

# ***Medical Industry Analysis Post-Pandemic from the Year 2020 to 2021***

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**Abstract:** This article collects data on the medical industry for 2020-2021 and explores various indicators that may affect the earnings of medical head companies. The categories of pharmaceutical companies are divided into Bioengineering, Medical Services, and Pharmaceuticals. According to the linear regression model, the R-squared and adjusted R-squared values are large and close to 1. It indicates that our data selection is relevant, and our independent variables can be used as predictors of the dependent variable. Differences in the percentage change in assets, the related industries of individual companies, and the number of employees can be strong predictors of changes in their revenue ratios.

**Keywords:** Medical Industry, Linear Regression, COVID-19

## **1. Introduction**

Medicine is the science of human beings fighting diseases and promoting health. Medical progress has played a significant role in safeguarding and improving human health. A rational view of medical progress and an objective assessment of the impact of medical technology development on human health may be of immense value to the development of medicine and the humanistic spirit guiding the direction of medicine. Health culture has a more special and essential status and role [1-6].

Medical companies are the actual carriers of modern medical science. Medical companies have an enormous impact on the volume of the economy, so when selecting the direction of research companies, the focus was on three types of medical companies. There is no substitute for the economic importance of medical enterprises in the chain of medical companies. In our project, we focus on three types of companies: bioengineering, medical service, and pharmaceutical, and we collect data on medical companies from 2020 to 2021. One important reason we selected the medical industry to explore was that we wanted to explore how medical companies grew due to the pandemic. The global pandemic is unprecedented post-industrialization. Our goal is to explore the relationship between the returns of medical companies and the factors that potentially affect the returns of companies. The factors that may affect the ultimate recovery of a company include revenue change percentage, assets change percentage, board member numbers, etc. Revenue growth percentage is a

critical factor because it directly reflects the change in the company's revenue. We brainstormed many variables to collect as our independent variables, and we want to see which variables serve as the best predictors of the revenue percentage change.

The data for this study is based on 47 companies in the healthcare industry. The sample period is focused on the fiscal year 2021. These samples represent the most influential companies in this sector. The model consists of companies distributed as follows. 30% are in the BIOE market, 38.3% in the healthcare services market, and 31.7% in the pharmaceuticals market (Table 1). The idea of analyzing the data collected was to build a model to see how each independent variable might affect our dependent variable, the percentage change in revenue.

## 2. Data Resource

### 2.1. Sample Construction

The data for this study is based on 47 companies in the healthcare industry. The sample period focuses on the fiscal year of 2021. The samples represent the most influential companies in this field that will follow the rank in 2022, such as “Pharm Exec” and others. The pieces composed by the firm were distributed as follows: 30% in the BIOE market, 38.3% in the medical service market, and 31.7% in the pharmaceutical market. (Table 1)

Our sample is collected from the macro trends database, which includes data from annual corporate reports and each company website.

Table 1: Companies components our samples distributed by market. [6-35]

market	number of firms in the sample	percentages
bioengineering	14	30%
medical service	18	38.30%
pharmaceutical	16	31.70%

### 2.2. Variables Measurement

Our study uses one financial attribute measure as revenue change percentages as the dependent variable. And we use eight variables as the independent variable, including the assets change ratio, industry, difference in the number of employees each year in percentage, board numbers, CEO age, CEO gender, and R&D expenditure (Table 2).

The asset change was measured using the net value of property, plant, and equipment between 2020 and 2021. Similarly, several employees' differences also use the same method to calculate.

In our sample, the board numbers, CEO age, and R&D expenditure are the absolute records from the year 2020 to 2021 as well.

In our sample of the industry and CEO gender, we use the duality variables. For the industry, we separate it into two different variables- medical service and pharmaceutical. We also use the duality variables. If the medical service is 1, it means this company belongs to the medical service; if the pharmaceutical is 1, it means this company belongs to the pharmaceutical market; if both these two are 0, it means it is a bioengineering company. And for the CEO gender, if the CEO is male, we give it 1, and 0 for female (Table 3 and 4).

One seemingly outlier data is Moderna. It has a significant increase of over 2000 percent. It is attributed to the development and widespread use of COVID-19 vaccines. Moderna is a substantial supplier of vaccines in Europe and the United States. Typically, such extreme data should be excluded.

Still, this company has a significant global impact and is an excellent example of the development of pharmaceutical companies during the pandemic, so we decided to keep the data.

Table 2: Descriptive statistics of the dependent variable total sample. [6-35]

Perform	Mean	Std.Dev	Min	Max
Revenue change percentage	72.54%	3.238496268	-27.63%	2200.25%

Table 3: Summaries the dependent and explanatory variables used in this study and their measurement. [6-35]

Variable	Label	Definition and computation
revenue change percentage	RC	Revenue change rate from 2020 to 2021
Assets change percentage	Asset	Net value of property, plant and equipment change between 2020 and 2021
Med Device	DUAL-M	Equal to 1 if company belongs to Med Device and 0 for otherwise
Pharmaceutical	DUAL-P	Equal to 1 if company belongs to pharmaceutical and 0 for otherwise
Difference of number of employees each year in percentage	NUEMPOLY	Number of employees change from 2020 to 2021
Board member numbers	BSIZE	Number of directors in 2021
CEO Age	CEO age	CEO age in 2021
CEO Sex	DUAL-CEO	Equal to 1 if CEO is male and 0 is female
R & D expenditure	R&D EX	Research and development expenditure in 2021

Table 4: Independent variable full sample.

Variable	Mean	Std.Dev	Min	Max
Asset	14.67%	40.78%	-8.04%	257.28%
DUAL-M	0.38	0.49	0.00	1.00
DUAL-P	0.32	0.47	0.00	1.00
NUEMPOLY	10.30%	22.93%	-17.78%	107.96%
BSIZE	12.13	3.32	6.00	26.00
CEO age	57.40	6.07	46.00	69.00
DUAL-CEO	0.94	0.25	0.00	1.00
R&D EX	4047061753	4286425837	297000	14799000000

### 2.3. Sources

We gathered this data mainly from the website called macro trends. We listed the website we used in the reference at the end.

### 3. Results and Explanation

After collecting and deciding upon our variables, we wanted to establish a model to see how each independent variable could potentially affect our dependent variable, the revenue change percentage. We suspected that among the independent variables that we chose, some useless variables might not be closely related to our dependent variables. Our final goal was to build a regression model with a sizeable R-adjusted value. By achieving that goal, we successfully built a model that analyzes how different factors in a medical company could potentially affect their revenue change percentage, in what way, and by how much.

Before running a regression analysis that accounts for all variables, we established a coefficient matrix overlooking different independent variables. (Table 5)

Table 5: Coefficient matrix for independent variables and dependent variable.

	Assets change percentage (from 2020 to 2021)	Med Device	Pharmaceutical	Difference of number of employees each year in percentage from 2020 to 2021	Board member numbers	CEO Age	CEO Sex	R & D expenditure (USD)	Revenue change Percentage (From 2020 to 2021)
Assets change percentage (from 2020 to 2021)	1								
Med Device	-0.192855542	1							
Pharmaceutical	0.107022219	-0.539396214	1						
Difference of number of employees each year in percentage from 2020 to 2021	0.590699768	-0.148204621	0.055305486	1					
Board member numbers	-0.112497034	0.115940436	0.126227544	-0.153249992	1				
CEO Age	-0.110938912	-0.373906876	0.07555756	-0.105264271	0.042701338	1			
CEO Sex	0.044718364	0.205717644	-0.007945522	0.039834626	0.089630751	0.03208692	1		
R & D expenditure (USD)	-0.124265412	-0.330004845	0.571049342	-0.144076707	0.274837812	0.095065075	0.062092581	1	
Revenue change Percentage (From 2020 to 2021)	0.878022388	-0.148832933	0.210082185	0.742988339	-0.104990316	-0.158776806	0.049415048	-0.084320497	1

From the coefficient matrix, we see that there is a strong correlation between Asset Change Percentage from 2020 to 2021 and Revenue Change Percentage from 2020 to 2021. Moreover, the difference in the number of employees each year in percentage from 2020 to 2021 also correlates strongly with the dependent variable.

We then built a frequency table to analyze the distribution of Revenue Change Percentage from 2020 to 2021, our independent variable, to give a brief overview of the post-pandemic medical companies. As we were expecting, most of the companies in our sample were growing dramatically, and the distribution according to their percentage revenue change follows below:

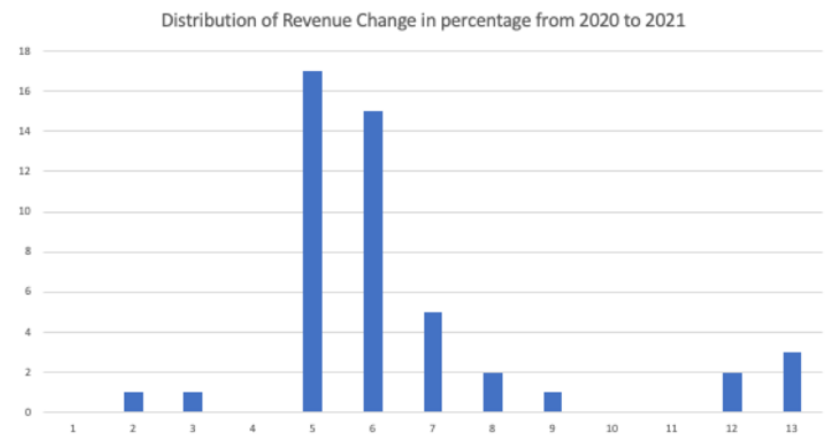


Figure. 1: Distribution of revenue change in percentage from 2020 to 2021.

Table 6: The frequency table of companies according to their percentage revenue change.

Bin	Frequency
-27.63%	1
-15.35%	1
-3.07%	0
9.21%	17
21.49%	15
33.77%	5
46.04%	2
58.32%	1
70.60%	0
82.88%	0
95.16%	2
More	3

Most medical companies have a positive percentage revenue change of more than 10 percent from 2020 to 2021 post-pandemic.

Then, we establish linear regression for each of our independent variables. We want to see from the graph how each of them relates to the dependent variable, either positively or negatively. Here are some examples of the plots:

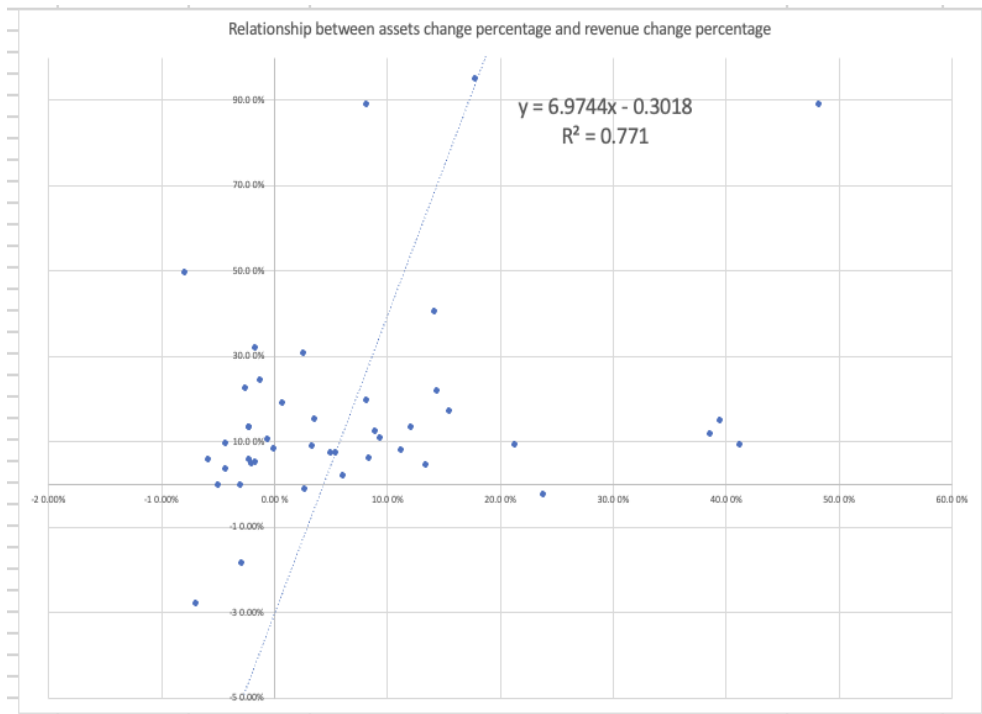


Figure 2: Relationship between assets change percentage and revenue change percentage.

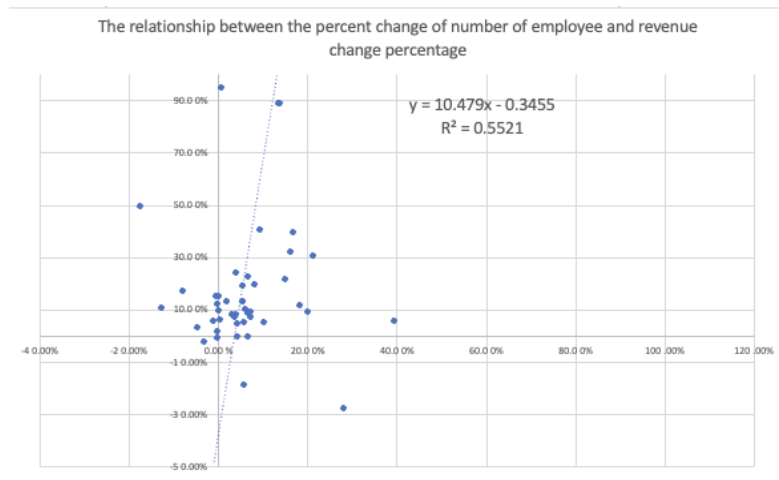


Figure 3: Relationship between the percent change of number of employee and revenue change percentage.

For example, we see that a higher asset change percentage will lead to a higher revenue change percentage, and hiring more employees will also indicate a higher revenue change percentage. Most of the plots lie with our prediction. However, we noticed when building the plots that there is an outlier, Moderna, which has over 22 times revenue growth from 2020 to 2021. We noticed it when doing our data collection. This outlier affects some plots dramatically, and we decided to pay close attention to it when building the multivariable regression plots. It has some dramatic power on our model establishment, and we finally decided to keep it.

As stated in our goal statements, we want to analyze how independent variables affect the dependent variable, the change in annual revenue, in the medical industry. We first built a regression model using all the variables above. Here is the stats summary generated:

Table 7: Summary of the outputs with all variables.

SUMMARY OUTPUT								
<i>Regression Statistics</i>								
Multiple R	0.9361 65324							
R Square	0.8764 05513							
Adjusted R Square	0.8510 52798							
Standard Error	1.2369 5285							
Observations	48							
<i>ANOVA</i>								
	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>			
Regression	8	423.133 0026	52.891 62532	34.568 5069	2.23516 E-15			
Residual	39	59.6720 4177	1.5300 52353					
Total	47	482.805 0444						
	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>	<i>Lower 95.0%</i>	<i>Upper 95.0%</i>
Intercept	- 0.7359 67695	2.14563 0364	- 0.3430 07681	0.7334 34758	- 5.07591 4749	3.6039 7936	- 5.0759 14749	3.6039 7936
Assets change percentage (from 2020 to 2021)	5.3585 53076	0.56519 9787	9.4808 12274	1.1328 1E-11	4.21532 8599	6.5017 77553	4.2153 28599	6.5017 77553
Med Device	0.9489 4306	0.53050 71	1.7887 47143	0.0814 25321	- 0.12410 8835	2.0219 94955	- 0.1241 08835	2.0219 94955
Pharmaceutical	1.3662 67094	0.48695 7276	2.8057 22724	0.0077 92139	0.38130 3034	2.3512 31154	0.3813 03034	2.3512 31154
Difference of number of employees each year in percentage from 2020 to 2021	4.9797 21614	0.99619 258	4.9987 53969	1.2573 5E-05	2.96473 1928	6.9947 11301	2.9647 31928	6.9947 11301
Board member numbers	- 0.0139 90003	0.05776 0365	- 0.2422 07667	0.8098 88438	- 0.13082 137	0.1028 41363	- 0.1308 2137	0.1028 41363
CEO Age	- 0.0035 40278	0.03433 3344	- 0.1031 14871	0.9184 00215	- 0.07298 6022	0.0659 05465	- 0.0729 86022	0.0659 05465
CEO Sex	- 0.2787 73965	0.77533 3179	- 0.3595 53767	0.7211 20505	- 1.84703 3347	1.2894 85416	- 1.8470 33347	1.2894 85416
R & D expenditure (USD)	- 6.6547 3E-13	2.49462 E-12	- 0.2667 63436	0.7910 5681	- 5.71131 E-12	4.3803 7E-12	- 5.7113 1E-12	4.3803 7E-12

The plots show that the regression model has a relatively large R square value and adjusted R Square value, very close to one. Thus, we concluded that this model is good. It indicates that our data selection is relevant, and our independent variables can predict our dependent variable. However, we can further improve our model by selecting the most relevant variables. We dismissed the variables with P-values more significant than 0.10 and built another model only with the variables with P-values smaller than 0.10. Namely, we only choose variables Assets to change percentage, Med Device, Pharmaceutical, and difference of the number of employees each year in rate from 2020 to 2021 to analyze. Here is the new model with fewer independent variables:

Table 8: Summary of the outputs with fewer variables.

SUMMARY OUTPUT								
<i>Regression Statistics</i>								
Multiple R	0.93570857							
R Square	0.87555052							
Adjusted R Square	0.86369819							
Standard Error	1.19562285							
Observations	47							
<i>ANOVA</i>								
	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>			
Regression	4	422.401883	105.600471	73.871589	1.9158E-18			
Residual	42	60.0395881	1.429514					
Total	46	482.441472						
	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>	<i>Lower 95.0%</i>	<i>Upper 95.0%</i>
Intercept	-1.3453361	0.33894604	-3.9691749	0.00027637	-2.0293569	-0.6613153	-2.0293569	-0.6613153
Assets change percentage (from 2020 to 2021)	5.35869951	0.54065824	9.91143587	1.4623E-12	4.267607	6.44979202	4.267607	6.449792
Med Device	0.90708429	0.43242968	2.09764579	0.04199372	0.03440587	1.7797627	0.03440587	1.7797627
Pharmaceutical	1.32318796	0.44464636	2.97582093	0.00483049	0.42585527	2.22052065	0.42585527	2.2205207
Difference of number of employees each year in percentage from 2020 to 2021	5.00233698	0.9544853	5.24087379	4.8543E-06	3.07610766	6.9285663	3.07610766	6.9285663



We notice that this model has a higher adjusted-R value, indicating that it is a better model with a more accurate prediction. From this model, we can build the following equation:

$$\text{revenue pchange} = -1.35\% + 5.36\% * \text{asset change} + 0.91 * \text{med device} + \\ 1.32 * \text{Pharmaceutical} + 5.00 * \text{Difference of number of employees}$$

We see that asset change percentage and the difference in the number of employees are positively related to revenue percentage change. Also, if the company is in the med device and pharmaceutical industry, it will likely be earning more money than biotech companies.

#### 4. Conclusion and outlook

Did the results match our original vision? Yes, according to the linear regression model, both the R-squared value of the model and the adjusted R-squared value are relatively large and very close to 1. The validity of the model is verified. It shows that our data selection is indeed relevant and that our independent variable can act as a predictor of the dependent variable. More specifically, in the period from 2020 to 2021, the asset change percentage, the related industry of the individual company, and the difference in the number of employees can be strong predictors predict its revenue percentage change.

At this stage, we only studied the correlation between each independent variable and corporate revenue. Still, we did not study how environmental factors shaped these dependent variables and then affected the revenue in the context of COVID-19, especially the extreme performance of some enterprises in this environment. Each company must have adjusted the independent variables due to the pandemic, but we can do a closer analysis to see how the pandemic has affected each medical company's decision on its independent variables or how the independent variables changed from the year 2019 to 2020, the year before the pandemic, to the year 2020 to 2021, the year post pandemic.

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Sunyu Wang, Runze Shao, Zichen Zhang contributed equally to this work and should be considered co-first authors.

#### References

- [1] Lavassani K M, Movahedi B, Iyengar R J. Multi-layer, multi-tier analysis of global supply chain in medical equipment sector: network science application[J]. *Transnational Corporations Review*, 2022, 14.
- [2] Baghbanian A, Safdari R, Erfannia L, et al. The Medical Tourism Industry in Iran: A Review of Websites Designed for Cross-border Patients[J]. *Health Scope*, 2021:108482.
- [3] Yadav R, Murria S, Sharma A. A research review on semantic interoperability issues in electronic health record systems in medical healthcare[M]. 2021.
- [4] Bogdanova M P. Problems And Prospects Of Digital Transformation Of Medical Industry Enterprises[J]. *Business Strategies*, 2021.
- [5] Yang H S. A study on Medical Device Security Status in Medical Convergence Industry[C]// 2021 21st ACIS International Winter Conference on Software Engineering, Artificial Intelligence, Networking and Parallel/Distributed Computing (SNPD-Winter). 2021.
- [6] Committee composition. 3M. (n.d.). Retrieved December 22, 2022, from <https://investors.3m.com/governance/committee-composition/default.aspx>
- [7] Alkermes revenue 2010-2022: Alks. *Macrotrends*. (n.d.). Retrieved December 22, 2022, from <https://www.macrotrends.net/stocks/charts/ALKS/alkermes/revenue>
- [8] Amgen Gross Profit 2010-2022: AMGN. *Macrotrends*. (n.d.). Retrieved December 22, 2022, from <https://www.macrotrends.net/stocks/charts/AMGN/amgen/gross-profit>

- [9] Biogen revenue 2010-2022: BIIB. *Macrotrends*. (n.d.). Retrieved December 22, 2022, from <https://www.macrotrends.net/stocks/charts/BIIB/biogen/revenue>
- [10] BioMarin Pharmaceutical Gross Profit 2010-2022: BMRN. *Macrotrends*. (n.d.). Retrieved December 22, 2022, from <https://www.macrotrends.net/stocks/charts/BMRN/biomarin-pharmaceutical/gross-profit>
- [11] Edwards Lifesciences revenue 2010-2022: EW. *Macrotrends*. (n.d.). Retrieved December 22, 2022, from <https://www.macrotrends.net/stocks/charts/EW/edwards-lifesciences/revenue>
- [12] Gilead Sciences Revenue 2010-2022: GILD. *Macrotrends*. (n.d.). Retrieved December 22, 2022, from <https://www.macrotrends.net/stocks/charts/GILD/gilead-sciences/revenue>
- [13] Illumina revenue 2010-2022: ILMN. *Macrotrends*. (n.d.). Retrieved December 22, 2022, from <https://www.macrotrends.net/stocks/charts/ILMN/illumina/Revenue>
- [14] Incyte revenue 2010-2022: Incy. *Macrotrends*. (n.d.). Retrieved December 22, 2022, from <https://www.macrotrends.net/stocks/charts/INCY/incyte/revenue>
- [15] Merck gross profit 2010-2022: MRK. *Macrotrends*. (n.d.). Retrieved December 22, 2022, from <https://www.macrotrends.net/stocks/charts/MRK/merck/gross-profit>
- [16] Mirati Therapeutics Revenue 2010-2022: MRTX. *Macrotrends*. (n.d.). Retrieved December 22, 2022, from <https://www.macrotrends.net/stocks/charts/MRTX/mirati-therapeutics/revenue>
- [17] Moderna Revenue 2017-2022: Mrna. *Macrotrends*. (n.d.). Retrieved December 22, 2022, from <https://www.macrotrends.net/stocks/charts/MRNA/moderna/revenue>
- [18] Regeneron Pharmaceuticals revenue 2010-2022: REGN. *Macrotrends*. (n.d.). Retrieved December 22, 2022, from <https://www.macrotrends.net/stocks/charts/REGN/regeneron-pharmaceuticals/revenue>
- [19] Seagen gross profit 2010-2022: SGEN. *Macrotrends*. (n.d.). Retrieved December 22, 2022, from <https://www.macrotrends.net/stocks/charts/SGEN/seagen/gross-profit>
- [20] Vertex Pharmaceuticals Gross Profit 2010-2022: VRTX. *Macrotrends*. (n.d.). Retrieved December 22, 2022, from <https://www.macrotrends.net/stocks/charts/VRTX/vertex-pharmaceuticals/gross-profit>
- [21] Agilent Technologies Gross Profit 2010-2022: A. *Macrotrends*. (n.d.). Retrieved December 22, 2022, from <https://www.macrotrends.net/stocks/charts/A/agilent-technologies/gross-profit>
- [22] Our leaders. AbbVie. (n.d.). Retrieved December 22, 2022, from <https://www.abbvie.com/our-company/leadership.html>
- [23] GE Board of Directors. General Electric. (n.d.). Retrieved December 22, 2022, from <https://www.ge.com/investor-relations/governance>
- [24] Baxter International: Bax - Assets. *TRADING ECONOMICS*. (n.d.). Retrieved December 22, 2022, from <https://tradingeconomics.com/bax:us:assets>
- [25] Roche Holding: Retrieved December 22, 2022 from <https://www.roche.com/investors/reports/>
- [26] BRISTOL-MYERS SQUIBB: Retrieved December 22, 2022 from <https://www.roche.com/investors/reports/>
- [27] Sanofi: Retrieved December 22, 2022 from <https://www.sanofi.com/en/investors/financial-results-and-events/financial-results/Q4-results-2021>
- [28] AstraZeneca: Retrieved December 22, 2022 from <https://www.astrazeneca.com/investor-relations/>
- [29] GSK: Retrieved December 22, 2022 from <https://www.gsk.com/en-gb/investors/financial-reports/>
- [30] Lilly Eli: Retrieved December 22, 2022 from <https://www.lilly.com/policies-reports/year-in-review>
- [31] Amgen: Retrieved December 22, 2022 from <https://investors.amgen.com/financials/annual-reports>
- [32] Moderna: Retrieved December 22, 2022 from <https://investors.modernatx.com/financials/annual-reports/default.aspx>
- [33] Bayer AG-REG: Retrieved December 22, 2022 from <https://www.bayer.com/en/investors/integrated-annual-reports>
- [34] Viatrix: Retrieved December 22, 2022 from <https://investor.viatrix.com/financial-and-filings/sec-filings>
- [35] Regeneron: Retrieved December 22, 2022 from <https://investor.regeneron.com/>