100.0	2.9	55.2	41.9	100.0
50-54	5.6	73.1	21.3	100.0	10.4	54.8	34.8	100.0
55-59	13.0	63.7	23.3	100.0	12.3	52.3	35.4	100.0
60-64	-3.6	65.5	38.1	100.0	-12.1	57.8	54.3	100.0

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