Fixed Costs Impact on Automobile Industry before and after COVID

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Abstract

English version

The Covid pandemic has created a lot of opportunities to study companies' financial status. This paper studies the fixed costs impact in companies of the automotive industry and their augmented effects during the pandemic. For this analysis, we first looked at the sample variable's correlation with revenue by year and then by regions. Three multiple linear regressions were created to have three different perspectives on the company's cost structure, liquidity and profitability. The results show the automotive industry and car's demand is highly correlated with general business cycle and that fixed costs affected the company's ability to be profitable and have liquidity.

Versão portuguesa

A pandemia criada pelo Covid gerou inúmeras oportunidades para estudar a situação financeira das empresas. Este trabalho estuda o impacto dos custos fixos nas empresas do setor automóvel e os seus efeitos que se fizeram notar durante a pandemia. Para esta análise, primeiro olhámos para correlação das variáveis da amostra com as vendas por ano e de seguida por regiões. Foram criadas três regressões lineares múltiplas a fim de obter três perspetivas diferentes sobre a estrutura de custos, liquidez e lucros das empresas. Os resultados mostram que a indústria automóvel e a procura de carros estão altamente correlacionadas com os ciclos económicos globais e que os custos fixos afetam a capacidade das empresas de serem lucrativas e ter liquidez.

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To Professor Ricardo Reis, who shared equal enthusiasm for the development of this dissertation and guided me on the right path,

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1. Introduction

For companies that do not have a healthy financial structure, fixed costs represent a risk factor since these costs will not go away as long as the company is operating. Understanding their impact and how they affect companies' viability is therefore especially important. They can be a strategic advantage in some industries like the automotive, as companies that are trying to enter the industry need to weight the potential profits against these costs to verify if the outcome of success is higher than the possibility of not recovering the investment. While market leaders can more easily spread these costs. Hence knowing and predicting business cycles and macroeconomic shocks is crucial for companies.

Over the years, the automotive industry has grown to be essential in the global economy specially for the countries that have high dependence of this industry like the United States. New regulations and changes in consumer preferences are changing the way automotive manufacturers develop their products and business models. Traditional revenue channels are no longer the future, and the industry is aware of that. Car manufacturers will need to take advantage of these new business models if they want to ensure their future. Companies in the industry are also facing continuous pressure to be more efficient and decrease their cost structure. Some of the approaches to face these challenges can go from merger and acquisitions or strategic partnerships.

Apart from the health crisis, Covid imposed an economic crisis and recession on the global economy. The social distancing and travel restrictions caused a reduction in the companies and its workforce efficiency. This was felt across all regions and economic sectors. In industries such as the automotive, 'working from home' was not a viable option and many people lost their jobs. The Covid related shutdowns also made a huge pressure on the supply side.

Even though some governments had an immediate response to the economic crisis caused by Covid, some conditions that were already representing a financial risk for households and the public sector were aggravated. According to the world health organization, Europe and Americas where the regions most affected by Covid however, it there is a certain uncertainty on the real magnitude of how affected Asia was affected by Covid, specifically China. The global economy is now recovering but the Covid effects are still present with high inflationary pressures driven by a decrease in consumer demand.

Having this said, Covid presented a good opportunity to have case studies on companies' financial viability and specifically their cost structure. This work will analyse the fixed costs

impact in the automotive industry before and during Covid. We selected a number of companies within the industry with revenue higher than $1,000M for our sample. The variables were then chosen to have four different perspectives: on sales (revenues); liquidity (cash); profit (net income); and on the general cost structure (COGS, SG&A, salaries and number of employees). First, we will look at the variable's correlation with revenue by year and by region. And finally, we will create three multiple linear regressions to verify how Covid impacted companies' financial viability before and during Covid and also how the companies cost structure relate to revenue. This will also give us an idea of how the governmental measures affected our sample.

2. Literature Review

(Maskin and Tirole 1988) defined fixed costs as cost that will continue as long as the company is operating but independent of it. (Spence 1976) had a more detailed definition, he associated fixed costs with costs from production and marketing incurred before production and sales but also not dependent of it.

In the same line of thinking, (Baumol and Willig 1981) also characterized fixed costs as *"those that are not reduced, even in the long run, by decreases in output as long as production is not discontinued"*. They can only be eliminated if the company stops producing that specific product or goes bankrupt. The authors point out that fixed costs are fixed in the long run as well as in the short. Therefore, large scale investment and equipment investments do not qualify as fixed. These usually become variable in the long run and are considered sunk costs. For example, if the price of petroleum rises to a point where only a handful of cars were used, auto assembly lines would disappear since its scale is no longer needed. Cars would be assembled manually at a higher cost and the equipment cost would be reduced drastically. For this reason, the assembly lines costs might be sunk but are not fixed (Baumol and Willig 1981).

(Baumol and Willig 1981) also described entry barriers as *"anything that requires an expenditure by new entrant into an industry, but that imposes an equivalent cost upon an incumbent."* In their article, they consider that a natural monopoly is formed if a single company can prevent entry by others with its price and quantities combination. The sustainability of prices can be guaranteed by the fixed costs if they have a certain magnitude suggesting that they can be an entry barrier. However, that is not the case. Entry barriers need to not be fixed as they vary according to the outputs of the entering companies and can be affected by deliberate acts of the market leaders. Fixed costs affect both the market entrants and leaders in an analogous way. They are only an advantage to the market leaders to the extent that since they have higher production, they can spread costs more widely than the entrants can. On the other hand, sunk costs can represent an entry barrier. Entry companies need to weight the potential profits against these costs to verify if the outcome of success is higher than the possibility of not recovering the investment.

(Baumol and Willig 1981) analysis demonstrate that fixed costs can lead to the creation of a monopoly. (Spence 1976) also considers that *"they contribute to imperfectly competitive market structures and therefore non-competitive pricing."* Fixed costs can avoid equilibrium from existing or being hard to reach in a monopolistic competition.

(Spence 1976) explained that under monopolistic competition there are several facts that might influence the supply and variety of products available in the market. The issue is that if there are new companies in a monopolistic competition, the entry of new products will squeeze profits for the existing companies which might lead to excessive or limited supply. For socially desirable products the revenues might not cover the costs, given its cost structure. Therefore, its production even on equilibrium is at a loss and hence its offer is more limited. The environment of monopolistic pricing competition is expected to create too many products given the high price elasticity. Hence, "*high fixed costs tend to reduce product variety, and high cross elasticities tend to augment it, relative to the optimum"* (Spence 1976).

In the short term competition is driven through prices and in the long term by economies of scale and technology developments that will ultimately choose the products that are more profitable to supply in the market (Maskin and Tirole 1988). In fact, when companies are selecting their output, they are choosing the optimum scale for that level of operation.

Usually, companies wait before they make adjustments in their capital to avoid paying fixed costs too frequently (House 2014). This author analysis shows that *"optimal investment behaviour is characterized by an extremely high intertemporal elasticity of substitution for investment purchases."* Companies are perfectly willing to time their investments according to the price volatility, since the costs of changing it are so low. If the price goes up, they will delay their investment and if it goes down they will accelerate it. However, in reality, this will only happen if the price volatility is significant. Meaning that companies will not change the timing of their investments if the price change is insignificant. The author refers that *"the extremely high intertemporal elasticity of investment demand is a feature that fixed-costs model shares with neoclassical investment models and is why the two models, thought very different at the micro-level are so similar at the aggregate level."*

(House 2014) refers that not all companies have the same amount of cash available for investment at a certain time *"in equilibrium, through a kind of intertemporal arbitrage, firms eliminate predictable price changes and price remains to steady state even though the distribution of capital is not."* However, in the event of some unexpected events like the pandemic, companies might need to reallocate their capital. This idiosyncratic demand or supply consequences represent a key factor on companies' investment timing. Understanding business cycles and macroeconomic shocks is crucial for companies' investment.

The fixed capital requirements or costs need to be considered in the real situations (Basso and Peccati 2001). When looking at new investments and how to finance them, companies usually pursue several proposals of how to finance their projects. They usually take into consideration the amount of cash that they are willing to pay, the amount of financing that these proposals offer and budget limitations (if any). According to the authors, project financing needs to establish the optimal proportions of their financial conditions to be financed internally. When looking at external financing companies cannot request them to finance 100% of their projects. They need to have some "skin in the game" to convince investors that the project will be profitable.

3. Covid'19 Pandemic

The World Health Organisation (WHO) declared the outbreak of Covid-19 as a Public Health Emergency of International Concern on 30 January 2020 and on 11 March 2020 it was then declared as a pandemic (Organization n.d.). This occurred after the first cases were found in China in December 2019 with the virus spreading globally after that. According to this source, "*as of 18 November 2022, there have been 633,601,048 confirmed cases of COVID-19, including 6,596,542 deaths, reported to WHO. As of 16 November 2022, a total of 12,943,741,540 vaccine doses have been administered"* globally.

Apart from the health crisis, Covid imposed an economic crisis and recession on the global economy. The social distancing and travel restrictions caused a reduction in the companies and its workforce efficiency. This was felt across all regions and economic sectors. In industries such as the automotive, 'working from home' was not a viable option and many people lost their jobs. On other industries most people were now working from home and with schools closed, the demand for commodities and manufactured products decreased (Nicola, et al. 2020). On the other side, the demand for medical supplies increased substantially.

Governments had an immediate response to this economic crisis and were actually effective on stabilizing output and safeguarding incomes (Bank 2022). However, some conditions that were already representing a financial risk for households and the public sector were aggravated.

On a positive note, according to (Jackson 2021), *"the economic downturn in 2020 was not as negative as initially estimated, due in part to the fiscal and monetary policies governments adopted in 2020"*.

The Covid related shutdowns also made a huge pressure on the supply side. The shortage of workforce, during this time, highly affected the labour markets. Ultimately, this caused bottlenecks in supply chain that are still causing an increase in prices globally (Jackson 2021).

The long-lasting duration of the pandemic has caused a health crisis that is still impacting the global economy (Jackson 2021). Even though the global economy is recovering, the Covid effects are still present with high inflationary pressures driven by a decrease in consumer demand. People are now afraid of spending their money and are increasing their personal savings, given the current economic uncertainty.

An analysis performed by McKinsey (Condon, et al. 2022) in September 2022, concludes that inflation is considered one of the biggest potential risks for economic growth across all regions, with the exception of Greater China where Covid'19 still represents the biggest concern (see figure 1). It is worth mention that in Europe the biggest concern is geopolitical instability driven by the war in Ukraine.

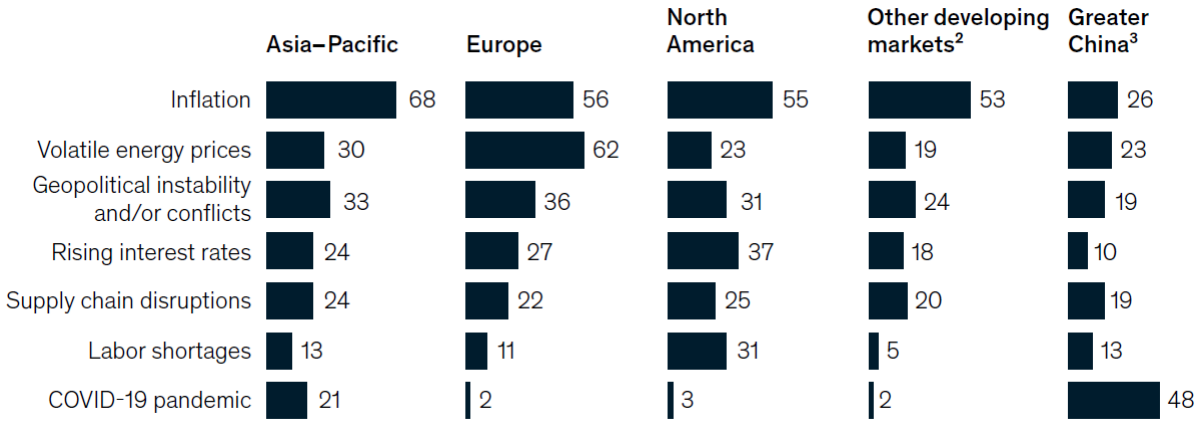

Figure 1. Potential risks to economic growth in respondents' countries, next 12 months, % of respondents, by office location[1]

[1] Sourced from McKinsey (Condon, et al. 2022)

4. Automotive Industry

4.1 Historical Industry Development

Ever since the Model T ford was launched that the automotive industry is leading changes across industries, not only on manufacturing and technology innovation but also on business models.

For the first half of the XX century, the industry was led by the United States given the advancements in the assembly lines that allowed the manufacturers to have mass productions. Companies were combining and standardizing processes with outside vendors and then, assembling together the components and parts manufactured and bought from them under credit lines. This allowed manufacturers to build cars with low initial investment (Rae and Binder 2022). The cars were then sold for cash to local dealers that would be in charge of marketing and selling the vehicles to end consumers. This represented a method of not only manufacturing but also of financing operations. However, this mass productions made it challenging for smaller competitors to endure. Mass producers were able to sell cars with profit at a lower price point given all the cost production efficiencies and small competitors could not simply keep up. At this point, Europe was trying to move on the same direction as the United States, but they had less purchasing power and lower living standards which made these advancements to be slower. To be noted that the automotive industry in the United States had a huge contribution in the II World War with its skills and productive capacity being directed to build military equipment.

After the II World War, the industry was mostly characterized by mergers and acquisitions that originated large scale organizations (known as OEMs in the industry) that had a significant impact on the market but could not fully control it. In early eighties, the United States automotive industry was already concentrated in four large companies: GM, Ford, Chrysler and AMC (Rae and Binder 2022). Mass production was also linked to high investment requirements in equipment and tooling which was only possible and available for these large companies. At this stage, the increasing competition from the European and Japanese markets were penetrating the American market and reducing market share from the domestic manufactures. Companies were more focussed in refining and improving their processes rather than innovating. Japanese companies invented the “just-in-time” inventory method where instead of having large volumes of inventory in the warehouse they were shipping noncritical components from their central locations to small facilities (mostly owned by third parties, called Tier 1 in the industry) to be assembled. Then, these large modules would be sent back to the central location to be assembled

in the vehicle in the exact sequence and time needed. Styling was also becoming a key selling and marketing point for the industry with the usage of chrome and extravagant design lines.

By the XXI century, there was an intensify concern about climate change, especially air pollution, which resulted in several policies and regulations to limit diesel cars and push for electric cars. Cars cannot run forever and therefore, there is an increase concern about the disposal of its scrap metal and parts. With CARS 21 (Competitive Automotive Regulatory System for the 21st century), European legislation started to mandate that manufacturers should take back their end-of-life vehicles leading companies to start engineering ways to incorporate and recycle parts into their new cars (European 2006).

Socially these developments in the industry lead to an approximation between rural and urban life (Rae and Binder 2022). Roads were improved and highways created allowing people to easily move from one place to another at their convenience and with better conditions. As mentioned initially, the industry also stimulated the use of credit which until then had very limited usage.

In today's world, the manufacturing process is far more sophisticated and elaborated. *"The first requisite of this process is an accurately controlled flow of materials into the assembly plants. No company can afford either the money or the space to stockpile the parts and components needed for any extended period of production. Interruption or confusion in the flow of materials quickly stops productions"* (Rae and Binder 2022). This usually leads to large fines to vendors if caused by them.

Over the years, the automotive industry has grown to be essential in the global economy specially for the countries that have high dependence of this industry like the United States. According to (Rae and Binder 2022), *"One of every six American businesses is dependent on the manufacture, distribution, servicing, or use of motor vehicles; sales and receipts of automotive firms represent more than one-fifth of the country's wholesale business and more than one-fourth of its retail trade. For other countries these proportions are somewhat smaller, but Japan, South Korea, and the countries of western Europe have been rapidly approaching the level in the United States."*

4.2 Current trends and market outlook

New regulations and changes in consumer preferences are changing the way automotive manufacturers develop their products and business models. However, in an industry that is changing so fast, companies are facing a lot of challenges driven not only by the economic crisis that the pandemic caused but also by the shortage of chip semiconductors and raw materials used in batteries. According to McKinsey (Hensley, et al. 2022), *"the demand for EVs will grow sixfold from 2021 through 2030, with annual unit sales going from 6.5 million to roughly 40 million over that period."*

There are several constrains that are challenging the industry and its capability of responding to the high electric vehicle (EV) demand. The low productivity and insufficient number of gigafactories are one of the key issues. The current number of gigafactories is not sufficient to face all the demand for batteries and building one with the current market conditions will require a large investment. On top of that, batteries manufacturers are having operational issues with many facilities facing not only labour shortages but also short supply in machinery (given its worldwide high demand). Many OEMs could be facing production shutdown periods due to this shortage of batteries supply. Some of the approaches to face this challenge can go from merger and acquisitions or strategic partnerships (Hensley, et al. 2022).Another challenge is the lack of sufficient charging solutions for end consumers. For EV's market to grow to its expected level, countries will need to make and support investments in charging infrastructures.

Digitization and technology developments are also playing a key role in the development of the automotive industry. In a world with constant technology disruption, the industry has no other option than following the same trend. Car manufacturers are now focusing on vehicle connectivity ecosystems and aftermarket services that can turn to be very profitable business models (Hensley, et al. 2022).According to McKinsey (Gao, et al. 2016), *"driven by shared mobility, connectivity services, and feature upgrades, new business models could expand automotive revenue pools by ~30 percent, adding up to ~USD 1.5 trillion"* in 2030.

Technology advancements such as autonomous driving will allow its users to take advantage of their transit times and use it for their own interests which can ultimately lead to developments in media and services (e.g. possibility to work while commuting or to use social media). Shared mobility will also change the way people use cars with an expected decrease in demand for private cars (Gao, et al. 2016). With these advancements in shared mobility, as per

image below (figure 2), consumer preferences are also expected to shift. However, this is likely to occur mainly in large cities with rural areas still preferring to use private cars.

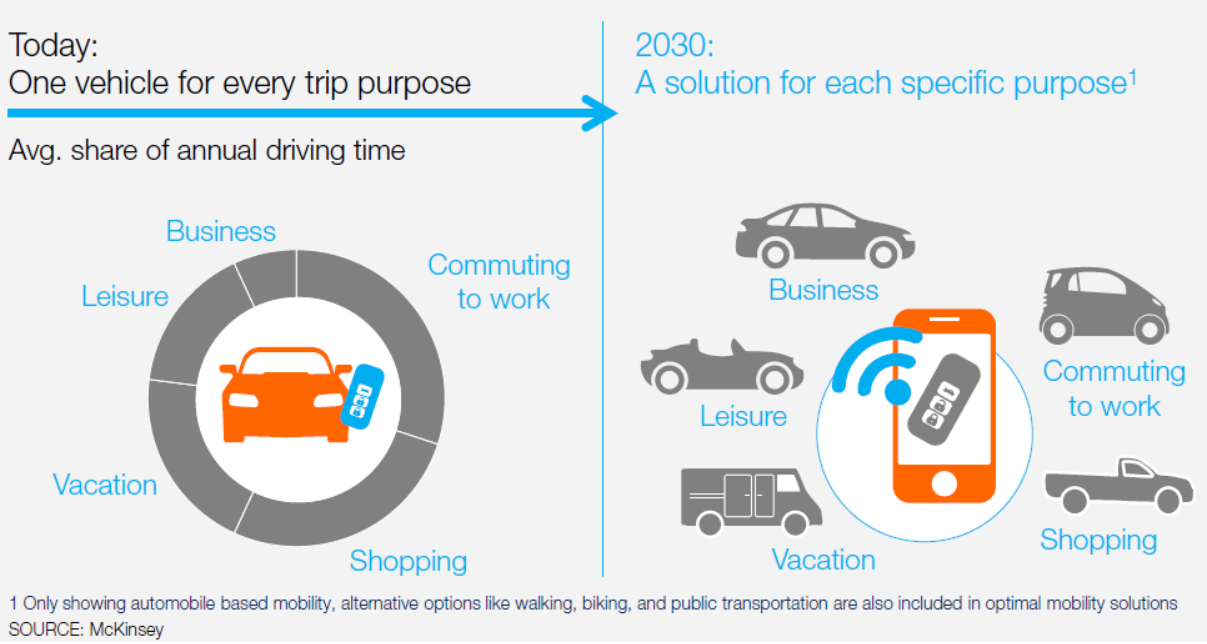

Figure 2. "Today consumers user their vehicles for all purposes; In the future, they will choose am optimal mobility solution for each specific purpose"[2]

Looking at the industry competition, *"over the last 15 years, only 2 new players appeared on the list of the top 15 automotive OEM's"* (Gao, et al. 2016). Companies are facing continuous pressure to be more efficient and decrease their cost structure. Ultimately, this will lead to consolidation via mergers and acquisitions which is a known characteristic of the industry as mentioned before. Market leaders need to prepare for the future, especially given the current war in Ukraine and economic uncertainty, by taking these strategic decisions. *"KMPG believes that many automakers and suppliers will not only divest non-strategic assets and raise cash to invest in new technologies, but also partake in unprecedented M&A activity in the next three years"* (Mazar 2021).

Traditional revenue channels are no longer the future and the industry is aware of that. Car manufacturers will need to take advantage of these new business models if they want to ensure their future.

[2] Information sourced from McKinsey (Gao, et al. 2016)

5. Sample Selection and Methodology

5.1 Sample Selection and Variables Description

The sample for this analysis consists in a group of 39 companies[3] selected by doing a screen on S&P Automobile Industry for Public and Operating companies with a Revenue higher than $1,000M. Representing 61% of the Global Industry Revenue in 2021. Figure 3 shows how the revenue of companies in the industry changed over the last three years.

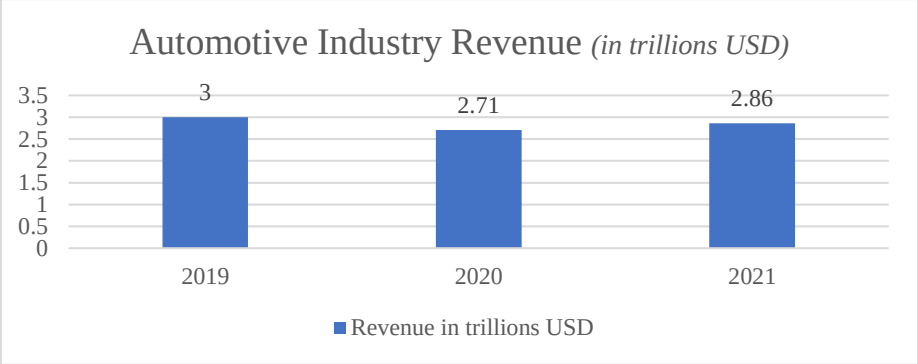

Figure 3. Yearly Revenue of Automotive industry[4]

The information represents a 7-year period from 2015 to 2021, 5 years of non-Covid years (2015-2019) and 2 years of Covid impact (2020-2021). Even though Covid started in 2019 its effects in the global economy where only felt in 2020. For comparation purposes, a dummy variable was created *"Covid dummy"* being 0 on the non-Covid years and 1 for Covid years. As per figure 4 below, we can verify that Europe and Americas where the regions most affected by Covid, accordingly to the world health organization. However, it should be noted that there is a certain uncertainty on the real magnitude of how affected Asia was affected by Covid, specifically China.

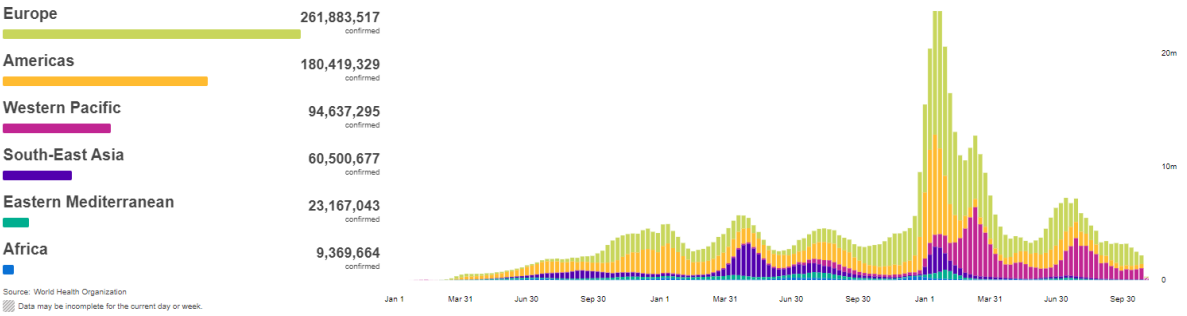

Figure 4. Number of confirmed Covid cases by region[5]

[3] A few companies were removed from the sample since they were only created during the sample period and therefore, had information missing.
[4] Information sourced from © Statista 2022
[5] Information sourced from World Health Organization as of 9th of November 2022

Companies in sample are originated from 14 different countries spread globally (see Appendix 8.1 for detailed list). For simplicity, countries were grouped in 3 main regions as follows: Americas (United States); Asia Pacific (Cayman Islands, China, India, Japan, South Korea and Taiwan); EMEA (Egypt, France, Germany, Netherlands, Pakistan, Turkey, United Kingdom). With this grouping, 62% of the sample is concentrated in Asia Pacific region (see figure 5 for count of companies by region). Two dummy variables were created. The *"EMEA dummy"* that will take value 1 if the company is in the EMEA region and 0 if not. And, lastly, the *"Americas dummy"* that will be 1 if the company is in the Americas region and 0 if not. By default, if both dummies are zero the model assumes that the observation is for a company in the Asia Pacific region.

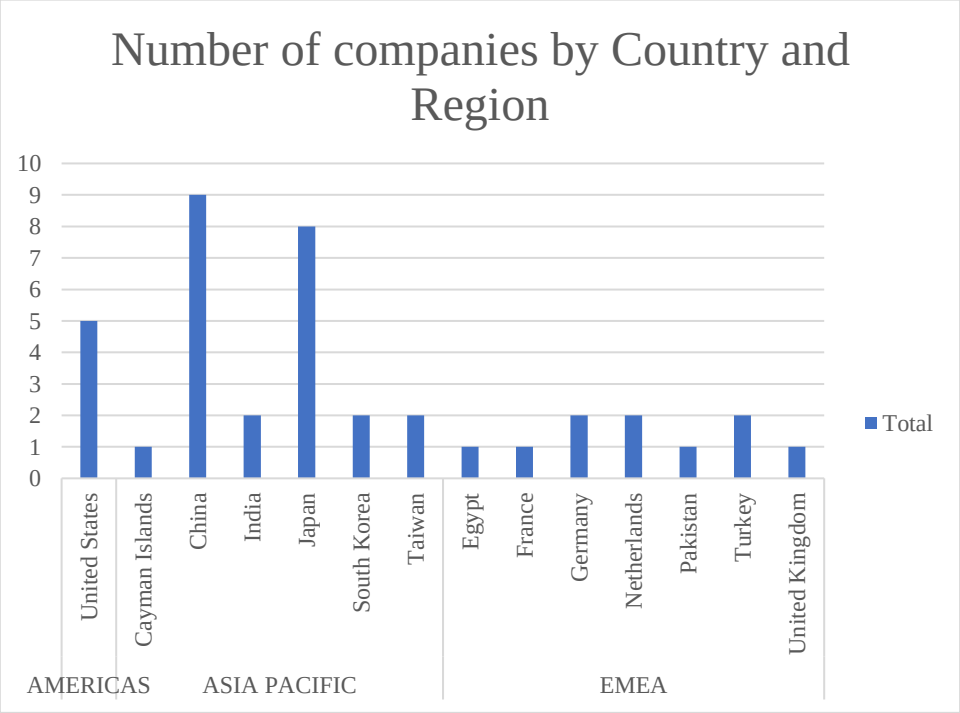

Figure 5. Distribution of sample companies by region and country

All financial data either from balance sheet, income statement and annual report data is presented in millions and in USD for comparability purposes. Information was retrieved and translated as of 17 of September of 2022 by Refinitiv Eikon Datastream which can be under or overestimating the numbers displayed given the volatility of the foreign exchanges. To be noted that on that day, USD and EUR were trading close to par.

It might occur that data is not available for all variables during the sample period for some companies which is due to the different accounting methods and standards or local

regulations, particularly in the Asia Pacific region where they report less information on their annual reports.

Variable	Obs	Mean	Std. dev.	Min	Max
Revenues	273	$ 44,259,881	$ 61,476,976	$ 1,329	$ 285,496,301
COGS	273	$ 32,791,729	$ 45,665,607	$ 422	$ 218,600,570
SG&A	273	$ 5,826,911	$ 7,562,134	$ 1,022	$ 30,445,661
Salaries	202	$ 2,321,951	$ 4,221,278	$ 592	$ 29,925,144
Net Income	273	$ 1,998,381	$ 4,249,733	$ -9,472,322	$ 22,557,391
Cash	273	$ 6,193,977	$ 8,872,617	$ 4	$ 58,382,123
Employees	242	80,040	93,109	18	370,870

Table 1. Summary of variables descriptive statistic (values in millions)

These variables were selected to have four different perspectives: on sales (revenues); liquidity (cash); profit (net income); and on the general cost structure (COGS, SG&A, salaries and number of employees).

Looking at revenues as a measure for the average sales price times number of units sold during the normal business operations, we have 273 observations with an average of $44mm throughout the sample period (see table 2). We can verify that during the Covid years the mean revenue was relatively stable comparing with the non-Covid years. However, its maximum in Covid years was higher, indicating that some companies where able to outperform their results prior to Covid.

Period	Obs	Mean	Std. Dev.	Min	Max
Non Covid Years	195	$ 44,142,392	$ 62,059,065	$ 1,329	$ 279,828,214
Covid Years	78	$ 44,553,601	$ 60,392,104	$ 517,675	$ 285,496,301
Total	**273**	**$ 44,259,881**	**$ 61,476,976**	**$ 1,329**	**$ 285,496,301**

Table 2. Revenue descriptive statistic (values in millions)

COGS (Costs of Goods Sold) which are also known as cost of sales include all direct costs related to the production of goods. Similarly to revenues, our sample has 273 observations and an average of $32mm (see table 3). Throughout Covid years, similarly to revenues COGS remained stable.

Period	Obs	Mean	Std. Dev.	Min	Max
Non Covid Years	195	$ 32,711,874	$ 46,190,703	$ 422	$ 212,835,090
Covid Years	78	$ 32,991,367	$ 44,618,948	$ 447,139	$ 218,600,570
Total	**273**	**$ 32,791,729**	**$ 45,665,607**	**$ 422**	**$ 218,600,570**

Table 3. COGS descriptive statistic (values in millions)

SG&A (Selling, General and Administrative Expenses) which we will be using as a proxy to the companies fixed costs, are expenses that are incurred and necessary for the business operations, they can be divide into three types: selling expenses (e.g. salaries, marketing, advertising expenses and travel expenses); general expenses (e.g. rent, utilities, office equipment and supplies); administrative (e.g. legal counsel and consulting fees). In this case, we have 273 observations and on average SG&A remained stable before and after Covid (see table 4). Nevertheless, its maximum increased suggesting that some companies were overspending during Covid years.

Period	Obs	Mean	Std. Dev.	Min	Max
Non Covid Years	195	$ 5,820,207	$ 7,606,943	$ 1,022	$ 28,787,646
Covid Years	78	$ 5,843,671	$ 7,497,709	$ 17,628	$ 30,445,661
Total	**273**	**$ 5,826,911**	**$ 7,562,134**	**$ 1,022**	**$ 30,445,661**

Table 4. SG&A descriptive statistic (values in millions)

Number of employees represent all the workers that receive a payment to perform tasks in the company in exchange for a specific compensation. This information is usually reported in the company's annual report. Our sample has 242 observations, as mentioned before, since some companies do not disclose this information (see table 5). We can verify that, as expected, on average the number of employees during Covid years decreased mostly due to all the shutdowns in manufacturing that ultimately led to layoffs. Given this significant impact, a new variable *"employees impact"* was created by multiplying the *"Covid dummy"* by the employee's variable.

Period	Obs	Mean	Std. Dev.	Min	Max
Non Covid Years	174	80,170	93,306	18	370,870
Covid Years	68	79,707	93,295	2,207	366,283
Total	**242**	**80,040**	**93,109**	**18**	**370,870**

Table 5. Number of employees descriptive statistic (values in millions)

Salaries which as mentioned above are usually reported by companies within SG&A, refer to the compensation that employees receive from their employers for their work. We have 202 observations since some companies do not usually report this separately from SG&A (see table 6). It is interesting to verify that, even though on average employees decreased during Covid years, both average and maximum salaries increased in those years. To analyse this, we

created a new variable *"salaries impact"* by multiplying the *"Covid dummy"* by the salary's variable.

Period	Obs	Mean	Std. Dev.	Min	Max
Non Covid Years	140	$ 2,129,191	$ 3,710,636	$ 592	$ 15,134,778
Covid Years	62	$ 2,757,215	$ 5,202,211	$ 17,225	$ 29,925,144
Total	**202**	**$ 2,321,951**	**$ 4,221,278**	**$ 592**	**$ 29,925,144**

Table 6. Salaries descriptive statistic (values in millions)

Net Income also known as "bottom line" is the total amount of income left earned in a specific period after deducting all expenses and taxes. For this variable, we have 273 observations (see table 7). We can note that it decreased on average throughout Covid years and that its minimum more than doubled showing that some companies in the sample were very affected by Covid. Thus, we made a new variable *"net income impact"* by multiplying the *"Covid dummy"* by the net income variable.

Period	Obs	Mean	Std. Dev.	Min	Max
Non Covid Years	195	$ 2,065,887	$ 3,851,175	$ -4,026,149	$ 22,557,391
Covid Years	78	$ 1,829,616	$ 5,137,019	$ -9,472,322	$ 20,476,617
Total	**273**	**$ 1,998,381**	**$ 4,249,733**	**$ -9,472,322**	**$ 22,557,391**

Table 7. Net Income descriptive statistic (values in millions)

Cash which is the only balance sheet item in the variable selection represents the company's most liquid assets. Our sample has 273 observations and is noticeable that the amount of cash that companies hold increased considerably (see table 8). To investigate more this variable impact, we created a new variable *"cash impact"* by multiplying the *"Covid dummy"* by the cash variable.

Period	Obs	Mean	Std. Dev.	Min	Max
Non Covid Years	195	$ 5,207,010	$ 7,090,424	$ 4	$ 33,094,475
Covid Years	78	$ 8,661,395	$ 11,949,430	$ 6	$ 58,382,123
Total	**273**	**$ 6,193,977**	**$ 8,872,617**	**$ 4**	**$ 58,382,123**

Table 8. Cash descriptive statistic (values in millions)

5.2 Methodology

Given the high correlation between all these variables, as a first step it was analysed how they correlate to revenues across the sample period to identify variations from non-Covid years to Covid years. The same process was performed across each region of the sample to identify any efficiency gains or specific actions to deal with Covid that other regions did not take.

"Regression analysis is a statistical technique for investigating and modelling the relationship between variables" (Montgomery, Peck and Vining 2021), we used this technique to verify the impact of Covid years and of fixed costs across the companies in the sample. Since we have more than one independent variable, we formulated a few multiple linear regressions as follows:

$$y = \beta_0 + \beta_1 x_1 + \cdots + \beta_n x_n + \varepsilon$$

$y = dependent\ variable$
$x_i = independent\ variables$
$\beta_i = coefficient$
$\varepsilon = error$

The first regression was built to see the effects on revenue of salaries and employees overall and also during Covid years. In this regression we also added SG&A and COGS to verify its relationship to revenue and ultimately, give us an overall look at the sample cost structure.

$$y = \beta_0 + \beta_1 SalariesImpact + \beta_2 Salaries + \beta_3 EmployeesImpact + \beta_4 Employees + \beta_5 SGA + \beta_6 COGS + \varepsilon$$

Then, since we wanted also a look at the profitability impacts and its association with revenues. We developed a regression to see revenue's relationship with net income and its impact during Covid, by region.

$$y = \beta_0 + \beta_1 NetIncomeImpact + \beta_2 NetIncome + \beta_3 EMEAdummy + \beta_4 Americasdummy + \varepsilon$$

Lastly and as mentioned before, we also wanted a liquidity measure to see how it affects revenues. We created a regression that calculates revenue's association with cash and its impact during Covid, by region also.

$$y = \beta_0 + \beta_1 CashImpact + \beta_2 Cash + \beta_3 EMEAdummy + \beta_4 Americasdummy + \varepsilon$$

6. Results Analysis

6.1 Variables Correlation with Revenue

Looking at the results of the variables' correlations with revenue across the sample period (table 10), the first thing that we notice is the really high correlation of COGS (close to1) represented by the yellow line on figure 6. This is a true indicator of how dependent of revenue they are, which is actually part of its definition We can conclude, that the variation of COGS follows very closely the variation of the revenues and hence this variable does not hardly contain any fixed costs in it.

Correlation with Revenue							
Variables/ Year	2015	2016	2017	2018	2019	2020	2021
Salaries	0.8745	0.8626	0.8754	0.8691	0.8954	0.9358	0.7807
Employees	0.7847	0.8109	0.7892	0.7403	0.7642	0.7916	0.8621
SG&A	0.9586	0.9571	0.9585	0.9607	0.9191	0.9215	0.9421
COGS	0.9966	0.9967	0.9961	0.9960	0.9961	0.9959	0.9980
Net Income	0.9333	0.8397	0.9012	0.9302	0.7510	0.1161	0.9121
Cash	0.7685	0.8605	0.8816	0.9013	0.9221	0.8657	0.9203

Table 9. Variables Correlation with Revenue across sample period

The level of correlation of SG&A (grey line on figure 6) is also very high. This indicates variability on these costs, which may be expected from the selling costs (sales commissions and other noticeably variable costs), even some of the administrative costs may be linked to bonuses and other rewards that are variable in nature, but one could expect a significant amount of fixed costs on the residual categories of SG&A. Even though it slightly decreased during Covid years, in 2021 we can see that its trend is already inversing again. This high degree of correlation represents a risk factor since revenues decreased throughout those years, it indicates that SG&A increased slightly showing the possible presence of fixed costs from those residual categories. This was probably due to the fact that companies had to spend more money in their offices to accommodate all local Covid rules and regulations to be able to continue their operations without shutting down. The correlation evolution during the Covid years, hints at a plausible explanation that the fixed SG&A costs are usually residual, except during those extraordinary crisis years, when they became prominent in relative (as the other variable costs disappeared) or even in absolute terms (as Covid implied additional costs).

Regarding Salaries (dark blue line on figure 6) it is interesting to verify that its correlation was fairly stable up to the Covid years, probably due to a stable inflation rate and a steady mix of fixed and variable salaries. It slightly increased in 2020 indicating that there are still variable portions inside the salaries but then in 2021 it had a huge spike down. It became

less correlated with revenue, which leads us to conclude that the variable component became less relevant. As mentioned before, however, on average, salaries went up during the Covid years. This situation could have been driven by governmental aids that injected cash in the companies, keeping the salaries levels despite the drop in revenues, or for the fact that companies had to compensate employees for their health risk and extra work driven by the overall smaller workforce, similar to the increase in administrative and general costs we identified above.

Employees correlation with revenue (orange line on figure 6), on the other hand, has been up and down over the years but with a relatively downwards trends until 2018. This is consistent with companies becoming more efficient over the years and needing the same or even less employees to increase the revenues. However, in 2019 this trend inversed, and employees became more correlated. During the three years, revenues decreased, and the labour force must have somehow accompanied the drop since the correlation changes to an increasing pattern. In other words, during the pandemic, the downward trend in revenues was followed closer by a decrease in the labour force, than the previous three years long upward trend in sales had been accompanied by an increase in the number of employees.

Throughout the years and up to 2018, net income correlation (blue line on figure 6) has also been up and down within the same very high interval (roughly between 85% and 95% correlation with revenues). This is a sign of homogenous profitability in the industry, confirming high levels of competition across the World. However, 2019 represented a turning point for sure, which is expected given that the pandemic did not affect the industry simultaneously, striking first in China and only in 2020 in other regions. Net income was no longer as correlated with revenue as before and in 2020 the correlation went off chart to a low 11%. A possible explanation for this abrupt behaviour in the correlation series lies in the fact that some of the companies started having negative net income in 2020, introducing a statistical disruption in the correlation with the positive revenues. The presence of negative income and the disruption of this correlation series really demonstrates the presence of fixed incompressible costs that were then having an enormous impact on the company's bottom line.

Contrastingly, cash correlation (green line on figure 6) trend was going up until 2019 showing that up until then most of the liquidity of the companies was being generated by its core operations and revenues. But from 2019 to 2020, this trend inversed indicating that the increase in cash levels (as mentioned on prior section) was driven by outside factors. During

Covid years, companies had to go to the market to get more liquidity to finance their operations and on top of that governments were injecting cash in companies to face Covid. This trend is now reversing to its normal levels.

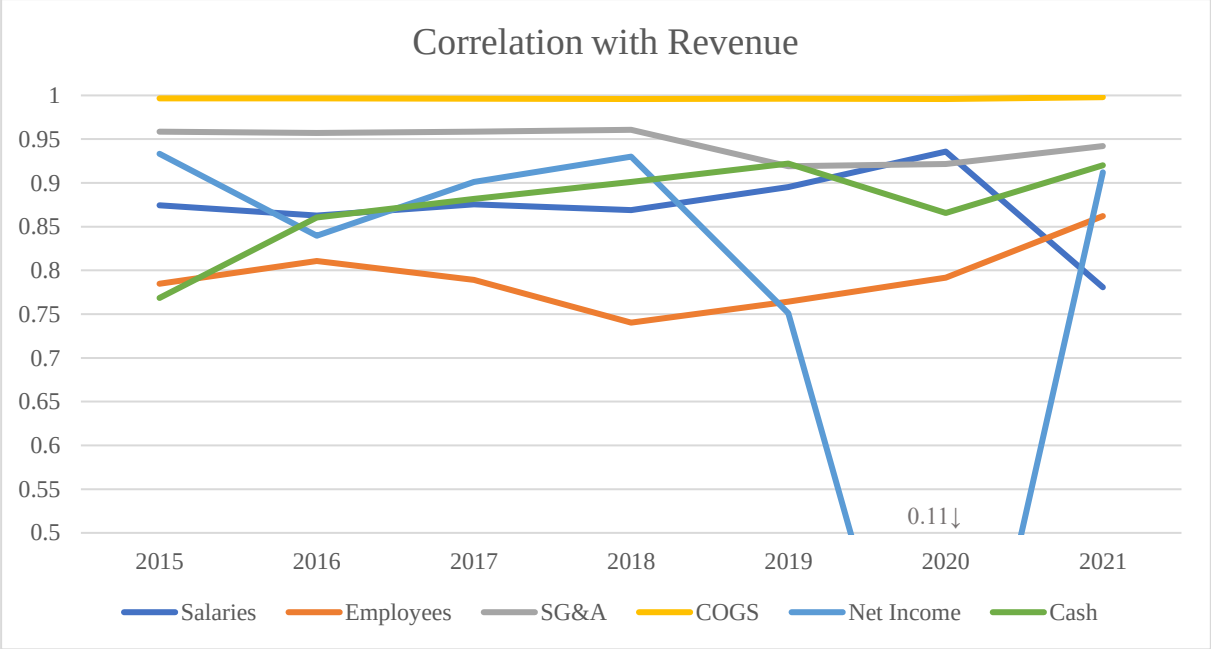

Figure 6. Variables Correlation with Revenue across sample period

Now looking at the variable's correlation to revenue by region (see table 10), we can verify that overall, COGS and net income had a similar correlation across these regions. Nevertheless, SG&A did not follow the same similarity. In Americas, the SG&A correlation is much higher than in the other two regions showing that American companies have a low level of fixed costs in comparison.

Correlation with Revenue			
Variables/ Year	AMERICAS	ASIA PACIFIC	EMEA
Salaries	N/A	0.8866	0.8457
Employees	0.9920	0.7694	0.8889
SG&A	0.9879	0.9377	0.9539
COGS	0.9989	0.9965	0.9966
Net Income	0.7230	0.7484	0.7668
Cash	0.8828	0.9089	0.8016

Table 10. Variables Correlation with Revenue across regions

We did not have sufficient information in Americas region to make conclusions on company's salaries correlation with revenue. But, looking at Asia Pacific and EMEA we can also verify that the two regions share similarities with parallel correlation levels.

The number of employees (orange line on figure 7), on the other side, is the variable that had the most distinct correlation between all region with Asia Pacific having the least

correlation levels. This is mostly driven by the fact that Asian company's productivity and efficiency. In fact, this region was where continuous improvement managerial processes and learnings (e.g. Lean Six Sigma) were created and tested before it spread globally and over industries.

Lastly, cash correlation across industries was also quite different on the three regions (green line on figure 7). In Americas it had a high correlation with revenue indicating that most of the cash in American companies drives from their operations. Contrastingly, in EMEA the correlation is much lower showing that the governmental aids and financial markets financing had higher impact in this region.

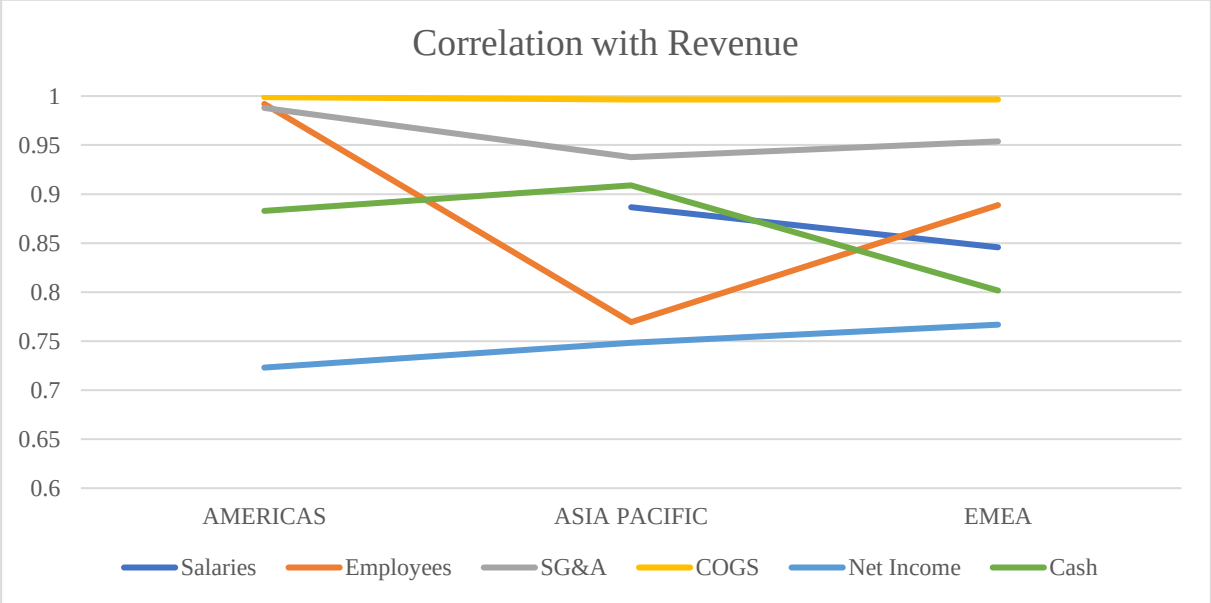

Figure 7. Variables Correlation with Revenue across regions

6.2 Multiple linear regressions

Our first regression, created to analyse the effects on revenue of the companies cost structure (specially salaries and employees) during Covid years, has a R-squared of 99.8% which indicates that our variables explain the variations on revenue by this percentage (see results in table 12). It is worth mentioning that this high result is due to the fact that some of the variables, specifically COGS and SG&A are highly correlated with revenue, as verified in the prior chapter and as per their coefficient results thar are remarkably close to 1. Looking at the p-value results, all variables are significant for a 10% level of confidence.

$$Revenue = -432{,}150 - 0.4056\,(Salaries\ Impact) + 0.4677\,(Salaries) + 20.7277\,(Employees\ Impact) - 13.0911\,(Employees) + 1.0791\,(SGA) + 1.1537\,(COGS)$$

As per the results below (see table 12), in general *salaries* usually have a positive effect on *revenues* with a coefficient of 0.4677. However, it is interesting to see that during Covid *salaries impact* has a negative relation with *revenues* with a coefficient of -0.4056 meaning that, as revenues were decreasing during Covid, salaries were increasing which is something that was noted on the correlation results and variables statistic description also.

For the *employee's* coefficient, we have the same conclusion, they have a negative relation with revenues with a coefficient of -13.0911, showing the efficiency gains over the years before Covid. On the other hand, looking at *employees' impact* it shows a that this variable has a positive relation with *revenues* (coefficient of 20.72) since during Covid it was important for companies to have a sufficient workforce to face all restrictions and absences related to health issues. During that period, the company's revenue will increase approximately by 21 units by having an additional employee which is actually very material.

Source	SS	df	MS	Number of obs.	=	179
				F(6, 172)	=	14331.59
Model	3.2675e+17	6	5.4458e+16	Prob > F	=	0.0000
Residual	6.5357e+14	172	3.7999e+12	R-squared	=	0.9980
				Adj. R-squared	=	0.9979
Total	3.2740e+17	178	1.8393e+15	Root MSE	=	1.9e+06

Revenues	Coefficient	Std. err.	t	P>t	[95% conf.	interval]
Salaries Impact	-0.4056	0.1027	-3.95	0.000	-0.6084	-0.2028
Salaries	0.4677	0.0883	5.30	0.000	0.2934	0.6420
Employees Impact	20.7277	5.5105	3.76	0.000	9.8507	31.6046
Employees	-13.0911	4.3071	-3.04	0.003	-21.5927	-4.5894
SG&A	1.0791	0.0639	16.89	0.000	0.9530	1.2051
COGS	1.1537	0.0134	86.42	0.000	1.1273	1.1800
_cons	-432,150	206,544	-2.09	0.038	-839,838	-24,463

Table 11. Regression results on salaries and employee's impact

For our second regression, that analyses the Covid impact on the company's profitability, we obtained a R-squared of 72% which is lower than the prior regression but still a good measure (see results in table 13). In this case, looking at the p-value results, the variable *EMEA dummy* is not significant for a level of confidence of 10% indicating that any conclusions that we take from this regression are not valid for the EMEA region. All the other variables are significant for this level of confidence.

$$Revenue = 1.61e^7 - 4.2836\,(Net\ Income\ Impact) + 13.6948(Net\ Income) + 4{,}149{,}635(EMEA\ dummy) + 1.53e^7\,(Americas\ dummy)$$

Overall and as expected, net income has a positive coefficient of 13.6948 revenues will increase by this amount if net income increases by one unit. Basically, as revenues go up or down net income will follow the same trend. However, this was not the case for the Covid years as showed by the *net income impact* coefficient of -4.2836 that is negative.

Then, looking at the *Americas dummy,* we can also take some nice conclusions. The coefficient of 1.53e+07 indicates that revenues will increase by this amount if the company headquarters is in the Americas region. Since by default, our model assumes that companies are from Asia Pacific, we should look at the model constant to analyse it. Revenues will increase by 1.61e+07 if companies' headquarters is in that region.

Source	SS	df	MS	Number of obs.	=	273
				F(4, 268)	=	176.04
Model	7.4461e+17	4	1.8615e+17	Prob > F	=	0.0000
Residual	2.8339e+17	268	1.0574e+15	R-squared	=	0.7243
				Adj. R-squared	=	0.7202
Total	1.0280e+18	272	1.8393e+15	Root MSE	=	3.3e+07

Revenues	Coefficient	Std. err.	t	P>t	[95% conf.	interval]
Net Income impact	-4.2836	0.8711	-4.92	0.000	-5.9987	-2.5685
Net Income	13.6948	0.5854	23.40	0.000	12.5423	14.8473
I. EMEA dummy	4,149,635	4,639,663	0.89	0.372	-4,985,190	1.33e+07
I. Americas dummy	1.53e+07	6,073,322	2.52	0.012	3,349,514	2.73e+07
_cons	1.61e+07	2,645,543	6.09	0.000	1.09e+07	2.13e+07

Table 12. Regression results on net income impact

At last, our third regression that explains the Covid impact on the company's liquidity, has a R-squared of 85% indicating that the variations on revenue are explained by these variables by this percentage (see results in table 14). In this case, looking at the p-value results, the variable *Americas dummy* is not significant for a level of confidence of 10% indicating that any conclusions that we take from this regression are not valid for the Americas region. All the other variables are significant for this level of confidence.

$$Revenue = 4{,}300{,}310 - 3.4419\ (Cash\ Impact) + 8.1240(Cash) - 5{,}694{,}422(EMEA\ dummy) - 2{,}985{,}109\ (Americas\ dummy)$$

Looking at *cash* coefficient of 8.1240, we can conclude that cash usually has a positive relation with revenues but that is not the case for Covid years. During those years, *cash impact* had a negative coefficient of -3.4419 showing that while revenues were decreasing the companies cash reserves where increasing, most likely due to all the measures that they took to

refinance their operations and provide liquidity to face their cost structures or the governmental aids.

For this regression, its also worth mentioning the results for the regions coefficients. *EMEA dummy* has a negative coefficient of -5,694,422 while the model constant (proxy for Asia Pacific region) is 4,300,310. Suggesting that companies in Asia Pacific have a much higher impact of around +132% on *revenues* in comparing with EMEA companies.

Source	SS	df	MS	Number of obs.	=	273
				F(6, 172)	=	381.19
Model	8.7433e+17	4	2.1858e+17	Prob > F	=	0.0000
Residual	1.5367e+17	268	5.7341e+14	R-squared	=	0.8505
				Adj. R-squared	=	0.8483
Total	1.0280e+18	272	3.7794e+15	Root MSE	=	2.4e+07

Revenues	Coefficient	Std. err.	t	P>t	[95% conf.	interval]
Cash Impact	-3.4419	0.2734	-12.59	0.000	-3.9803	-2.9036
Cash	8.1240	0.2333	34.82	0.000	7.6646	8.5834
I. EMEA dummy	-5,694,422	3,440,827	-1.65	0.099	-1.25e+07	1,080,068
I. Americas dummy	-2,985,109	4,516,514	-0.66	0.509	-1.19e+07	5,907,252
_cons	4,300,310	2,039,811	2.11	0.036	284,218	8,316,402

Table 13. Regression results on cash impact

7. Conclusion

Even thought, there is lot of analysis on how to analyse companies' financials. It is still unclear how companies identify and report fixed costs. For this reason, the research available for this matter is limited. There are articles on this matter but, most of them are from the XX century. I used some of them used on my literature review as I believe that the definitions and conclusions made by the authors are still applicable.

Historically, the automotive industry has been known to be one of the industries that is most affected by the macroeconomic shocks either for the good or for the bad. Covid represented one of the biggest economic shocks in the century. And we conclude that this was the case looking at our results.

Even though some companies outperform their pre-Covid revenue levels, most of them were not able to grow during the pandemic. Their cost structure imposed a risk factor, specially for companies that were overspending until then. On average COGS and SGA remained relatively stable however, this indicates that SGA has a variable portion in it.

When a negative macroeconomic shock occurs, one of the first things that companies do is laying off their workforce. Sometimes this is the easiest way to cut off costs, but it highly affects the company results, as we saw on our results. During Covid the number of employees in our sample decreased considerably which, then affected the company's ability to generate revenue, as verified in the regression results. With Covid, companies became more reliant and dependent from their employees and their productivity. Companies needed to have a sufficient workforce to face all restrictions and absences related to health issues.

On the other side, it was interesting to see that overall, during the pandemic, salaries increased which was shown by its correlation with revenue and the regression results. Companies had to compensate employees for their health risk and extra work driven by the overall smaller workforce but this was, most likely, not the only reason.

Ultimately, all these factors had a significant impact on the company's bottom line. On average it decreased throughout Covid years and its minimum more than doubled. In 2020, we noted that net income was no longer as correlated with revenue as per its historical trend. This fact really demonstrates the presence of fixed costs, all else equal, that were then having an enormous impact on the company's bottom line.

Financing strategies and governmental aids boosted the amount of cash that companies hold increased considerably. And the decrease on its correlation with revenues in 2020 showed that. The results of our third regression also show the same conclusion.

Covid affected the different parts of the world in different ways. Some countries and regions were more affected than others. This was also shown by the different levels of the variables correlation with revenue across the industries. Number of employees was the variable that had the most distinct results across the three regions. In Asia, this variable is much lower than in the other regions. Asia has been known for its efficiency gains and these results proves just that.

The governmental aids that impacted cash substantially, as mentioned before, were also different across regions. In this case, EMEA was the region with the least correlation with revenues showing that these measures were more impactful in the region most likely due to the way the European Union addressed Covid. However, looking at the constant and dummy variables of the regression that analyses cash impact we saw that companies in Asia s have a much higher amount of cash on their balances.

In conclusion, car's demand is highly correlated with general business cycle, due to several reasons. One of them being its linkage with global economy and another its large representation on household's expenditure. In a post pandemic world with high inflation rates and the threat of a recession in the horizon, consumer behaviour and spending habits are changing drastically. Tech companies such as Meta, Amazon and Twitter that actually grew during the Covid pandemic are now starting to lay off its workforce. The automotive industry is most likely going to follow. Unless the companies in the industry have a robust plan for the future, we might see a lot of companies in the industry having financial issues in a near future given their heavy cost structure.

8. Appendix

8.1 Detailed list of companies in sample

Company Name	Headquarters Country	Region
TOYOTA MOTOR CORP	Japan	ASIA PACIFIC
STELLANTIS NV	Netherlands	EMEA
MERCEDES BENZ	Germany	EMEA
FORD MOTOR COMPANY	United States	AMERICAS
GENERAL MOTORS CO	United States	AMERICAS
BAYER. MOTOREN WERKE	Germany	EMEA
HONDA MOTOR CO., LTD	Japan	ASIA PACIFIC
HYUNDAI MOTOR CO	South Korea	ASIA PACIFIC
NISSAN MOTOR CO.	Japan	ASIA PACIFIC
TESLA INC	United States	AMERICAS
KIA CORP	South Korea	ASIA PACIFIC
RENAULT REGIE	France	EMEA
BYD COMPANY LTD	China	ASIA PACIFIC
TATA MOTORS LTD	India	ASIA PACIFIC
SUZUKI MOTOR CORP	Japan	ASIA PACIFIC
BAIC MOTOR CORP LTD	China	ASIA PACIFIC
MAZDA MOTOR CORP	Japan	ASIA PACIFIC
SUBARU CORP	Japan	ASIA PACIFIC
ISUZU MOTORS LIMITED	Japan	ASIA PACIFIC
CHONGQING CHANG AUTO	China	ASIA PACIFIC
MITSUBISHI MOTORS	Japan	ASIA PACIFIC
GEELY AUTOMOBILE	Cayman Islands	ASIA PACIFIC
THOR INDUSTRIES, INC	United States	AMERICAS
MAHINDRA & MAHINDRA	India	ASIA PACIFIC
CHINA RAI	China	ASIA PACIFIC
BEIQI FOTON MOTOR	China	ASIA PACIFIC
ANHUI JIANGHUAI AUTO	China	ASIA PACIFIC
FORD OTOMOTIV SANAYI	Turkey	EMEA
JIANGLING MOTORS	China	ASIA PACIFIC
FERRARI	Netherlands	EMEA
WINNEBAGO INDUSTRIES	United States	AMERICAS
YULON MOTOR	Taiwan	ASIA PACIFIC
TOFAS TURK OTOMOBIL	Turkey	EMEA
GB AUTO S.A.E	Egypt	EMEA
BAIC BLUEPARK NEW	China	ASIA PACIFIC
ASTON MARTIN LAGO	United Kingdom	EMEA
INDUS MOTOR COMPANY	Pakistan	EMEA
CHINA MOTOR	Taiwan	ASIA PACIFIC
SERES GROUP	China	ASIA PACIFIC

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