Manufacturing Jobs at Home

An Interactive Qualifying Project

Submitted to the Faculty

of the

WORCESTER POLYTECHNIC INSTITUTE

In partial fulfillment of the requirements for the

Degree of Bachelor of Science

in Mechanical Engineering

by

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August 2022

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Abstract

With the outbreak of COVID-19 a few years ago, the global manufacturing industry was dealt an unprecedented blow. Many industries, not just manufacturing, have been forced to shift to telecommuting at the cost of their health. Working online in all different industries has become a worldwide trend. This report will discuss how education, employment affect manufacturing, and most important, the benefits and potential drawbacks of manufacturing at home.

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Chapter 1

Introduction

Manufacturing industry can be said to be one of the most important industries in a country. The prosperity of manufacturing industry is the foundation for the development of all industries. Without manufacturing industry, there will be no equipment and no industrial chain. Over the past few years, with the steady development of various countries, the world economy has been steadily rising every year. However, the sudden global outbreak of COVID-19 in 2019 has brought an economic and health disaster to almost every country and region in the world. Many people are quarantined at home for their own health, which means manufacturing has been hit like never before, as people can't get to work in factories, and much of the assembly and infrastructure is shut down. Manufacturing, along with other many industries, is working on shifting to working from home as a desk job.

However, manufacturing is different from other industries. What manufacturing needs is entity and manufacture. Working from home might seem like nothing to do with manufacturing, but fortunately, in the 21st century, there are so many high-tech robots out there that people can let robots do their manufacturing with a few clicks on their computers, phones and tablets. This is why there is a possibility of working from home in manufacturing. So, as manufacturing jobs at home becomes mainstream in the coming years, the economics will become our consideration. For example, the money needed for machinery purchase and routine maintenance, factory rent, electricity and living expenses.

Chapter 2

Related Work

From WPI's previous Manufacturing Jobs at Home Interactive Qualifying Project, we found that the author mainly discussed how nowadays technology would affect and motivate manufacturing with the help of 3D printers and CNC machines. While the project was going on, the world has been under Covid-19's devastation for two years. In the past two years, everything has changed dramatically. In this project, we will discuss some very different perspectives from the previous project [Aki20]. We will go through manufacturing value, employment and education to analyze how manufacturing is affected, also the possibility and economics of manufacturing jobs at home in post-Covid-19 period.

In this project, we will collect most of the data from internet such as [Ban22] (where we obtain all the manufacturing values of each country for every year); [Bana] (where we get the graph for employment globally); [CH06] (where we get technology's influence on employment). From [Tre], where we get some analysis between education and employment in manufacturing, we will go further with the analysis discussed in the webpage. This website[WL18] is very helpful. It tells us the changes of the global manufacturing industry in recent years, including detailed analysis in terms of employment, output value and manufacturing environment.

After reading a lot of useful materials on the Internet, I found that there are not many resources to understand the impact of the COVID-19 pandemic on the manufacturing industry worldwide. Nor is there much impact of education and

employment on manufacturing. So I'm going to use Google as my main and only search engine and by searching some key words to look for all the data and analysis needed. We will use some key words include but not limited to "manufacturing value", "education level in manufacturing", "employment in manufacturing". From the search from all those keywords, there are more than millions of results coming out. Faced with so many results, it is impossible to use them all. So we need to make a reasonable filter to exclude the options we don't need. When doing a search, we obviously can't put all the keywords in the search bar. What we should do is to search for a keyword and then observe the results and use other keywords for further filtering. For example, when we search for "manufacturing at home" in the search engine, some of the first options that come up are "Sustainable Manufacturing", "Electronics Manufacturing" and "Manufacturing - No Special Handling Surcharges" and others. It is obvious that these topics are not relevant to what we will be discussing. These are the ones that need to be excluded. When we search for information using other keywords, we need to do the same process to ensure the efficiency and correctness of our access to information.

I will use the method mentioned above and use this project to discuss and analyze the impact of education, employment and economic development on manufacturing.

Chapter 3

Methodology and Data

In this chapter, we will discuss what exactly we are analyzing and will display all the data needed. We will list the countries, manufacturing values and employment respectively for future discussion in this project. Also, we will show the education level in different industry. Finally, In the analysis chapter, we will combine all those elements into our consideration talking about how one element influents another.

3.1 Countries Selection

When we talk about the economy of manufacturing from home, we need to think about the scope of manufacturing. Do we discuss manufacturing in all countries on a global scale, or just a few of the leading manufacturing countries? Because there are more than 200 countries and regions in the world which is a large base, so we choose the top 10 countries with the highest output value of the global manufacturing industry as the objects of our analysis.

In this project, we will use the phrase "manufacturing value" a lot. First of all, let's introduce the definition of manufacturing value. From [Def], we can know the definition of manufacturing value is "the total estimate of net-output of all resident manufacturing activity units obtained by adding up outputs and subtracting intermediate consumption".

Obviously, it is very accurate to conduct our analysis only based on the most recent manufacturing value. However, we are not just analyzing the nowadays man-

ufacturing, but also the future of manufaturing. We need to put our analysis upon on the past few years in order to get a much more fair trend in order to make our prediction. The figure 3.1 below shows the rankings of countreis that have top manufacturing values globally in the past 10 years. By applying the average method in Microsoft Excel, we can easily get the average ranking for countries and use them as the base to conduct future analysis.

Manufacturing Values Ranking in the Past 10 Years											
Country	**2020**	**2019**	**2018**	**2017**	**2016**	**2015**	**2014**	**2013**	**2012**	**2011**	**Average Ranking**
China	1	1	1	1	1	1	1	1	1	1	1
USA	2	2	2	2	2	2	2	2	2	2	2
Japan	3	3	3	3	3	3	3	3	3	3	3
Germany	4	4	4	4	4	4	4	4	4	4	4
South Korea	5	5	5	5	5	5	5	5	5	5	5
India	6	6	6	6	6	6	6	6	6	9	6.3
Italy	7	7	7	7	7	8	7	8	7	6	7.1
France	8	8	8	8	8	9	8	7	8	8	8
UK	9	9	9	9	9	7	9	9	10	10	9
Indonesia	10	10	12	11	11	12	13	13	12	12	11.6
Russia	11	12	11	13	13	13	11	11	11	11	11.7
Mexico	12	11	10	12	12	10	12	12	13	13	11.7
Brazil	13	13	13	10	10	11	10	10	9	7	10.6

Figure 3.1: Manufacturing Values Ranking in the Past 10 Years

3.2 Manufacturing Output Values

With the ranking of top 10 countries with the highest manufacturing values we get, next we will have to get the output value of each country. From the website [Ban22], by changing the year catagory, we can get all the manufacturing values needed for each countries in different time period. All the data are listed below (Figure 3.2).

Manufactory Value of Top 10 Countries (Billion US Dollars)												
Ranking	**Country**	**2020**	**2019**	**2018**	**2017**	**2016**	**2015**	**2014**	**2013**	**2012**	**2011**	**Average**
1	China	3853.31	3823.41	3868.46	3460.33	3153.12	3202.5	3184.24	2935.34	2690.09	2421.37	3259.217
2	USA	2337.55	2341.85	2308.05	2174.94	2094.07	2121.79	2042.34	1981.75	1919.7	1857.68	2117.972
3	Japan	995.31	1045.55	1041.97	1007.66	1015.15	909.54	959.5	1007.49	1233.57	1217.68	1043.342
4	Germany	698.9	755.86	796.98	752.58	716.94	683.2	786.55	743.97	710.95	758.6	740.453
5	South Korea	406.37	416.53	459.47	437.57	395.4	389.98	401.4	380.89	355.81	353.87	399.729
6	India	348.37	382.56	401.2	398.2	347.94	327.82	307.21	283.21	289.08	294.23	337.982
7	Italy	280.4	298.84	313.99	292.58	277.64	264.39	302.17	297.3	289.04	326.21	294.256
8	France	247.03	273.1	278.31	263.05	254.3	254.5	293.61	291.15	278.07	297.86	273.098
9	UK	238.69	255.62	256.63	241.5	244.93	272.4	287.91	266.47	252.74	249.8	256.669
10	Brazil	141.15	190.43	201.82	221.24	193.69	189.61	253.88	259.14	263.19	308.28	222.243

Figure 3.2: Manufacturing Values of Top 10 Countries from 2011-2020

3.3 Employment in Manufacturing

Next, we want to get the employment in manufacturing of each country. We will use the employee number and employment rate to make a prediction for manufacturing in the next few years. From the International Labor Organization website, we managed to get the data for year 2017 (Figure 3.3). However, we couldn't find such data for each country in other years which might affect the accuracy and conclusion. But in the analysis chapter, there will be several figures showing the tendency of employee number and employment rate for different countries in the years range required.

Country	**Total Number Employed in Manufacturing Sector**	**Percentage of Population Employed in Manufacturing**
China	128,869,000	16.9%
USA	16,381,000	10.5%
Japan	10,958,000	16.9%
Germany	7,911,000	19.0%
South Korea	4,499,000	16.9%
India	57,244,000	11.4%
Italy	4,090,000	18.5%
France	3,396,000	12.4%
UK	3,069,000	9.5%
Brazil	10,388,000	11.4%

Figure 3.3: Total number employed and employment rate of Top 10 Countries in 2017

3.4 Education Level in Industry

Education is another important factor for manufacturing. The figure 3.4below shows education level distribution in different manufacturing industries. In the following chapter 4, we will dig into how education and employment affect each other.

Industry	Primary education (less than 6 grades)	Secondary education (6–12 grades)	Higher education (more than 12 grades)
Auto parts	3.0	69.5	27.5
Electrical appliances	3.1	68.9	28.0
Electronic components	2.5	66.4	31.1
Furniture and wood products	14.8	67.5	17.7
Food processing	21.8	56.1	22.1
Garments	16.1	69.8	14.1
Machinery and equipment	8.5	63.5	28.0
Rubber and plastics	11.1	69.6	19.2
Textiles	14.8	71.8	13.4
Average	12.0	67.6	20.4

Source: Calculated from PICS Data 2007.

Figure 3.4: Table 4-Education Level in Manufacturing

Chapter 4

Analysis

In this chapter, we will put all the data listed in chapter 3 into real use. We will make graphs based on all the data we collected and also collecting useful figures from internet to conduct a deeper analysis.

4.1 Economic Development

Firstly, we need to put our focus on 2019 and 2020 because the key point of this project is to analyze how Covid-19 affect manufacturing because for year 2019 and 2020, the whole world is having a severe time. Plotting a line graph of manufacturing values of countries we selected in the past 10 years allows people to see the trend and progress.

From the figure 4.4 below, we can easily observe that before 2019, almost all the countries are making modest progress and some regressing very little, except that China made a pretty optimistic development. Starting from 2019, we can see that almost every country is making negative growth. Although the negativity might not be very evident for countries besides China, we can use China's economnic stagnation as a typical example of the of COVID-19 on the country's manufacturing sector. From the graph 4.4 below, we can easily forecast that without Covid-19, Chinese manufacturing industry should continue to develop vigorously from 2019-2020 instead of stagnating. A large part of the reason for this is that China implemented strict quarantine policies when the virus was found to be transmissible from person

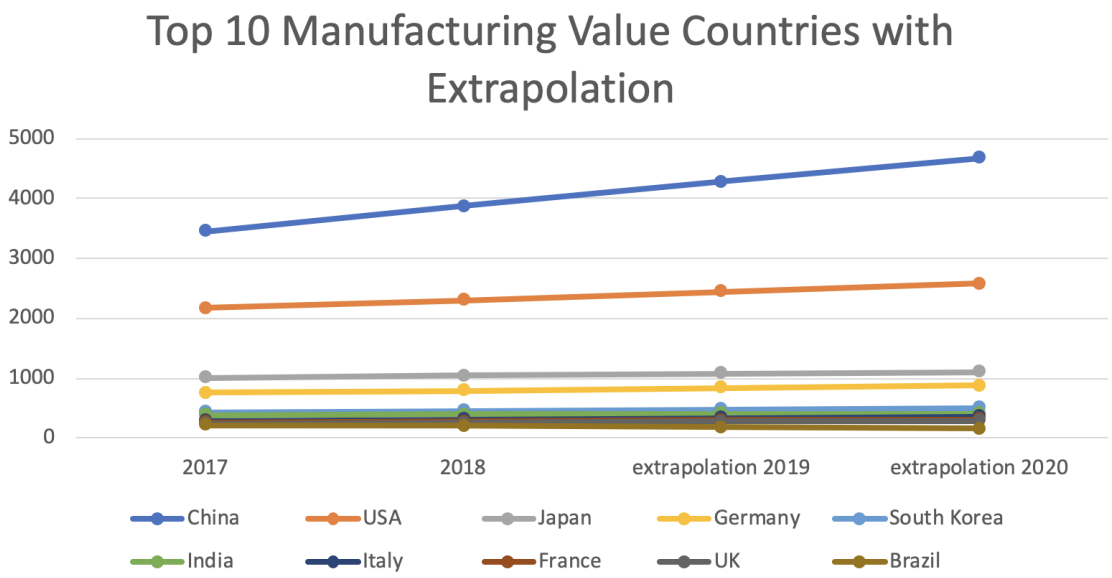
to person. At the end of 2019 and the beginning of 2020, a lot of people were quarantined in their homes. Because of people's willingness of staying at home, life in China had fully returned to normal starting from the second quarter of 2020, and the virus was killed in the cradle before it spread wildly. While different countries may have less stringent quarantine policies than China has, other countries have seen slower progress or even slightly retrogressing for similar reasons, as people have been forced to stop going to factories and other places where people can gather together.

From 2020-21, we can see that almost all countries have made more or less progress in manufacturing output. We can also infer that two years after the outbreak, the impact of the epidemic on countries has been slowly reduced. Since manufacturing is the most fundamental industry in every country, we can even venture to predict that the economy is slowly recovering.

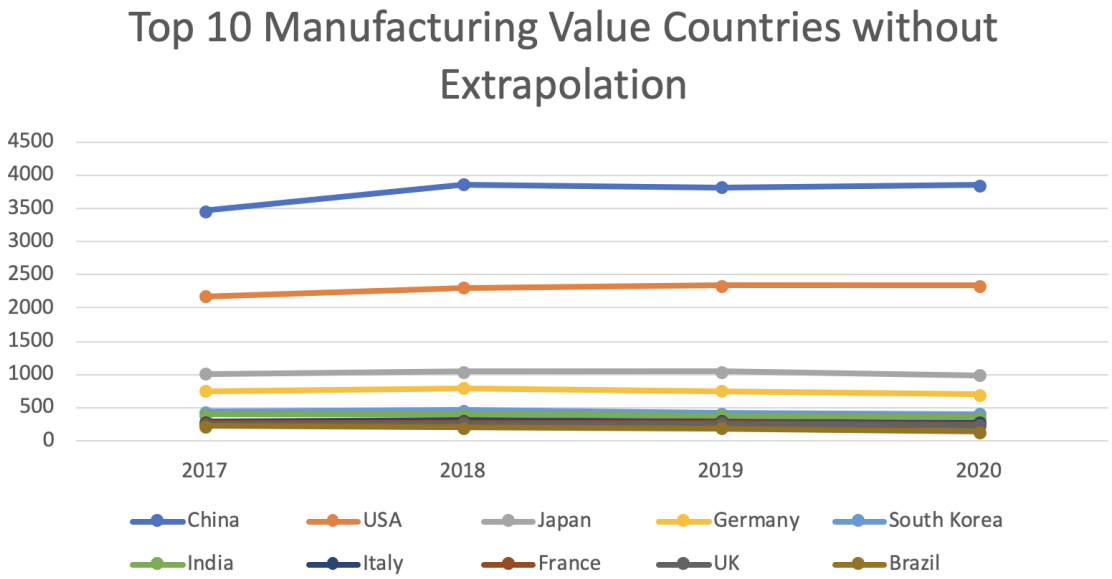
	2011	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
China	2421.37	2690.1	2935.3	3184.24	3202.5	3153.12	3460.33	3868.46	3823.41	3853.31	4865.82
USA	1857.68	1919.7	1981.8	2042.34	2121.79	2094.07	2174.94	2308.05	2341.85	2337.55	
Japan	1217.68	1233.6	1007.5	959.5	909.54	1015.15	1007.66	1041.97	1045.55	995.31	
Germany	758.6	710.95	743.97	786.55	683.2	716.94	752.58	796.98	755.86	698.9	772.25
South Korea	353.87	355.81	380.89	401.4	389.98	395.4	437.57	459.47	416.53	406.37	456.6
India	294.23	289.08	283.21	307.21	327.82	347.94	398.2	401.2	382.56	348.37	446.6
Italy	326.21	289.04	297.3	302.17	264.39	277.64	292.58	313.99	298.84	280.4	319.84
France	297.86	278.07	291.15	293.61	254.5	254.3	263.05	278.31	273.1	247.03	269.8
UK	249.8	252.74	266.47	287.91	272.4	244.93	241.5	256.63	255.62	238.69	279.39
Brazil	308.28	263.19	259.14	253.88	189.61	193.69	221.24	201.82	190.43	141.15	155.2

Figure 4.1: Manufacturing Value from 2011-2021 (Data for USA and Japan in 2021 missing) [Banb]

So how do we define or determine the impact of the epidemic on manufacturing? We decided to use extrapolation to define "impact". If the result of extrapolation is higher than the actual result, then the epidemic has a negative impact, while the opposite is a positive impact. We can see the difference between impact and no impact in the comparison chart above. As we can see4.2, all the top manufacturing



(a) Extrapolated manufacturing value for 2019&2020



(b) Actual manufacturing value from 2016-2020

Figure 4.2: Manufacturing value comparison between with and without extrapolation

countries have been affected, not to mention the countries outside the top 10. The impact of the epidemic on them could be fatal.

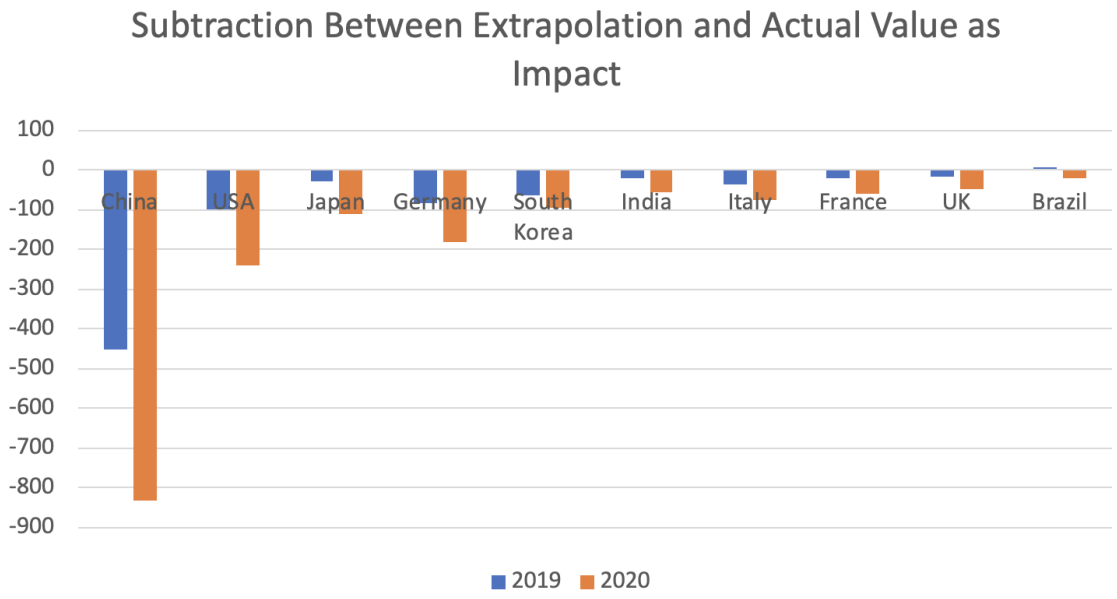


Figure 4.3: Economic impact of Covid-19 for the top manufacturing value country

From figure 4.5, we can find that there is indeed a decline in output value in 2020, which proves that the countries we choose can reflect the process of global manufacturing to a certain extent. So we can continue to choose the top several countries for further inference and analysis.

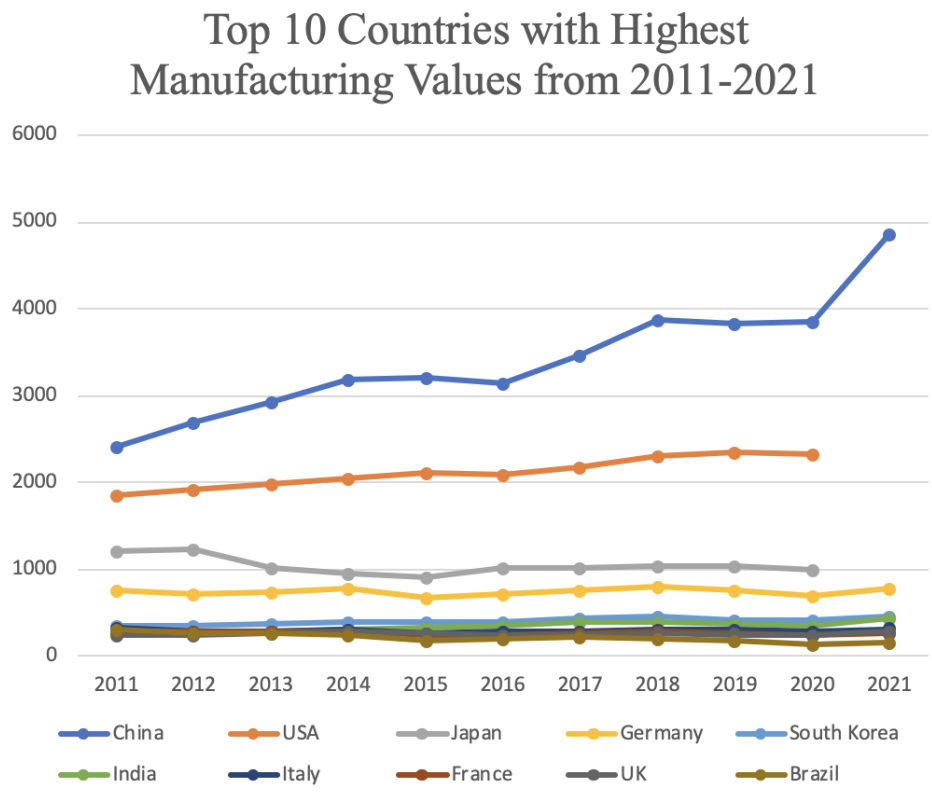
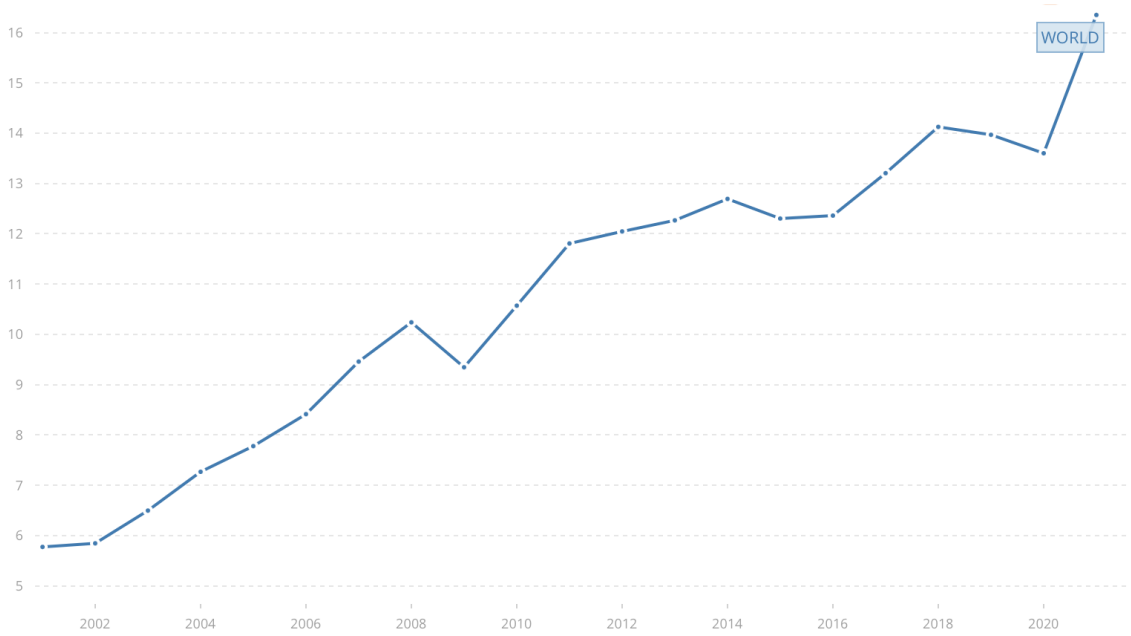
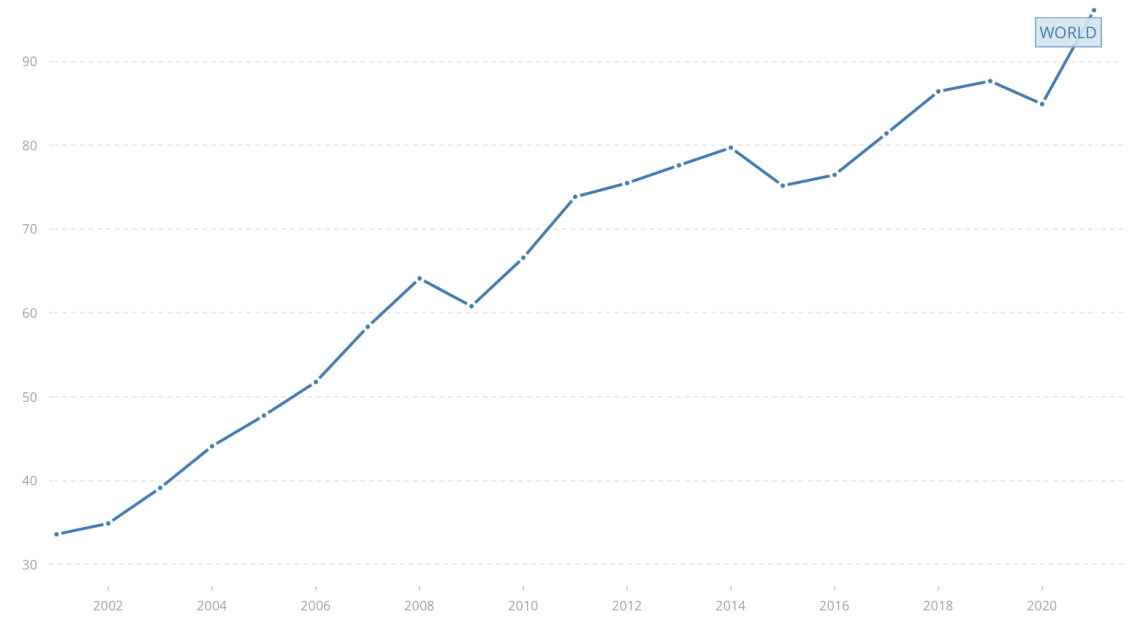


Figure 4.4: Top 10 Countries with Highest Manufacturing Values from 2011-2021

At the same time, by comparing the two figures (Figure 4.5), we can also confirm our view that the manufacturing industry can reflect the global economy mentioned above is correct. Because they have almost a same shape overall. It also proves that manufacturing is the foundation of the global economy.



(a) Global Manufacturing Values from 2001-2021



(b) Global GDP from 2001-2021

Figure 4.5: Comparison between Global Manufacturing Values and Global GDP

4.2 Manufacturing and Employment

There is no doubt that manufacturing provides a very large share of jobs in any country. From the chartof manufacturing employment in 2017 below 3.3, we can observer that the top 10 countries in terms of manufacturing output value can be seen that manufacturing provides more than 10% of the total population in almost every country, and in some cases as much as 20%.

Country	Total Number Employed in Manufacturing Sector	Percentage of Population Employed in Manufacturing
China	128,869,000	16.9%
USA	16,381,000	10.5%
Japan	10,958,000	16.9%
Germany	7,911,000	19.0%
South Korea	4,499,000	16.9%
India	57,244,000	11.4%
Italy	4,090,000	18.5%
France	3,396,000	12.4%
UK	3,069,000	9.5%
Brazil	10,388,000	11.4%

Figure 4.6: Total number employed and employment rate of United States in 2017

According to the statistics 4.7 from the U.S. Bureau of Labor [Fed22], we can observe that between March and April of 2020, the two months with the most severe COVID-19 outbreak in the United States, from the y-axis we can find that in March, more than 1.3 million people lost their jobs. The dramatic gap between the two months illustrates the impact of the pandemic on the manufacturing powerhouse.

However, after passing the trough in April 2020, the manufacturing industry recovered rapidly, perhaps because all countries realized the indispensability of basic industries, and all countries are actively resuming working on back to work and manufacturing.

Therefore, we can see the importance of manufacturing industry. As the most fundamental industry, it is not difficult to join manufacturing industry, so people can easily join manufacturing and obtain stable income. Although the income might

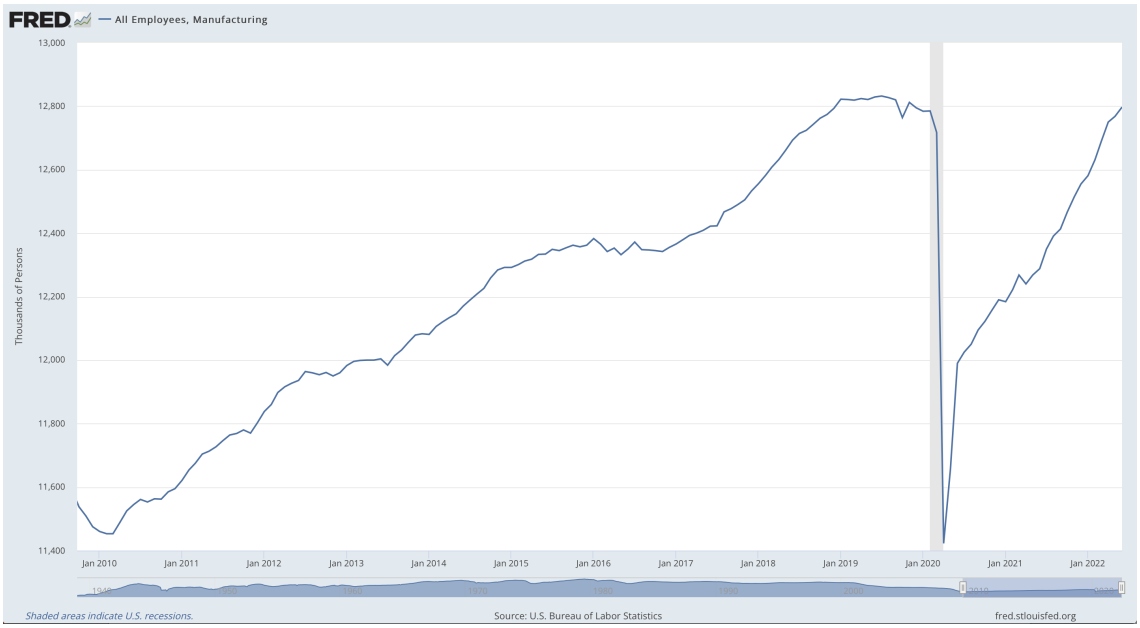


Figure 4.7: Manufacturing employment of United States in the past 10 years.

not be a large number of money, it ensures people's living quality on track. Also, it provides a chance for those who might not have had the chance to earn a degree to survive and start a family.

4.3 Education

So as we look more closely at the decline in manufacturing employment in recent years, part of that is because of the coronavirus pandemic. At the same time, from some articles [Tre] I have read, we can also find that some people left the manufacturing industry by themselves. The biggest reason for this is education. Because the threshold to enter the manufacturing industry is relatively low compared with other industries, people only need to master some very basic machine operation, manual production and other skills. Then they can have a spot in the manufacturing industry.

Manufacturing, for example, differs from other industries in that it requires different levels of education. The workers in charge of painting paint now only need to put the objects to be painted into the painting machine to ensure that the machine works properly and that the product is of good quality. But where did the painting machine come from? So we can imagine that the person who built and developed this painting machine needed a lot more expertise than a manufacturing worker.

Industry	Primary education (less than 6 grades)	Secondary education (6–12 grades)	Higher education (more than 12 grades)
Auto parts	3.0	69.5	27.5
Electrical appliances	3.1	68.9	28.0
Electronic components	2.5	66.4	31.1
Furniture and wood products	14.8	67.5	17.7
Food processing	21.8	56.1	22.1
Garments	16.1	69.8	14.1
Machinery and equipment	8.5	63.5	28.0
Rubber and plastics	11.1	69.6	19.2
Textiles	14.8	71.8	13.4
Average	12.0	67.6	20.4

Source: Calculated from PICS Data 2007.

Figure 4.8: Table 4-Education Level in Manufacturing

As can be seen from the chart, a large part of these manufacturing industries do not require particularly high education. For all the manufacturing industries listed in the chart, we can easily find that more than 60% of the people in all the manufacturing industries have reached secondary education. Then we look at the average, and we find that across all industries, the combined average of the number of people with primary and secondary education has reached a staggering 79.6%, almost 80%.

Looking further, we can still find from the average, the proportion of people with primary education is 12%, secondary education is 67.6%, and higher education is

20.4%. We can also infer that the requirement for higher education in manufacturing is not very high. It also proves that manufacturing is the very fundamental industry of the country, and even the world. Let's look at the level of education in manufacturing in a bigger picture around the world. We know from the data [Dep22] that in 2020, 90 percent of the world's population had completed primary education, whereas only 66 percent had attained a secondary education. The numbers were even lower in tertiary education, with around 40 percent of the global population having attained some kind of tertiary education. By contradiction, if higher qualifications are required for basic industries, more people with higher education will join manufacturing, and people with primary education will decrease. This goes against the idea that manufacturing is the world's number one industry. Also confirmed our point of view from the side.

Chapter 5

Results and Conclusions

5.1 Potential Drawbacks of Manufacturing at Home

In fact, I believe many people can feel the disadvantages of home for manufacturing industry during the COVID-19 outbreak in all walks of life. Overseas students are unable to travel to their countries for further study, and they have to study intensively with jet lag every day. Some offline stores are on the verge of closing down due to lack of customers (people getting quarentined at home). These are all disadvantages at the individual and society perspectives. At the national perspective, when the country has no way to come up with solutions when the people are in trouble, or when the people have different opinions with the country leaders, the country will gradually be divided and people are of different minds. The consequences are unpredictable and irreversible.

And that leads us to manufacturing, where workers can't get to work, so factories can't make money without people working, and factories can't pay their workers. The workers are not willing to go back to the factory until they are getting paid. Workers can't support their families if they don't earn money. Then workers and factories are trapped in a vicious cycle. But in the end, the impact is not only on the people, but also on the national economy.

So what are the downsides of manufacturing from home? The first thing we need

to know is the difference between manufacturing from home and manufacturing in a factory. The biggest difference is the working environment. The environment of home is generally the most comfortable environment for the individual. The working environment requires people to focus and be productive at the highest level. When people are at home, they will have a lazy mentality. But it's not the fault of the individual, it's the whole work environment that makes people feel comfortable. There's a saying, get out of your comfort zone. That's what people need to keep in mind at the home office.

Sometimes, working side by side with colleagues makes work more fun. One of the main factors contributing to employee engagement and satisfaction is maintaining friendships with colleagues. In fact, one study showed that loneliness can affect employee performance and that maintaining positive social communication relationships can alleviate loneliness in the workplace. Despite these drawbacks, the number of home-based companies has been steadily increasing in industries where it is possible to avoid them, especially the Internet, digital marketing, and education industries. Not only that, many freelancers these days such as illustrators, influencers, designers, writers, media stars and so on work from home. In a word, this is the trend of the new era.

5.2 Benefits of Manufacturing at Home

Although the COVID-19 pandemic has brought a lot of harm to the manufacturing, we will find that there are advantages from an optimistic perspective. Working from home makes it possible to eliminate or reduce commuting time and have more time and energy to devote to work. Working from home, when organized properly, can also reduce common office distractions, such as loud co-workers calling, ringing

phones, unexplained smells, and unnecessarily strict policies. Working from home makes workers less distracted by eliminating chores, and will be able to focus more on what they're doing and get things done quickly.

On the other hand, working from home can also save money, because you don't need to commute every day, so you will save a little bit on your travel and gas bills every day, which can add up to thousands of dollars over the years. It's not just the cost of travel. Eating out every day must cost more than cooking at home. People can also save a very considerable sum of money over time.

In terms of employment, working from home can lead to higher employee retention. People who work from home are more likely to stay with the company than leave, and companies can also give employees the right to work in the office, giving them more choice and freedom. In this way, working from home improves job and life satisfaction, reduces employee turnover, and saves employers the cost of hiring and training new employees when they don't leave the company as often. This can increase the employment rate, which can directly lead to the rapid development of the national economy and the people's livelihood is guaranteed.

5.3 Conclusion

After so many detailed arguments, we already know the advantages and disadvantages of working from home in manufacturing. No one's life is easy in today's society, which has been so severely affected by the COVID-19 pandemic. Even not to mention manufacturing as an industry, the transition to the home manufacturing must be beset with difficulties.

Taking all those factors into consideration, I think the shortcomings mentioned in the previous section 5.1 can be overcome by human efforts. There is no free lunch.

Only through people's own efforts, they can let themselves become valuable. For example, a solution for not having a working atmosphere could be creating a small space with as little noise as possible, reducing visual distractions. We could also do something to increase self-suggestions. For instance put some focus quotes on the wall within people's sight. The whole transformation process to home manufacturing can not be accomplished by just one person or one simgle company. It takes everyone's firm determination, the courage to change and innovate, also the most important, the willingness to give of themselves.

On the other hand, I think the advantages of home manufacturing are more than the disadvantages in general. The main reason is economic because people can save a lot of money and put it into use on other things. For example, people can use the money saved to go on a family trip every year. People can decorate their homes better to make them feel better and more relaxed, and also they can make their working rooms more hospitable to work.

From my perspective, I would recommend that people choose to do manufacturing from home. Because I think saving time is more important than saving money. We can use the time saved by not having to go to work to do other things, such as making a good breakfast to put us in a better mood and getting an extra hour of sleep to be more productive. When you run out of money, you can earn more, but when you run out of time, you lose it.

Chapter 6

Limitation

6.1 Missing Data

Throughout this article, all the data is from the Internet. We have some missing data in the data we selected3.2. In this figure, for example, we're missing data for 2021, but that doesn't really affect the results of our discussion. Because the report as a whole is more conclusive than statistical. We use the data just to get a sense of the trends in some of the details of manufacturing.

Appendices

Bibliography

[Aki20] Jesulona Akinyele. *Manufacturing Jobs from Home*. PhD thesis, Worcester Polytechnic Institute, 2020.

[Bana] The World Bank. Employment in industry.

[Banb] The World Bank. Manufacturing, value added (current us dollar).

[Ban22] The World Bank. Manufacturing value added by country around the world, Jul 2022.

[CH06] Yongsung Chang and Jay H. Hong. Do technological improvements in the manufacturing sector raise or lower employment? *American Economic Review*, 96(1):352–368, March 2006.

[Def] What is manufacturing value added? back to learning centernbsp;.

[Dep22] Statista Research Department. Topic: Education worldwide, Aug 2022.

[Fed22] St.Louis Fed. All employees, manufacturing, Jun 2022.

[Tre] Understanding trends in manufacturing employment.

[WL18] Darrell M. West and Christian Lansang. Global manufacturing scorecard: How the us compares to 18 other nations, Jul 2018.