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National and regional analysis of convergence of real wages in the U.S. agricultural sector

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Abstract. This study investigates convergence of real wages for hired farm labor in U.S. counties from 1978 to 1992. The analysis is conducted at the national and regional levels to examine the effect of exogenous factors on long-run convergence in wages. The analysis tests whether real farm wages are sufficiently flexible to adjust to region-specific and national shocks to labor productivity. The findings support convergence at the national and regional levels. The results imply that regional and national agricultural policies contribute to the elimination in wage differences between high wage and low wage counties. Convergence also supports the mobility of labor across counties.

1. Introduction

A significant body of research has examined the issue of whether regions or countries are becoming more similar in their factor returns. This work, stimulated by the resurgence of factor-price equalization research, has examined whether factor returns converge to a steady state level. The sources of factor price movements at the sectoral level have not been explored.

The within country focus for analyzing whether factor returns converge to a steady state level is important because aggregate analysis may conceal large variations among regions. Nissan and Carter (1993) argue that regions in the U.S. have maintained some degree of autonomy despite powerful homogenizing cultural and social forces. States within regions also may have similar conditions in natural and human resource patterns that make factor mobility and technology transfer across such states relatively easy. Such conditions encourage the process of convergence.

Barro and Sala-i-Martin (1991) explain the convergence process in an open economy using the standard neoclassical theory of production and growth. The theory suggests that factor mobility diminishes regional differences and the economy ultimately reaches a steady state in employment, wages, and economic growth (Smith 1975; McCombie 1988; Mallick and Carayannis 1994). Regional wage differentials encourage the migration of labor (capital) from low wage (high wage) to high wage (low wage) states; states with low capital-labor ratios therefore will have higher

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marginal products of capital that will enable these states to grow faster. This result hinges on the assumption of diminishing returns to capital. If correct, this assumption means that high wage states will post slow growth, while poorer states will show strong growth in wages. Empirical studies do not consistently find convergence. Abraham and Van Rompuy (1995) find that the regional income gap narrowed in the European Community (EC) over a 30 year period, although no distinct pattern of convergence in per capita GDP levels are observed. [See also Coe (1985).] Convergence is more plausible for states that have similar determinants of wage growth.

This paper focuses on convergence in real wages for hired labor in U.S. counties at the national and regional levels. The study examines the relationship between real farm wages and labor productivity, the unemployment rate, and rural farm population. Once we account for these determinants of steady state wage growth, the economy exhibits convergence (Solow 1956). The approach here is similar to that of Abraham and Van Rompuy (1995) who incorporate conditional variables in convergence analysis. This framework allows us to study the response of farm labor to changes in labor productivity, the unemployment rate, and rural farm population.

2. Modeling convergence

The conventional test for convergence is:

$$(1)\ \frac{1}{T}\ln\left(\frac{w_{ij}^{t}}{w_{ij}^{t-T}}\right) = \beta_0 + \beta_1 \ln\left(w_{ij}^{t-T}\right) + \varepsilon_{ij}$$

where w_{ij}^{t} and w_{ij}^{t-T} denote real wage rate in county i of region j at time t, the final year (1992), and t - T, the initial year (1978), respectively; β_is are the parameters to estimated. (The j subscripts are dropped for convenience.) A regional dummy variable, D, is included in equation (1) to capture potential differences in regional agricultural policies, technologies, and preferences. Equation (1) is rewritten as:

$$(2)\ \frac{1}{T}\ln\left(\frac{w_{ij}^{t}}{w_{ij}^{t-T}}\right) = \beta_0 + \beta_1 \ln\left(w_{ij}^{t-T}\right) + \beta_2 D + \varepsilon_{ij}\,.$$

While the inclusion of the regional dummy variable allows for potential differences among regions, it does not capture the influence of exogenous factors or conditional variables on wage rates. To account for such factors, equation (2) is modified to test for conditional convergence in wages.

$$(3)\ \frac{1}{T}\ln\left(\frac{w_{ij}^{t}}{w_{ij}^{t-T}}\right) = \beta_0 + \beta_1 \ln\left(w_{ij}^{t-T}\right) + \beta_2 D + \beta_3 \ln\left(\frac{S_{ij}^{t-T}}{P_{ij}^{t-T}}\right) + \beta_4 \ln\left(U_{ij}^{t-T}\right) + \beta_5 \ln\left(RP_{ij}^{t-T}\right) + \varepsilon_{ij}$$

Convergence is conditional on labor productivity, $(S_{ij}^{t-T}/P_{ij}^{t-T})$, the unemployment rate, U_{ij}^{t-T}, and the rural farm population, RP_{ij}^{t-T}. Wages converge if $\beta_1 < 0$, where β_1 is the speed of convergence. [See Bernard and Durlauf (1996) for discussions of problems associated with this measure.] Convergence is absolute only if $\beta_3 = \beta_4 = \beta_5 = 0$ and conditional if $\beta_3 \neq \beta_4 \neq \beta \neq 0$. The coefficient, β_2, is the vector of coefficients for the dummy variable.

The dependent variable, $\ln(w_{ij}^{92}/w_{ij}^{78})/14$, in the above equations is the average growth in real farm wages per worker from 1978 to 1992. The independent variables are expressed in natural logarithms. The variable, $\ln(w_{ij}^{78}$, is included in the regression as an independent variable to search for evidence of convergence, i.e. $\beta_1 < 0$, which implies that high wage counties in 1978 experienced low wage growth in 1992. In other words, the average growth of wages from 1978 to 1992 is negatively correlated with the initial wages. The logarithm of initial per capita real agricultural sales calculated as $\ln(S_{ij}^{78}/P_{ij}^{80})$ where P_{ij}^{80} is the population of county i of region j in 1980 (P_{ij}^{78} is unavailable because the population census was not performed in 1978) is a proxy for labor productivity in the agricultural sector. A negative coefficient, ($\beta_3 < 0$), implies that counties with high initial labor productivity experienced high initial wages which then led to a declining rate of growth of average wages. The initial unemployment rate, $\ln(U_{ij}^{78})$, is included in the estimations to capture structural differences in economic activities across regions. The rural farm population, $\ln(RP_{ij}^{78})$, is included in the equation to capture the influence of technology on the wages of rural farm families and other opportunities in the off farm labor market. Tavernier, Temel, and Li (1997) show that the availability of off farm income influences the decision of farm operators with respect to their participation in the off farm labor market.

In sum, initial per capita real agricultural sales, the initial unemployment rate, and initial rural farm population are included in the convergence model to capture the effects of changes in tastes/demand, factor supply, production technologies, and regional policies (taxes, subsidies) on wage movements. The inclusion of these variables in the wage-specification model is salient for two reasons. First, the variables allow analysis of conditional convergence. Second, national and regional shocks matter for regional adjustment (Decressin and Fatas 1993).

Estimations of equations (1), (2), and (3) are performed under the assumption that national and regional steady-state wage rates exist. Aggregate analysis may not account for regional differences and thus may mask regional variations. Moreover, regional estimations allow for the possibility that different regions may converge at different rates to their respective steady states. The literature has only recently included analysis of convergence across regions (Barro and Sala-i-Martin 1991; Demeester and Van Rompuy 1994; Loewy and Papell 1995; Carlino and Mills 1993 and 1996; Bernard and Jones 1995). Carlino and Mills (1993) find convergence in U.S. regional incomes. Bernard and Jones (1995) examine the sources of aggregate labor productivity movements and convergence in U.S. states and across sectors from 1963 to 1989. The authors find evidence of convergence in labor productivity for manufacturing and mining, although convergence does not hold for all sectors over the period examined.

3. Data and variable description

The data used in this study are obtained from the 1978 and 1992 Census of Agriculture and the 1980 Census of Population. Counties in the U.S. form the units of observations. The sample consists of 3,130 counties. Following the classification of the Bureau of Census, the U.S. is divided into four main regions: northeast (NE), midwest (MW), south (S), and west (W).

The real farm wage per worker in county i of region j at time t is denoted by w_{ij}^t. This variable is calculated by deflating the cost of hired farm/ranch labor divided by the number of hired farm/ranch workers by the Consumer Price Index (1982-84=100). The cost of hired labor includes gross salaries and wages, commissions, dismissal pay, vacation pay, bonuses paid to hired workers, family members, hired managers, administrative and clerical employees, salaried corporate officers, and supplemental costs for benefits such as employer's Social Security contributions, unemployment compensation, worker's compensation insurance, life and medical insurance, and pension plans. The number of hired workers includes the number of paid farm or ranch workers doing agricultural labor (including paid family members) and such workers as hired bookkeepers, office workers, and maintenance workers if their work is primarily associated with agricultural production; hired workers also include any short-term or temporary workers but does not include contract labor or custom workers.

The independent variables used to test conditional convergence are defined as follows. The variable, S_{ij}^t, is defined as the ratio of total agricultural product sales, s_{ij}^t (including the total gross value of all crops and livestock products sold by landlords, partnership organizations, institutions, co-ops, and pooled arrangements) to the Consumer Price Index, i.e., $S_{ij}^t = (s_{ij}^t/p^t)$. The variable U_{ij}^t is the proportion of unemployed labor force, and the variable RP_{ij}^t is the rural farm population.

4. Estimation results

This section provides the results of national and regional dispersion of real farm wages and empirical evidence of national and regional convergence in real farm wages as an adjustment mechanism to national and regional shocks. The disparities in farm labor income are measured by the coefficient of variation, while a cross-section wage model estimated for the U.S. and its four regions provides evidence of convergence. To correct for possible cross-sectional dependence the results are obtained using White's heteroscedasticity-consistent estimation procedure in which standard errors are adjusted for heteroscedasticity. This generalized least squares procedure generates more efficient results than the standard ordinary least squares (OLS) procedure.

Table 1 reports the national and regional coefficient of variation (CV) as a measure of dispersion in real farm wages. The coefficient indicates that except for the south region with a CV of 153, regional dispersions in real farm wages are greater than the national level (233). The low dispersion measure for the south suggests that the region experienced the smallest wage dispersion between 1978 and 1992. This result is not surprising because the south has a climate conducive to year-round pro-

Table 1. Coefficient of variation for $\frac{Ln(w^{92}/w^{78})}{14}$

Regions, Divisions	Mean	Standard deviation (S.D.)	Coefficient of variation = (S.D./mean)
U.S..	0.0225	0.0525	233
Northeast	0.0128	0.0415	347
Midwest	0.0067	0.0416	621
South	0.0358	0.0548	153
West	0.0215	0.0623	290

duction which moderates labor demand (Department of Labor 1994). This geographical factor helps stabilize the wage structure. Among the regions, the midwest had the highest interregional disparity in real farm wages (621) between 1978 and 1992.

4. 1. Convergence at the national level

This section provides the results of convergence of real farm wages per worker at the national level for equations (1) through (3) (Table 2). Single equation models are estimated using White's heteroscedasticity consistent ordinary least squares procedure. The coefficient, β_1, represents the speed of convergence and is interpreted as initially low wage counties experiencing wage increases toward the year 1992.

Equation (1) estimates absolute convergence. The equation accounts for 58 percent of the variation in the average growth rate of wages in the U.S. White's heteroscedasticity-consistent t-values are significant at the conventional levels. According to equation (1), between 1982 and 1992 the estimated annual rate of absolute convergence was 6.2 percent.

Equation (2) explains 63 percent of the variation in the average growth rate of wages. The inclusion of regional dummy variables increases the speed of convergence by 0.2 percent, from 6.2 percent to 6.4 percent. The t-values are significant at the conventional levels.

Equation (3) provides the estimations of conditional convergence. Convergence is conditional on labor productivity, the unemployment rate, and the rural farm population. The inclusion of the conditional variables increases the explanatory power of the model and the speed of convergence 8 percent and 0.7 percent, respectively.

Region-specific variation in the intercept is captured by regional dummies; the northeast region is omitted. [See pp. 225-233 in Johnston (1984) for a detailed discussion of the use of dummy variables.] With this specification, the constant of the regression equation [-0.208 in equation (2)] measures the intercept for the omitted region (northeast). The coefficients of $DUMMY_{MW}$ (-0.025), $DUMMY_S$ (-0.009), and $DUMMY_W$ (0.008) in equation (2) measure differential effects for the midwest, south, and west regions compared to the northeast region, respectively. The estima-

Table 2. Coefficients of convergence for hired farm labor wage (U.S..)

Independent variables	Equation (1)	Equation (2)	Equation (3)
C	-0.212	-0.208	-0.194
	(-54.20)	(-50.20)	(-25.70)
$Ln(w^{78})$	-0.062	-0.064	-0.071
	(-62.10)	(-64.20)	(-66.20)
$DUMMY_{MW}$		-0.025	-0.017
		(-10.10)	(-6.70)
$DUMMY_S$		-0.009	-0.001
		(-3.04)	(-0.2) ns
$DUMMY_W$		0.008	0.037
		(2.4)	(10.9)
$Ln(S^{78}/P^{80})$			0.012
			(14.7)
$Ln(U^{78})$			0.019
			20.2)
$Ln(RP^{80})$			0.0003
			(0.34) ns
R^2	0.58	0.63	0.71
N	3026	3026	2999

Figures in brackets are t-statistics. All of the coefficients, except those with (ns), are statistically significant at 0.05 or better

ns = Not significant
$DUMMY_{MW}$ = Dummy variable for the midwest region
$DUMMY_S$ = Dummy variable for the south region
$DUMMY_W$ = Dummy variable for the west region

tion results indicate that these three regions are statistically different from the northeast region with respect to region-specific variations. The significant intercepts suggest that there is a difference between the sample means of average growth of wages across the regions.

The corrected coefficients of the regional dummies are obtained by adding the coefficients of the regional dummies to the intercept for the northeast region. The coefficients are -0.208 for the northeast, -0.233 for the midwest, -0.217 for the south, and -0.2 for the west regions. These coefficients imply that the west and midwest have the highest and lowest intercept terms, respectively. By the same token, the differential effect for $DUMMY_{MW}$ compared to $DUMMY_S$ is -0.016 (-0.025 + 0.009); the differential effect for $DUMMY_{MW}$ compared to $DUMMY_W$ is -0.033 (-0.025 - 0.008); and the differential effect for $DUMMY_S$ compared to $DUMMY_W$ is -0.017 (-0.009 - 0.008). Thus, the highest differential effect (-0.033) occurs between the midwest and the west regions.

When regional labor productivity, the unemployment rate, and rural farm population are included in equation (3), the coefficient of $DUMMY_S$ is no longer statistically significant. This result suggests that the conditional convergence process in the south becomes similar to that in the northeast when regional variables are considered. The sample means of the average growth of wages in these regions are not statistically different. Further, analysis of the corrected intercepts indicates -0.194 for northeast, -0.211 for midwest, -0.195 for south, and -0.157 for west. Except for the south, the coefficients are statistically significant at the 0.05 level. The northeast and west

Table 3(a). Coefficients of convergence for hired farm labor (northeast region)

Independent variables	Equation (1)	Equation (4)
C	-0.191	-0.244
	(-9.3)	(-6.8)
$Ln(w^{78})$	-0.059	-0.076
	(-9.9)	(-12.4)
$Ln(S^{78}/P^{80})$		0.006
		(1.9)
$LN(U^{78})$		0.014
		(4.2)
$Ln(RP^{80})$		0.002
		(1.1) ns
R^2	0.37	0.48
N	203	198

regions have the lowest and highest intercepts, respectively. The differential effects in equation (3) are -0.016 for $DUMMY_{MW}$ compared to $DUMMY_S$; -0.054 for $DUMMY_{MW}$ compared to $DUMMY_W$; and f-0.038 for $DUMMY_S$ compared to $DUMMY_W$. The highest differential effect (-0.054) again occurs between the midwest and west regions.

Overall, the regression results support the convergence of wages at the national level. The speed of convergence increases from 6.2 percent to 7.1 percent with the inclusion of regional dummy, regional labor productivity, and unemployment rate variables. Particularly, the findings in equation (3) show that the average growth rate of wages responds positively to an improvement in labor productivity and that the counties with high initial unemployment experience an increase in wages over time. The finding of a positive relationship between the initial unemployment rate and the growth rate of wages suggests that the low cost of labor pulls farming activities into a region or cheap labor moves to regions with higher wages.

4. 2. Analysis of regional convergence

This section analyzes the pattern of regional convergence of real farm wages per worker in the four regions of the U.S. In addition to equation (1) which examines absolute convergence, conditional convergence is investigated with the model,

$$(4)\ \frac{1}{T}\ln\left(\frac{w_{ij}^{t}}{w_{ij}^{t-T}}\right) = \beta_0 + \beta_1 \ln\left(w_{ij}^{t-T}\right) + \beta_3 \ln\left(\frac{S_{ij}^{t-T}}{P_{ij}^{t-T}}\right) + \beta_4 \ln\left(U_{ij}^{t-T}\right) + \beta_5 \ln\left(RP_{ij}^{t-T}\right) + \varepsilon_{ij}$$

where j = NE, MW, S, and W. The primary difference between equation (3) and equation (4) is the exclusion of the dummy variable D, in the latter. The estimations of the equations for the four regions of the U.S. are reported in Tables 3(a) through 3(d).

Table 3(a) reports the estimations for the northeast region. Equations (1) and (4) account for 37 percent and 48 percent of the variation in the average growth rate of wages, respectively. Correspondingly, the speed of convergence is 5.9 percent and 7.6

Table 3(b). Coefficients of convergence for hired farm labor (midwest region)

Independent variables	Equation (1)	Equation (4)
C	-0.257	-0.225
	(-45.8)	(-22.9)
$Ln(w^{78})$	-0.070	-0.071
	(-48.0)	(-47.7)
$Ln(S^{78}/P^{80})$		0.003
		(3.6)
$Ln(U^{78})$		0.010
		(9.5)
$Ln(RP^{80})$		0.004
		(-4.1)
R^2	0.71	0.76
N	1069	1065

percent. The t-values are significant at the conventional levels (except for rural farm population). The inclusion of labor productivity and unemployment rate in the region significantly improves the speed of convergence by 1.7 percent (7.6 percent to 5.9 percent). This finding supports the importance of region-specific policy changes affecting labor mobility. The positive coefficients of labor productivity and unemployment rate indicate that the average growth rate of wages in the northeast region increases in counties with high initial labor productivity and unemployment. The rural farm population is not significant during the process of regional convergence.

Table 3(b) presents the estimations for the midwest region. The equations explain between 71 percent and 76 percent of the variation in the average growth rate of wages. The speed of convergence is 7 percent and 7.1 percent in equation (1) and equation (2), respectively. The t-values are significant at conventional levels. The contribution of labor productivity, unemployment, and rural farm population to conditional convergence is 0.1 percent (7.1 percent to 7 percent). The coefficients of labor productivity (0.003), the unemployment rate (0.01), and rural farm population (-0.004) indicate that the average growth of wages in the midwest region from 1978 to 1992 increased in counties with high initial labor productivity, a high initial unemployment rate, and low initial farm population.

The estimations for the south region are reported in Table 3(c). Equations (1) and (4), respectively, account for 65 percent and 71 percent of the variation in the average growth rate of wages. Correspondingly, the speed of convergence is 6 percent and 7.1 percent The t-values are significant at the conventional levels (except for rural farm population). Convergence in real farm wages per worker increases 1.1 percent (7.1 percent to 6 percent) when the influence of labor productivity, unemployment, and rural farm population are considered. The coefficients of these variables are all positive, suggesting that their marginal contribution to the average growth rate of wages is high in counties with high initial productivity, high unemployment, and high farm population.

Table 3(d) reports the results for the west region. Equations (1) and (4), respectively, account for 42 percent and 68 percent of the variation in the average growth of

Table 3(c). Coefficients of convergence for hired farm labor (south region)

independent variables	Equation (1)	Equation (4)
C	-0.202	-0.157
	(-43.2)	(-14.8)
$Ln(w^{78})$	-0.060	-0.071
	(-52.7)	(-41.8)
$Ln(S^{78}/P^{80})$		0.012
		(9.6)
$Ln(U^{78})$		0.015
		(8.6)
$Ln(RP^{80})$		0.001
		(0.7) ns
R^2	0.65	0.71
N	1369	1360

wages. Correspondingly, the speed of convergence is 7.1 percent and 7.8 percent. The t-values are significant at all the conventional levels. The inclusion of initial labor productivity, unemployment, and rural farm population in equation (4) improves convergence 0.7 percent (7.8 percent to 7.1 percent). The coefficients of these variables are all positive which suggests that their marginal contribution to the average growth of wages increases in counties with high initial productivity, high unemployment, and high rural farm population.

Overall, the regression results in equation (4) reported in Tables 3(a) to 3(d) suggest that the speed of regional convergence of wages varies between 7.1 percent (midwest and south) and 7.8 percent (west). The average rate of regional convergence is 7.4 percent, (i.e., the sum of the rates across regions divided by four). Furthermore, labor productivity and the unemployment rate are among the factors that positively and significantly contribute to convergence in all regions. The contribution of the rural farm population is not robust with respect to sign and significance. Further, the estimated coefficient for labor productivity varies between 0.3 percent in the midwest to 1.2 percent in the south, while the estimated coefficient for unemployment varies between 1 percent in the midwest to 1.6 percent in the west.

5. Implications of convergence

There is evidence that convergence in real wages occurred at the national and regional levels. This finding indicates that counties with initially low wages in 1978 are posting higher wage growth than initially high wage counties. The speed of convergence at the national level, however, is slower than those obtained in analysis of regional convergence. The rate of national convergence is 7.1 percent, while regional convergence occurred at a speed of 7.4 percent. This finding suggests that labor is likely to be more mobile within regions than across regions and that regional policies appear to be instrumental in affecting developments in regional labor markets.

The unemployment variable is positive and significant at the national and regional levels. This finding suggests a tendency for labor to leave states with domi-

Table 3(d). Coefficients of convergence for hired farm labor (west region)

Independent variables	Equation (1)	Equation (4)
C	-0.226	-0.227
	(-13.0)	(-10.6)
$Ln(w^{78})$	-0.071	-0.078
	(-14.4)	(-19.0)
$Ln(S^{78}/P^{80})$		0.009
		(5.3)
$Ln(U^{78})$		0.016
		(8.7)
$Ln(RP^{80})$		0.006
		(3.5)
R^2	0.42	0.68
N	408	399

nant agricultural sectors during periods of low agricultural prices. Thus, in the presence of adequate transportation and communication infrastructure, high labor mobility would increase wages. Further, the finding of regional convergence implies that agricultural markets in the states of a region facilitate across state labor mobility. (Labor mobility of the same kind is expected to occur when labor is abundant.) The evidence of convergence at the national level suggests that regional policies suppressing variability in agricultural prices have been accompanied by policies that encourage labor mobility and economy-wide convergence of wages.

Convergence further presents evidence of farm labor flexibility as an adjustment mechanism to regional and national shocks. The results suggest that positive and significant labor productivity in the agricultural sector captures a small proportion of the national shock to wage growth. This finding is also true for the northeast, midwest, south, and west regions. The unemployment variable also captures the influence of national and regional shocks to the growth in wages. The results show that national labor productivity and national unemployment variables perform better than regional variables in capturing shocks to the growth in wages. The asymmetric response to shocks experienced by the regions may be due, in large part, to distinctly different farming activities pursued by the regions. Finally, the influence of the rural farm population on convergence is not robust across models.

6. Summary and conclusion

This paper estimates the speed of convergence of real wages for hired farm labor in the U.S. agricultural sector from 1978 to 1992. The study investigates whether the cross-sectional dispersion of real farm wages in U.S. counties has narrowed during the period. Real wage differentials across and within regions are examined using county-level data. The estimations are performed at national and regional levels using per farm real wages from a total of 3,138 U.S. counties. Overall, the performance of the models is high.

The results lend strong support to the catch-up view of farm wages. The catch-up view suggests that initially low wage counties will experience high wage increases toward the end of the period. Convergence is robust at both the national and regional levels. Convergence appears to be stronger, however, at the regional level than at the national level.

The results further show that farm wages have large and persistent variations across regions and within regions. The findings suggest that labor productivity in the agricultural sector positively and significantly contributes to growth in wages, as does the unemployment rate. An interesting observation is the lack of robustness of the rural farm population on the average growth rate of wages with respect to its sign. Demographic differences in rural areas, across regions and within regions, appears to be insignificant.

Other approaches to convergence exist. The national and regional approach pursued here, however, allows comparison of the speed of convergence at both levels. The analysis also could be performed at the level of U.S. divisions. [See Tavernier and Temel (1997).] While the results of this study point to convergence, Lee (1996) argues that the evidence supporting convergence is sensitive to the sample chosen. Moreover, the lack of research on convergence in wages for hired labor means that the results should be interpreted with caution.

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