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The Illinois Institute for Rural Affairs (IIRA) works to improve the quality of life for rural residents by partnering with public and private agencies on local development and enhancement efforts.

Western Illinois University

Impacts of Automation on Employment: Metro and Nonmetro Illinois

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Abstract

This paper explores the impact of automation on occupations in Illinois. Many foresee negative impacts, that automation will wipe out millions of jobs. Empirical analysis suggests that the role of labor in industry output has decreased in the nonmetro; and at the peak of automation in the 2030s, a quarter of a million jobs in the nonmetro would be disrupted; production family of jobs will be the worst affected in the nonmetro.

Introduction

Automation is the conversion of a work process, a procedure, or equipment to automatic rather than human operation or control[2]. In 1950, the Ford Company automated its engine production[3], work-feeding mechanisms connected stand-alone machines in production processes. Although this created unemployment concerns, the then secretary of labor, James P. Mitchell, stated that,

> *… department studies made in a big office and a manufacturing plant where automation was introduced*

[1] Professor, Illinois Institute for Rural Affairs, Western Illinois University.
[2] Noble, D. F. (1984). *Forces of Production: A Social History of Industrial Automation.* New York: Knopf/Random House.
[3] Hearst, J. (1956). Automation and your Job. *Chicago Tribune*, October 14, p. F30.

> *indicate there is no reason to believe this new phase of technology will displace workers.*[4]

Then, in 1961, a *Time* article highlighted that automation has resulted in "bigger production with a smaller workforce". The article went on to cite statistics such as, "… the number of production jobs has fallen 3% since 1956 while output has soared 27%"[5]; policy recommendations included a guaranteed minimum income for each family[6]. These predictions of adverse impacts of automation on employment continues today (Table 1).

Table 1: Impacts of AI and Robots on Employment

Observation	Source
In 1870, the agricultural sector employed 50% of the nation's workforce; a century later, the share is down to 4% because of mechanization.	Daly, P. A. (1981). Agricultural employment: Has the decline ended? *Monthly Labor Review*, 104, 11-17.
AI and robotics will affect not only repetitive tasks such as farming, but also cognitive jobs such as medical diagnoses.	Brynjolfsson, E., and McAfee, A. (2014). *The Second Machine Age*: *Work, Progress, and Prosperity in the Age of Automation*. Princeton University Press.
The increasing adoption of automation suggests that the role of humans in the economy will shrink drastically, wiping out millions of jobs in the process.	Strack, R. et al (2021). The future of jobs in the era of AI. Boston Consulting Group.

Science is concerned with both observations and explanations; observations that are of interest in this study include the strength of the covariation between productivity and labor input, changes in labor force numbers, changes in occupational employment shares over 2001 – 2020, etc.

Explanations about the impacts of automation on employment are often drawn from a variety of study areas including economics, business strategy, and social psychology. Since theoretical explanations should converge with reality, we start with an explanation about the relationship between automation and employment.

Conceptual Framework

The theory of production abstracts the relationship between factors of production and firm output[7] (TP) using a production function[8]. For two inputs, labor (L) and capital (K), the production function would be:

$$TP = f(L, K) \quad .$$

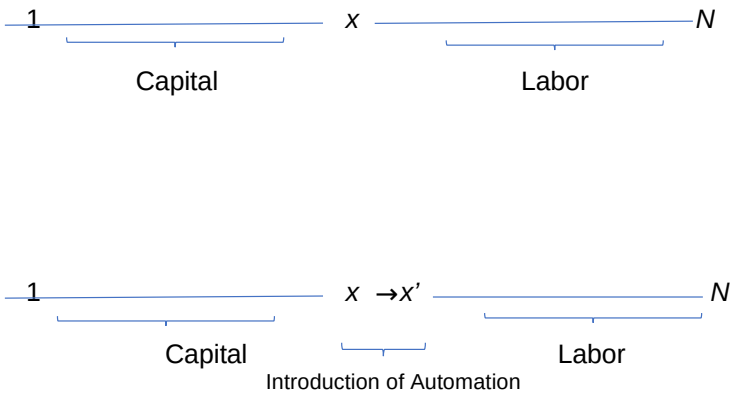
[4] James P. Mitchell, Secretary of Labor, 1953-1961; same reference as Footnote 3.
[5] *TIME* (1961). The automation jobless. February 24.
[6] *The Herald Press* (1966). Skirting the automation question. February 7.
[7] Technically, a firm's total output is called total product.
[8] See Steiner, P. O., & Purvis, D. D. (1987). *Economics*. Harper-Collins College Division.

If we conceptualize industry in terms of a typical firm employing an average technology, then the square of the correlation between industry's GDP and labor, r^2, is the variance in industry GDP explained by labor and 1-r^2 is the contribution of other factors of production to industry GDP.

The strength of the correlation between industry's GDP and its labor would indicate the relevance of labor to industry output; also, if labor is being substituted by technology, then the average product of labor would be decreasing[9].

For labor[10] to be displaced by technology such as machines, robots, and computer programs, technology should mimic human cognitive and physical performance. Consider Figure 1, it summarizes the allocation of work to capital and labor[11]. For *N* tasks, tasks above *x* cannot be automated, only labor can perform the tasks. If tasks are fixed, then an increase in *x to x'* would represent the introduction of automation.

Figure 1: Partition of Work into Capital and Labor



[9] Given TP, the marginal product (MP) for labor is $\frac{\Delta TP}{\Delta L}$ and the average product for labor is $\frac{TP}{L}$.

[10] Production function does not model jobs, so we assume labor = jobs or work; a job is defined as the performance of some physical act or cognitive skill in return for economic reward, or in the expectation of receiving reward.

[11] Adapted from Acemoglu, D., and Restrepo, P. (2019). Automation and new tasks: How technology displaces and reinstates labor, *Journal of Economic Perspectives*, 33(2), 3-30.

In the case of agriculture (Table 1), low-income work, the physical and repetitive work of farm workers, was replaced by automation. The resulting productivity, increases in GDP, fueled the growth of other labor-intensive sectors. Put simply, the disruptive effects of automation were minimal as farm workers migrated to the city for work[12].

Now, with the advent of AI and robotics, disruption is predicted for both physical and cognitive work[13]; the risk of automation is present for all types of jobs. For example, research from PwC[14] suggests that jobs in financial services are highly vulnerable to automation in the 2020s; transportation jobs face a higher threat in the next decade, 2030s (Table 2).

Table 2: Vulnerable Jobs, 2020 - 2030

Threat and Time Period	Definition	Example of Impacted Industry	Total Number of Jobs Impacted in the US
Algorithmic Automation (to early 2020s)	Automation of simple computational tasks.	Finance	5%
Augmentation wave (to late 2020s)	Robotic process automation; for example, moving objects in warehouses.	Health	26%
Autonomous wave (to mid-2030s)	Automation of real-time problem solving in dynamic context.	Transportation	38%

A more specific measure of risk of job automation is the automation risk index (ARI)[15]. It is based on an algorithm that matches the abilities required for an occupation with robotic technologies that possess the abilities to calculate an ARI for the occupation. ARI ranges from 0, "low automation", to 1, "complete automation". Table 3 shows the ARI for each of the job families in the O*NET[16].

[12] Frey, C. B. (2019). *The Technology Trap*: *Capital, Labor, and Power in the Age of Automation*. Princeton University Press.
[13] Gentili, A., Compagnucci, F., Gallegati, M., & Valentini, E. (2020). Are machines stealing our jobs? *Cambridge Journal of Regions, Economy and Society*, *13*(1), 153-173.
[e]See www.pwc.com.
[15] Paolillo, A., Colella, F., Nosengo, N., Schiano, F., Stewart, W., Zambrano, D., ... & Floreano, D. (2022). How to compete with robots by assessing job automation risks and resilient alternatives. *Science Robotics*, *7*(65), eabg5561.
[16] O*NET is a US Department of Labor initiative; it is designed to help job seekers browse jobs based on their goals and needs and learn about requirements, attributes and skills required for an occupation. See, https://www.onetonline.org/.

Table 3: Automation Risk: O*NET Occupation Families

Occupation Family	Median ARI (Q1, Q3)	Occupation Family	Median ARI (Q1, Q3)
Education, Training and Library	0.57 (.55, .58)	Protective Service	0.65 (.61, .71)
Community and Social Service	0.58 (.56, .59)	Inst, Main & Repair	0.65 (.64, .67)
Management	0.56 (.54, .59)	Office & Admin	0.65 (.61, .69)
Legal	0.57 (.56, .62)	Healthcare Support	0.66 (.65, .69)
Life, Physical, & Soc. Science	0.57 (.55, .60)	Personal Care	0.66 (.63, .69)
Computer and Mathematical	0.58 (.57, .59)	Transp. & Mat Mov	0.67 (.63, .69)
Business & Financial	0.58 (.57, .59)	Production	0.67 (.65, .70)
Architecture & Engineering	0.58 (.56, .61)	Farming & Forestry	0.68 (.62, .70)
Healthcare & Technical	0.59 (.56, .62)	Const & Extracting	0.68 (.62, .71)
Sales and Related	0.61 (.60, .66)	Build & Grounds Main	0.68 (.65, .75)
Arts, Design, Ent, Sports & Media	0.65 (.63, .67)	Food Prep & Service	0.72 (.67, .73)

Note: Author's estimates based on Footnote 15, Figure 1.

In summary, the threat of automation is real; no job is immune. Data from Tables 2 and 3 can be used to estimate the magnitude or the size of the automation threat, in terms of job numbers, for Illinois.

Methodology

Illinois counties were the geographical unit of analysis. For each county, data on industry output and employment during 2001-2020 were sourced from the BEA (Table 4); industry data were at the two-digit NAICS level.

For each of the NAICS sectors, the zero-order correlation between employment numbers and industry output was computed to gain insights into the salience of labor for the industry. The $1 - r^2$ statistic was used to infer the importance of other factors of production for industry output.

In an earlier paper, I presented county-wise labor force statistics[17]. These data were used to calculate county-wise employment numbers (E_i) using the formulation:

$$E_i = N_i \times LFPR_i \times (1 - UR_i)$$

where, for county *i*, *N* is the population, *LFPR* is the region's labor force participation rate, and *UR* is the unemployment rate[18]. The E_i were then projected to 2030 using a growth equation discussed in Athiyaman (2022)[19] and weighted by data in Table 2 to deduce automation impacts at the macro level.

[17] Athiyaman, A. (2022). Rural Illinois in Numbers: Content-Valid Indicators for Governance. *Research Brief*, 4(11), June 17, 1-55. Available: http://www.iira.org/wp-content/uploads/2022/06/Rural-Illinois-in-Numbers-Content-Valid-Indicators-for-governance_RB4_11_2.pdf.

[18] Athiyaman, A. (2021). Unused Human Resources in Rural Illinois: A Profile of "Not in the Labor Force" Population. *Research Brief*, 3(19), November 28, 1-6. Available: http://www.iira.org/wp-content/uploads/2021/11/Unused-human-resources.pdf.

[19] Athiyaman, A. (2022). *Advanced Economic Development: Primer and Software*. Macomb, IL: IIRA. Growth was modeled using exponential rate of growth based on 2001-2020 data.

To gain 'micro' insights into industry occupations that could be impacted by automation, the "Browse by Industry" webpage on O*NET was mined to extract a list of occupations by 2-digit NAICS; the size of the occupation, that is, employment numbers, were obtained from the BLS' *Occupational Outlook Handbook*[20]. The occupations were then reclassified into occupation families, using 22 categories listed in the O*NET[21]; the variable, "employed by this industry", was used to determine the size of occupation families for each of the NAICS, 2-dgit industry. Finally, the employment numbers were weighted by the ARIs in Table 3 to get a 95% confidence interval for automation-influenced job-displacement numbers, by occupation family and industry for each of the Illinois' counties. Hinge spread was the statistic used to compute the confidence intervals. Appendix 1 presents computational examples for NAICS 11, the agricultural sector.

Table 4: Data Sources

Variable and Labels	Data Source
GDP: County GDP by Industry	BEA API; Table CAGDP2
E: Employment by Industry by County	BEA API; Table CAEMP25N
N: County population	Research Brief 4(11); see Footnote 17
LFPR: Labor-force participation rate by county	
UR: Unemployment rate by county	
Occupations by industry	O*NET; see Footnote 16
Occupation Families	
Occupation size	BLS; see Footnote 21
Metro and nonmetro counties	ERS' Rural-Urban Continuum Codes[22]

[20] See, for example, https://www.bls.gov/ooh/life-physical-and-social-science/agricultural-and-food-science-technicians.htm.

[21] We excluded the "military specific" occupation family from data analysis.

[22] https://www.ers.usda.gov/data-products/rural-urban-continuum-codes/.

Findings

Table 5 shows employment numbers by industry for the metro and the nonmetro regions. A phenomenological interpretation of the employment numbers indicates that the nonmetro is home to a large number of employees in the agricultural, manufacturing, and government sectors whereas the metro is the base for a large number of professional, scientific, and technical personnel.

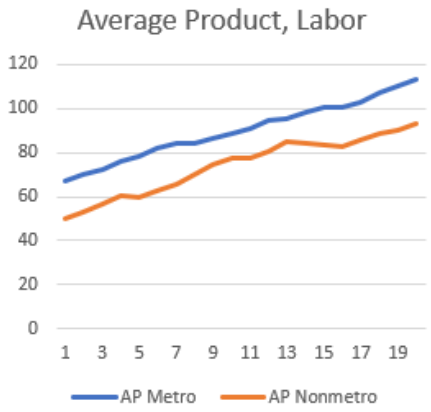
From an empirical viewpoint, the role of labor in industry output has decreased in the nonmetro; r^2, the percentage of variance in industry GDP explained by labor, has decreased from 0.5 during 2001-2010 to 0.35 during 2011-2020. In contrast, the metro has posted a slight increase in the use of labor to generate industry output, GDP (Figure 2).

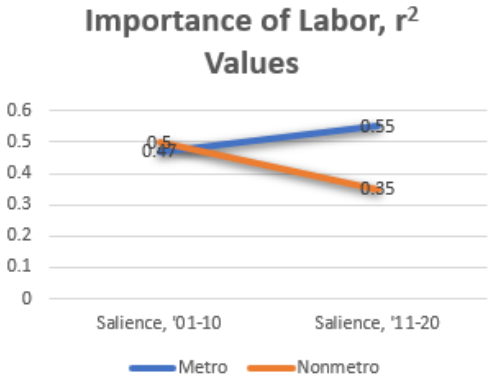
In spite of the low r^2, the average product of labor (AP) has increased during 2001-2020 (Figure 2); one plausible explanation is the use of algorithmic automation to enhance labor productivity. Our forthcoming *Research Brief*, a September, 2022 publication, explores this idea further using survey data from a national sample of labor force participants.

Table 5: Employment Numbers: Metro and Nonmetro Illinois, 2020

NAICS Sector	Metro	Nonmetro	NAICS Sector	Metro	Nonmetro
Accommodation & Food Services	7%	7%	Management Cos and Enterprises	2%	0%
Admin & Support Services	9%	4%	Manufacturing	9%	15%
Agri, Forestry, Fishing, and Hunting	1%	9%	Mining, Quarrying, and Oil and Gas Extraction	0%	1%
Arts, Entertainment, and Recreation	2%	1%	Professional, Scientific, and Technical Services	10%	3%
Construction	6%	7%	Real Estate, Rental, and Leasing	5%	3%
Educational Services	4%	1%	Retail Trade	11%	15%
Finance and Insurance	9%	6%	Transportation and Warehousing	8%	5%
Government	14%	19%	Wholesale	5%	4%
Information	2%	1%	**N**, All Jobs	5,493,093	514,479

Figure 2: Salience of Labor as a Factor of Production: Metro and Nonmetro

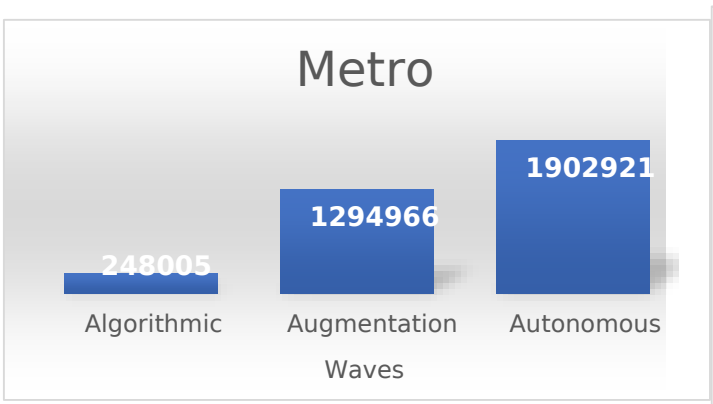


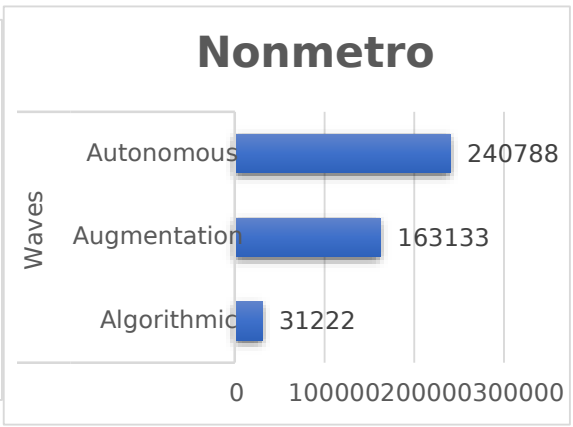


<u>Impact of Automation, Macro-Level Analysis</u>

Figure 3 highlights the impacts of automation on employment, for each of the three waves of automation highlighted in Table 2, for both the metro and the nonmetro regions. At the peak of automation in the 2030s, the 'autonomous wave' in Table 2, around quarter of a million jobs in the nonmetro would be disrupted; the metro region of Illinois could witness job disruptions of around 1.9million.

Figure 3: Total Number of Vulnerable Jobs in the Metro and the Nonmetro, 2020 – Mid-2030





Impact of Automation, Micro Analysis

This section explores job disruptions for families of occupations. Tables 6 and 7 show the percentage of jobs in each of the occupation family categories for the metro and the nonmetro regions; the 'modal' values are highlighted. For example, for the occupation family, "Architecture and Engineering", NAICS 54, "Professional, Scientific, and Technical Services", is a major employer in the metro region whereas NAICS 31-33, "Manufacturing", houses the most architecture and engineering jobs in the nonmetro.

Figure 4 shows the distribution of occupation families among the industries; a low Modal value indicates widespread distribution of an occupation among the industries, a desirable feature for jobseekers. Occupations in the "Management" family in the metro and the "Office and Admin Support" group in the nonmetro have presence across industries.

Table 6: Metro Jobs by Occupation Family and 2-Digit NAICS

Occupation Family	72	56	11	71	23	61	52	92	51	55	31-33	21	54	53	44-45	48-49	22	42	N
Architecture and Engineering	0%	3%	0%	0%	2%	0%	0%	16%	1%	2%	25%	0%	**50%**	0%	0%	0%	0%	1%	296763
Arts, Design, Entertainment, Sports, and Media	1%	3%	0%	15%	0%	3%	0%	6%	**27%**	2%	2%	0%	11%	8%	15%	0%	0%	8%	186613
Building and Grounds, Cleaning and Maintenance	7%	**87%**	0%	0%	0%	0%	0%	3%	0%	0%	0%	0%	0%	0%	0%	0%	0%	3%	126341
Business and Financial Operations	0%	2%	1%	2%	1%	1%	**50%**	14%	0%	6%	2%	0%	9%	11%	0%	0%	0%	3%	383183
Community and Social Service	0%	0%	0%	0%	0%	10%	0%	**90%**	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	26557
Computer and Mathematical	0%	0%	0%	0%	0%	1%	29%	12%	6%	8%	0%	0%	**44%**	0%	0%	0%	0%	0%	198538
Construction and Extraction	0%	13%	0%	0%	**72%**	0%	0%	6%	0%	0%	1%	1%	2%	0%	2%	2%	0%	0%	316573
Educational Instruction and Library	0%	0%	0%	6%	0%	**86%**	0%	7%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	161657
Farming, Fishing, and Forestry	0%	0%	**51%**	0%	0%	0%	0%	16%	0%	0%	12%	0%	0%	0%	0%	0%	0%	21%	43354
Food Preparation and Serving Related	**94%**	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	6%	0%	0%	0%	264636
Healthcare Practitioners and Technical	0%	0%	0%	0%	0%	3%	0%	26%	0%	0%	1%	0%	13%	0%	**58%**	0%	0%	0%	105517
Healthcare Support	0%	22%	0%	0%	0%	0%	0%	14%	0%	0%	0%	0%	18%	0%	**47%**	0%	0%	0%	38628
Installation, Maintenance and Repair	0%	9%	0%	1%	9%	0%	0%	4%	2%	0%	3%	0%	0%	6%	**42%**	9%	1%	14%	464972
Legal	0%	0%	0%	0%	0%	0%	14%	**55%**	0%	0%	0%	0%	31%	0%	0%	0%	0%	0%	52430
Life, Physical, and Social Science	0%	2%	1%	0%	0%	5%	0%	**43%**	0%	2%	6%	0%	39%	0%	0%	0%	1%	1%	313301
Management	9%	0%	0%	1%	1%	3%	10%	**17%**	0%	10%	9%	0%	16%	15%	2%	3%	0%	5%	300635
Office and Administrative Support	5%	15%	0%	1%	0%	1%	**33%**	16%	1%	1%	1%	0%	5%	0%	5%	11%	0%	5%	432228
Personal Care and Service	29%	4%	1%	**34%**	0%	1%	0%	8%	6%	0%	0%	0%	1%	12%	3%	2%	0%	0%	165385
Production	2%	10%	0%	0%	0%	0%	0%	3%	0%	1%	**66%**	0%	1%	0%	13%	2%	2%	0%	486569
Protective Service	2%	26%	0%	2%	0%	2%	0%	**64%**	0%	0%	0%	0%	0%	0%	0%	4%	0%	0%	205972
Sales and Related	2%	10%	0%	1%	0%	0%	10%	1%	1%	0%	1%	0%	3%	**30%**	25%	0%	0%	16%	366152
Transportation and Material Moving	2%	6%	0%	0%	1%	0%	0%	8%	0%	0%	2%	0%	0%	3%	13%	**53%**	0%	11%	557089

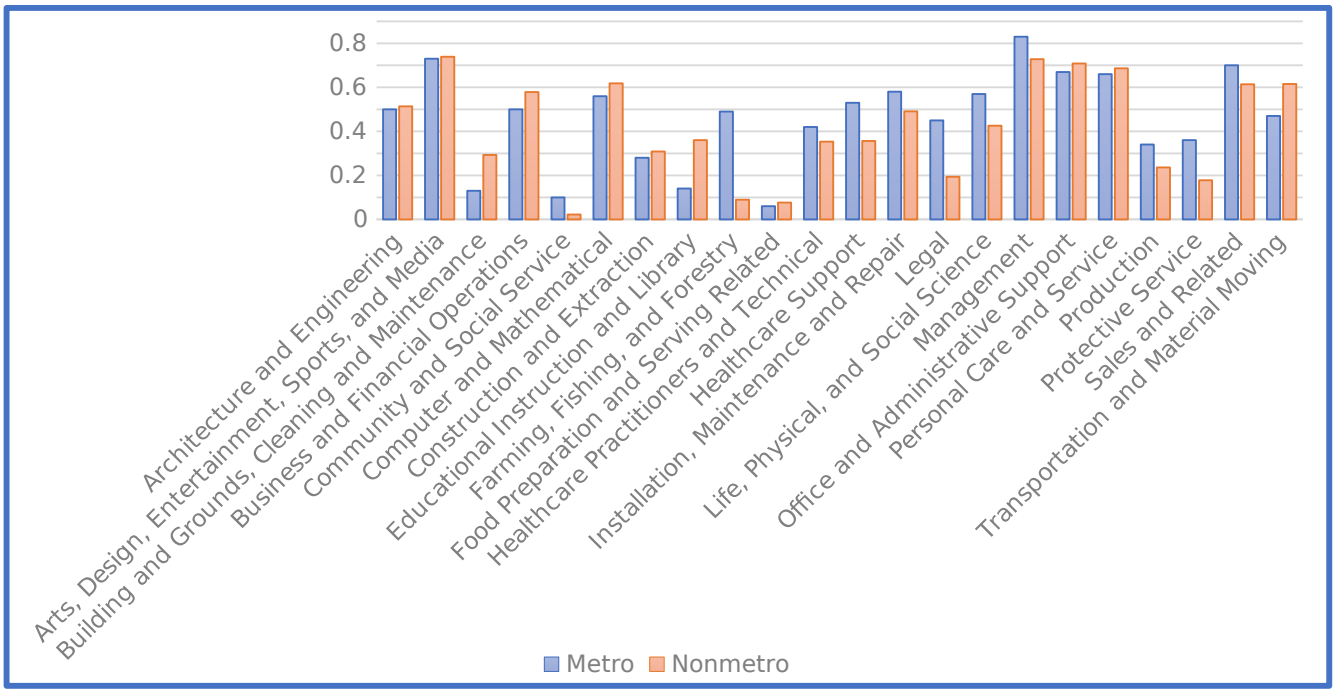
Note: NAICS Codes: 11: Agriculture, Forestry, Fishing and Hunting; 21: Mining, Quarrying, and Oil and Gas Extraction; 22: Utilities; 23: Construction; 31-33: Manufacturing; 42: Wholesale Trade; 44-45: Retail Trade; 48-49: Transportation and Warehousing; 51: Information; 52: Finance and Insurance; 53: Real Estate and Rental and Leasing; 54: Professional, Scientific, and Technical Services; 55: Management of Companies and Enterprises; 56: Administrative and Support and Waste Management and Remediation Services; 61: Educational Services; 62: Healthcare and Social Assistance; 71: Arts, Entertainment, and Recreation; 72: Accommodation and Food Services; 92: Public Administration.

Table 7: Nonmetro Jobs by Occupation Family and 2-Digit NAICS

Occupation Family	72	56	11	71	23	61	52	92	51	55	31-33	21	54	53	44-45	48-49	22	42	N
Architecture and Engineering	0%	2%	0%	0%	3%	0%	0%	26%	1%	0%	**49%**	2%	16%	0%	0%	0%	1%	1%	23370
Arts, Design, Entertainment, Sports, and Media	2%	2%	0%	11%	0%	1%	2%	10%	22%	0%	4%	0%	4%	6%	**26%**	0%	0%	9%	13343
Building and Grounds, Cleaning and Maintenance	11%	**71%**	7%	0%	0%	0%	0%	6%	0%	0%	0%	0%	0%	0%	0%	0%	0%	5%	7076
Business and Financial Operations	0%	1%	12%	1%	1%	0%	**42%**	23%	0%	1%	3%	0%	3%	9%	0%	0%	0%	3%	29508
Community and Social Service	0%	0%	0%	0%	0%	2%	0%	**98%**	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	3146
Computer and Mathematical	0%	0%	0%	0%	0%	0%	**38%**	31%	7%	1%	0%	0%	22%	0%	0%	0%	0%	0%	9889
Construction and Extraction	0%	5%	0%	0%	**69%**	0%	0%	7%	0%	0%	1%	15%	1%	0%	2%	1%	0%	0%	37707
Educational Instruction and Library	0%	0%	0%	9%	0%	**64%**	1%	26%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	5958
Farming, Fishing, and Forestry	2%	0%	**91%**	0%	0%	0%	0%	3%	0%	0%	2%	0%	0%	0%	0%	0%	0%	2%	35332
Food Preparation and Serving Related	**92%**	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	8%	0%	0%	0%	24256
Healthcare Practitioners and Technical	0%	0%	0%	0%	0%	1%	0%	30%	0%	0%	1%	0%	3%	0%	**65%**	0%	0%	0%	11669
Healthcare Support	0%	11%	0%	0%	0%	0%	0%	20%	0%	0%	0%	0%	5%	0%	**64%**	0%	0%	0%	3481
Installation, Maintenance and Repair	0%	4%	2%	1%	10%	0%	0%	5%	1%	0%	5%	0%	0%	4%	**51%**	5%	1%	12%	47230
Legal	0%	0%	0%	0%	0%	0%	10%	**81%**	0%	0%	0%	0%	9%	0%	0%	0%	0%	0%	4580
Life, Physical, and Social Science	0%	1%	17%	0%	1%	1%	0%	**57%**	0%	0%	9%	1%	10%	0%	0%	0%	1%	1%	30164
Management	11%	0%	6%	0%	2%	1%	8%	**27%**	0%	1%	17%	0%	5%	11%	3%	2%	0%	5%	23832
Office and Administrative Support	7%	9%	0%	0%	0%	0%	**29%**	27%	1%	0%	2%	0%	2%	0%	8%	8%	0%	5%	32233
Personal Care and Service	31%	2%	10%	**21%**	0%	0%	3%	12%	5%	0%	0%	0%	0%	9%	4%	1%	0%	0%	13644
Production	1%	4%	0%	0%	0%	0%	0%	3%	0%	0%	**76%**	0%	0%	0%	12%	1%	2%	0%	64889
Protective Service	2%	12%	0%	1%	0%	0%	0%	**82%**	0%	0%	0%	0%	0%	0%	0%	2%	0%	0%	20520
Sales and Related	2%	6%	0%	1%	0%	0%	8%	1%	1%	0%	2%	0%	1%	23%	**39%**	0%	0%	17%	29287
Transportation and Material Moving	2%	3%	0%	0%	2%	0%	0%	14%	0%	0%	4%	2%	0%	3%	20%	**38%**	0%	12%	43365

Note: NAICS Codes: 11: Agriculture, Forestry, Fishing and Hunting; 21: Mining, Quarrying, and Oil and Gas Extraction; 22: Utilities; 23: Construction; 31-33: Manufacturing; 42: Wholesale Trade; 44-45: Retail Trade; 48-49: Transportation and Warehousing; 51: Information; 52: Finance and Insurance; 53: Real Estate and Rental and Leasing; 54: Professional, Scientific, and Technical Services; 55: Management of Companies and Enterprises; 56: Administrative and Support and Waste Management and Remediation Services; 61: Educational Services; 62: Healthcare and Social Assistance; 71: Arts, Entertainment, and Recreation; 72: Accommodation and Food Services; 92: Public Administration.

Figure 4: Occupation Families that Span Across Industries: Metro and Nonmetro



Note: Data points are 1-Modal value for the occupation family; the Modal values are from Tables 6 and 7.

Although an occupational family may be present across several industries, see Figure 4, and attractive for job seekers, it doesn't mean that jobs in the segment are secure from automation disruptions. As shown in Table 8, the variables, "industry spread" and "automation risk", are independent; in summary, automation risk is real for all industries

Table 8: Automation Risk and the Presence of Occupational Family in Industries

	Occupational Family, Widespread or Concentrated Across Industries	
	Widespread	**Concentrated**
High Threat of Automation	9	15
Low Threat of Automation	9	11

Note: Numbers indicate families; χ^2 =0.038; Critical value = 3.841; p = 0.95.

Tables 9 and 10 present the 'best' estimates of automation impacts for each of the occupation family, by industry, for the metro and the nonmetro. The qualifier, "best", denotes that the numerical estimates are the lower confidence intervals of the ARIs. In all, both the metro and the nonmetro are expected to face disruptions to more than 50% of their jobs.

Table 9: Jobs Impacted in the Metro, by Occupation Family and 2-Digit NAICS: Best Scenario

Occupation Family	72	56	11	71	23	61	52	92	51	55	31-33	21	54	53	44-45	48-49	22	42
Architecture and Engineering	0	3,929	0	0	3,169	0	0	24,167	1,365	2,700	37,379	153	75,135	0	0	0	420	1,448
Arts, Design, Entertainment, Sports, and Media	1,570	2,783	0	16,869	0	2,857	0	6,416	30,056	2,158	2,105	0	11,707	8,299	16,534	0	0	8,748
Building and Grounds, Cleaning and Maintenance	4,557	58,120	195	0	0	224	0	1,838	0	0	0	0	0	0	0	0	0	2,027
Business and Financial Operations	0	3,633	1,327	3,553	2,099	1,292	104,805	29,163	619	12,379	3,640	0	18,541	24,177	0	0	0	5,523
Community and Social Service	0	0	0	0	0	1,408	0	12,800	0	0	0	0	0	0	0	0	0	0
Computer and Mathematical	0	0	0	0	0	645	31,932	12,935	6,841	8,510	0	0	48,332	0	0	0	0	0
Construction and Extraction	0	22,106	0	0	124,869	0	0	10,521	0	0	961	1,913	4,133	0	4,121	3,907	0	0
Educational Instruction and Library	0	0	0	5,338	0	73,028	0	6,210	294	0	0	0	0	0	0	0	0	0
Farming, Fishing, and Forestry	0	0	12,451	0	0	0	0	3,923	0	0	2,817	0	0	0	0	0	0	5,088
Food Preparation and Serving Related	156,985	0	0	0	0	488	0	0	0	0	0	0	0	0	9,248	0	0	0
Healthcare Practitioners and Technical	0	0	0	0	0	1,720	0	16,561	0	0	646	0	7,952	0	36,432	0	0	0
Healthcare Support	0	5,096	0	0	0	0	0	3,182	0	0	0	0	4,090	0	10,809	0	0	0
Installation, Maintenance and Repair	0	26,394	459	2,818	23,996	155	0	10,240	5,414	0	9,362	0	0	17,552	117,075	25,020	2,312	40,502
Legal	0	0	0	0	0	0	3,494	13,802	0	0	0	0	7,870	0	0	0	0	0
Life, Physical, and Social Science	0	3,852	1,751	0	769	6,991	0	66,728	305	3,344	8,764	106	60,187	0	0	0	984	1,303
Management	13,703	0	463	1,129	1,664	3,761	14,127	24,463	626	14,328	12,884	0	23,224	21,320	3,128	4,146	0	6,842
Office and Administrative Support	12,588	35,371	0	1,402	0	1,880	76,442	35,776	2,715	1,492	2,757	0	11,858	0	10,374	25,499	409	10,517
Personal Care and Service	26,960	4,034	544	32,167	0	763	0	7,363	6,064	0	0	0	566	11,526	2,788	1,493	0	0
Production	4,508	30,027	0	0	924	238	0	9,426	0	1,676	192,222	79	2,279	0	38,645	4,511	4,973	0
Protective Service	1,740	26,529	0	2,381	0	1,834	0	65,633	0	0	0	0	459	0	0	4,412	0	0
Sales and Related	2,877	19,253	0	2,036	0	454	19,670	1,554	2,108	0	1,922	0	5,697	56,688	47,308	0	0	30,832
Transportation and Material Moving	5,461	19,286	0	736	3,903	1,349	0	27,286	0	0	5,883	278	488	11,219	41,154	170,704	0	35,363

Table 10: Jobs Impacted in the Nonmetro, by Occupation Family and 2-Digit NAICS: Best Scenario

Occupation Family	72	56	11	71	23	61	52	92	51	55	31-33	21	54	53	44-45	48-49	22	42
Architecture and Engineering	4	178	0	0	360	0	0	3,107	79	20	5,738	238	1,897	0	0	0	63	118
Arts, Design, Entertainment, Sports, and Media	157	127	0	874	0	76	122	825	1,769	17	322	0	295	510	2,057	0	0	723
Building and Grounds, Cleaning and Maintenance	410	2,653	279	0	0	4	0	236	0	0	0	0	0	0	0	0	0	169
Business and Financial Operations	0	167	1,921	181	239	35	6,839	3,749	33	92	559	0	471	1,486	0	0	0	457
Community and Social Service	0	0	0	0	0	37	0	1,646	0	0	0	0	0	0	0	0	0	0
Computer and Mathematical	0	0	0	0	0	16	2,076	1,662	403	63	0	0	1,220	0	0	0	0	0
Construction and Extraction	0	1,009	0	0	14,207	0	0	1,353	0	0	147	2,997	105	0	513	221	0	0
Educational Instruction and Library	0	0	0	276	0	2,000	39	798	15	0	0	0	0	0	0	0	0	0
Farming, Fishing, and Forestry	413	0	18,017	0	0	0	0	502	0	0	431	0	0	0	0	0	0	422
Food Preparation and Serving Related	14,116	0	0	0	0	13	0	0	0	0	0	0	0	0	1,152	0	0	0
Healthcare Practitioners and Technical	0	0	0	0	0	46	5	2,129	0	0	99	0	11	687	4,526	0	0	0
Healthcare Support	0	233	0	0	0	0	0	409	0	0	0	0	202	0	1,345	0	0	0
Installation, Maintenance and Repair	0	1,204	665	144	2,730	3	0	1,316	320	0	1,439	0	103	0	14,547	1,417	344	3,345
Legal	0	0	0	0	0	0	21	1,774	0	0	0	0	0	1,080	0	0	0	0
Life, Physical, and Social Science	42	175	2,533	0	86	193	227	8,578	16	25	1,345	166	198	0	0	0	146	108
Management	1,266	0	670	58	189	101	0	3,143	36	107	1,979	0	1,517	0	389	234	0	565
Office and Administrative Support	1,208	1,614	0	72	0	50	927	4,601	161	12	424	0	585	1,311	1,288	1,445	60	869
Personal Care and Service	2,436	182	787	1,665	0	20	4,980	946	355	0	0	0	299	0	348	84	0	0
Production	412	1,370	0	0	103	4	233	1,214	0	13	29,508	125	12	708	4,802	255	745	0
Protective Service	163	1,211	0	123	0	49	0	8,437	0	0	0	0	58	0	0	250	0	0
Sales and Related	274	878	0	106	0	11	18	200	124	0	294	0	11	0	5,875	0	0	2,545
Transportation and Material Moving	491	879	0	39	444	37	1,294	3,507	0	0	904	437	144	3,484	5,113	9,675	0	2,920

Summary and Conclusion

This paper explores the impact of automation on occupations in Illinois. Automation is the conversion of a work process, a procedure, or equipment to automatic rather than human operation or control. Practitioners foresee negative impacts, that automation will wipe out millions of jobs.

For labor to be displaced by technology such as machines, robots, and computer programs, technology should mimic human cognitive and physical performance. Recent innovations in AI and robotics, for example, machine learning, suggests that the risk of automation is present for all types of jobs.

Empirical analysis suggests:

1. that the role of labor in industry output has decreased in the nonmetro; r^2, the percentage of variance in industry GDP explained by labor, has decreased from 0.5 during 2001-2010 to 0.35 during 2011-2020; and
2. at the peak of automation in the 2030s, a quarter of a million jobs in the nonmetro would be disrupted; the metro region of Illinois could witness job disruptions of around 1.9million occupations. Production family of jobs will be the worst affected in the nonmetro.

There are at least two ways of looking at the results; one, by hoping that AI and robotics will create new jobs, or two, by recognizing that in the mature US market, improvements in production technology will not increase demand, so labor will be displaced.

I am optimistic; technological unemployment should result in retraining of the labor force. It means immediate increases in the output of the "educational services" sector and its interdependence sectors, assuming that technology doesn't outpace the time it takes to retrain workers.

Finally, this exercise made me ponder whether the 'Luddite fallacy' – the thinking that innovation will harm employment – is true.

Appendix 1: Automation Impacts on Employment at the Micro Level: Computational Details for NAICS 11, Agricultural Sector

Table A1 shows the proportion of each occupation-family in the sector. Table A2 shows the size of the occupation-family in the top three counties in terms of agricultural employment; cell entries are the product of Table A1 values and the variable "Total Number of Jobs" in Table A2.

Table A1: Percentage of Jobs in Each of the Occupation Family

Occupation Family	Agriculture Forestry Fishing and Hunting
Building and Grounds Cleaning and Maintenance	1.17%
Business and Financial Operations	7.73%
Farming Fishing and Forestry	71.22%
Installation Maintenance and Repair	2.43%
Life Physical and Social Science	11.33%
Management	3.06%
Personal Care and Service	3.06%
All	100.00

Table A2. Occupation-Family Size in the Top Three Agricultural Counties

Occupation Family	LaSalle	Champaign	Iroquois
Building and Grounds Cleaning and Maintenance	21	19	16
Business and Financial Operations	141	128	106
Farming Fishing and Forestry	1298	1182	981
Installation Maintenance and Repair	44	40	33
Life Physical and Social Science	206	188	156
Management	56	51	42
Personal Care and Service	56	51	42
Total Number of Jobs	1822	1659	1377

To compute ARI at the occupation-family level, data from A2 are weighted by the hinge-spread statistics[23] computed from Table 3 in the text. The results suggest that more than half of all existing jobs in the agricultural sector are under the threat of automation (Table A3).

[23] Hinge spread = dH = (Q3-Q1) x 1.5.

Table A3: Number of Jobs at Risk from Automation

	LaSalle		Champaign		Iroquois	
Occupation Family	**Low**	**High**	**Low**	**High**	**Low**	**High**
Building and Grounds Cleaning and Maintenance	11	17	10	16	8	13
Business and Financial Operations	78	86	70	78	58	65
Farming Fishing and Forestry	727	1038	662	946	549	785
Installation Maintenance and Repair	27	31	24	28	20	23
Life Physical and Social Science	102	133	93	121	77	101
Management	27	36	25	32	20	27
Personal Care and Service	32	42	29	38	24	32