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Navn:	Sean Robin Kihlstrand Hauge

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Navn på veileder *:	Per Botolf Maurseth

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Title:

How were developing (low-income) countries economically affected by the covid-19 pandemic compared to industrial (high-income) countries?

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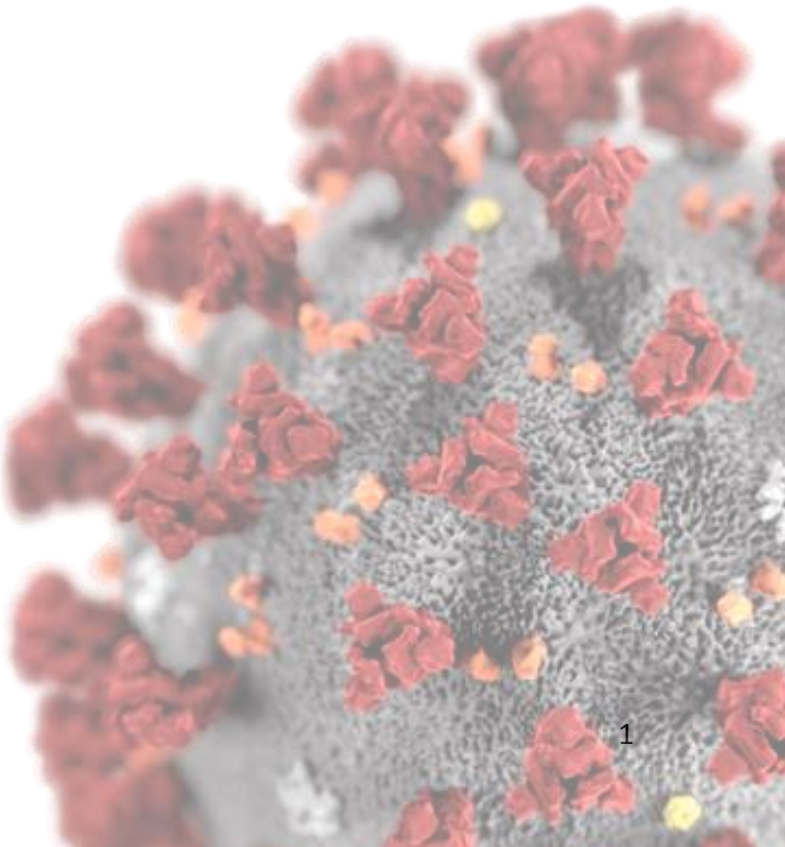
Supervisor: Per Botolf Maurseth



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Introducing the topic

Research question

The research question I have written about is:

How were developing (low-income) countries economically affected by the covid-19 pandemic compared to industrial (high-income) countries?

Introduction

March 11, 2020, the World Health Organization (WHO) declared the infectious Covid-19 as a global Pandemic (Cucinotta & Vanelli, 2020). One month later, over 80% of all countries were reporting cases of infections (Loayza, 2020). Every country was forced to initiate measures to inhibit import of the virus from other countries, but also decrease the spread of the virus internally within their own countries.

The ability to implement useful measures against the virus highly depended on the financial stability of the countries, access to medical care prior to the pandemic, and other cultural differences. High competency in the government was also important through their ability to analyze the situation and correctly implement measures. These factors had a different level of quality in high- and low-income countries, both prior to and during the pandemic, making it probable that Covid-19 might have had an unequal economic impact on the country types. My hypothesis is that the unequal impact was worse for low-income countries than high-income countries.

In this paper, I wish to investigate how developing, low-income, countries and industrial, high-income, countries have been affected by the Covid-19 pandemic. First, I will discuss the GDP growth per capita in both country types, then present the most discussed factors which might have led to the unequal economic impact by using aggregate data and articles. Then I will use a statistical and econometric analysis (with Stata) to analyze whether there is a statistical significance supporting the discussed factors using panel data. Contingent on significance, this will in turn either confirm or reject my hypotheses.

GDP per capita growth

The GDP (Gross Domestic Product) is a measure of the production of value of all goods and services in a country. A high GDP is consistent with high-income countries, while lower GDP is consistent with low-income countries.

GDP is estimated by the sum of private consumption, business investments, government spending, and net export. Often, private consumption is approximate 2/3 of the GDP, while investments and governmental spending are approximately 1/6 each. Net exports are often a small negative number (Amadeo, 2022). All factors are expected to decrease during a negative economic shock. The change in percentage of GDP from the prior year gives the growth in the GDP. To get a more comparable variable, one could also use the GDP per capita (GDP divided over the population). The growth in GDP per capita decreased in both high- and low-income countries during the pandemic.

High- and low-income countries is defined through The World Bank by the GNI (Gross National Income) per capita index. In 2018, the threshold for being classified as a low-income country was below $1026, and high-income was defined as having a GNI per capita above $12375 (Prydz & Wadhwa, 2019).

The graphs below, shows GDP per capita growth rate in percentage on the y-axis, and the years on the x-axis:

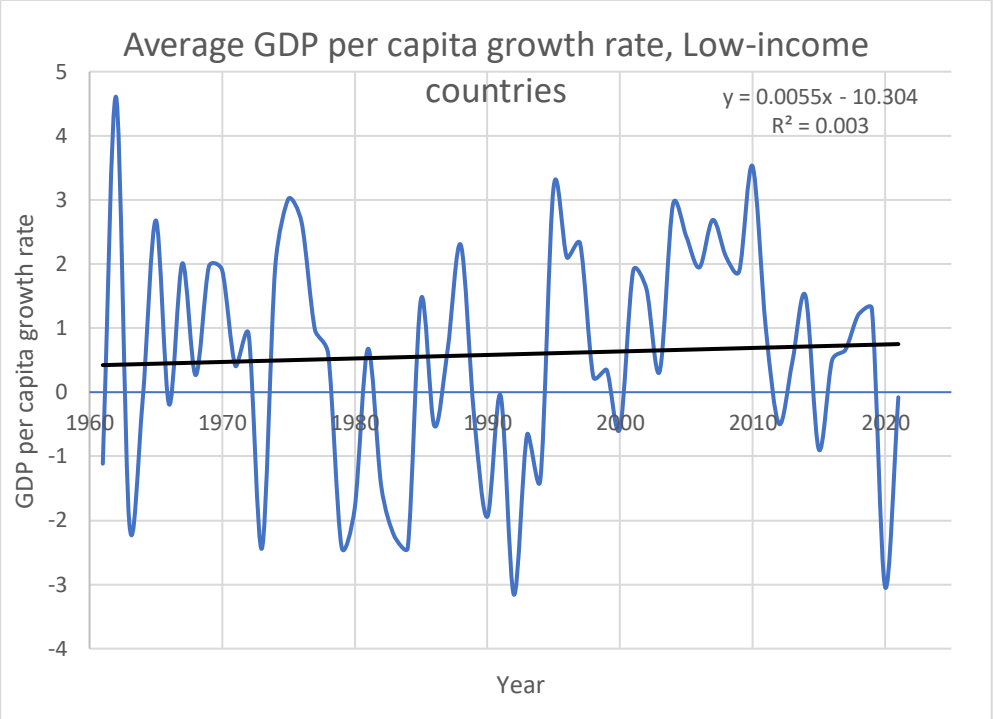

Figure 1 - Yearly GDP per capita growth (%) in low-income countries (The World Bank, 2021)

The low-income countries had a decrease in growth (from 1,3% to -3% change in 2020), and then increased to a growth of -0.08% in 2021. Even after the increase in 2021, the growth was still negative and lower than before the pandemic hit. However, the low-income countries seem to have an increasing trend of approximately 0,0055% growth yearly in the period of 1961 to 2021.

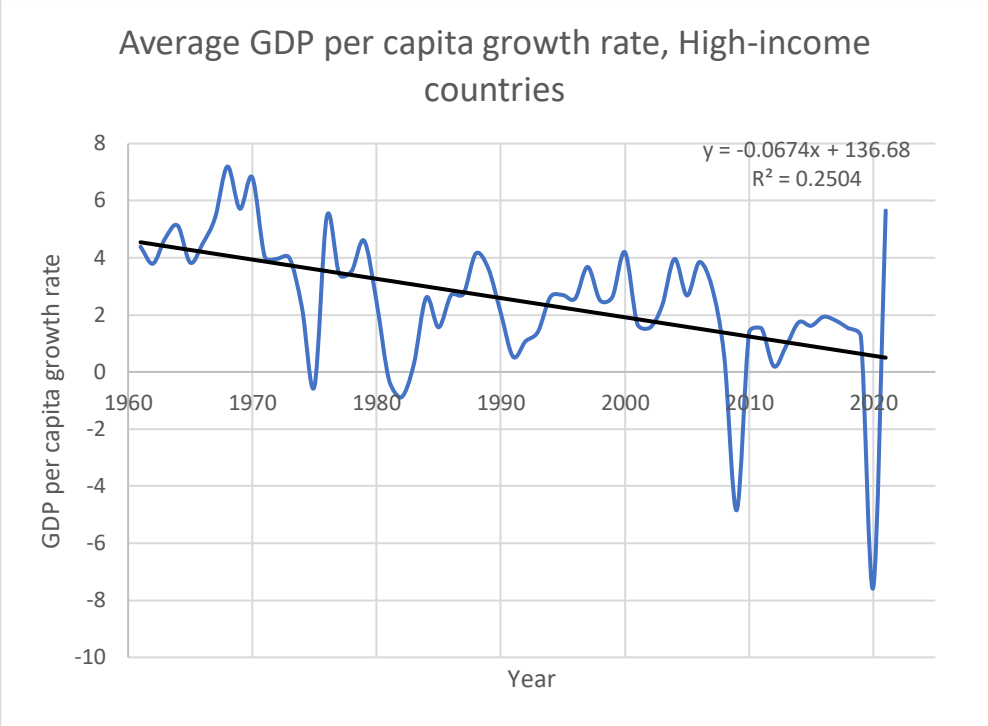

Figure 2 - Yearly GDP per capita growth (%) in high-income countries (The World Bank, 2021)

Growth in high-income countries decreased from 1.24% to – 7.5% in 2020. Compared to low-income countries, the high-income countries had a larger fall in GDP per capita growth. In the following year, the GDP per capita growth increased to almost 5.6% growth, a higher growth rate than prior to the pandemic. The high increase might be because households were saving due to uncertainties, and due to lower availability of goods. This might have initiated a consumption boom when the society started to reopen. However, high-income countries have a decreasing trend in GDP per capita growth with a decrease of approximately -0,067% yearly, in the period of 1961 to 2021.

Different trends can be a consequence of high-income countries spending a lot on research and development compared to low-income countries.

High-income countries improve efficiency and discover solutions for new issues, while low-income countries might have the second mover advantage and can replicate the innovations of high-income countries. This will lead to more expensive research and development in high-income countries, decreasing their GDP per capita growth. A high level of research and development might also be the reason for the large drop in GDP per capita growth, as high a lot of resources went to developing vaccines against Covid-19.

The decreasing trend of GDP per capita growth in high-income countries and increasing trend of GDP per capita growth in low-income countries suggest that there is a convergence between the country types. In other words, both types of countries will converge to an equal level of GDP per capita over time. The idea is based on Solow's model on diminishing marginal returns on savings and investments. The marginal returns are diminishing in high-income countries, while the marginal returns still are at a high point in low-income countries. The marginal diminishing return on the invested capital might also be a consequence of investing in more complex and demanding projects now than earlier. In other words, the easier innovations are already developed, and only tougher innovations remains. This, alongside the second mover advantage, can explain the difference in GDP per capita growth. Initial GDP per capita will also affect how large the changes will seem percentagewise. A specific increase in GDP per capita in high-income countries will seem like a smaller percentage wise than the same change in low-income countries.

The average GDP per capita growth of 2020 and 2021 gives rate of -1,56% in low-income countries, and -0.95% in high-income countries. This suggests a harder impact of the pandemic on low-income countries.

Factors leading to an unequal impact of the pandemic.

Quality and accessibility of medical care

The availability of medical care was worse in low-income countries than in high-income countries prior to the pandemic, and a sudden boom in Covid-19 infections could have led to hospital beds being filled up quickly (Stiglitz, 2020). In low-income countries, the number of hospital beds per thousand was on average 0,75, while high-income have a rate of 4,3 in 2017 (The World Bank, 2021). The exact numbers might differ from this calculation due to little data coverage in low-income countries. In addition, the number of physicians was a lot lower in low-income countries than in high-income countries with 0.3 per thousand against 3.2 per thousand before the pandemic in 2018 (The World Bank, 2018).

Hospital filled with Covid-19 patients would in turn also reduce the availability for patients with other pressing health issues like malaria or malnutrition, which is more common in low-income countries. In addition, the hospitals in low-income countries might be harder to reach for the sick, both because of distance and ways of travel.

Initially lower quality and accessibility to medical aid makes it more difficult to set up enough temporary testing stations, vaccination stations and temporary hospitals to cover the entire increased demand for health care. At the same time, the demand for temporary medical care will increase.

My hypothesis is that the low quality and accessibility of medical care contributed to a harder economic impact of the pandemic on low-income countries than high-income countries. This due to costs connected to improving access to medical care, and prolonged cases of infections due to lack of medical care. Access to medical care is difficult to test through an econometrical analysis due to lack of recent data, but I expect this influence the economy.

Access to vaccine

During the Covid-19 pandemic, the possibility to vaccinate the population was helpful to control the numbers of infected, and to reach population immunity sooner. Alternatively, countries could also have reached population immunity when the entire population had been infected, but immunity through vaccinations should reduce absence from work and costs due to illness.

The vaccine prices were too high for the 46 least developed countries (Light & Lexchin, 2021). The cost of one vaccine was between 2 to 40 dollars, and in low-income countries, the average health expenditure initially amounts to 41 dollars per year per capita. Obtaining a vaccination rate of 70% would require an increase of 56.6% in health care spending (Nations Development Programme, 2023).

In the beginning of the pandemic, there were only a few firms producing vaccines, but because of different side effects, and necessary number of doses, they never reached the state of perfect competition. Instead, this led to a monopolistic competition where the firms were able to maximize their profits through price discrimination between their different markets.

Factors affecting the discrimination was for example whether the buyer contributed to their research and development, the buyers national income classification, and further negotiations (Dyer, 2021), (Jimenez, 2021). The pricing led to high-income countries being able to buy large stocks of vaccines, more than they could use, keeping the low-income countries from being vaccinated.

High-income countries did state that they would export vaccine doses to low-income countries as a charity, however a large part of the doses was never exported. The export was affected by export bans, new waves of infections in their own country (more doses used in their own country, and less available for export), and difficult logistics (Irfan, 2021).

My hypothesis is that poor access to vaccines led to a prolonged pandemic for the low-income countries and a tougher recovery, which in turn have led to relatively more costly measures and a harder economic impact.

Culture

In low-income countries, larger families live together, they live in smaller housing spaces, and they are physically close to household members. Household consisting of over 5 people are common in countries in Africa and in the middle east, while countries in Europe and North America has an average of below 3 people, based on data from 2017 (United Nations, 2017). In addition, 14% of African households are multigenerational (three different generations), while this was the case for only 2% of European and northern American countries, based on data from 2010 (United Nations, 2017). This assumingly made it more difficult not to infect other family members in low-income countries.

The cultural aspect also contributes to a different effect from the pandemic through the attitude in the population towards the government, and to imposed restrictions. In low-income countries, the population are more including, and they care about the people close to them. Even though they live tight, they will still be motivated to keep distance and try not to infect each other.

Some richer countries, for example the US, are less willing to change their behavior for others health. This has led to a very high death rate in some high-income countries compared to other high-income countries, as they could use the space to keep distance, but they don't utilize it optimally (Stiglitz, 2020)**.**

My hypothesis is that tighter living spaces, and uncooperative attitudes would lead to a worse effect of the pandemic. This is however difficult to examine through an econometrical analysis due to lack of data, but I expect this to have influenced the economy.

Working from home

Working from home ended up as a useful tool to keep the employment rate and household income as unaffected as possible, while limiting social contact. This option depended on whether the workers had access to internet at home and the share of workplaces where this was possible. In 2021, low-income countries reported a rate of internet users (internet penetration rate) to be 22%, while high-income countries reported a rate of 90%. The low rate of internet users implies that the rate of household with internet is 22% or lower. This makes it difficult to work from home in low-income countries (The World Bank, 2021).

Physical workplaces often taking place in the primary (gathering natural resources and agriculture) and secondary sector (production and industry) will not be able to transfer to home office as these sectors depend on physical attendance. The tertiary industry is mostly based on services and is suppliable even with restrictions as meetings can be done using online meeting rooms, and tasks in general can be done separately.

In addition to a lower rate of internet users, the largest share of workers in low-income countries are in the primary sector, while the largest share of workers in the high-income countries are in the tertiary sector (The World Bank, 2021).

Shown in the pie charts below:

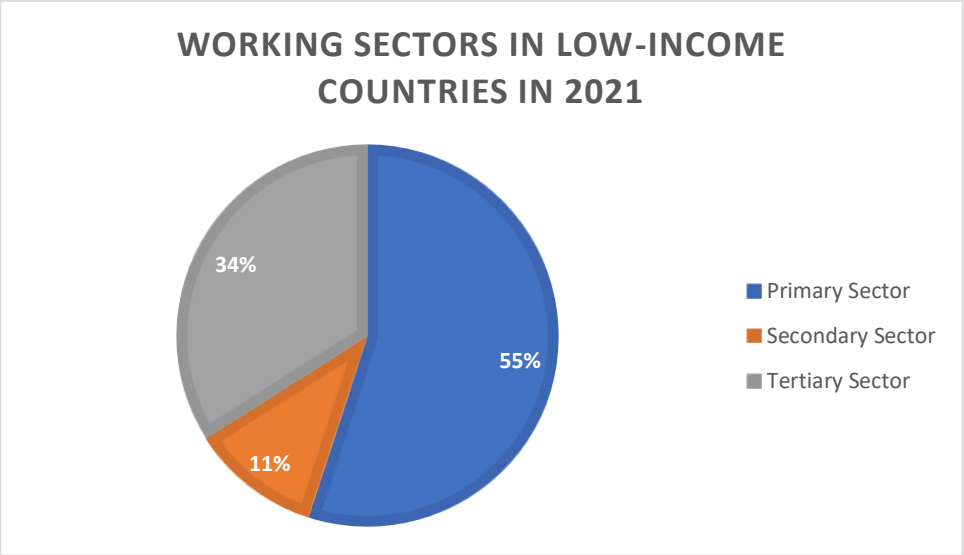

Figure 3 - Distribution of working sectors I Low-income countries (The World Bank, 2021)

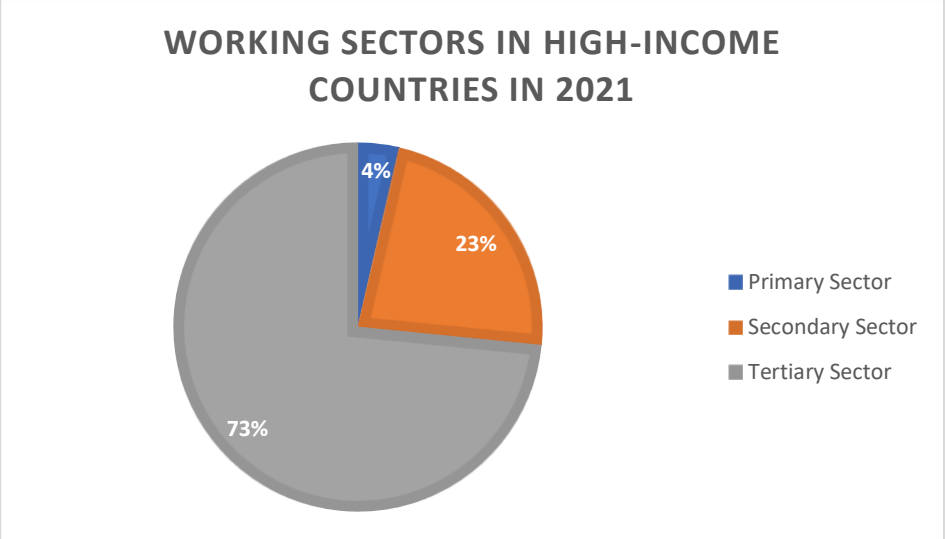

Figure 4 - Distribution of working sectors I High-income countries (The World Bank, 2021)

High-income countries have the largest share of workers in the tertiary sector with approximately 73%, while only 23% and 4% in secondary and primary sector in 2021. Low-income countries have the largest share of workers in the primary sector with 55%, while only 34% and 11% in the tertiary and secondary sector in 2021. The data is based on percentage of total labor force, which excludes informal workers in low-income countries. If these workers had been included, primary and secondary sector would most probably have increased their share of the pie chart.

The combination of internet access and distribution across working sectors makes working from home possible for approximately 35%-45% of the population in high-income countries, and only 5%-25% in low-income countries (Loayza, 2020).

A low internet penetration rate might also inhibit the positive effects of digitalizing and setting up online working opportunities (Broom, 2020). If a worker doesn't have access to internet at home, they will not be able to login to work from home, even if the opportunity is offered by the workplace.

Missing internet access also makes it more difficult for the population to access information about the virus, and contact health personnel for services regarding Covid-19 (Broom, 2020).

Another factor affecting internet penetration rate was the price of data plans as data plans were more expensive in low-income countries than in high-income countries. Streaming and downloading videos/files for work could get very costly, for example, streaming a one-hour video would, for some households, cost over 40% of their monthly wage (Broom, 2020). This would also inhibit the positive effect of making online working possible as the workers still wouldn't be able to attend work from home.

My hypothesis is that a high internet penetration rate would lead to a better chance at maintaining the GDP per capita growth during the pandemic, as large parts of the population would be able to maintain initial income though working from home. Easier access to information would probably also be helpful to decrease the infection rate, and the possibility to shift consumption to online options.

Access to internet

Access to the internet was suddenly a necessity during the pandemic as working from home became more common. It is however connected to GDP growth in other ways as well.

Internet can lead to more productive production processes, and more effective task completions in general at work. Internet makes communication easier, and tasks such as different analysis's can be digitalized rather than performed manually. This increase both number of analysis possible to complete at a certain time, but also removes some of the risks regarding user error.

Productivity is also increased through increasing the skills of the workers, both on work and in studies (Hjort & Sacchetto, 2022). This is easier using internet through online courses and certifications.
Internet access is also connected to GDP growth through private consumption. Online shopping leads to distant sellers and buyers to connect making it easier to purchase goods from distant sellers. Internet also support GDP growth through easier access to information on different goods prior to the purchase, this removes some of the uncertainty around purchases (Hjort & Sacchetto, 2022).

A research article on Nordic countries proves that GDP and internet penetration is highly correlated (Amiri & Reif, 2013).
In their research, they set up a graph with GDP per capita along the x-axis, and internet penetration rate along the y-axis. Internet penetration rate is a term used for the percentage of a population using internet. They marked the Nordic countries to illustrate that they had some of the highest rates of internet penetration rates, and a some of the highest values of GDP per capita. This relationship is also shown by the trend line. Generally, plots with a high internet penetration rate also have a high GDP per capita, while plots with low internet penetration rate also have a low GDP per capita (Amiri & Reif, 2013).

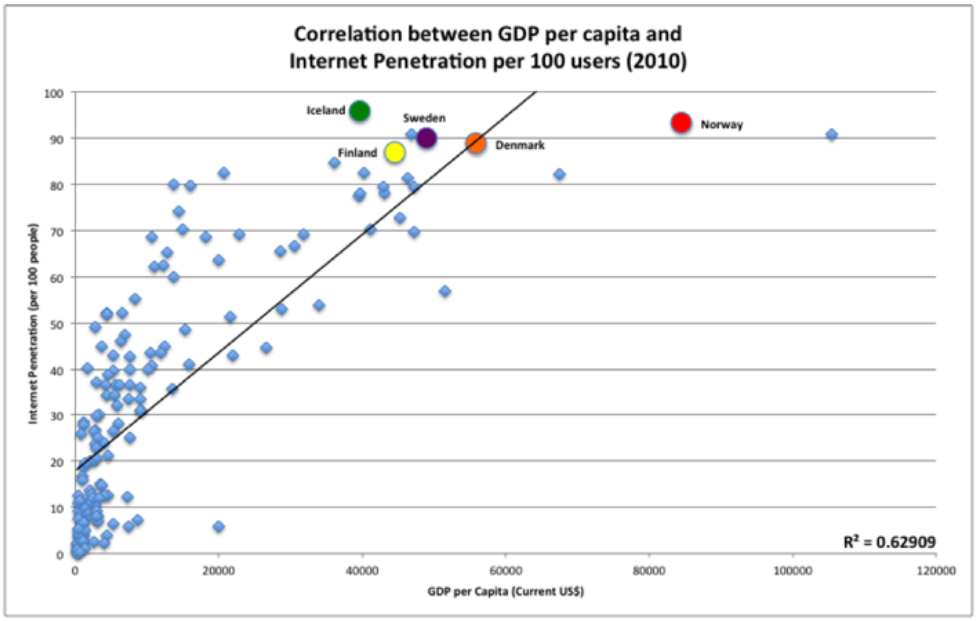

Figure 5 - Correlation between GDP per capita and Internet penetration rate (Amiri & Reif, 2013)

Amiri & Reif uses a linear trend line in their article. A more accurate trend line would however be a curved trend. The shape of the scatterplot shows that a small increase in GDP has a higher effect on internet penetration rate when the level of GDP is low, rather than when it is high, confirming that the optimal trend line should be curved.
Also, an internet penetration rate higher than 100% is impossible suggesting a curved trend line would be more accurate.
However, both a linear trend line, and a curved trend line both proves the same result, higher internet penetration rate is connected to higher level of GDP per capita.

Using data from 2017 (most recent year with good coverage on internet penetration rate and GDP per capita) for high- and low-income countries, and a logarithmic curved trend line gives the following graph:

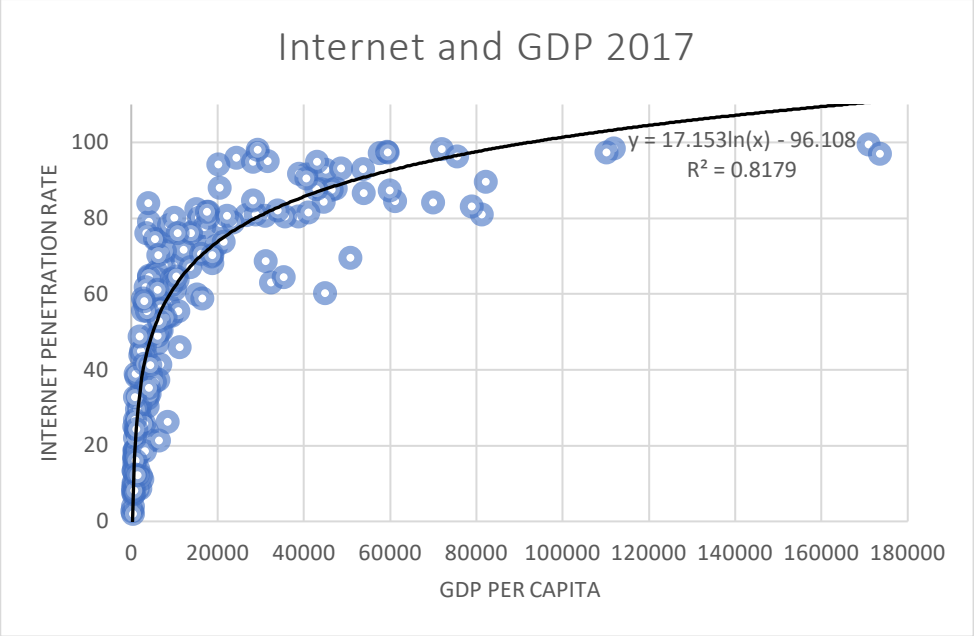

Figure 6 - Correlation between GDP per capita and Internet penetration rate, data from thesis (The World Bank, 2021)

Using more recent data, and a logarithmic trend line increases the R^2 value from 0,62909 to 0,8179. My trend line also continues above the maximum value of penetration while it should have flattened out just below 100%, as more than 100% is impossible. The findings do however replicate the results of Amiri & Reifs research, that internet penetration rate and GDP per capita are connected.

Amiri & Reifs research also provides evidence of causality, as the boom on internet penetration rate increased from approximately 45% in 2001 to approximately 75% in 2003. GDP per capita increased with a steeper rate from 2002 suggesting that internet penetration rate has a lagged effect on GDP per capita (Amiri & Reif, 2013).
Internet penetration rate is not a driver of GDP per capita at the same time as internet penetration rate increases as internet must be implemented in businesses, and the users must be thought how to use it effectively.

The lagged effect is shown in the following graph:

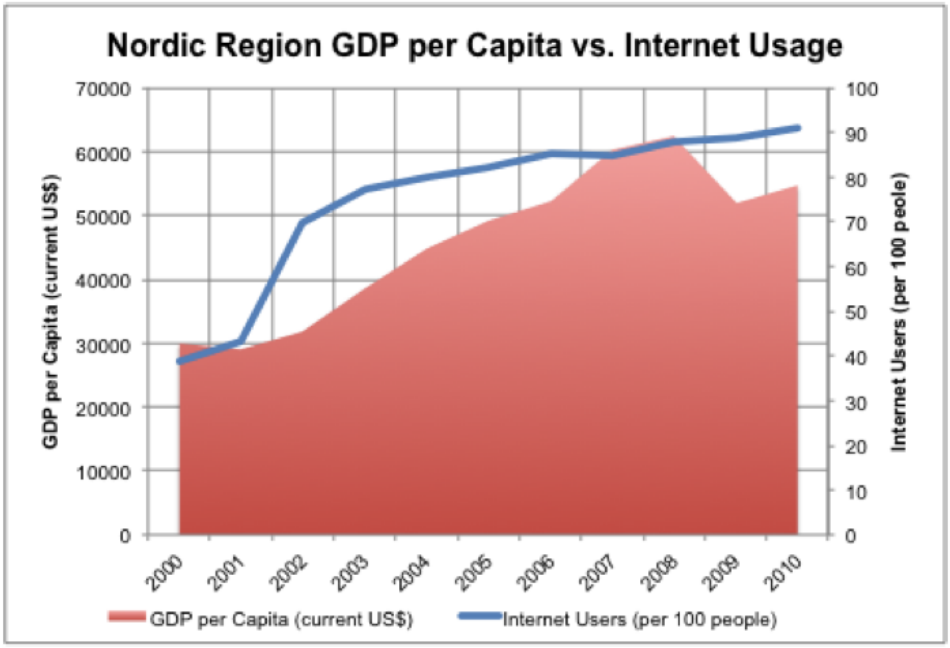

Figure 7 - Evolution of GDP & Internet usage, 2000 to 2010 (Amiri & Reif, 2013)

Both GDP per capita and internet penetration rate continued to increase until the recession in 2008 giving different paths in the time after. At this time, internet penetration rate hit 90% so even more increase would be difficult to achieve flattening out the internet penetration rate (Amiri & Reif, 2013).

Amiri & Reifs article was based on Nordic countries but reproducing the same research/graphs using low-, and high-income countries gives the same results.

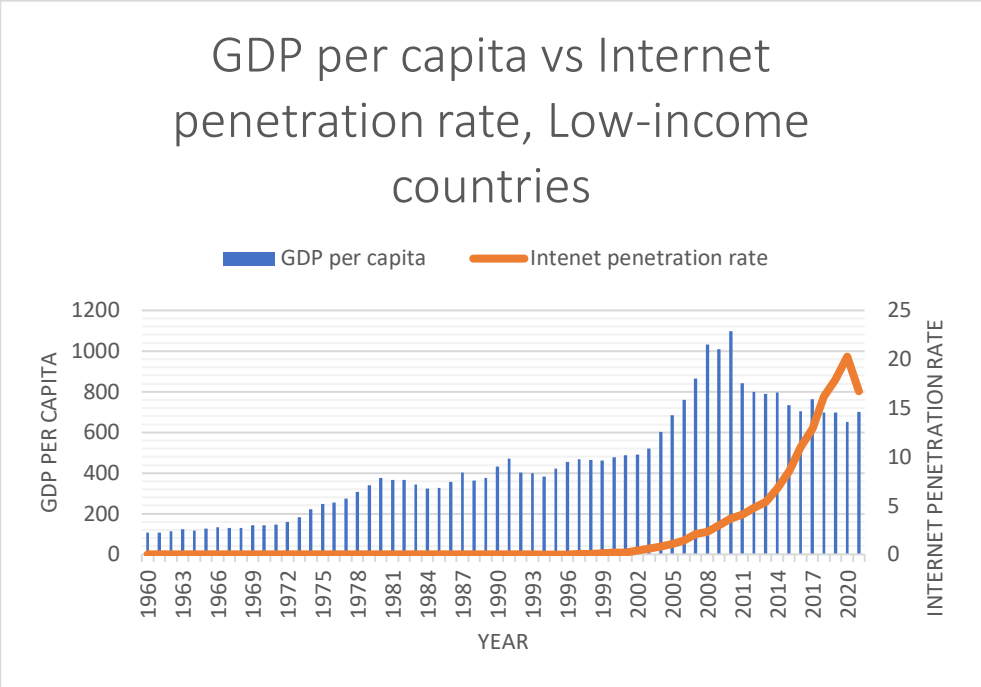

Figure 8 - Evolution of GDP & Internet usage, Low-income countries (The World Bank, 2021)

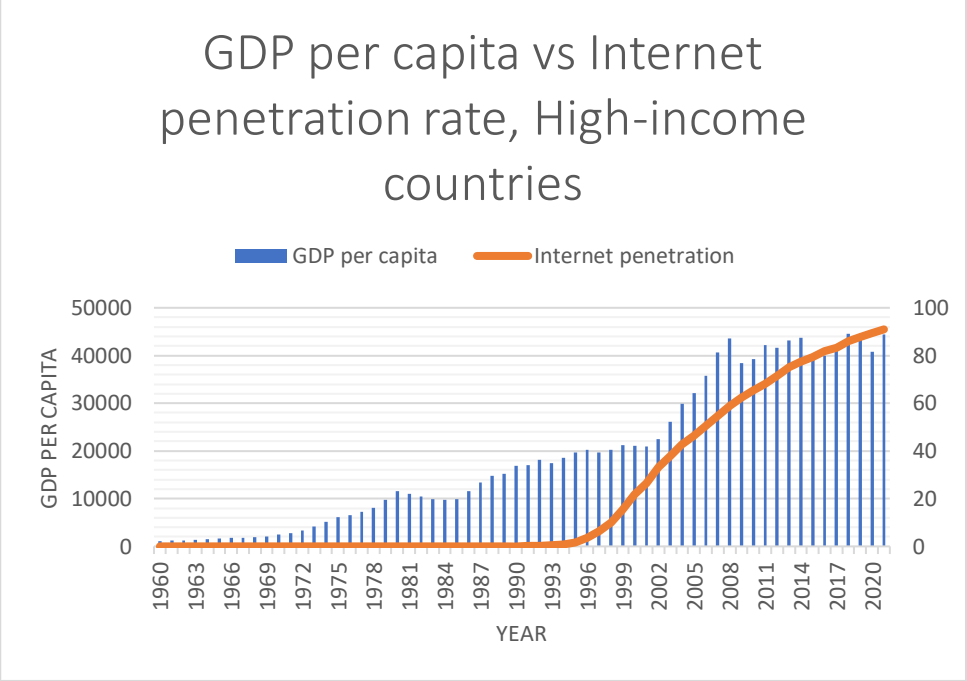

Figure 9 - Evolution of GDP & Internet usage, High-income countries (The World Bank, 2021)

Expanding the period from 2000-2010 to 1960-2021 gives a better impression of the effect of internet on GDP as the moving average before the breakthrough is visible as well. Both country-types had increasing GDP per capita prior to the internet breakthrough, and the GDP per capita were boosted even more shortly after. Internet penetration rate is based on internet users, and not internet access at home, which might explain the drop-in internet penetration rate in 2021. Internet at home is not as common in low-income countries as in high-income countries, and a larger fraction of the users might therefore use internet exclusively at work or internet cafes. Restrictions due to Covid-19 will therefore make it more difficult to access internet.

Subsidies and financial aid

During the pandemic, workers getting resigned or on a leave of absences would in many countries receive financial aid from the government. This was offered to minimize the effect of the pandemic on household income, and to remove some of the uncertainties at that time.

Low-income countries might have been affected harder by the pandemic as the informal sector have a higher ratio of total potential workers than in the high-income countries. A high rate of informality leads to a higher rate of workers without the right to financial aid, and in some cases medical care. This would in turn lead to a lower household income during a leave of absence or a resignation, and buying necessities like food would become more difficult. If governmental subsidies and financial aid was implemented it would have little or no effect on these households as they wouldn't have had right to the financial aid (Loayza, 2020).

Limited fiscal space was also a possible factor leading to a harder effect on low-income countries. A lot of the countries was not able to deploy public funds during the pandemic, which could have led to a reduction in households' economy during leave of absence or a resignation. Unlike the effect of informality, this would affect both formal and informal workers. Without any financial aid to supply, and unemployment due to restrictive measures and bankruptcies, households would have to decrease consumption and use saved up funds instead (Loayza, 2020).

Poor governance could also have been a factor contributing to a harder effect on low-income countries as corruption and low governmental competence makes it harder to deploy the financial aids in the correct way (Loayza, 2020). Countries with corruption might publicly state that they will deploy financial aid, but the money might end up in other parts of the system. Corruption over time might also have been an underlying factor leading to the limited fiscal space.

My hypothesis is that the low access to subsidies and financial aid have led to a more negative effect of the pandemic on low-income countries. This because governmental support works as an automatic stabilator during unemployment and in times of crisis´. Without support, maintain the high GDP per capita is more difficult.

Lockdown

All mentioned factors can lead to different approaches regarding measures against the pandemic, but also different effects of the same measures. In turn, this would lead to different infection and mortality rates, and different psychosocial effects. This might have affected the economy both in the long term, and in the short term. During the pandemic, all countries experienced numbers of infected as “waves”.

The number of infected increased in one period and decrease the next period, making the number of infected moves up and down like “waves”. Factors leading to new “waves” of infected were, for example, new and more infectious variants of the virus, and colder seasons leading to more gatherings inside.
As Covid-19 were spread through the air, gatherings inside would have led to smaller spaces and difficulties maintaining the recommended distance.

During the first wave, a measure spreading across the world was “lockdown”. Countries locked down their borders and minimized social contact internally by a set of restrictions. The lockdown was a common approach both in high- and low-income countries. It has over time been implemented at different degrees from shutting down borders completely to milder versions only limiting social contact.

The different degrees have been discussed as a stringency index from 0-100, where 0 is an open society, and 100 is a complete lockdown. During the pandemic (data from 2020 to 2021), low-income countries on average had a stringency index of 47,1 while high-income countries had an average of 54,4 (Mathieu & et.al, 2023). In other words, the difference in degree of lockdown on average was very small.

"Lockdown" was an expensive measure as a lot of activities within a country was shut down. For the lockdowns to be effective the positive effects of decreased infections had to outweigh the negative economic effects.

In high-income countries, "lockdown" led to a decrease in infection rate and ended the current spikes of infections before they before they ran out of hand. At the same time, many workplaces offered a method to work from home making it possible to earn the regular income. Simultaneously, workers getting resigned, or on a leave of absence received financial support from the government. High-income countries were also able to do research on the virus and vaccinate the population simultaneously as the "lockdown" and give the country a better chance of reopening and returning to normal without reaching a new peak short after. This implies that a "lockdown" would be an effective measure in high-income countries.

In low-income countries, the opportunity to work from home was uncommon, and due to the already lower income, and informal work agreements, being able to afford necessities like food and clean water was harder (Eyawo, Viens, & Ugoji, 2021). Low-income countries did not have the same ability to subsidize the population, and informal workers might not have had right to subsidies at all. The low-income countries would decrease current numbers of infected as well during a lockdown, but without the same opportunities of improving their chances of successfully reopening as research and vaccination was limited. Reopening a low-income country would therefore often be followed by an increase in the number of infected. This implies that a "lockdown" was less effective in low-income countries even though the costs were still high.

My hypothesis is that the lockdown in general would be more effective in high-income countries than in low-income countries as they were more equipped to cover the associated costs and vaccinate the population.

Consumption

Investigating the effect of consumption during the pandemic, economic theory would suggest a smaller change in consumption in high-income countries, due to consumption smoothing. Optimizing consumption through smoothing is easier in countries with a lower share of liquidity constrained consumers, and countries with a higher consumption rate implies higher rate of liquidity constrained consumers. Liquidity constrained consumers are unable to take up loans, which makes it difficult to consume the necessary amount, and to smooth consumption (Judd & Hubbard, 1986). Because of this, liquidity constrained consumers consume a large fraction or all income and, sudden windfalls of money they receive. This is a consequence of initially having less funds than necessary. Periods of lower income should not affect periodical consumption as one should smooth the lost income by decreasing lifetime consumption instead (giving a very small effect on periodical consumption).

The consumption expenditure in percentage of GDP have been higher in low-income countries than in high-income countries from year 1960 to current date. Both started between 70% and 80% in 1960, but in 2021 the consumption expenditure was still just below 80% in low-income countries, while high-income countries have dropped to approximately 50%.

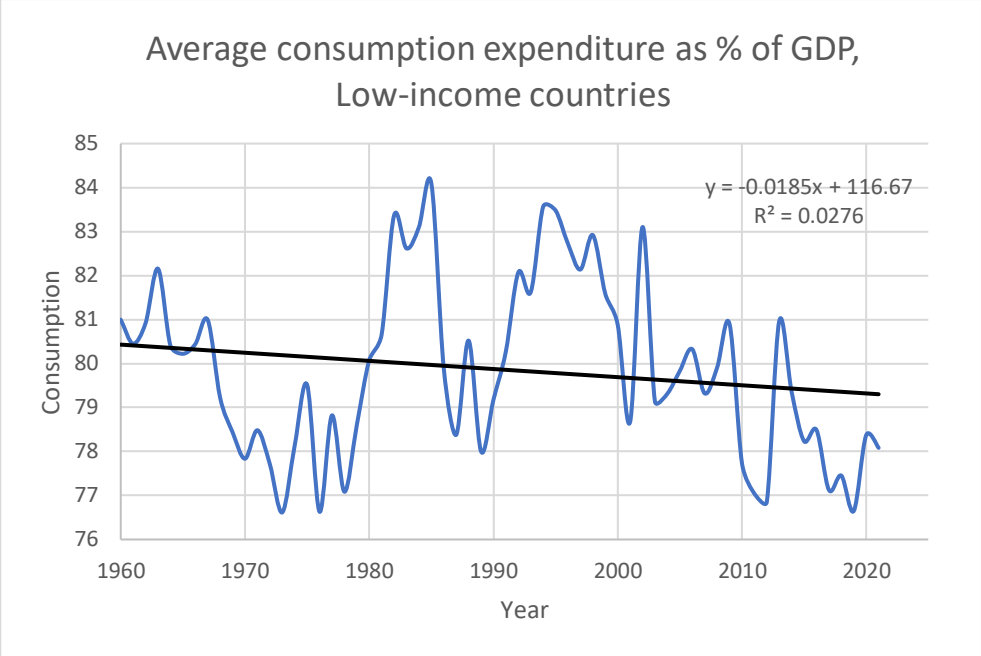

Figure 10 - Consumption expenditure in % of GDP, Low-income countries (The World Bank, 2021)

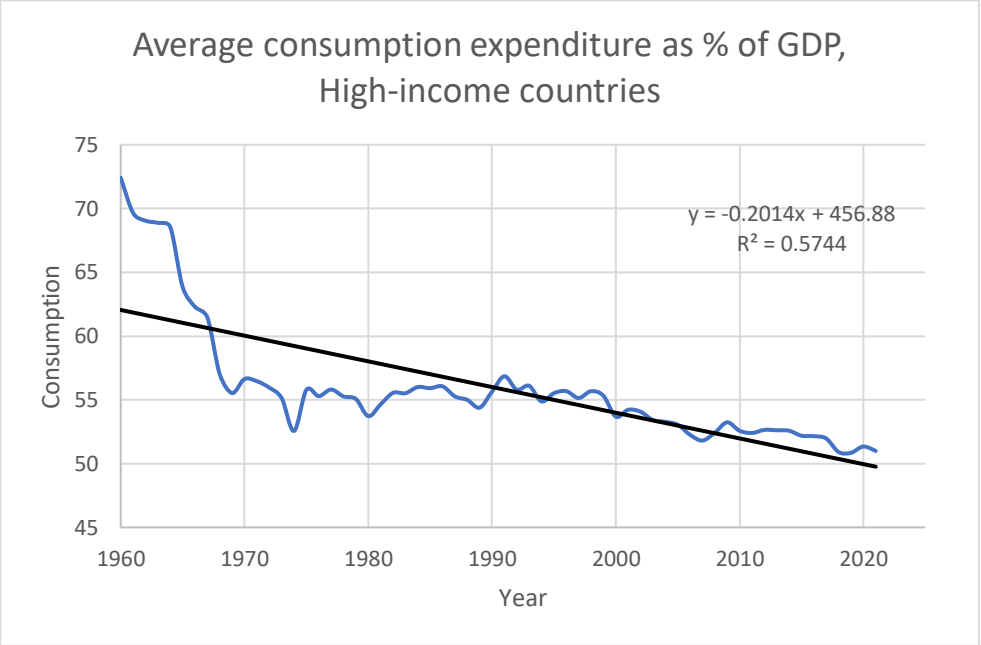

Figure 11 - Consumption expenditure in % of GDP, High-income countries (The World Bank, 2021)

High-income countries have a steeper trend line than low-income countries. As countries become more industrialized, production becomes more effective leading to higher profits, which in turn leads to higher GDP and higher private income.
A higher income will over time reduce the share of liquidity constrained consumers in the population. This will give the consumers the opportunity to smooth consumption and set aside a part of their income for savings. As the consumers income increase and a higher fraction is set aside for savings, their percentage of income going to consumption decreases. In other words, as GDP continues to increase, and consumption rate is constant because of a higher saving rate, the total effect will be a decrease the consumption expenditure in percentage of GDP. The decreasing trend of consumption expenditure in percentage of GDP can be explained by the long period of high GDP per capita growth in high-income countries (1960-2000, figure 2), compared to the low, almost constant, GDP per capita growth in low-income countries (figure 1). Consumption expenditure in percentage of GDP is a calculated as a fraction where actual consumption is at top, and GDP is at the bottom. Increasing GDP affects the lower part of the fraction, making the results of the fraction smaller.

Unlike the trend of consumption expenditure as percentage of GDP, there is an increase in 2020 for both types of countries (higher for low-income countries) during the pandemic. To get this effect, either the consumption needs to increase (top part of the fraction), or the GDP must decrease (bottom part of the fraction).

Analyzing the actual consumption using constant 2015 dollars, it becomes clear that the reason for the increase in consumption relative to GDP is because of reduced GDP. The share of consumption in low-income countries had a slight increase during the pandemic and rose sharply right after.

The slight increase might be a consequence of purchases of new types of necessities, such as medical equipment etc. Lower income countries will have less saved up funds available, and it will be harder to shift from consumption to saving with new occurring necessitates.

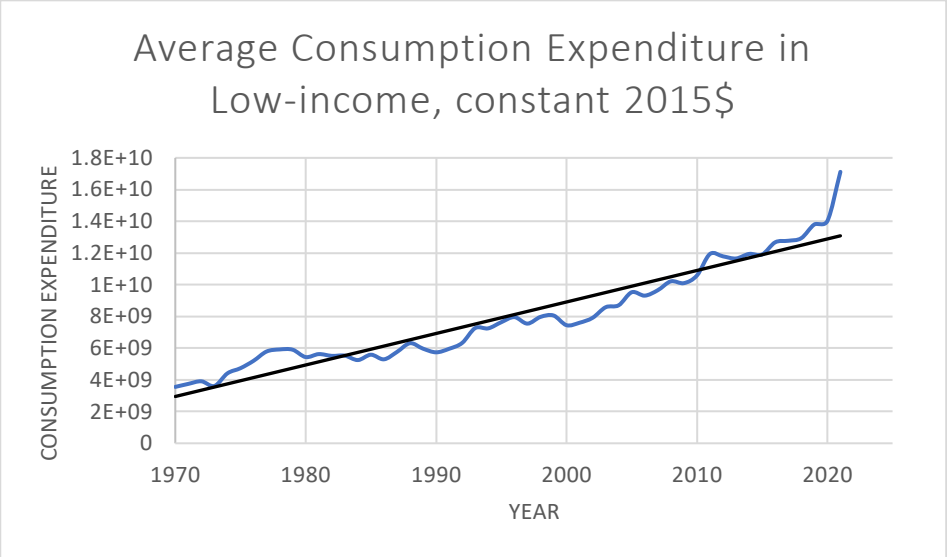

Figure 12 - Consumption expenditure in Low-income countries, (The World Bank , 2021)

Analyzing the share of the consumption expenditure spent on food, visualizes my theory that low-income countries had an increase in consumption because of an increase in necessities. This is shown in the graph below. The size of the plots describes level of GDP per capita. Large plots indicate high level of GDP per capita, while small plots indicate lower levels of GDP per capita.
Low-income countries in general have a lower consumption, but at the same time, a larger fraction of the consumptions goes to necessities such as food and is found in the upper left corner of the graph. High-income countries, on the other hand, have larger consumption, but a lower fraction goes to necessities, and is found in the lower right corner of the graph. This is also known as Engels Law, as income increase, the percentage spent on food decreases (CFI Team, 2022).

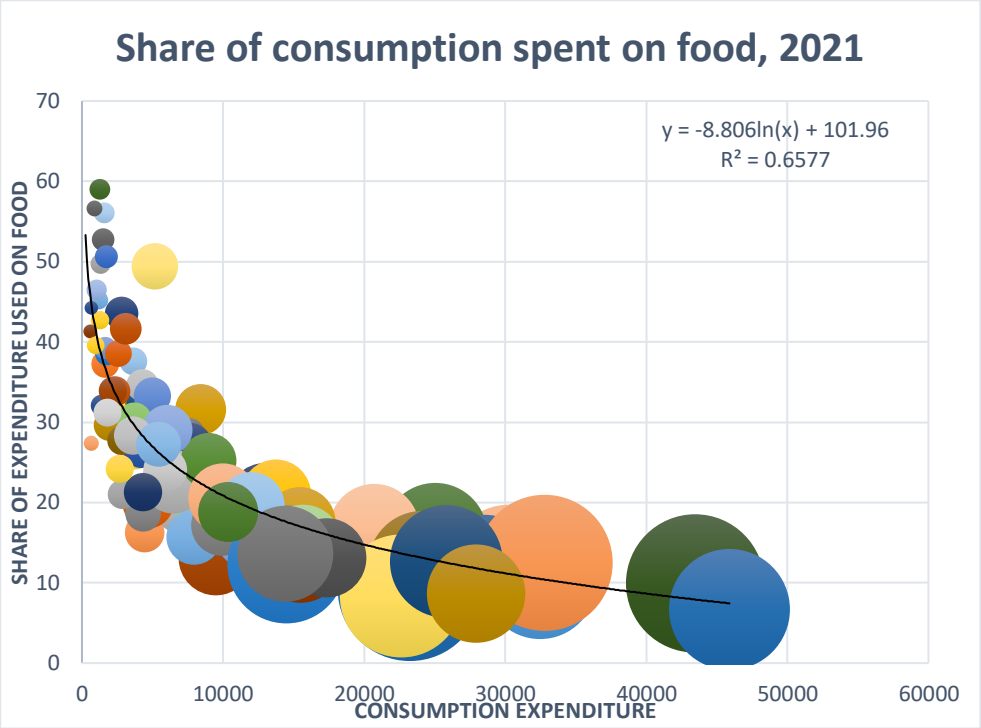

Figure 13 - Engels Law, (USDA, 2021)

The consumption in high-income countries had a drop during the pandemic and experienced a large increase right after the pandemic. Reasons for the drop might be reduced income and uncertainties, and unavailability of goods. Unlike low-income countries, a shift from unnecessary goods to saving was possible, and they will still be able to save even though medical expenses increase marginally. In other words, the total effect on consumption was a decrease as the ability to shift away from unnecessary goods decreases consumption more than the increase of medical expenses.

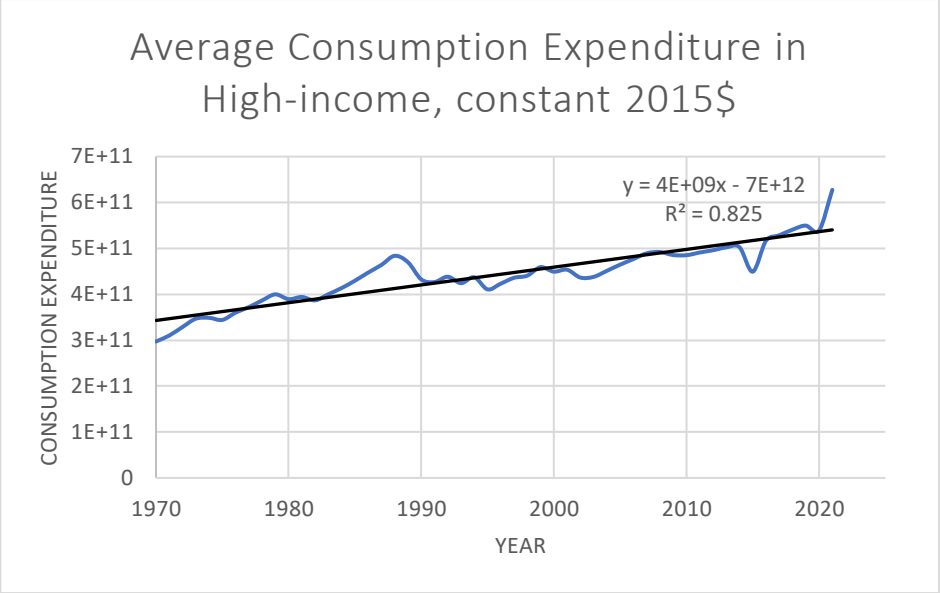

Figure 14 - Consumption expenditure in High-income countries, (The World Bank, 2021)

The change in consumption expenditure appear to move procyclical to the GDP per capita growth and decreased largely the first year (small increase for low-income countries), and then increase the year after. As consumption is one of many factors explaining GDP, I expect the change in consumption to be lower than the change in GDP. It is however one of the largest contributors, so it will be a large part of the change in GDP per capita growth.

The procyclicality suggests that one of the main reasons why GDP per capita growth decreased more in high-income countries, than in low-income countries might therefore be because of the change in consumption as high-income countries have a large drop and low-income countries have a slight increase.

The higher GDP per capita growth one year after the pandemic hit might be because of fiscal and monetary policies, people returning to new lines of work, and shift in consumption from services to goods (which at the same time increases consumption as it shifts from the unavailable services to the available goods), and a shift from physical to online shopping (Bishop, Boulter, & Rosewall, 2022). In other words, the increased consumption might have led to increase in GDP per capita growth. Access to fiscal and monetary policies makes it easier for high-income countries to adapt and recover from the initial shock to the economy (Bishop, Boulter, & Rosewall, 2022).

My hypothesis is that a higher consumption in percentage of GDP will make it more difficult for the population to adjust to the pandemic. As they will be more exposed to uncertainties, decrease in income and higher costs connected to Covid-19. In addition will high-income countries be able to shift consumption away from unnecessary goods and towards additional saving to counter the uncertainties, which is harder with an initially high consumption rate.

Household consumption is also directly connected to unemployment as more unemployed workers leaves less workers able to consume (Bishop, Boulter, & Rosewall, 2022).

Unemployment:

During the pandemic, demand for certain lines of work decreased. For example, less tourism led to a decrease in demand of employees on flights, and less social contact reduced work dependent on direct contact to others.

With support from the government, employees could be guided towards the new important lines of work and can be educated to qualify for the new jobs through online courses and assisted with subsidies. With little governmental support, both financial and educational, the inequalities between high- and low-income countries could increase. The population would struggle to make ends meet with little financial support, and they would struggle to reenter the labor market without educational support.

The unemployment in low-income countries had been steady on approximately 6,1% since 1991. During the first year of the pandemic, it jumped up to approximately 6,7% and dropped to approximately 6,5% in 2021, as seen in the following graph:

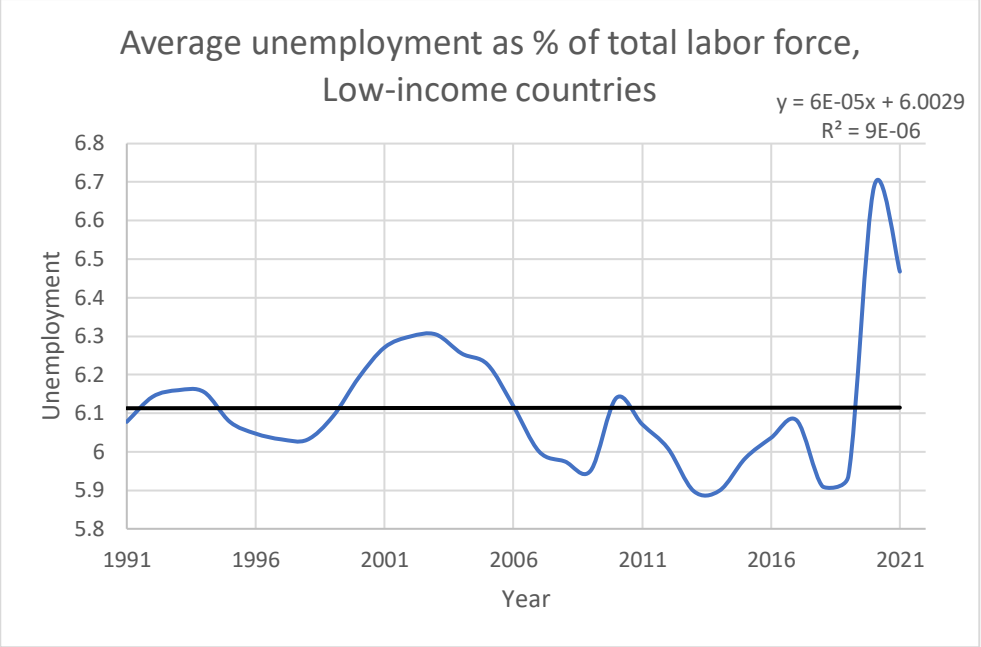

Figure 15 - Unemployment (%) in low-income countries (The World Bank, 2021)

The high rate of unemployment and the fact that low-income countries still were above their trend line in 2021 can be a result of workers that struggle to come out of the unemployment, and that their lines of work have been outdated. This can be a sign of hysteresis in the work force, but it is difficult to be certain that this is the case without having data for more following years.
Hysteresis is a term used to explain the effects of certain shocks, permanently altering the capacity of, in this case, labor (Furlanetto, Robstad, Ulvedal, & Lepetit, 2020)
If that's the case, the trend will shift upwards, and the economic effect might become long term. In addition, many of the workers might also have lost their jobs because of bankruptcy, which is more probable in countries with less fiscal support.

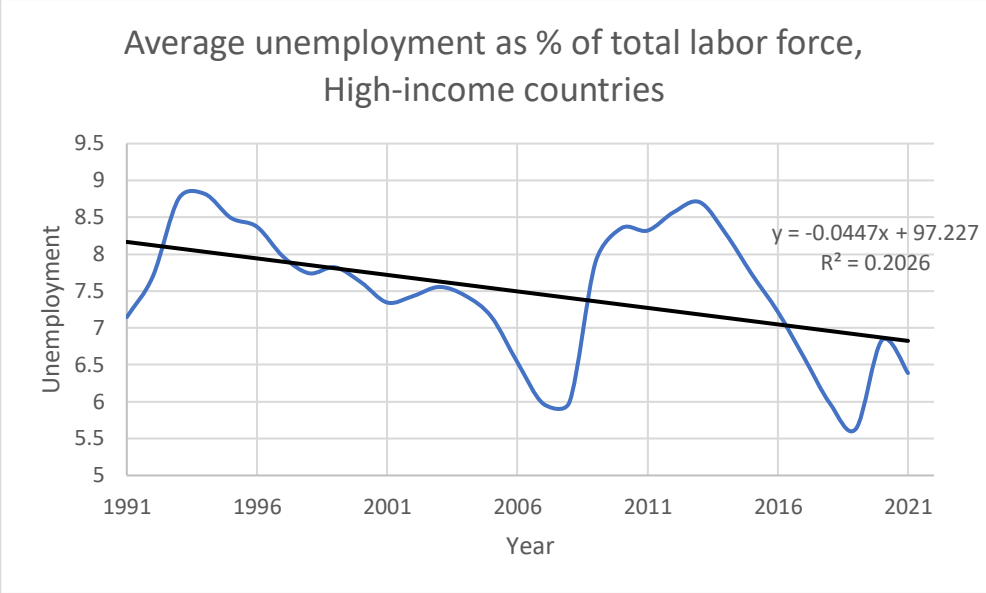

Figure 16 - Unemployment (%) in high-income countries, (The World Bank, 2021)

The graph describing the high-income countries on the other hand have had a higher trend since 1991 falling from approximately 8,25% to approximately 6,8%. Unlike low-income countries, high-income countries have a volatile graph for unemployment, seemingly affected more by incidents like the financial crisis. During the pandemics first year, the unemployment had a peak, but it decreased in 2021. The unemployment was below the trend line in both years, unlike low-income countries.

Both high-, and low-income countries reacted with a sudden increase, and a drop in unemployment the year after. They only differ in the fact that high-income countries managed to stay below their current trend line, while low-income countries have had their largest share of unemployment since 1991 above their trend line.

High-income countries have better support systems and is assisted out of unemployment. The result implying a higher unemployment rate is therefore surprising.

The informality of many workers employment would have affected the data as these workers are kept out of the statistics. The total labor in the graphs above includes people at work, and people officially searching for work.

Informal workers, students etc. are kept out of the statistics and these workers might have returned to their original workplaces after the pandemic (affecting the drop in 2021) but without being recorded. Also, informal workers´ unemployment over time wouldn't have been recorded either, including would possibly have affected the trend line. Adding informal workers could have increased the unemployment in low-income countries given a more accurate effect of the pandemic. Informal workers would not have affected the unemployment in high-income countries as much as their informal sector is smaller. The following graph confirms that informality is more common in low-income countries:

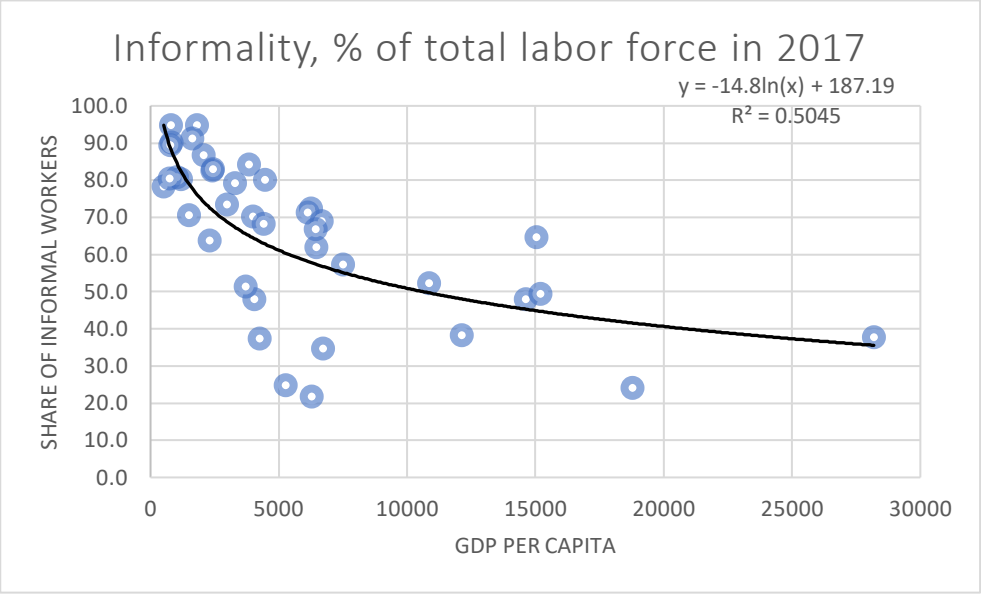

Figure 17 - Informality in the labor force (The World Bank, 2021)

Adding plots regarding informality from additional high-income countries would give a more accurate trend line, but this supplementary data is unavailable (The World Bank, 2021). The current trend line appears to flatten out above 30% which seems unrealistic for countries with high GDP per capita. Expectedly, the trend line would have been steeper, and would have flattened lower with data from more high-income countries.

My hypothesis is that countries with high unemployment will be worse off during a pandemic as it will become even harder to reenter the job market, and increased uncertainties regarding the income and the market will make it harder to keep consumption steady.

Research methodology/design

I wish to investigate the effect on Covid-19 on high-, and low-income by running regressions in STATA. STATA is a statistical program used for econometric analyses such as OLS (Ordinary Least Squares) regressions. It calculates the effect of different independent variables on one specific dependent variable. General data is gathered from The World Bank, while covid data is gathered from Our World in Data. In addition, the data for HDI is from the United Nations development program (UNDP, 2022) The World Bank works together with the UN OECD, and IMF delivering statistics internationally accepted and reliable (The World Bank, 2023). Our World in Data collects data from OECD, the world bank, UN, and government sources, making it highly reliable (Our World in Data, u.d.). United Nations development program is highly reliable as data is collected from 170 countries and territories (UNDP, u.d.), and they have been highly ranked on the topic of transparency (UNDP, 2018).

My regressions will be based on yearly data of GDP per capita growth data as this is available for most countries. Covid-19 only lasted for a short period, so it would be preferable to use quarterly data, but this is not possible as only a few countries report general economic indicators at a quarterly level. Using quarterly data would limit the number of countries in the regression too much, and in turn limit the number of observations even more.

The pandemic started in 2020 and lasted until 2022, but at this point, only data for 2020 and 2021 is available. Due to unavailable data, the results might lead to less accurate results than if 2022 was available as well. I expect this to be the case for the variables connected to the pandemic, but also for the general independent variables.

To get as many observations as possible in my regression, I have included 214 different countries whereas 195 of the countries are official sovereign states, and the remaining 19 countries are country-like territories. Country-like territories have a varied degree of self-governance, and these are usually, in some level, administered by a larger sovereign state (Thorup, 2023).

To measure the effect of Covid-19 on the GDP per capita growth, a Covid-19 variable must be included. The Covid-19 variable can either be numbers of infected, numbers of hospitalized, or number of deaths. Several countries lack data for hospitalized so it would not be the best alternative as it would limit the data points even more.

Death rate is also suboptimal as it possibly may have either a positive or a negative effect of GDP per capita growth. It might be negative because of costs and losses regarding the death rate, but it might also be positive because the GDP per capita growth would be divided over a smaller population. This would lead to unnecessary uncertainties when reading of the results.

Another important factor on this choice is the amount of dark numbers (missing data/values), due to lack of registration. Using numbers of infected might be more biased than the other options because the process of taking a test might be more difficult in some countries as test stations might be less accessible, the culture doesn't front the importance of testing, or a high fraction of young people in the population have little to no symptoms etc.

Using "hospitalized" will give fever data points, but the registered numbers will be less uncertain and biased by dark numbers. Dark numbers will be lower as infected in need of medical care have to seek help, while infected could decide to stay at home instead. The rate of covid-19 related deaths might also lead to a biased result as a lot of countries inaccurately reported covid-19 as the cause of death for cases where cause of death was something else, if they were infected at the time of death. Cause of death is based on the judgment of the coroners and wrongly examined bodies might lead to bias due to human error (Office of national statistics, 2021). Some examinations were less obvious, for example if a terminally ill cancer patient dies with covid, should this be registered as a covid-death or a cancer-death? Wrong decisions in such cases would also lead to a bias (Boyle, 2021). The death rate might reduce the uncertainties regarding dark numbers as reason of death must be registered, but it might be biased because of overestimation instead.

There are pros and cons for using all the variables, but in my thesis, I will use infected per million. Per million is more useful than actual numbers as it is generalized and more comparable than direct numbers. A regression based on infected per million will have some bias from dark numbers, but at the same time have less uncertainties than the other alternatives.

I will also add a variable covering the degree of lockdown using a stringency index. This variable is given a value from 0 to 100 describing the degree of lockdown in the country, where a high stringency index implemented strict measures. The stringency index consists of school and workplace closures, cancellations and restrictions at public events, closures of public transportations and controls on international travel, requirements to stay at home and different information campaigns (Hale, 2022).

To investigate the uneven effect of Covid-19 and lockdowns in high- and low-income countries, I will add an interaction variable. The interaction variable consists of either infected per million or lockdown, and the variables discussed as drives of the unequal impact. This will present the additional effect of infected and lockdown in the different country types.

Based on earlier discussion, the regression will have the following form:

$$GDP\ per\ capita\ growth_{it}$$
$$= \beta_0 + \beta_1 lnPopulation + \beta_2\ Investments/GDP_{it}$$
$$+ \beta_3 Consumption_{it} + \beta_4 Rate\ of\ internet\ users_{it}$$
$$+ \beta_5 Lockdown_{it} + \beta_6\ Unemployment_{it}$$
$$+ \beta_7 GDP\ per\ capita, constant\ 2017\$$
$$+ \beta_8\ Access\ to\ vaccine_{it} + \beta_9\ Infected\ per\ million_{it}$$
$$+ \beta_{10}\ HDI$$
$$+ \beta_{11}\ Interaction\ term\ ((Infected\ per\ million\ or\ lockdown)$$
$$* Variable\ in\ focus_{it})$$

To investigate the difference in effect, I will run regressions with focus on the independent variables typically separating low-income from high-income countries discussed earlier in the thesis and their effect on the dependent variable "GDP per capita growth". GDP per capita growth as a dependent variable is useful as it gives a relative effect of the independent variables in percentage, rather than a specific change in value, and the value is relative to the countries´ populations. This is easier comparable for high- and low-income countries.

The independent variables will be added separately in the regression, but they will also be expressed as the "Variable in focus" and be multiplied with either the number of infected per million or lockdown.
This will, as mentioned, work as an interaction variable describing the additional and conditional effect of the variables either on infected per million, or lockdown. This will make it possible to determine how well high- and low-income countries handled a higher number of infected, and how well they handle costly measures as the lockdown.

The effect of infected per million and lockdown equals the derivative of the regression, with respect to either infected per million or lockdown:

$$dGDP\ per\ capita\ growth\ /_{dInfected\ or\ dLockdown} = \beta_{Infected\ or\ Lockdown} + \beta_{Interaction} * Variable\ in\ focus$$

By look at this function, it's clear that the variables in focus, does affect how well the GDP per capita growth is maintained under different numbers of infected, and different degrees of lockdown.

I will start by using the rate of internet users, consumption, unemployment, and access to vaccines. In addition to investigating the commonly discussed factors, I will also use Human Development Index as a "Variable in focus" to investigate the general different effect on highly and lowly developed countries.

Population, Investments, Consumption, Unemployment and GDP per capita using constant 2017 dollars is added to cover some of the general effects on GDP per capita growth to get more accurate results.

When running the regressions on the different independent variables, some of the basic independent variables such as unemployment and investments will have a lower statistical significance than usual. This because these variables have a long-term effect and need to include more periods to capture the entire effect and increase the significance.

General regression

Before adding all the different variables specifically added to determine the effect of Covid-19, it is useful to run one general regression including only a few of the explaining variables to investigate general effect and significance. The top left variable is the dependent variable, the other variables on the left are the independent variables. The column β explains the economic effect of each independent variable, and the standard error is given in parenthesis. The column "p-value" indicates the statistical significance of each variable. The stars indicate the usual levels of significance, 99% (***), 95% (**) and 90% (*). The actual p-value is given in square brackets.

Table 1: general regression

GDP per capita growth	β	p-value
ln Population	0,4929318	** [0,037]
	(0,2365108)	
ln GDP per capita constant 2017 dollars	-0,75094	***[0,000]
	(0,4812714)	
Investments	0,0246	-- [0,699]
	(0,0635729)	
Consumption as % of GDP	-0,05723	* [0,061]
	(0,0305063)	
Unemployment	0,0365019	-- [0,626]
	(0,0747959)	
Access to vaccines	-0,1006708	*** [0,000]
	(0,0283591)	
Level of lockdown	0,0620656	*** [0,000]
	(0,0068976)	
Infected per million	0,0000293	** [0,022]
	(0,0000127)	
_cons	12,35762	-- [0,101]
	(7,542743)	
Standard errors in parenthesis		
*** p<0,1, ** p<0,05, * p<0,01		
R^2: Within = 0,4991, Between = 0,1273, Overall = 0,3946		
Number of: Observations = 280, Groups = 145		
Sigma_u = 0,6583709, Sigma_e = 4,8240398 rho = 0,01822868		

The general regression (table 1) gives significant results on population, GDP per capita, consumption, access to vaccines, level of lockdown and infected per million. Investments, consumption, and unemployment are expected to be significant, but they require more periods to be gain a significant effect.

This is because a current change in these variables will affect GDP per capita growth several periods forward.
The results further imply, with statistical significance, that large countries have a higher GDP per capita growth, while richer countries have lower GDP per capita growth, as expected from the results in figure 1 and 2.

It also suggests that high access to vaccines is negative for GDP per capita growth, and that lockdown and number of infected increase GDP per capita growth, all three results are unexpected. Vaccinating the population might be negative as it was costly to both obtain and set vaccines, and it was costly to develop the vaccines. The level of lockdown might be positive as it reduces cost regarding medical care, and number of infected might be positive as it leads to population immunity and less infections at later periods.

With 214 countries and country-like territories, included in the data set, only 145 were used due to lack of data for some of the variables. The values would have been more accurate if all areas had proper data coverage and had been included.

Hausman Test

To get more accurate results, it is possible to control the variables for either fixed effects or random effects. Fixed effects mean that there is a fixed relationship between the dependent and the independent variables in all groups. Random effects on the other hand suggests that there are different effects from the independent variables on the dependent variables between the groups. Whether the model should be based on fixed or random effects can be determined by initiating a Hausman test in Stata.
The test gives the following results:

Table 2: Hausman test

	(b)	**(B)**	**(b-B)**	**√(diag(V_bV_B))**
	Fixed	Random	Difference	Std. Err.
ln Population	78,53567	0,4929318	78,04274	56,75195
ln GDP per capita 2017 $	176,5261	-1,75094	178,2771	20,16499
Investments	0,0122732	0,0246	-0,0123268	0,1938667
Consumption as % of GDP	0,1672252	-0,05723	0,2244553	0,1312246
Unemployment	-0,7465625	0,0365019	-0,7830645	0,8836166
Acccess to vaccines	-0,0569979	-0,16708	0,0436729	0,0615337
Level of lockdown	0,0041639	0,0620656	-0,0579017	0,0098313
Infected per million	3,93E-06	0,0000293	-0,0000253	0,0000187
b = Consistent under H0 and Ha; obtained from xtreg				
B = Inconsistent under Ha, efficient under H0; obtained from xtreg				
Test of H0: Difference in coefficients not systematic				
chi2(7) = (b-B)'[(V_b-V_B)^(-1)](b-B) = 108,11				
Prob > chi2 = 0,0000				

By using the Hausman test in STATA, we test the null hypothesis that the coefficient isn't systematic (not fixed). As the p-value is 0, we fail to reject the hypothesis that the variables aren't systematic. In other words, the Hausman test suggest controlling for fixed effects rather than random effects.

This is the expected result as the thesis discuss the different effects of covid-19 from different types of countries. Different types of countries have a different initial value in the dependent variable, and other differently affecting preconditions.
Using fixed regressions will exclude country specific effects from the variables and give a more specific value for the variables alone.

In this case however, using random effects might be more interesting as we want to examine how the variables have affected countries differently. I will therefore start by examining the regression controls for random effects, which allows different values in the different country types, and then analyze the regressions controlling for fixed effect later.

Controlling for heteroskedasticity

One of the assumptions for running an OLS regression is homoscedasticity, in other words no heteroskedasticity. Homoscedasticity means that the variance of the error terms should be equal for all observations. Controls for heteroskedasticity must be used as the error terms will be unequally scattered between the different countries in such a large data set. The inequalities are due to a different level of variance in the data sets which can be explained by systematic differences in the countries. For example, different income levels will affect the variance regarding how different countries will react to certain affecting factors or shocks.

Regressions controlling for random effects.

New general regression

Adding the terms correcting for random effects and heteroskedasticity gives the following results:

Table 3: General regression controlling for random effects.

GDP per capita growth	**β**	**p-value**
ln Population	0,4929318	** [0,015]
	(0,2027838)	
ln GDP per capita constant 2017 dollars	-0,75094	*** [0,002]
	(0,5689306)	
Investments	0,0246	-- [0,766]
	(0,082601)	
Consumption as % of GDP	-0,05723	-- [0,199]
	(0,0445593)	
Unemployment	0,0365019	-- [0,550]
	(0,0610739)	
Access to vaccines	-0,1006708	*** [0,000]
	(0,0066034)	
Level of lockdown	0,0620656	*** [0,000]
	(0,026186)	
Infected per million	0,0000293	*** [0,001]
	(0,0000114)	
_cons	12,35762	-- [0,221]
	(10,0966)	
Standard errors in parenthesis		
*** p<0,1, ** p<0,05, * p<0,01		
R^2: Within = 0,4991, Between = 0,1273, Overall = 0,3946		
Number of: Observations = 280, Groups = 145		
Sigma_u = 0,6583709, Sigma_e = 4,8240398 rho = 0,01822868		

Controlling for heteroskedasticity and random effects in table 3 improves the statistical significance for several of the independent variables but decreases significance of consumption.

Internet

Internet and Covid-19

Internet have a negative effect on GDP per capita growth of -0,02% for an increase of 1% in internet users (insignificant), and the number of infected per million increases GDP per capita growth by 0,0003587% (***). When combining internet penetration rate and infected per million, the effect of the interaction term is -3,97*e^-6 statistically significant at 99%.

Results shown in the following table:

Table 4: Results using Infected per million * Internet, RE

GDP per capita growth	**β**	**p-value**
ln Population	0,2233719	-- [0,559]
	(0,3820205)	
ln GDP per capita constant 2017 dollars	1,955111	-- [0,288]
	(1,841339)	
Investments	0,0466514	-- [0,708]
	(0,1243952)	
Consumption as % of GDP	-0,0772326	-- [0,358]
	(0,084041)	
Unemployment	-0,2788142	*** [0,001]
	(0,0838593)	
Internet penetration rate	-0,0200615	-- [0,704]
	(0,0528136)	
Access to vaccines	0,590424	*** [0,000]
	(0,0075959)	
Level of lockdown	-0,1582093	*** [0,000]
	(0,0393965)	
Infected per million	0,0003587	*** [0,002]
	(0,0001163)	
HDI	-20,49189	* [0,053]
	(10,56893)	
Infected per million * Internet	-0,00000397	*** [0,002]
	(-0,00000128)	
_cons	4,616114	-- [0,837]
	(22,42527)	
Standard errors in parenthesis		
*** p<0,1, ** p<0,05, * p<0,01		
R^2: Within = 0,7949, Between = 0,3464, Overall = 0,5273		
Number of: Observations = 179, Groups = 124		
Sigma_u = 4,3448535, Sigma_e = 2,266794 rho = 0,78604546		

This means that keeping a constant number of infected, an increase in internet users would lead to a more negative effect on the GDP per capita growth. High-income countries with high internet penetration rate should therefore be worse off than low-income countries with low internet penetration rate keeping numbers of infected constant. This rejects the hypothesis that internet was useful to keep a steady GDP per capita growth during the pandemic, and rather suggest the opposite.

A high internet penetration rate is common in high-income countries, and a high internet penetration is therefore related to a high GDP per capita (figure 13). The effect is negative in this regression implying that countries with high internet penetration rate should be worse of by the Covid-19 pandemic. The result might possibly be because the regression is based on GDP per capita growth and not GDP per capita. The negative sign might be because of costs connected to research and development for increasing internet penetration rate, or because of the general falling trend of GDP per capita growth in high-income countries. With an already high internet penetration rate, the marginal costs of increasing the users by 1% might be higher than the economic gain from the increase. Marginal costs might, for example, be connected to constructing necessary infrastructure to reach the new users. These costs would assumingly be more expensive than the contribution of that 1% of new users to the GDP per capita growth.

Another possible explanation for the negative effect of increasing internet penetration rate might be that other factors relating to high- and low-income countries is expressed instead. High-income countries might appear to be affected more negatively than low-income countries because the virus initially spread from China to Europe, and then to the low-income countries after.

As the infection rate started to increase in high-income countries before low-income countries, measures as the lockdown would have been initiated earlier and more often in high-income countries.

Also, high-income countries, for example Italy, have larger fractions of elderlies in the population, which can lead to higher cost connected to infections due to higher medical aid spending. The life expectancy in low-income countries were 61,6 years compared to 78,8 years in high-income countries in 2021 (The World Bank, 2021). Covid-19 affected the population older than 60 years the hardest (WHO, u.d.). A larger fraction of elderlies above 60 years might therefore lead to more costs.
Countries with lower internet penetration rate are often found in developing low-income countries, and low-income countries initially have a higher GDP per capita growth trend than industrialized high-income countries. This might be a factor affecting the regression and penalizing higher internet penetration rate.

Internet and lockdown

The hypothesis that internet penetration rate and the ability to work from home helped to maintain economic growth in high-income countries, more than low-income countries can be examined by running a regression with the interaction term Lockdown*Internet. In this regression lockdown have a negative effect on GDP per capita growth of -0,084% (insignificant) and internet have a positive effect of 0,064% (insignificant). The negative sign of lockdown might be due to the high costs related to the restrictions. The interaction term of lockdown*internet gives a negative effect of -0,0014%. The results are however not statistically significant, so we can't determine with certainty that the effect is different from zero.

Results shown in the following table:

Table 5: Results using Lockdown * Internet, RE

GDP per capita growth	**β**	**p-value**
ln Population	0,3633543	-- [0,343]
	(0,3830021)	
ln GDP per capita constant 2017 dollars	1,986701	-- [0,251]
	(1,731863)	
Investments	0,0775891	-- [0,527]
	(0,1227473)	
Consumption as % of GDP	-0,0386654	-- [0,636]
	(0,0815876)	
Unemployment	-0,2054509	** [0,011]
	(0,080593)	
Internet penetration rate	0,0647435	-- [0,553]
	(0,1090901)	
Access to vaccines	0,053745	*** [0,000]
	(0,0080772)	
Level of lockdown	-0,0849745	-- [0,307]
	(0,0831906)	
Infected per million	0,0000191	-- [0,257]
	(0,0000168)	
HDI	-33,05373	** [0,046]
	(11,0316)	
Lockdown * Internet	-0,0013658	-- [0,293]
	(0,0012983)	
_cons	-4,79128	-- [0,832]
	(22,59376)	
Standard errors in parenthesis		
*** p<0,1, ** p<0,05, * p<0,01		
R^2: Within = 0,7949, Between = 0,3464, Overall = 0,5273		
Number of: Observations = 179, Groups = 124		
Sigma_u = 4,3448535, Sigma_e = 2,266794 rho = 0,78604546		

The interaction term implies that the hypothesis of being able to work from home wasn't a contributor to maintain GDP per capita growth. As the interaction term isn't statistically significant, my hypothesis can't be rejected. The negative effect is however possibly because the lockdown was a costly measure, and that the benefits of being able to work from didn't neutralize the cost of several lockdowns.

Lockdown was more expensive in countries with high internet penetration rate than in countries with low internet penetration rate, as they were able to initiate it more often, and to a higher degree. The results might also express some of the general differences in high- and low-income countries as discussed under "Internet and Covid-19".

Consumption

Consumption and Covid-19

By using the household expenditure (% of GDP), an increase of 1% in consumption leads to a decrease of -0.12% on GDP per capita growth (insignificant), and an increase of infected per million gives an effect of -0,00015% (***). Combining these variables gives a decrease of - 2,9*e^-6% per infected and percentage of consumption. This means that, holding numbers of infected constant, a higher consumption rate leads to a worse effect of the pandemic. These findings are statistically significant at 99%, meaning the results are reliable.

Results shown in the following table:

Table 6: Results using Infected per million * Consumption, RE

GDP per capita growth	β	p-value
ln Population	0,1966021	-- [0,606]
	(0,3811939)	
ln GDP per capita constant 2017 dollars	1,951089	-- [0,246]
	(1,747959)	
Investments	0,0359563	-- [0,774]
	(0,1249647)	
Consumption as % of GDP	-0,1205998	-- [0,172]
	(0,0883838)	
Unemployment	-0,2730153	*** [0,001]
	(0,0841737)	
Internet penetration rate	-0,0377928	-- [0,419]
	(0,0467503)	
Access to vaccines	0,0604731	*** [0,000]
	(0,0072805)	
Level of lockdown	-0,1417814	*** [0,000]
	(0,0355987)	
Infected per million	-0,0001514	*** [0,000]
	(0,0000401)	
HDI	-20,0684	-- [0,760]
	(11,31988)	
Infected per million * Consumption	-0,0000029	*** [0,000]
	(-0,000000576)	
_cons	8,117397	-- [0,710]
	(21,84808)	
Standard errors in parenthesis		
*** p<0,1, ** p<0,05, * p<0,01		
R^2: Within = 0,8205, Between = 0,3763, Overall = 0,5675		
Number of: Observations = 179, Groups = 124		
Sigma_u = 4,2607562, Sigma_e = 2,2395481 rho = 0,78352792		

A higher expenditure rate means that a large part of the income goes to consumption. A high rate is typical in low-income countries, and the consumption typically goes towards necessities rather than unnecessary goods. In such countries, making a shift from unnecessary goods to savings would be difficult, as fractions of the population already spend the entire income on necessities. In addition, the high rate of consumption might become even higher as they are unable to shift away from unnecessary goods, and at the same time must spend extra on medical aid.
This confirms my hypothesis that countries with a high consumption expenditure rate will be worse off than countries with lower consumption expenditure rate.

Consumption and lockdown

Combining consumption with lockdown instead of numbers of infected gives the separate effects of 0,090% on consumption (insignificant), and -0,039 at lockdown (insignificant), and a combined effect of -0,001994%. This would mean that countries consuming a larger fraction of their GDP was affected harder by initializing restrictive measures. This result however lacks statistical significance and is therefore unreliable. We cannot with certainty know whether the effect is different from zero or not, so the results do not reject my hypothesis.

Results shown in the following table:

Table 7: Results using Lockdown * Consumption, RE

GDP per capita growth	β	p-value
ln Population	0,312011	-- [0,402]
	(0,3725797)	
ln GDP per capita constant 2017 dollars	2,444489	-- [0,186]
	(1,8447192)	
Investments	0,0925395	-- [0,477]
	(0,1300558)	
Consumption as % of GDP	0,0907328	-- [0,698]
	(0,23343484)	
Unemployment	-0,2095042	*** [0,009]
	(0,0796565)	
Internet penetration rate	-0,0272945	-- [0,581]
	(0,0494722)	
Access to vaccines	0,0547389	*** [0,000]
	(0,0078411)	
Level of lockdown	-0,0390262	-- [0,843]
	(0,1974979)	
Infected per million	0,0000187	-- [0,253]
	(0,0000164)	
HDI	-22,00031	** [0,047]
	(11,08069)	
Lockdown * Consumption	-0,001994	-- [0,507]
	(0,003008)	
_cons	-11,24603	-- [0,699]
	(29,03996)	
Standard errors in parenthesis		
*** p<0,1, ** p<0,05, * p<0,01		
R^2: Within = 0,7951, Between = 0,3401, Overall = 0,5291		
Number of: Observations = 179, Groups = 124		
Sigma_u = 4,3552651, Sigma_e = 2,2669416 rho = 0,07868276		

The Covid-19 pandemic which limited social contact, and limited the possibility of physical workplaces affects countries with a higher consumption rate more as the consumers will have less saved up for periods of restrictions without income. Also, a high level of informality in the working sectors limits governmental support to some workers forcing them to change their consumption behavior.

Unemployment

Unemployment and Covid-19

Unemployment of total labor force does affect GDP in the long run but is not statistically significantly in the short run. The hypothesis that high level of informal workers has given a harder effect on low-income countries is difficult to test as data covering enough countries is difficult to find, but it is possible to examine general unemployment of total labor force participation to find the importance of labor. The unemployed is defined as workers searching for work, and informal workers are kept out of the equation (The World Bank, u.d.). Both higher unemployment in a country and a higher number of infected in general has a negative effect on GDP, where a 1% increase in unemployment leads to a negative effect of -0.323% on GDP per capita growth (***) and the infected per million gives a decrease of -0,00003 (insignificant). Combining these gives a negative interaction term of -6,35*e^-6% with statical significance at 95%.

Results shown in the following table:

Table 8: Results using Infected per million * Unemployment, RE

GDP per capita growth	**β**	**p-value**
ln Population	0,2631935	-- [0,494]
	(0,3851229)	
ln GDP per capita constant 2017 dollars	2,407445	-- [0,192]
	(1,844452)	
Investments	0,0715184	-- [0,570]
	(0,1258403)	
Consumption as % of GDP	-0,0559651	-- [0,501]
	(0,0831939)	
Unemployment	-0,3230589	*** [0,001]
	(0,0959431)	
Internet penetration rate	-0,0221759	-- [0,653]
	(0,0492799)	
Access to vaccines	0,0564065	*** [0,000]
	(0,007326)	
Level of lockdown	-0,1551558	*** [0,000]
	(0,0357584)	
Infected per million	-0,0000307	-- [0,181]
	(0,000023)	
HDI	-23,84747	** [0,037]
	(11,41739)	
Infected per million * Unemployment	-0,00000635	** [0,012]
	(-0,00000153)	
_cons	0,8333836	-- [0,970]
	(22,07811)	
Standard errors in parenthesis		
*** p<0,1, ** p<0,05, * p<0,01		
R^2: Within = 0,8061, Between = 0,3554, Overall = 0,5472		
Number of: Observations = 179, Groups = 124		
Sigma_u = 4,3157199, Sigma_e = 2,2669304 rho = 0,7875339		

High unemployment was affecting GDP per capita growth negatively as it was costly for the government through subsidies, and it slows down consumption because of uncertainty around the consumers income. Workers with a secure income will still be able to consume due to consumption smoothing, but this will be harder for consumers with already unsecure income.
The reason why countries with high unemployment was affected worse than countries with low unemployment combined with infected, might be that the unemployed also will depend on governmental support in terms of medical care.
As the results are statistically significant, it confirms my hypothesis that a high rate of unemployment led a harder impact of the pandemic.

Unemployment and lockdown

The fraction of unemployed interacted with the lockdown variable gives a statistically significant effect of -0,022%. The separate values changed to 1,16% for unemployment (*), and -0,02% for lockdown (insignificant). The interaction term implies that countries with a high fraction of unemployed potential workers was struck harder by lockdowns than countries with a lower rate of unemployment. Also, statistically significant at 95%.

Results shown in the following table:

Table 9: Results using Lockdown * Unemployment, RE

GDP per capita growth	β	p-value
ln Population	0,3541282	-- [0,327]
	(0,3611902)	
ln GDP per capita constant 2017 dollars	1,380678	-- [0,458]
	(1,861514)	
Investments	0,0505118	-- [0,687]
	(0,1253296)	
Consumption as % of GDP	-0,0522454	-- [0,532]
	(0,0836327)	
Unemployment	1,162013	* [0,075]
	(0,0824103)	
Internet penetration rate	-0,0249884	-- [0,616]
	(0,049881)	
Access to vaccines	0,0540652	*** [0,000]
	(0,0077482)	
Level of lockdown	-0,0240644	-- [0,706]
	(0,0638024)	
Infected per million	0,0000179	-- [0,263]
	(0,000016)	
HDI	-16,49875	-- [0,150]
	(11,4615)	
Lockdown * Unemployment	-0,0222618	** [0,041]
	(0,108687)	
_cons	-4,562403	-- [0,831]
	(21,36607)	
Standard errors in parenthesis		
*** p<0,1, ** p<0,05, * p<0,01		
R^2: Within = 0,7975, Between = 0,3737, Overall = 0,5476		
Number of: Observations = 179, Groups = 124		
Sigma_u = 4,2352232, Sigma_e = 2,2635013 rho = 0,77782674		

A high share of unemployment will be worse in periods of lockdown as layoffs and leave of absences increases the number of unemployed. The demand side of labor decrease, while the supply side of labor increase.

Lockdown was therefore more costly in countries with high unemployment as an increase in already high unemployment would make it more difficult to reenter the labor market, leading to higher cost connected to subsides for unemployed. Also, with a higher competition in the labor market workers might fall out of the labor force as their skills become outdated, and lead to a longer cost for the government. As the results are statistically significant, it confirms my hypothesis that unemployment gave a harder impact of the pandemic.

Vaccination

Vaccinations and Covid-19

Using vaccines per hundred, we get a positive effect of 0.057% for an increase of 1 per hundred (***), and a positive effect of numbers of infected of 0,0000287% (insignificant). The interaction term combining the effect of vaccinations and infected suggests an effect on GDP of -7,35*e^-8. This means that, keeping a constant number of infected per million, a higher rate of vaccinations will contribute negatively to GDP. The result is however not reliable as it isn't statistically significant, and we can't be certain that the effect is different from zero.

Results shown in the following table:

Table 10: Results using Infected per million * Access to vaccines, RE

GDP per capita growth	β	p-value
ln Population	0,3529045	-- [0,350]
	(0,3775345)	
ln GDP per capita constant 2017 dollars	2,287959	-- [0,204]
	(1,801795)	
Investments	0,0942133	-- [0,463]
	(0,1283829)	
Consumption as % of GDP	-0,0331002	-- [0,690]
	(0,0829022)	
Unemployment	-0,201875	** [0,014]
	(0,0824103)	
Internet penetration rate	-0,0299123	-- [0,571]
	(0,0527731)	
Access to vaccines	0,0572323	*** [0,000]
	(0,0107863)	
Level of lockdown	-0,1657505	*** [0,000]
	(0,0395325)	
Infected per million	0,0000287	-- [0,314]
	(0,0000285)	
HDI	-21,68081	* [0,056]
	(11,32537)	
Infected per million* Access to vaccines	-7,35E-08	-- [0,673]
	(-0,000000174)	
_cons	-2,990091	-- [0,892]
	(21,99648)	
Standard errors in parenthesis		
*** p<0,1, ** p<0,05, * p<0,01		
R^2: Within = 0,7931, Between = 0,3452, Overall = 0,5311		
Number of: Observations = 179, Groups = 124		
Sigma_u = 4,345529, Sigma_e = 2,2664987 rho = 0,7861661		

The interaction term might be negative because a high infection rate, and a high vaccination rate would mean that the vaccines didn't work. In that situation, countries have had a large cost from buying vaccines and, for some countries, a large cost in research and development for the vaccines without achieving immunity and stopping the infections. The results are however, as mentioned, not significant, so it does not reject my hypothesis.

Vaccinations and lockdown

Investigating the effect of the interaction between access to vaccines and lockdown instead gives the separate values of 0,0026% (insignificant) and -0,19% (***).

The combined effect of vaccinations and degree of lockdown is 0,005877%, meaning a high level of vaccinations with a constant level of lockdown would have a positive effect in GDP per capita growth. The results lack reliability as it isn't statistically significant at any of the usual levels, but with a p-value of 0,111, it is very close to be significant at a 90% significance level.

Results shown in the following table:

Table 11: Results using Lockdown * Access to vaccines, RE

GDP per capita growth	**β**	**p-value**
ln Population	0,3104688	-- [0,409]
	(0,3762937)	
ln GDP per capita constant 2017 dollars	2,622661	-- [0,152]
	(1,828594)	
Investments	0,0891423	-- [0,482]
	(0,1267812)	
Consumption as % of GDP	-0,0244065	-- [0,766]
	(0,0820895)	
Unemployment	-0,1912289	** [0,019]
	(0,0818628)	
Internet penetration rate	-0,040486	-- [0,432]
	(0,0515341)	
Access to vaccines	0,0026248	-- [0,933]
	(0,0311554)	
Level of lockdown	-0,1902942	*** [0,000]
	(0,0434644)	
Infected per million	0,0000237	-- [0,153]
	(0,0000166)	
HDI	-21,444	* [0,058]
	(11,29039)	
Lockdown * Access to vaccines	0,000898	-- [0,111]
	(0,0005642)	
_cons	-3,869547	-- [0,860]
	(22,00694)	
Standard errors in parenthesis		
*** p<0,1, ** p<0,05, * p<0,01		
R^2: Within = 0,8048, Between = 0,3454, Overall = 0,537		
Number of: Observations = 179, Groups = 124		
Sigma_u = 4,3504373, Sigma_e = 2,2490912 rho = 0,78909856		

One of the reasons discussed for why low-income countries have been affected more than high-income countries is that they had implemented a lot of lockdowns, while having a low vaccination rate. Being able to vaccinate during a lockdown was seen as one of the requirements for an efficient lockdown. Inefficient lockdowns lead to new spikes right after exiting the lockdown.
The positive result on the interaction term support this as a cause, as a higher vaccination rate combined with a higher stringency index gives a higher positive effect on GDP per capita growth. In other words, lockdown is more effective in countries with better access to vaccines. The results are not entirely statistically significant, so it can't be used to confirm my hypothesis with certainty.

Human Development Indicator

Human Development Indicator (HDI) measures the degree of development within a country. It is based on life expectancy, years of schooling, and the gross national income (GNI) per capita, assigned a value between 0 and 1, where a high level implies high development. In general, the effect of HDI on GDP per capita is concave, and the trend line should flatten out just below 1. This means that a decrease from a high value of GDP to a lower value will differ from the effect of an initially low GDP value to an even lower.

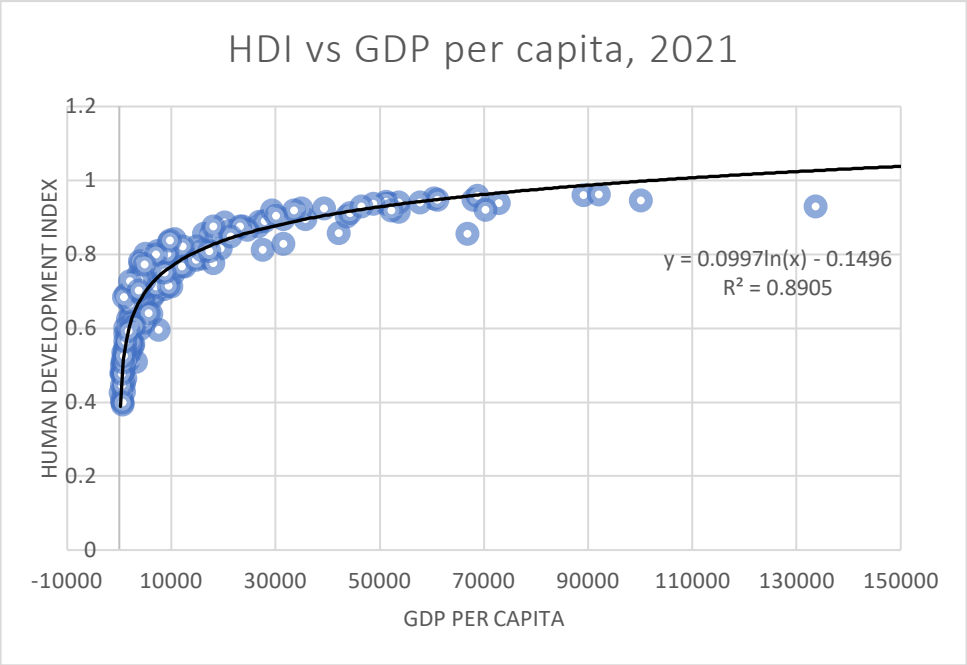

Figure 1 - Relationship between HDI and GDP in 2021, (UNDP, 2022), (The World Bank, 2021)

Testing the effect of the interaction terms of HDI, and Covid-19 and lockdown will give a more general indication of the general effect on the high-income countries (developed, high value of HDI) and the low-income countries (developing, low value of HDI).

Human Development Indicator and Covid-19

HDI initially get a value of -20,26% (*), and infected per million get a value of 0,0000836% (insignificant). The general term for HDI is significant at 90%, meaning level of development affects GPD per capita growth. The combined interaction term of HDI and infected per million get a value of -0.0000777% change in GDP per capita growth. The results are however not statistically significant, so we can't determine with certainty that the effect is different from zero.

Results shown in the following table:

Table 12: Results using Infected per million * HDI, RE

GDP per capita growth	β	p-value
ln Population	0,3283077	-- [0,402]
	(0,3921453)	
ln GDP per capita constant 2017 dollars	2,451809	-- [0,168]
	(1,777411)	
Investments	0,0863958	-- [0,496]
	(0,1267611)	
Consumption as % of GDP	-0,0330947	-- [0,692]
	(0,083564)	
Unemployment	-0,2088761	** [0,012]
	(0,0835194)	
Internet penetration rate	-0,0383077	-- [0,479]
	(0,0541544)	
Access to vaccines	0,558986	*** [0,000]
	(0,0079436)	
Level of lockdown	-0,164449	*** [0,000]
	(0,0395061)	
Infected per million	0,0000836	-- [0,591]
	(0,0001557)	
HDI	-20,25815	* [0,089]
	(11,90809)	
Infected per million * HDI	-0,0000777	-- [0,663]
	(0,000178)	
_cons	-4,299345	-- [0,841]
	(21,44821)	
Standard errors in parenthesis		
*** p<0,1, ** p<0,05, * p<0,01		
R^2: Within = 0,7923, Between = 0,3488, Overall = 0,5326		
Number of: Observations = 179, Groups = 124		
Sigma_u = 4,3185809, Sigma_e = 2,2666366 rho = 0,78402183		

The results imply that highly developed countries were affected harder by high numbers of infected. Reasons for this might be as mentioned earlier, a lot of elderly in the high-income countries, the travel path of the virus, level of subsidies etc. The results are however not statistically significant, and thereby not reliable.

Human Development Indicator and lockdown

Changing the interaction term to HDI and lockdown gives the separate values of -5,39% (insignificant) and 0,038% (insignificant), valuing the interaction term at -0,29% change in GDP per capita growth. This result isn't statistically significant either, but it does have low p-value of 0,219. Making it significant at almost 80% significance level. Due to the lower significance level, we can't determine with absolute certainty that the effect is different from zero, but an almost 80% significance level still makes an impression of the actual effect.

Results shown in the following table:

Table 13: Results using Lockdown * HDI, RE

GDP per capita growth	β	p-value
ln Population	0,3821463	-- [0,324]
	(0,3875532)	
ln GDP per capita constant 2017 dollars	2,026755	-- [0,251]
	(1,765439)	
Investments	0,0770102	-- [0,538]
	(0,1250249)	
Consumption as % of GDP	-0,0386996	-- [0,64]
	(0,0826502)	
Unemployment	-0,2030285	** [0,012]
	(0,0806494)	
Internet penetration rate	-0,01703	-- [0,741]
	(0,0516162)	
Access to vaccines	0,0534369	*** [0,000]
	(0,0080781)	
Level of lockdown	0,0380465	-- [0,814]
	(0,1619675)	
Infected per million	0,0000194	-- [0,248]
	(0,0000168)	
HDI	-5,293398	-- [0,742]
	(16,05246)	
Lockdown * HDI	-0,29055	-- [0,219]
	(0,23662)	
_cons	-12,40718	-- [0,611]
	(24,3856)	
Standard errors in parenthesis		
*** p<0,1, ** p<0,05, * p<0,01		
R^2: Within = 0,7959, Between = 0,3452, Overall = 0,5261		
Number of: Observations = 179, Groups = 124		
Sigma_u = 4,3446795, Sigma_e = 2,265856 rho = 0,78617421		

The results imply that countries with high development will be affected harder than countries with lower development regarding the level of lockdown. The reason why high-income countries are harder affected than low-income countries might be that they in addition to locking down the community supplies fiscal support. The results are however not statistically significant, and not reliable.

Summary of results, controlling for random effects

When adding all variables, including the interaction term, the sign of vaccinations and lockdown are switched for most of the regressions. It turned the effect of vaccinations positive, while the effect of lockdown was negative. Vaccinations might have led to a positive effect on GDP per capita growth as population immunity is reached, making it easier to keep workers employed. Lockdown might be negative if the costs connected are higher than the positive effects of restrictions.

In summation, only the interaction variables of infected per million and internet (99%), consumption (99%) and unemployment (95%) are statistically significant. The only lockdown interaction variable which was proven significant was lockdown and unemployment (95%).

Table 14: Summary of results, RE

Summary of Interaction Values	β	p-value
Infected per million * Internet	-0,00000397	*** [0,002]
	(-0,00000128)	
Lockdown * Internet	-0,0013658	-- [0,293]
	(0,0012983)	
Infected per million * Consumption	-0,0000029	*** [0,000]
	(-0,000000576)	
Lockdown * Consumption	-0,001994	-- [0,507]
	(0,003008)	
Infected per million * Unemployment	-0,00000635	** [0,012]
	(-0,00000153)	
Lockdown * Unemployment	-0,0222618	** [0,041]
	(0,108687)	
Infected per million* Access to vaccines	-7,35E-08	-- [0,673]
	(-0,000000174)	
Lockdown * Access to vaccines	0,000898	-- [0,111]
	(0,0005642)	
Infected per million * HDI	-0,0000777	-- [0,663]
	(0,000178)	
Lockdown * HDI	-0,29055	-- [0,219]
	(0,23662)	

To illustrate the difference in effect of Covid and lockdown, it would be useful to set up a table with calculations of the different interaction terms. This is done by first determining a standard number for infected and a standard number for degree of lockdown. Many countries had a value of 100 infected per million at some point during the pandemic, and a degree of lockdown at approximately 40 was common, so these values will be good indicators to use in the calculations. This should be multiplied with the average value of the other independent variables in the different country types.

To get the entire effect of the interaction term, this will also be multiplied by the beta (effect) of the interaction term. By doing this we calculate the additional effect of the numbers of infected, and the degree of lockdown in each country type. Although the process of the calculation is inaccurate, it helps to visualize which variables contributes to the unequal effect on high- and low-income countries.

Low- and high-income countries is, as mentioned earlier, defined through The World Bank by the GNI per capita index. In 2018, the threshold for being classified as a low-income country is below $1026, and high-income is defined as having a GNI per capita above $12375. (Prydz & Wadhwa, 2019).

The calculations give the following results for high-income countries:

Table 15: Calculating effects in high-income countries, RE

	Infected per million			
	Interaction	Avg. variable	Covid	Result
Internet	-0,00000245	78,00	100	-0,01911
Consumption	0,00000269	51,18	100	0,01376688
Unemployment	0,00000648	6,56	100	0,00425023
Vaccines	-0,000000147	85,62	100	-0,0012586
HDI	-0,0000446	0,89	100	-0,003956
	Lockdown			
	Interaction	Avg. variable	Lockdown	Result
Internet	-0,00132	78,00	40	-4,1184
Consumption	-0,00105	51,18	40	-2,149476
Unemployment	-0,0210198	6,56	40	-5,5147547
Vaccines	0,005877	85,62	40	20,1275496
HDI	-0,2615074	0,89	40	-9,2782826

The calculations give the following results for low-income countries:

Table 16: Calculating effects in low-income countries, RE

	Infected per million			
	Interaction	Avg. variable	Covid	Result
Internet	-0,00000245	10,00	100	-0,00245
Consumption	0,00000269	78,23	100	0,02104495
Unemployment	0,00000648	6,58	100	0,00426384
Vaccines	-0,000000147	21,02	100	-0,000309
HDI	-0,0000446	0,48	100	-0,0021319
	Lockdown			
	Interaction	Avg. variable	Lockdown	Result
Internet	-0,00132	10,00	40	-0,528
Consumption	-0,00105	78,23	40	-3,285828
Unemployment	-0,0210198	6,58	40	-5,5324114
Vaccines	0,005877	21,02	40	4,9413816
HDI	-0,2615074	0,48	40	-5,0000215

The interaction of Covid-19 and internet, access to vaccines, and HDI seems to affect high-income countries the hardest. The interaction of Covid-19 and consumption, and unemployment affects low-income countries the hardest.

In general, numbers of infected seem to affect high-income countries harder, possibly because of more cost connected to measures, support, and medical care.

The interaction of lockdown and internet, unemployment and HDI also seems to affect high-income countries the hardest. Low-income countries are affected hardest by the interaction variables of lockdown and consumption, and vaccinations. The large positive effect of the interaction between lockdown and vaccines creates a great divide between the two country types.

The effect of vaccinations increases GDP per capita growth with approximately 15 percentage points more in high-income countries than in low-income countries in combination with lockdown.

In general, lockdown seems to affect low-income countries harder than high-income countries, and it might be because the high-income countries handle a decrease in income better than low-income countries. The high-income countries initially have a better economic starting point. And the possibility of vaccinating the population during the lockdown increases the GDP per capita growth largely.

The value of R^2

Within: Approximately 0.8 for each regression.
This value describes the degree of explanation of the variance within each panel. In other words, how much of the variance within each country the regression explains. 0.8 is a relatively high value, meaning a lot of the variance is explained.

Between: Approximately 0.34 for each regression.
This value describes how much of the variance between each panel is described. 0.34 a relatively low number, meaning a small part of the variance is explained. However, this thesis mostly focuses on variables connected to Covid-19, and it is not surprising that there are more factors possible to include to describe more of the variance between the countries.

Overall: Approximately 0.53 for each regression.
This value describes the average of the other values, and describes the overall variance explained by the regressions. This is low, but expected as more factors than included contributes to difference within the panels.

Regressions controlling for fixed effects.

New general regression

When controlling for fixed effects and heteroskedasticity, the regressions give the following results:

Table 17: General regression controlling for fixed effects.

GDP per capita growth	**β**	**p-value**
ln Population	78,53567	* [0,086]
	(45,36963)	
ln GDP per capita constant 2017 dollars	176,5261	*** [0,000]
	(28,97373)	
Investments	0,0122732	-- [0,956]
	(0,2206916)	
Consumption as % of GDP	0,1672252	-- [0,330]
	(0,1711254)	
Unemployment	-0,7465625	-- [0,150]
	(0,5163679)	
Access to vaccines	-0,0569979	-- [0,381]
	(0,006567)	
Level of lockdown	0,0041639	-- [0,527]
	(0,0649247)	
Infected per million	0,00000393	-- [0,848]
	(0,0000204)	
_cons	-2951,817	** [0,002]
	(924,0157)	
Standard errors in parenthesis		
*** p<0,1, ** p<0,05, * p<0,01		
R^2: Within = 0,7802, Between = 0,0391, Overall = 0,011		
Number of: Observations = 280, Groups = 145		
Sigma_u = 229,27215, Sigma_e = 4,8240398 rho = 0,99955749		

Controlling for fixed effects decreased the statistical significance making only GDP per capita with constant 2017 dollars statistically significant. By controlling for fixed effects, the sign of the variables shifts, implying higher GDP per capita growth for richer countries.

This result is not as expected as the trend of GDP per capita growth has been decreasing for a longer period, while low-income countries have had an increasing trend. During the pandemic (2020-2021) however, GDP per capita growth rate were higher in high-income countries than in low-income countries.
Including more periods would have given a more accurate result. The value of the variables is also very high, which might be a consequence of the high fluctuations in GDP per capita growth during the pandemic when controlling for the fixed country-specific effects.

Internet

Internet and Covid-19

Adding the interaction term of infected per million and internet gives a statistically significant result for GDP per capita with constant 2017 dollars, investments, internet penetration rate, access to vaccines and HDI. The result implies that GDP per capita growth is highly affected by how rich and developed the countries are, a little affected by investments, access to vaccines and internet penetration rate. All statistically significant variables have a positive effect.

Results shown in the following table:

Table 18: Results using Infected per million * Internet, FE

GDP per capita growth	β	p-value
ln Population	-28,54966	-- [0,541]
	(46,57831)	
ln GDP per capita constant 2017 dollars	120,5697	*** [0,000]
	(17,74356)	
Investments	0,6174568	** [0,015]
	(0,2494572)	
Consumption as % of GDP	0,1798286	-- [0,361]
	(0,1960184)	
Unemployment	-0,9158991	-- [0,153]
	(0,637182)	
Internet penetration rate	0,1867099	*** [0,000]
	(0,0368609)	
Access to vaccines	0,0133737	* [0,091]
	(0,0078612)	
Level of lockdown	-0,0132719	-- [0,793]
	(0,0505026)	
Infected per million	0,0000514	-- [0,587]
	(0,0000945)	
HDI	211,7384	** [0,020]
	(89,80738)	
Infected per million * Internet	-4,39E-07	-- [0,687]
	(-0,00000109)	
_cons	-898,2475	-- [0,315]
	(890,3935)	
Standard errors in parenthesis		
*** p<0,1, ** p<0,05, * p<0,01		
R^2: Within = 0,9357, Between = 0,0141, Overall = 0,0176		
Number of: Observations = 179, Groups = 124		
Sigma_u = 188,79792 Sigma_e = 2,2644737 rho = 0,99985616		

The interaction term is not statistically significant. It would suggest that countries with higher internet penetration rate is worse off than countries with lower internet penetration rate. It implies that the hypothesis that working from home during a pandemic maintains GDP per capita growth, but as it is statistically insignificant, we can't be sure that effect is different from zero, so it doesn't reject my hypothesis.

Internet and lockdown

Using the interaction term of lockdown and internet penetration rate gives approximately the same results as infected per million and internet penetration rate. GDP per capita with constant 2017 dollars, investments, internet penetration rate, and HDI are statically significant with a positive effect, but access to vaccines lost it significance.

Results shown in the following table:

Table 19: Results using Lockdown * Internet, FE

GDP per capita growth	**β**	**p-value**
ln Population	-25,07	-- [0,638]
	(53,15629)	
ln GDP per capita constant 2017 dollars	123,8451	*** [0,000]
	(18,02503)	
Investments	0,6452482	*** [0,006]
	(0,2301085)	
Consumption as % of GDP	0,1858675	-- [0,379]
	(0,2106957)	
Unemployment	-0,8577855	-- [0,173]
	(0,6257263)	
Internet penetration rate	0,2003617	** [0,046]
	(0,0992372)	
Access to vaccines	0,0121024	-- [0,121]
	(0,0077432)	
Level of lockdown	0,002035	-- [0,985]
	(0,1081062)	
Infected per million	0,0000128	-- [0,249]
	(0,0000111)	
HDI	201,8402	** [0,016]
	(82,77241)	
Lockdown * Internet	-0,0001934	-- [0,895]
	(0,00146)	
_cons	-982,221	-- [0,332]
	(1009,21)	
Standard errors in parenthesis		
*** p<0,1, ** p<0,05, * p<0,01		
R^2: Within = 0,9356, Between = 0,0144, Overall = 0,0181		
Number of: Observations = 179, Groups = 124		
Sigma_u = 188,77672 Sigma_e = 2,266794, rho = 0,99985583		

The interaction term is also negative and unsignificant. It suggests that countries with high income countries with higher internet penetration rate is worse of during a lockdown, than low-income countries with a low internet penetration rate. The result doesn't reject my hypothesis either as the results are statistically insignificant, and we can't be certain that the effect is different from zero.

Consumption

Consumption and Covid-19

Adding the interaction term of infected per million and consumption rate gives similar results as the earlier regressions with GDP per capita 2017 dollars, investments, internet penetration rate, access to vaccines and HDI statistically significant, and positive.

Results shown in the following table:

Table 20: Results using Infected per million * Consumption, FE

GDP per capita growth	β	p-value
ln Population	-29,82127	-- [0,531]
	(47,51592)	
ln GDP per capita constant 2017 dollars	117,7207	*** [0,000]
	(18,70136)	
Investments	0,6254963	*** [0,006]
	(0,2217575)	
Consumption as % of GDP	0,1068958	-- [0,607]
	(0,2072374)	
Unemployment	-0,8449058	-- [0,178]
	(0,6232374)	
Internet penetration rate	0,177678	*** [0,000]
	(0,0353962)	
Access to vaccines	0,0155855	* [0,064]
	(0,0083245)	
Level of lockdown	-0,0085091	-- [0,864]
	(0,0497014)	
Infected per million	-0,000033	-- [0,313]
	(0,0000326)	
HDI	209,4775	** [0,013]
	(83,43606)	
Infected per million * Consumption	-7,84E-07	* [0,098]
	(-0,00000047)	
_cons	-843,8384	-- [0,354]
	(907,4089)	
Standard errors in parenthesis		
*** p<0,1, ** p<0,05, * p<0,01		
R^2: Within = 0,9372, Between = 0,014, Overall = 0,0175		
Number of: Observations = 179, Groups = 124		
Sigma_u = 186,51043 Sigma_e = 2,2395481, rho = 0,99985584		

The interaction term implies a worse effect of Covid-19 on countries with a higher consumption rate in percentage of GDP, than countries consuming a lower share of their GDP. It supports my hypothesis that low-income countries consuming large parts of their GDP is worse of during a pandemic. The interaction term is statistically significant at 90% and confirms my hypothesis.

Consumption and lockdown

Adding the interaction term of lockdown and consumption instead gives approximately the same results for the general variables as GDP per capita 2017 dollars, investments, internet penetration rate and HDI are statistically significant and positive. The interaction term switches from negative to positive.

Results shown in the following table:

Table 21: Results using Lockdown * Consumption, FE

GDP per capita growth	**β**	**p-value**
ln Population	-26,27568	-- [0,660]
	(59,6384)	
ln GDP per capita constant 2017 dollars	123,9145	*** [0,000]
	(22,30108)	
Investments	0,6507911	*** [0,005]
	(0,2264256)	
Consumption as % of GDP	0,1713748	-- [0,548]
	(0,2847455)	
Unemployment	-0,853032	-- [0,192]
	(0,6500656)	
Internet penetration rate	0,188387	*** [0,000]
	(0,0379523)	
Access to vaccines	0,0121137	-- [0,160]
	(0,008576)	
Level of lockdown	-0,0225798	-- [0,915]
	(0,2100693)	
Infected per million	0,000129	-- [0,252]
	(0,0000112)	
HDI	201,368	** [0,026]
	(89,23943)	
Lockdown * Consumption	0,0001808	-- [0,961]
	(0,0038087)	
_cons	-961,0923	-- [0,402]
	(1142,232)	
Standard errors in parenthesis		
*** p<0,1, ** p<0,05, * p<0,01		
R^2: Within = 0,9356, Between = 0,0143, Overall = 0,0179		
Number of: Observations = 179, Groups = 124		
Sigma_u = 189,57426, Sigma_e = 2,2269416, rho = 0,99985703		

The positive interaction term suggests that countries with a higher consumption rate handles a lockdown best. This is not as expected in my hypothesis, as a higher rate on consumption will make it difficult to smooth consumption during a decrease in income. Also, less funds are saved in low-income countries leading to an increased uncertainty. This result is not statistically significant, so we can't be certain that the results differ from zero, so the results does not reject my hypothesis.

Unemployment

Unemployment and Covid-19

Adding the interaction term for infected per million and unemployment does not change the general variables a lot as GDP per capita 2017 dollars, investments, internet penetration rate and HDI are still statistically significant and positive. The interaction term however resulted in a negative effect.

Results shown in the following table:

Table 22: Results using Infected per million * Unemployment, FE

GDP per capita growth	**β**	**p-value**
ln Population	-27,45977	-- [0,556]
	(46,49269)	
ln GDP per capita constant 2017 dollars	123,3402	*** [0,000]
	(17,86075)	
Investments	0,6478411	*** [0,007]
	(0,2354827)	
Consumption as % of GDP	0,1815851	-- [0,369]
	(0,2014501)	
Unemployment	-0,8614334	-- [0,172]
	(0,6264419)	
Internet penetration rate	0,1883349	*** [0,000]
	(0,0380349)	
Access to vaccines	0,0123426	-- [0,128]
	(0,0080443)	
Level of lockdown	-0,0119556	-- [0,814]
	(0,505928)	
Infected per million	0,0000121	-- [0,562]
	(0,0000208)	
HDI	202,3799	** [0,014]
	(81,021209)	
Infected per million * Unemployment	-9,9E-08	-- [0,964]
	(-0,0000216)	
_cons	-937,2318	-- [0,296]
	(893,1803)	
Standard errors in parenthesis		
*** p<0,1, ** p<0,05, * p<0,01		
R^2: Within = 0,9356, Between = 0,0,0141, Overall = 0,0177		
Number of: Observations = 179, Groups = 124		
Sigma_u = 189,85305, Sigma_e = 2,2669304, rho = 0,99985745		

The negative interaction term suggests that countries with higher unemployment handles the pandemic worse. This supports my hypothesis as higher unemployment leads to higher uncertainties for the consumers, and higher costs in the countries, but the regression does not confirm my hypothesis as the results are statistically insignificant. We can't determine an effect different from zero with certainty.

Unemployment and lockdown

The general variables do not change much adding the interaction term of lockdown and unemployment either. GDP per capita 2017 dollars, investments, internet penetration rate and HDI are all still statistically significant and positive, and the interaction term are still negative and statistically insignificant.

Results shown in the following table:

Table 23: Results using Lockdown * Unemployment, FE

GDP per capita growth	β	p-value
ln Population	-21,57463	-- [0,674]
	(51,13158)	
ln GDP per capita constant 2017 dollars	123,6616	*** [0,000]
	(17,71714)	
Investments	0,6265306	*** [0,008]
	(0,2314177)	
Consumption as % of GDP	0,208759	-- [0,325]
	(0,2114485)	
Unemployment	-0,5197617	-- [0,616]
	(1,034875)	
Internet penetration rate	0,1902278	*** [0,000]
	(0,037849)	
Access to vaccines	0,0122166	-- [0,109]
	(0,0075738)	
Level of lockdown	0,0266474	-- [0,809]
	(0,1101499)	
Infected per million	0,0000127	-- [0,253]
	(0,0000111)	
HDI	200,7689	** [0,018]
	(83,76953)	
Lockdown * Unemployment	-0,0053935	-- [0,678]
	(0,0129764)	
_cons	-1039,784	-- [0,287]
	(973,0316)	
Standard errors in parenthesis		
*** p<0,1, ** p<0,05, * p<0,01		
R^2: Within = 0,9358, Between = 0,0147, Overall = 0,0187		
Number of: Observations = 179, Groups = 124		
Sigma_u = 186,0845, Sigma_e = 2,2635013, rho = 0,99985206		

The negative interaction term suggests that countries with high unemployment is worse of during a lockdown than countries with low unemployment. This supports my hypothesis as it will be harder to obtain a new job during lockdown because of bankruptcies and restrictions. The results do not confirm my hypothesis however as the results are statistically insignificant, and we can't be sure that the effect is different from zero.

Vaccination

Vaccination and Covid-19

Analyzing the interaction term of infected per million and access to vaccines, GDP per capita 2017 dollars, investments, and internet penetration rate, HDI is still statistically significant and positive. The interaction term is still negative and insignificant.

Results shown in the following table:

Table 24: Results using Infected per million * Access to vaccines, FE.

GDP per capita growth	β	p-value
ln Population	-26,26864	-- [0,566]
	(45,66028)	
ln GDP per capita constant 2017 dollars	124,2063	*** [0,000]
	(17,1997)	
Investments	0,638528	*** [0,008]
	(0,2363202)	
Consumption as % of GDP	0,1816231	-- [0,367]
	(0,2004318)	
Unemployment	-0,849763	-- [0,166]
	(0,6102652)	
Internet penetration rate	0,1922319	*** [0,000]
	(0,0468125)	
Access to vaccines	0,0114375	-- [0,291]
	(0,0107941)	
Level of lockdown	-0,0113133	-- [0,821]
	(0,0498201)	
Infected per million	-0,00000933	-- [0,711]
	(0,0000251)	
HDI	194,9026	* [0,065]
	(104,5744)	
Infected per million * Access to vaccines	-2,19E-08	-- [0,897]
	(-0,000000169)	
_cons	-959,6137	-- [0,275]
	(876,0021)	
Standard errors in parenthesis		
*** p<0,1, ** p<0,05, * p<0,01		
R^2: Within = 0,9356, Between = 0,0142, Overall = 0,0179		
Number of: Observations = 179, Groups = 124		
Sigma_u = 189,00328, Sigma_e = 2,2664987, rho = 0,99985622		

The interaction term claims that countries with high access to vaccines and the possibility to vaccinate their population was worse of during the Covid-19 pandemic with many infected. This is expected as the vaccines are costly for the countries, and with a high infection rate as well, they might seem ineffective.
The result is not statistically significant and does not confirm my hypothesis that access to vaccines are necessary to maintain GDP per capita growth. Due to the insignificance, we can't be certain that the effect differs from zero.

Vaccination and lockdown

Changing the interaction term from infected per million to lockdown and access to vaccines, GDP per capita 2017 dollars, investments, internet penetration rate and HDI are statistically significant, and positive.

Results shown in the following table:

Table 25: Results using Lockdown * Access to vaccines, FE.

GDP per capita growth	**β**	**p-value**
ln Population	-43,38779	-- [0,428]
	(54,50049)	
ln GDP per capita constant 2017 dollars	117,5426	*** [0,000]
	(18,81417)	
Investments	0,584807	** [0,039]
	(0,279841)	
Consumption as % of GDP	0,2049003	-- [0,307]
	(0,1995554)	
Unemployment	-0,8476785	-- [0,165]
	(0,6068939)	
Internet penetration rate	0,1771111	*** [0,000]
	(0,0359243)	
Access to vaccines	-0,0048489	-- [0,849]
	(0,009063)	
Level of lockdown	-0,044103	-- [0,490]
	(0,0637321)	
Infected per million	0,0000152	-- [0,130]
	(0,00001)	
HDI	216,5851	** [0,012]
	(85,04807)	
Lockdown * Access to vaccines	0,000331	-- [0,515]
	(0,000507)	
_cons	-626,636	-- [0,546]
	(1033,996)	
Standard errors in parenthesis		
*** p<0,1, ** p<0,05, * p<0,01		
R^2: Within = 0,9366, Between = 0,0121, Overall = 0,015		
Number of: Observations = 179, Groups = 124		
Sigma_u = 197,09879, Sigma_e = 2,2390912, rho = 0,99986981		

The interaction term is now positive, meaning countries with access to vaccines handles lockdowns best. This supports my hypothesis that vaccination is a necessity for effective lockdowns, but my hypothesis is not confirmed as the results are insignificant, and we can't be sure that the effect is different from zero.

Human Development Indicator

Human Development Indicator and Covid-19

Adding the interaction term of infected per million and HDI makes GDP per capita 2017 dollars, investments, internet penetration rate and HDI positive and statistically significant. The interaction term is again negative, and statistically insignificant.

Results shown in the following table:

Table 26: Results using Infected per million * HDI, FE

GDP per capita growth	**β**	**p-value**
ln Population	-28,65766	-- [0,540]
	(46,67501)	
ln GDP per capita constant 2017 dollars	123,1109	*** [0,000]
	(17,39298)	
Investments	0,6398922	** [0,016]
	(0,2627554)	
Consumption as % of GDP	0,1920949	-- [0,437]
	(0,243033)	
Unemployment	-0,8826189	-- [0,183]
	(0,6589447)	
Internet penetration rate	0,1848213	*** [0,000]
	(0,0359347)	
Access to vaccines	0,0126611	-- [0,165]
	(0,009063)	
Level of lockdown	-0,0115684	-- [0,822]
	(0,0512379)	
Infected per million	0,0000268	-- [0,808]
	(0,0001103)	
HDI	208,7845	* [0,052]
	(106,4215)	
Infected per million * HDI	-0,0000165	-- [0,903]
	(0,0001343)	
_cons	-920,2596	-- [0,301]
	(886,0315)	
Standard errors in parenthesis		
*** p<0,1, ** p<0,05, * p<0,01		
R^2: Within = 0,8189, Between = 0,354, Overall = 0,554		
Number of: Observations = 179, Groups = 124		
Sigma_u = 4,3225743, Sigma_e = 2,2644737, rho = 0,7865749		

The negative interaction term implies that highly developed countries is affected worse than lowly developed countries. Highly developed countries have a higher GDP per capita, but also decreasing GDP per capita growth. It supports my hypothesis as highly developed countries will have more costs connected to the infection numbers. Even though the result support my hypothesis, it is not confirmed as the results are statistically insignificant, and we can't be certain that the effect differs from zero.

Human Development Indicator and lockdown

Changing the interaction variable to an interaction between lockdown and HDI gives statistical significance for GDP per capita 2017 dollars, investments, internet penetration rate and HDI, all with a positive effect on GDP per capita growth.

Results shown in the following table:

Table 27: Results using Lockdown * HDI, FE

GDP per capita growth	**β**	**p-value**
ln Population	-21,95947	-- [0,689]
	(54,78735)	
ln GDP per capita constant 2017 dollars	124,1948	*** [0,000]
	(18,01568)	
Investments	0,6358223	*** [0,007]
	(0,2324849)	
Consumption as % of GDP	0,1938949	-- [0,356]
	(0,2091174)	
Unemployment	-0,857178	-- [0,175]
	(0,6282327)	
Internet penetration rate	0,1900968	*** [0,000]
	(0,0376932)	
Access to vaccines	0,0119067	-- [0,125]
	(0,0771785)	
Level of lockdown	0,0586938	-- [0,793]
	(0,2234455)	
Infected per million	0,0000127	-- [0,252]
	(0,0000111)	
HDI	203,1424	** [0,017]
	(84,18013)	
Lockdown * HDI	-0,0935835	-- [0,752]
	(0,2955709)	
_cons	-1037,351	-- [0,316]
	(1031,052)	
Standard errors in parenthesis		
*** p<0,01, ** p<0,05, * p<0,01		
R^2: Within = 0,9357, Between = 0,0147, Overall = 0,0186		
Number of: Observations = 179, Groups = 124		
Sigma_u = 186,614, Sigma_e = 2,2658356, rho = 0,9998526		

The negative interaction term implies that countries with a higher level of development will have a larger setback of lockdowns. This does not support my hypothesis of the efficient lockdown, as my hypothesis implied that low-income countries will be worse off by initiating lockdowns. It does however not reject my hypothesis as the results are statistically insignificant, meaning we can't be sure that the effect differs from zero.

Summary of results, controlling for fixed effects

Correction for fixed effects gives values with negative effect of all interaction variables, except the interaction between lockdown and vaccines. The only result confirming any of my hypothesis´ is the interaction variable of infected per million and consumption which implies that a higher consumption rate gives a harder impact from the Covid-19 pandemic. The other interaction variables are insignificant and can't be used to reject or confirm my hypothesis´.

Results summarized in the table below:

Table 28: Summary of results, FE

Summary of Interaction Values	β	p-value
Infected per million * Internet	-4,39E-07	-- [0,687]
	(-0,00000109)	
Lockdown * Internet	-0,0001934	-- [0,895]
	(0,00146)	
Infected per million * Consumption	-7,84E-07	* [0,098]
	(-0,00000047)	
Lockdown * Consumption	0,0001808	-- [0,961]
	(0,0038087)	
Infected per million * Unemployment	-9,9E-08	-- [0,964]
	(-0,0000216)	
Lockdown * Unemployment	-0,0053935	-- [0,678]
	(0,0129764)	
Infected per million * Access to vaccines	-2,19E-08	-- [0,897]
	(-0,000000169)	
Lockdown * Access to vaccines	0,000331	-- [0,515]
	(0,000507)	
Infected per million * HDI	-0,0000165	-- [0,903]
	(0,0001343)	
Lockdown * HDI	-0,0935835	-- [0,752]
	(0,2955709)	

Setting up a calculation with the interaction term, the average value of each independent variable, and a standard value of Covid-19 and lockdown gives the following results for high-income countries:

Table 28: Calculating effects in high-income countries, FE.

	Infected per million			
	Interaction	Avg. variable	Infected	Result
Internet	-0,00000397	78,00	100	-0,030966
Consumption	-0,0000029	51,18	100	-0,0148416
Unemployment	-0,00000635	6,56	100	-0,004165
Vaccines	-7,35E-08	85,62	100	-0,0006293
HDI	-0,0000777	0,89	100	-0,006892
	Lockdown			
	Interaction	Avg. variable	Lockdown	Result
Internet	-0,0013658	78,00	40	-4,261296
Consumption	-0,001994	51,18	40	-4,0819573
Unemployment	-0,0222618	6,56	40	-5,8406058
Vaccines	0,000898	85,62	40	3,0754704
HDI	-0,29055	0,89	40	-10,308714

The calculations give the following results for the low-income countries:

Table 29: Calculating effects in low-income countries, FE.

	Infected per million			
	Interaction	Avg. variable	Infected	Result
Internet	-0,00000397	10,00	100	-0,00397
Consumption	-0,0000029	78,23	100	-0,0226879
Unemployment	-0,00000635	6,58	100	-0,0041783
Vaccines	-7,35E-08	21,02	100	-0,0001545
HDI	-0,0000777	0,48	100	-0,0037141
	Lockdown			
	Interaction	Avg. variable	Lockdown	Result
Internet	-0,0013658	10,00	40	-0,54632
Consumption	-0,001994	78,23	40	-6,2399438
Unemployment	-0,0222618	6,58	40	-5,8593058
Vaccines	0,000898	21,02	40	0,7550384
HDI	-0,29055	0,48	40	-5,555316

The interaction variables of infected per million with internet penetration rate, vaccinations and HDI suggest a harder impact on high-income countries. The interaction variable of lockdown combined with internet penetration rate and HDI also suggest a harder impact on high-income countries.

The interaction variable with infected per million suggest a harder effect for low-income countries for consumption rate and unemployment. Using the interaction term of lockdown suggests a harder effect for low-income countries using the variables consumption, unemployment, and vaccines.

In general, it seems like high-income countries handles a high number of infected worse than low-income countries, while low-income countries handle a high rate of lockdown the worst.

The only significant interaction term is infected per million with consumption, implying that low-income countries handles a high rate of infected the worst.
None of the other results are statistically significant, so we can't be certain whether they have an effect, or if the only effect separating the two country types are shown in the interaction of infected per million and consumption.

The value of R^2

Within: Approximately 0.93 for each regression.
This value is higher with fixed effects rather than random effects, meaning a higher fraction of the variance is explained within each country.

Between: Approximately 0.014 for each regression.
As all fixed factors within each country is adjusted for, the variance described between each panel (countries) becomes a lot smaller.

Overall: Approximately 0.017 for all regressions.
The overall explanation of variance is lower for fixed effects than for random effects, because of the little variance explained between each panel.

Random or fixed effects?

The Hausman test suggest controlling for fixed effects in the regression, but as this removes some of the country specific factors I wish to investigate, it is not optimal. When controlling for fixed effects, only one interaction term is statistically significant while the other interaction terms lack significance, and most of my hypotheses´ is therefore neither rejected nor confirmed. The positive aspect of using fixed effects is the high value of R^2 within each group, but the R^2 between each group were very low.

Controlling for random effects gives four significant interactions terms and a higher value of R^2 between each group, but lower value of R^2 within each group. The regressions do confirm my hypothesis that a high rate of unemployment and consumption is bad during a pandemic, but also reject my hypothesis that a high internet penetration rate is useful for maintaining GDP per capita growth.

Weaknesses

Number of observations

Although the analysis consists of a high number of countries, the analysis might still be inaccurate because of lack of the most recent data. The infection rate was high in the beginning of the pandemic in high-income countries, the infection rate decreased in 2022. Low-income countries however had a higher infection rate in 2022 than high-income countries. Being able to include data for 2022 would therefore give more accurate results. Number of observations without 2022 is only 179, even though data is gathered from 214 countries and territories. Adding more countries is not possible so the only way to include more data would be by increasing the number of years.

Infection route

The virus emerged in China 2020, and short time after traveled to European countries, and America. Infected were observed in the low-income countries a while after.

Countries like Italy were affected early, and Italy have a large fraction of elderlies in their population. Covid-19 affected people from age 60 and above the hardest (WHO, u.d.), making the costs higher for populations with high share of elderlies.

Low-income countries in general have a lower life expectancy, and as the virus affected young and elderlies differently, it wasn't as obvious when the virus arrived in these countries. However, when researchers analyzed fraction of population with antibodies in the low-income countries, a large fraction of the population had been infected at some point (WHO Africa, 2022).

Dark numbers

Missing data necessary for the analysis is called dark numbers. Dark numbers regarding infections will bias the results. As mentioned, the infection rate in African countries seemed small, but when searching for antibodies, a lot more cases of infected were discovered (WHO Africa, 2022).

A reason for the high share of dark numbers related to infections in the African countries might be because many of the infections were caused by the delta variant, giving little symptoms.

In addition, difficulties regarding testing and inaccurate registration of infected will bias the results as well.

GDP per capita growth trend

The GDP per capita growth rate had, as described earlier, a declining trend in high-income countries, while the low-income countries had a slightly increasing trend. High-income countries have been through the industrialization processes and is doing slow and expensive research for further industrialization, while low-income countries can follow the high-income countries footsteps. They will be able to industrialize faster and will see a higher GDP per capita growth rate due to this.

The trend however is not expressed in the regression, which might bias the result. Both countries start with a low negative GDP per capita growth value in 2020, and both increase to a higher positive GDP per capita growth value in 2021. During these two years, high-income countries will seem to have a higher GDP per capita growth trend than low-income countries.

Using a per capita variable

GDP per capita growth is the natural choice when comparing different countries, across different time periods. It gives a result based on change in percentage dependent on the country specific population, making it easier to compare within the different country types. However, infected per million seems to achieve a positive effect on GDP per capita growth, which is unexpected. This might however be because infections might lead to a lower population, and thereby a lower population to distribute the GDP growth on.

Reverse Causality

In my thesis, I have investigated the effect of a set of independent variables on GDP per capita growth. In some cases, however, GDP per capita growth might have a causal effect on the independent variables instead. For example, in my thesis, I have investigated the unemployment as a factor affecting GDP per capita growth, but it could also be possible that the GDP per capita growth steers the unemployment rate. If this is the case, the result will be biased.

Conclusion

According to my analysis, High- and low-income countries have been unequally affected by the pandemic. Researchers have often discussed, among other factors, access to vaccines, opportunity to work from home, lockdowns, and fiscal space as some of the main contributors to the unequal effect. Internet penetration rate were statistically significant, but with an unexpected result as high internet penetration rate led to worse effect of the pandemic on the GDP per capita growth. Consumption expenditure rate were also statistically significant, confirming that countries consuming the largest fractions in percentage of GDP handled the pandemic the worst. Lastly, the unemployment factor was statistically significant as well, suggesting that a high unemployment made it harder to handle the Covid-19 pandemic. The average rate of unemployment was however approximately the same in both high- and low-income countries (a little higher in high-income countries) so the unequal impact is difficult to attribute to this factor. Of all the statistically significant variables, internet and consumption combined with number of infected had the highest statistical significance.

High-income countries generally seemed to be more affected by a higher number of infected than low-income countries. This result is possibly because high-income countries have a better support system with subsidies, and the possibility to implement restricting measures more often. High-income countries with many infected would therefore experience a lower GDP per capita growth than others. Another reason for the worse effect of number of infected on high-income countries can be because they have more elderlies, more tests have been registered, and that Covid-19 spread to the high-income countries before the low-income countries.
Also, high-income countries have more costs connected to the vaccines through vaccinations, and through research and development.

Low-income countries were generally more affected than high-income countries by costs connected to lockdowns.
The low-income countries on average had a stringency index of 47,1 in 2020 and 2021, while high-income countries had an average of 54,4. The difference is stringency index were small, but the lockdowns became more costly as their initial GDP per capita were lower, and that the vaccination possibilities were low.

The factor separating the effect the most are whether countries could vaccinate their population or not. As this factor isn't statistically significant at any of the usual levels, it can't be determined as the main factor, but it would be interesting to run the regression again when 2022-data are available, to see whether the significance increase. The p-value is however 0,111 combined with lockdown so it is very close to significant. The results would confirm my hypothesis that the effectivity of lockdowns depends on vaccinations, which in turn would make this the factor separating high- and low-income countries the most.

The total effect of the pandemic affected the low-income countries harder than the high-income countries, as their costs connected to lockdown gave a harder impact than the costs of actual numbers of infected did to high-income countries.

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