

# **Does Automation improve firm performance, and investment and labor efficiency?**

## **Background**

There is increasing interest in automation and other workforce technologies that disrupt conventional business practices and the competitive landscape. This is especially true in the manufacturing sector, an industry in which a shift from manual processes to automation is most prevalent. This includes automated assembly lines using robots equipped with sensors, autonomous vehicles, predictive analytics applications with embedded artificial intelligence algorithms, and blockchain for enterprise resource planning and/ or supply chain management. Economists see the manufacturing sector as an industry that has the highest potential to benefit from increased automation as it can provide higher levels of output, better quality, and fewer errors; however, despite the obvious potential benefits, about three percent of all goods produced are the result of automated processes. Against this background, this report addresses two important issues. First, I provide descriptive evidence on the adoption of automation in manufacturing firms that are members of the S&P 1500 index over the last three decades. Second, I examine the impact of automation on labor efficiency.

## **Motivation**

Note that the need for automation in manufacturing has become even more apparent as firms have been affected by the global COVID-19 pandemic, exposing vulnerabilities in global supply chains and production scale and leaving millions of workers in various sectors (including manufacturing) unemployed at a rapid pace. According to a March 2020 survey from the National Association of Manufacturers, about 53 percent of manufacturing firms expect a change in operations due to the pandemic. As such, firms in the manufacturing sector are under renewed pressure to evolve their production processes while maintaining low costs and reasonable quality. Contracting and sourcing for automation equipment has increased by 150% from 2019 to 2020 and it is expected that automation will become faster and easier to deploy in the near future.

## **Research Design and Data**

I begin the sample selection process by identifying the manufacturing firms that are members of the Standard and Poor's (S&P) 1500 index as of 2019, based on the Standard Industrial Classification (SIC) industry codes 2000-3990 in Compustat. There are approximately 578 manufacturing firms in the S&P 1500 index as of 2019. The sample period starts from the year 1994 and runs through 2019. In addition, I use the annual 10-K filings that disclose the addition

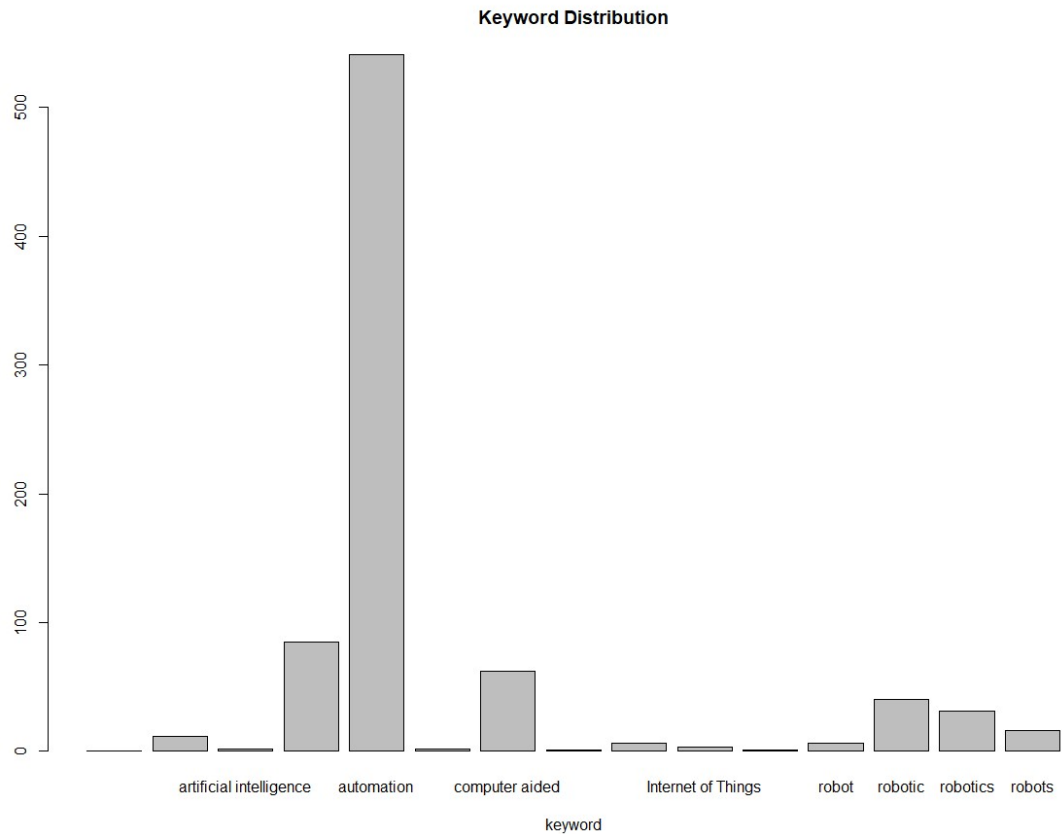
or investment in automation in manufacturing processes and/or operations based on word/phrase searches.

[1]	"automation_disclosure"	"count_keywords_usage"	"year"		"at"		"lifecycle"		"firstterm"
[7]	"lnat"	"at_1"	"mtb"		"firmage"		"lnfirmage"		"loss"
[17]	"dividend"	"debt"	"roa"		"ffind"		"fasset_turn"		"fineffnethire"
[19]	"restructuring_dum"	"workforce_reduc_dum"							
	automation_disclosure	count_keywords_usage	year		at		lifecycle		firstterm
	Min. :0.00000	Min. :0.0000	Min. :1994	Min. :0.0	Min. :0.000		Min. :0.000	Min. :12160	Min. :lnat
	1st Qu.:0.00000	1st Qu.:0.0000	1st Qu.:2001	1st Qu.:425.1	1st Qu.:1.000	automation	1st Qu.:1.000	1st Qu.:541	1st Qu.:6.052
	Median :0.00000	Median :0.0000	Median :2008	Median :1306.9	Median :2.000	automated assembly	Median :2.000	Median :85	Median :7.175
	Mean :0.06231	Mean :0.0903	Mean :2007	Mean :8058.6	Mean :1.742	computer aided	Mean :1.742	Mean :62	Mean :7.257
	3rd Qu.:0.00000	3rd Qu.:0.0000	3rd Qu.:2014	3rd Qu.:4766.3	3rd Qu.:2.000	robotic	3rd Qu.:2.000	3rd Qu.:40	3rd Qu.:8.469
	Max. :1.00000	Max. :8.0000	Max. :2019	Max. :479921.0	Max. :4.000	robotics	Max. :4.000	Max. :31	Max. :13.081
						(other)		49	
	at_1	mtb	firmage	lnfirmage	loss	dividend	debt	roa	
	Min. :0.0	Min. : -1881.432	Min. :0.00	Min. :0.000	Min. :0.0000	Min. :0.000	Min. :0.0000	Min. : -81.36364	
	1st Qu.:425.1	1st Qu.:1.678	1st Qu.:9.00	1st Qu.:2.398	1st Qu.:0.0000	1st Qu.:1.000	1st Qu.:0.0359	1st Qu.:0.02292	
	Median :1306.9	Median :2.590	Median :21.00	Median :3.091	Median :0.0000	Median :1.000	Median :0.1709	Median :0.06021	
	Mean :8058.6	Mean :3.605	Mean :26.14	Mean :2.921	Mean :0.1637	Mean :0.996	Mean :0.1930	Mean :0.03358	
	3rd Qu.:4766.3	3rd Qu.:4.110	3rd Qu.:38.00	3rd Qu.:3.664	3rd Qu.:0.0000	3rd Qu.:1.000	3rd Qu.:0.2857	3rd Qu.:0.09846	
	Max. :479921.0	Max. :5603.074	Max. :93.00	Max. :4.533	Max. :1.0000	Max. :1.000	Max. :50.7273	Max. :7.23171	
			NA's :529	NA's :1037					
	ffind	fasset_turn	fineffnethire	restructuring_dum	workforce_reduc_dum				
	Min. :2.00	Min. : -0.1271	Min. :0.0000	Min. :0.0000	Min. :0.0000				
	1st Qu.:13.00	1st Qu.:0.6679	1st Qu.:0.0274	1st Qu.:0.0000	1st Qu.:0.0000				
	Median :19.00	Median :0.9488	Median :0.0671	Median :0.0000	Median :0.0000				
	Mean :20.63	Mean :1.0310	Mean :0.1087	Mean :0.4055	Mean :0.2532				
	3rd Qu.:35.00	3rd Qu.:1.2818	3rd Qu.:0.1318	3rd Qu.:1.0000	3rd Qu.:1.0000				
	Max. :48.00	Max. :4.7344	Max. :2.0308	Max. :1.0000	Max. :1.0000				
		NA's :574	NA's :1549						

Based on the summary statistics above, about 6 percent of the firms in the sample had an automation disclosure within their 10-K annual report (automation\_disclosure). The maximum number of times that automation is mentioned by a firm in an annual report is 8 (count\_keyword\_usage). The mean total assets (at) of the firms is \$8.06 million, and the mean firm age (firmage) is 26 years. The mean life cycle ratio is 1.74, which suggests that most firms are between growth and mature stages (lifecycle). About 16.4 percent of the firms reported negative net income (variable: loss) and almost all (99.6 percent) firms paid dividends (variable: dividend). The mean unconditional likelihood of a firm engaging in a restructuring event and employee layoff is 41 percent and 25 percent, respectively (restructuring\_dum, workforce\_reduc\_dum).

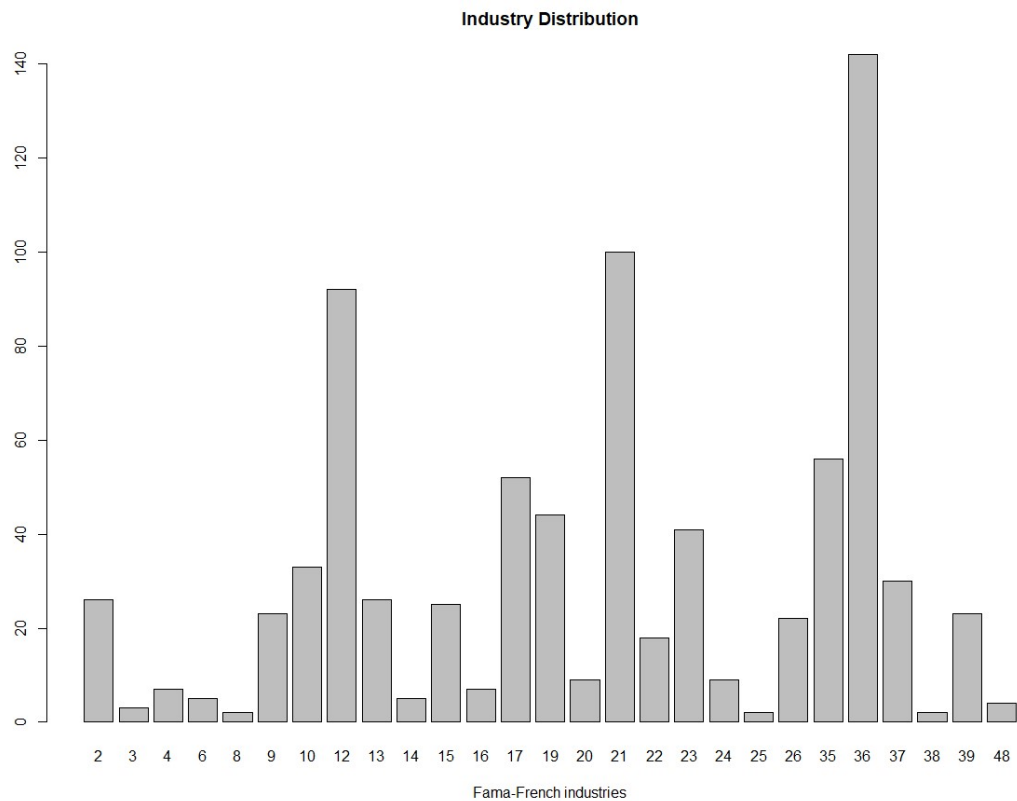
## Findings: Keyword Distribution

The visual shown below includes the specific keywords used in annual 10-K reports over the sample period. The keyword “automation” is used most frequently (67%) which is reasonable given this is a more general term for describing the adoption of technology into manufacturing processes.



## Findings: Industry Distribution

The visual shown below is the sample distribution based on the Fama-French industries. The largest representation in the sample are industries 36 (Electronic Equipment), 13 (Pharmaceutical Products), 21 (Machinery), 12 (Medical Equipment), and 14 (Chemicals). This makes sense because these Fama-French industries consist of the Standard Industrial Classification (SIC) industry codes for manufacturing (SIC 2000-3990). Likewise, the sample distribution by industry excludes non-manufacturing industries, such as business services, construction, telecommunications, retail, and transportation.



## Findings: Automation Disclosure by Year

The visual shown below presents the sample distribution of automation keywords by year. This table shows the firm-year observations conditional on having an automation disclosure in the annual 10-K report. Over time, there has been an increase in the firms disclosing automation, suggesting the firms that adopt automation has been increasing over time. Most importantly, this provides preliminary evidence that manufacturing firms are increasingly adopting over the time period 1994-2019.

