The Impact of Technology on the American Printing Industry in the Past 20 Years

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ABSTRACT

Digital printing has revolutionized how documents, pictures, and other materials are printed, providing high-quality results rapidly using inkjet or laser printers compared to traditional methods that were reliant on offset printing techniques that took hours or even days to finish just one print job. This condition has led to many changes in the industry, including: 1) A decline in the number of jobs in the printing industry, as automation has replaced many manual tasks. 2) A shift in the types of printing services in demand, with more emphasis on short-run, high-quality jobs, and 3) The emergence of new markets for printed materials, such as digital labels and packaging. In the United States, the printing industry digitization has produced significant changes, including shifting markets and declining sales, resulting in the obsolescence of numerous jobs. We argue that this phenomenon aligns with the Schumpeterian concept of creative destruction. We then examine the effects of digitization on employment and wages within the U.S. printing industry between 2002 and 2021. By employing exploratory statistical analysis, we aim to determine if the printing industry has experienced any deviations in employment and wages compared to the overall national trend. Empirical evidence indicates a continuous decline in active workers in the U.S. printing industry from 2001 onwards. However, average wages have shown slower growth compared to the broader economy.

Keyword: United States; Industrial Sectors; Technical Change; Employment; Schumpeterian paradigm;

1. INTRODUCTION

Information and Communication Technologies (ICTs) have revolutionized vital sectors in the United States. Several well-known firms such as Blockbuster, Borders, Kodak and Polaroid crumbled in the last 30 years, while companies like Google, Apple, Facebook, and Amazon, which no one could conceive of in the 1990s, are now well-known corporations that are ruling the techno-economic milieu due to ICTs [1], [2], [3].

ICTs and their corresponding digital versions have thus opened up new markets, asking for specialized jobs such as web technicians, artificial intelligence programmers, digital designers, software developers and Big Data analysts [2]. As a result, ICTs have accelerated the necessity for better technical skills for harnessing the so-called knowledge-based economy, especially since the turn of the century [4], with ICT jobs growing more quickly than those related to traditional sectors [5].

This research examines the effect of the technical change brought about by the digitization of the American printing industry in the last two decades. To explain these changes, we draw on Schumpeter's approach to understand this process, thus interpreting digitization as a revolutionary technology [6]. To this end, we define digitization as the innovative conversion of tangible goods into electronic formats. In economic terms, digitization is a technological weapon innovative firms harness to increase users' value [7], [8].

We focus our analysis on the sectoral performance of the American printing industry in the last twenty years (2002-2021). We have decided to examine the long-established U.S. printing sector because this period coincided with the speedy introduction of several digital technologies that forced traditional firms in the industry to face drastic economic and technical adjustments that could be characterized through the Schumpeterian winds of creative destruction sweeping into their business [6].

This paper has two exploratory aims. The first is to identify patterns that might explain the downward trend in the American printing industry from 2002 to 2021. The second is to determine the extent of the impact. The paper is structured into seven sections. The next presents a brief literature review. The third section describes the methodology. The fourth section presents the results. The fifth section develops a model to provide insight into the changing sectoral pattern of industrial employment across the U.S. and the printing sector in the four-digit NAICS category 3231. Finally, empirical results will be presented, and conclusions will be drawn.

2. LITERATURE REVIEW

From 1990 onwards, the rapid advance of ICTs has profoundly transformed most economic activities worldwide [8]. In the case of traditional industrial activities, the transformation has been fast and radical [5]. As a result, new technologies have compelled well-established firms, like those in the printing business, to quickly adjust to technical advancements, with most of the changes stemming from the digital transformation of the products and services offered and marketed.

In the case of the United States, the rapid diffusion of digital processes in the economy has been a transformative force, revolutionizing various sectors and fundamentally altering how business is conducted [2]. This phenomenon, driven by technological innovations and increased connectivity, has reshaped enterprises, regions, sectors, organizational patterns, and economic dynamics [5].

Digitalization has swiftly infiltrated diverse sectors such as manufacturing, finance, healthcare, and retail in recent decades. Businesses have embraced digital tools and platforms to streamline operations, enhance efficiency, and reach wider audiences. Automation, data analytics, and e-commerce have become integral to modern business strategies, enabling companies to make informed decisions, optimize processes, and personalize customer experiences [7].

As a result, adopting digital processes has spurred opportunities and challenges in the American labor market. While automation has led to the displacement of specific routine and manual jobs, it

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has also created the demand for highly skilled workers proficient in areas like programming, data analysis, and digital marketing. As traditional job roles evolve or disappear, upskilling and retraining have become essential for maintaining workforce relevance [11]. Moreover, the rapid diffusion of digital processes has blurred traditional industry boundaries and catalyzed the rise of innovative business models. The sharing economy, characterized by platforms like Uber and Airbnb, leverages digital connectivity to facilitate peer-to-peer transactions and resource utilization, transforming how people access transportation and accommodations [3].

However, the digital divide remains a pressing concern. Disparities in digital access and skills can exacerbate inequalities, as individuals without adequate technological resources may be left behind in an increasingly digitalized economy [2]. In particular, the rapid diffusion of digital processes across the American economy has ushered in a new era of business operations and economic dynamics. While generating efficiencies, innovation, and novel opportunities, this digital transformation has also presented challenges related to workforce adaptation and equitable access. As technology continues to evolve, understanding and effectively managing the implications of digital diffusion will be pivotal in shaping the future of the American economy [1], [8].

In this context, the so-called digital economy was born from the works of Nicholas Negroponte and David Yoffie, who trailblaze the concept. The former famously claimed that interactive multimedia would draw on the personal computer to offer entertainment and information services, thus replacing the outmoded T.V. set. Negroponte anticipated that Americans would spend more hours online than watching television. His forecast fatally evolved into a dismal end for T.V. broadcasters [9].

For his part, Yoffie considered digitization a revolutionary innovation that would rewrite the world economy. He described several market opportunities that would arrive by the turn of the 21st century. He presaged the merging of telecommunications, broadcasting, and computing into a new technology that would spur new ventures in video-on-demand, interactive television, and online services to deliver novel digital content [10]. In hindsight, Negroponte and Yoffie forecasted the current digital world as a revolutionary paradigm with destructive effects on many long-established economic sectors, as Schumpeter would have argued.

For the research, digitization refers to the analog-to-electronic transformation of tangible documents and printed media. That is, information technologies spur productivity when digitized data steps in to automate processes, thus enhancing entry. Typical uses include analog music encoding, photograph scanning, and transforming paper reports into portable file documents (PDF). In short, digitization encodes real stuff in a digital format. The constant advance of ICTs has significantly changed several traditional industries. Among those more seriously transformed are the publishing industry and paper and printing manufacturing. Digitalization creates new ways for printing companies to generate added value for the business [11].

Digitization has produced both benefits and drawbacks, however. To begin with, firms can encourage users to shift from printed invoices and paper bills by offering immediate cost savings and lower prices. Suppliers can also switch to digitally delivering all relevant information. Governments can digitize their services by transferring face-to-face interactions to online-only processes, such as requesting tax records, licenses, and permits [5]. Yet, they have also produced workers' dismissal and decay [2].

We argue that ongoing technical change is vital in enhancing firms' value chains. Following [3], we distinguish three forms of digitization and their outcomes. Vertical convergence induces changes along the value chain, e.g., for video delivery. Horizontal convergence cuts across existing platforms, such as cable, T.V., and wireless communications, and platform convergence currently serves as a universal platform on the mobile Internet. The following section describes the methodological approach used in this study.

3. METHODS

The research follows a time-series analysis approach that draws on the yearly statistics collected by the U.S. Bureau of Labor Statistics (BLS). This database relies on the periodic survey, Occupational Employment and Wage Statistics (OEWS), freely available at https://www.bls.gov/oes/tables.htm.

We collected data for the last twenty-year employment and wage statistics (2002-2021) from the American sector named printing and related support activities (NAICS 3231). We selected this industry because it produces and relies primarily on tangible goods, epitomizing the pre-internet economy. Although the OEWS database reports sectoral economic information for the U.S. industry based on the North American Industry Classification System (NAICS), a preliminary methodological note is worth presenting.

The time series from the OEWS website provides industry data since 1988, but we restrict our analysis to the 2002-2021 period because of methodological issues. First, digitization's effects on jobs and wages can safely be attributable to the rapid diffusion of ICTs during those years. Second, the selected time series data are relatively homogeneous. Yet, one limitation of our approach is that it is based on aggregate data. Thus, we do not measure how specific jobs were affected by the ongoing digitization process. However, we argue that aggregate industrial employment data still helps explain the downward trend in the examined sector.

Finally, printing is an industry focused on producing printed matter. Thus, printing firms typically make newspapers, business cards, labels, books, business forms, stationery, etc. Additional activities comprise supporting processes such as plate-making services, data imaging, and bookbinding. So, this sector embraces business units handling paper stuff to make printed material.

According to the NAICS Association, as of 2022, there were 53,874 commercial establishments registered in the four subsectors, which are distributed as follows. Commercial Printing (NAICS 323111): 43,605 Commercial Screen Printing (NAICS 323113): 8,257. Books Printing (NAICS 323117): 362, and Support Activities for Printing (NAICS 323120): 1,670.

4. RESULTS AND DISCUSSION

Regarding the impact of industrial innovation, the printing industry has traditionally been a study case for labor sociologists and historians, who have been interested in analyzing working conditions in the sector. Yet, digitization started to affect the printing, publishing and paper manufacturing sectors as early as the mid-1980s. The digitization process encouraged the capital consolidation that newspaper production finally achieved during

the 1990s when the first electronic tools to deliver digitally printed material appeared [12].

We seek to assess digitization's impact on printing through different means. One is by examining the change of job creation (or destruction) registered in the available datasets. We chose this approach to gauge the macroeconomic results on wages and employment due to digitization, limiting our analysis to 2002-2021 to keep the OEWS data set consistent.

5. SAMPLE DESCRIPTIVE DATA

We explore the evolution of employment and wages in the U.S. printing industry by drawing upon historical labor market data from the United States Bureau of Labor Statistics Occupational Employment and Wage Statistics (OEWS) Survey between 2002 and 2021.

Table 1 reports total employment for the printing industry and the entire U.S. industrial sector in the twenty years the research covers. Preliminary analysis shows a noticeable reduction in total employment in the printing sector (NAICS 3231), remarking that the printing activity was a more significant employer in 2002 than in 2021.

Table 1: Total employment, 2002-2021 (Million workers)

Year	Printing	U.S. National
2002	0.697	127.5
2003	0.688	127.5
2004	0.666	128.1
2005	0.652	130.3
2006	0.638	132.6
2007	0.628	134.3
2008	0.608	135.1
2009	0.552	130.6
2010	0.494	127.0
2011	0.479	128.2
2012	0.465	130.2
2013	0.456	132.5
2014	0.455	135.1
2015	0.452	137.8
2016	0.451	140.4
2017	0.444	142.5
2018	0.434	144.7
2019	0.429	146.8
2020	0.391	139.1
2021	0.368	140.8
Difference 2002-21	-329.7	13,379.9

However, the 2008-2009 world financial crisis that also hit the U.S. economy strongly affected the printing sector with a 10.4% workforce reduction from 2009 to 2010. This situation became permanent from 2010 onwards when the printing industrial activity experienced a constant contraction.

On the other hand, Table 2 reports the average annual wages for the printing industry and those of the entire U.S. manufacturing sector between 2002 and 2021. The depicted data show that printing (NAICS 3231) has experienced a net gain of almost fourteen thousand dollars from 2002 to 2021. This wage increase was more than three thousand dollars higher than the average salary in U.S. manufacturing. The OEWS reports that the U.S. manufacturing sector increased its wages from 2002, albeit at different rates, with printing below the U.S. mean wage.

Table 2: Average Wages, 2002-2021 (Thousand U.S.$)

Year	Printing	U.S. National
2002	35.1	17.5
2003	35.5	17.8
2004	35.8	18.2
2005	36.6	18.6
2006	37.5	19.2
2007	38.5	19.9
2008	39.7	20.5
2009	40.5	21.1
2010	40.9	21.6
2011	41.5	22.0
2012	41.7	22.0
2013	42.2	22.3
2014	42.5	22.7
2015	43.0	23.2
2016	43.8	23.9
2017	44.2	24.3
2018	45.4	25.0
2019	46.1	25.7
2020	47.6	27.1
2021	48.9	28.0
Difference 2002-21	13.9	10.5

According to the figures above, the printing industry (NAICS 3231) reduced its workforce by 329,700 jobs, a 47.3 percent contraction from 2002 to 2021. These figures strongly contrast with the national U.S. labor market, which created 13,379,890 jobs in the same period (see Table 1).

In the case of average wages, Table 2 shows that the printing sector's salaries rose even higher than the average national wage. It is worth noting that all U.S. sectors (including printing) tended to pay higher salaries (in current thousand U.S. $) in 2021 compared to 2002. However, more detailed comparisons are worthy of discussion.

To begin with, statistical analysis shows that the printing sector exhibited a contrasting performance during the 19 years. On the other hand, workers enjoyed a total salary increase of 13,860 dollars between 2002 and 2021, meaning that they got a mere 1.68% increase per annum. Yet, the salary increase was (apparently) caused by a reduction in the total workforce.

This downward trend in the printing industry is crucial to our research. The effect of digitization on printing performance is inconclusive because workers' dismissal must be contrasted with payments. Therefore, we need to examine aggregated data to detect these trends.

To some extent, the explanation lies in how the digitization process evolved. The reason why technical change significantly impacted wages and employment in the U.S. printing industry has to do with industrial innovation. First, as technology became, traditional printing methods gave way to digital alternatives, leading to a decline in demand for labor-intensive tasks like typesetting, plate making, and manual printing. This shift led to reduced employment opportunities for workers in these roles, resulting in job losses and wage stagnation.

Conversely, the digitization process created new opportunities in design, prepress, and digital printing, requiring skills in graphic design, computer programming, and digital technology. These positions often commanded higher wages, reflecting the increased skill requirements and the added value of digital capabilities. However, the overall employment levels in the printing industry

did not fully compensate for the jobs lost, as the digital processes often streamlined production and required fewer workers.

In summary, we can argue that digitization led to the restructuring of the U.S. printing industry, causing job losses in traditional printing roles while generating new, higher-skilled positions. Besides, wages were influenced by the skill demands of these new roles, resulting in a mixed impact on overall employment and compensation within the industry.

6. EMPIRICAL MODEL

We have argued that the rapid advance of ICTs (i.e., digitization) has led to three visible changes in the printing industry: 1) A decline in the number of jobs as automation has replaced many manual tasks. 2) A shift in the types of printing services in demand, with more emphasis on short-run, high-quality jobs, and 3) The emergence of new markets for digitally printed materials has made old labor skills obsolete.

To test these ideas, we now shall perform statistical tests to verify whether digitization has affected traditional printing outlets, forcing them to shrink their workforce. So far, we have shown that the printing industry faced a drastic transformation between 2002 and 2021. It scrapped over three hundred thousand jobs while salaries grew below the national average.

Although we argue that digitization is behind this condition, we can only assess its macroeconomic effects. Yet, the general tendency seems to confirm the negative digitization effect concerning the employment variable. To support our approach, we should inspect the interrelation of the employment variable with the national trend. Bivariate Pearson correlations between printing and U.S. federal employment between 2002 and 2021 show a negative correlation value of -0.66, which is significant at the 0.01 level (2-tailed).

In contrast, bivariate Pearson correlations between wages in printing and the total U.S. between 2002 and 2021 exhibit a strong positive correlation of 0.99. Although this pattern demonstrates the detrimental effect of digitization on employment, further study is worth performing. Therefore, we must conduct a trend analysis of jobs from 2022 to 2021.

Several studies have examined which factors influence U.S. industrial employment. The most frequently cited are recessionary trends, international trade gaps, de-industrialization, offshoring, technological change, and, recently, the COVID-19 pandemic [5], [13].

We test if digitization has contracted the printing industry, forcing it to dismiss workers. What interests us is whether the employment increase (decrease) rate differs from zero. So, we carried out a trend analysis of the two available time series: national U.S. and printing. As sketched before, there are two opposing views. One view is that U.S. total employment increased from 2002 to 2021, along with the industry examined. The alternative view is that only national employment grew, whereas the other decreased. In the first case, all of the regression coefficients must be positive. All coefficients must be negative except for the U.S. total in the second case. Eq. (1) describes the formula used to produce the regression.

$$Ei = a + bT \quad (1)$$

Ei denotes employment in sector i, and T is a time trend over the 19 years. What interests us is the sign of the coefficient b. A negative sign will suggest that employment (in either sector) trended downwards. Tables 3 and 4 report the results.

Table 3: Model Summary

Model	R	R2	Adjusted R2	Std. Error	Durbin-Watson
National	0.826	0.682	0.664	3.5 E6	0.642
Printing	0.963	0.927	0.923	29,739	0.307

Predictors: (Constant), trend (n = 19). Dependent Variable: Employment

Table 4: Coefficients (OLS Estimates)

Model	Label	B	Std. Error	t	Sig.
National	C	1.256 E8	165,770	75.76	0.00
	Trend	859,361	138,382	6.21	0.00
Printing	C	705,309	13,814	51.05	0.00
	Trend	-17,381	-1,153.27	-15.1	0.00

As regression results show, the second view stands since the printing industry exhibits a downward trend. The b coefficient for printing is negative and significant. While national employment grew to almost 860,000 jobs per year, the printing sector expelled hundreds of workers yearly. Yet, due to the time-dependent nature of the dataset, the Durbin Watson (D.W.) statistic values point to positive autocorrelation. Although these values are of concern, our intention is only to test for the sign of the trend. A more robust autocorrelation analysis would ask for a larger dataset, however.

Overall, regression analysis confirms a contrasting effect. Whereas total employment was diminishing, wages were rising. We think that skill composition may explain this condition. We believe that traditional printing was facing stricter business conditions derived from widespread digitization and thus being forced to adopt more advanced production practices, which, in turn, increasingly depended on more complex activities and processes. Then, the industry would try to overcome the trend by substituting unskilled workers with more qualified staff. This interpretation is nevertheless limited because a more informed examination is required. For example, controlling for external economic effects is necessary to separate the innovation effect (i.e., digitization) from other contemporary forces. Unfortunately, the research carried out in this work could not get more disaggregated data to test for this condition. Yet, it would be a promissory beginning if more detailed information could be available.

7. CONCLUSIONS

We argue that digitization has produced profound economic and social changes. In this article, we have discussed how the Schumpeterian tradition of analyzing the effects of technical change on economic activity can explain the current situation of the printing industry.

By exploring the impact of new technologies, such as digitization, on employment in traditional sectors, which often receive less attention in existing research focusing primarily on emerging industries. Companies must be innovative to survive and remain competitive. Hence, this research examined digitization's disruptive effect under the Schumpeterian paradigm of rapidly evolving industrial innovations. We argue that businesses producing real, paper-based stuff have undergone the blow of digital versions of their traditional products. Even though we

could only analyze the macroeconomic effects, we could infer that the swift deterioration of market conditions induced employment and salary changes due to digitization.

Our analysis dealt with the printing industry, a clear example of a pre-digital manufacturing sector. This industry has faced shrinking sales of traditional print stuff as digital versions supplant physical items. Its troubles began when publishers and advertisers, its main customers, started an accelerated transition to the digital world in 2002. Also, online advertising platforms have lured many long-time printing customers because they are cheap and provide practical tracking tools for measuring investment returns. Moreover, advertisers' expenditures have also declined on other printed products like magazines and newspapers. So, when advertising spending shrinks, newspapers and magazines drop page output and seek to consolidate operations, further shrinking the industry's supply. Additional threats are appearing from social concerns regarding the long-term sustainability of paper production.

We must acknowledge, however, that the Schumpeterian paradigm is a theoretical concept that can only partially explain the distress caused by the digitization of traditional businesses. Yet, our analysis faces the limitation of this conceptual approach. Policy implications from our research suggest that traditional sectors must rapidly adapt to innovation by introducing products and services based on high-value-added technologies.

Moreover, the transition must also consider upgrading workers' skills. One plausible route is improving in-site training practices and ICT education since digitization is constantly evolving and progressing. In this regard, future research must consider the implications of rapidly changing technologies such as robotics, quantum and cloud computing, and artificial intelligence on industrial structure and labor conditions.

Finally, we think digitization is far from being accomplished because continual discoveries guarantee a constant flux of innovations for the foreseeable future. As a result, many more sectors can face unpredictable changes similar to those experienced by paper-based industries. We claim that the so-called "creative destruction paradigm," proposed several years ago by Joseph Schumpeter, is still valid for firms relying on antiquated processes and techniques. Unfortunately, they cannot assume that previous responses would work well under the newer conditions. So, it seems safer to think that digitization must force traditional companies to offer competitive new services and products, thus reaffirming Schumpeter's conviction that innovative entrepreneurs spur profitable ventures.

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REFERENCES

[1] H. C. Lucas and J. M. Goh, "Disruptive Technology: How Kodak Missed the Digital Photography Revolution," Journal of Strategic Information Systems, vol. 18, pp. 46-55 March 2009 2009.

[2] F. Martel, Smart: The Digital Century, 5 July 2018 ed. Delhi: HarperCollins India, 2018.

[3] G. G. Parker, M. W. Van Alstyne, and S. P. Choudary, Platform Revolution: How Networked Markets Are Transforming the Economy And How to Make Them Work for You, 29 August 2017 ed. New York: W. W. Norton, 2017.

[4] H. Merritt, "Factors Affecting the Adoption of an Emerging Technology: The Diffusion of Wi-Fi Internet in Mexico," in PICMET '12: Technology Management for Emerging Technologies, Vancouver, Canada, 2012, pp. 1440-1449.

[5] OECD, Digital Economy Outlook, 27 November 2020 ed. Paris: OECD, 2020.

[6] J. A. Schumpeter, Capitalism, Socialism and Democracy, 5th (1976) ed. London: George Allen & Unwin, 1943.

[7] I. Abaidi and E. Vernette, "Does Digitalization Create or Reduce Perceived Global Value?," Journal of Consumer Marketing, vol. 35, pp. 676-687, November 2018 2018.

[8] B. McCullough, How the Internet Happened: From Netscape to the iPhone, 23 October 2018 ed. New York: Liveright, 2018.

[9] N. Negroponte, Being Digital, January 1995 ed. London: Hodder & Stoughton, 1995.

[10] D. B. Yoffie, "Competing in the Age of Digital Convergence," California Management Review, vol. 38, pp. 31-53, Summer 1996 1996.

[11] W. D. Holford, "The Future of Human Creative Knowledge Work within the Digital Economy," Futures, vol. 105, pp. 143-154, January 2019 2019.

[12] H. L. Vogel, Entertainment Industry Economics: A Guide for Financial Analysis, 8th edition ed. New York: Cambridge University Press, 2011.

[13] D. Acemoglu and P. Restrepo, "Automation and New Tasks: How Technology Displaces and Reinstates Labor " Journal of Economic Perspectives, vol. 33, pp. 3-30, Spring 2019 2019.