Sjur Brekke Espedal & Dennis Aleksander Janzso

Major Stock Indices as Indicators of the State of the Economy

Master's thesis in Financial Economics
Supervisor: Knut Anton Mork
May 2022

Master's thesis

NTNU
Norwegian University of Science and Technology
Faculty of Economics and Management
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Kunnskap for en bedre verden

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Abstract

This thesis investigates major stock indices in 24 countries and the relationship to 16 macroeconomic variables. The analysis consists of several OLS regressions with variable lag in the stock indices prices. A logarithmic first difference model was used to transform the data. For the macroeconomic metrics: female labor participation, tertiary education, GDP per capita, unemployment, and household income, a significant relationship was found applying various lags for different countries. This suggests a causal relationship from the stock market index prices to the mentioned variables. For the variables: fertility, income share of the lowest 10%, life expectancy, number of patents, pollution, GINI index, energy use, electrical energy usage, access to electricity, and primary and secondary education, no significant relationship was found. The findings suggest a relationship from stock market prices to certain macroeconomic variables exists with varying with a delayed effect. Thus, the stock market holds some validity as an indicator of the state of the economy.

Sammendrag

I denne oppgaven undersøkes sentrale aksjeindekser i 24 land og sammenlignes med 16 makroøkonomiske variabler. Sammenligningen er gjort med flere OLS-regresjoner med variabel lag i aksjeindeksprisene. Dataene ble transformert med en log first differences-modell. For de makroøkonomiske målene kvinnelig arbeidsdeltakelse, høyere utdanning, BNP per innbygger, arbeidsledighet og husholdningsinntekt ble det funnet en signifikant sammenheng med ulike lag for forskjellige land. Denne sammenhengen foreslår et kausalt forhold fra aksje indeks prisene til de overnevnte makroøkonomiske variablene. For variablene: fruktbarhet, inntektsandel av de laveste 10%, forventet levealder, antall patenter, forurensning, GINI-indeks, energibruk, elektrisk energibruk, tilgang på elektrisitet og grunnskole og videregående opplæring, ble det ikke funnet noen signifikant sammenheng. Funnene tyder på at en sammenheng mellom aksjemarkedskurser og visse makroøkonomiske variabler eksisterer med en viss lag, og dermed at aksjemarkedet kan ha gyldighet som en indikator på tilstanden til økonomien.

Preface

This master thesis concludes our 2-year Master of Science degree in Financial Economy at the Faculty of Economy and Management at the Norwegian University of Science and Technology, NTNU.

We would like to thank our supervisor, Knut Anton Mork, for his expertise in the research area and for being helpful and understanding throughout our work.

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Sjur Brekke Espedal
Dennis Aleksander Janzso
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List of Acronyms

ADF augmented Dickey-Fuller.

AIC Akaike information criterion.

ASEAN Association of Southeast Asian Nations.

CPI Consumer Price Index.

ECM Error Correction Model.

GDP Gross domestic product.

GNP Gross national product.

Lerp Linear interpolation.

MICE Multiple Imputation by Chained Equations.

NTNU Norwegian University of Science and Technology.

OECD Organisation for Economic Cooperation and Development.

OLS Ordinary Least Squares.

PPP Purchasing power parity.

R&D Research and Development.

VAR Vector Autoregression.

VECM Vector Error Correction Model.

WIPO World Intellectual Property Organization.

Chapter 1
Introduction

The stock market is often discussed in the media, and an implication of correlation between the state of a nation's economy and the trend in the market is often implied. A general consensus exists assuming that the economy at large follows the stock market. This notion influence political and economic decision-making at the highest levels. This assumption is not unfounded, as there are correlations between capital markets and other key economic indicators, such as GDP and unemployment, in the existing literature. The relationship between these metrics is governed by an array of complex mechanisms, and thus the actual connections and causalities may not be as trivial as sometimes implied.

The stock market fluctuates with the interest rate, inflation, individual company results, and several other factors. A nation's economy is a difficult concept to measure or discuss, as the economy can be defined in many ways depending on the context and purpose of the discussion. This thesis aims to measure the relationship between the fluctuations in the stock market and developments in other key macroeconomic indicators. There exists a large body of research which have studied how macroeconomic factors influence the stock market. In this article, the reverse implication will be investigated. With multiple regressions, the macroeconomic variables will be attempted explained by the most recognized stock indices for a set of countries with different levels of lag.

In this chapter, the research objective and hypothesis will be presented along with the limitations. The chapter concludes with the methodology and an outline of this thesis.

1.1 Objectives and hypothesis

In this thesis, the objective is to determine if the stock market can be a good indicator of the economy in general. The stock market will be measured by the nation's largest stock index. Is the stock market a good estimator in any country, and is it better for some countries than for others? The three main hypotheses that will be tested and analyzed in this thesis will be presented here, along with a brief presentation of the reasoning for the selection of these hypotheses. Further arguments and reasoning for each of the hypotheses will be presented in Chapter 2 as relevant literature is reviewed.

H1 - There exists a measurable relationship from the stock market prices to the macroeconomic variables.

From the literature and from, general economic consensus, and the media, we expect there to be such a relationship for traditional economic metrics. For other macroeconomic variables, such as energy use, education, access to electricity, and female labor participation, the relationship is unclear in previous research. The previous research supporting and discussing this hypothesis will be presented in Chapter 2.

H2 - Growth in stock market prices leads, over time, to positive development in other macroeconomic variables.

We expect that growth in stock market prices will, over time, lead to positive development in macroeconomic measures. This is in line with the general assumption that the stock market is a good indicator of the state of the economy. We expect this to hold true for most of, if not all, the macroeconomic measures included in this thesis. Note that the hypothesis does not require causality between stock market prices and macroeconomic variables, only the presence of a linear relationship. Causality is not strictly required by this hypothesis. This point will be further discussed in Chapter 2 and 5.

H3 - For developed countries, the stock exchange will be a better indicator for the economy than for developing countries.

Intuitively the assumption would be the contrary, that for developing countries, investment in the capital market will lead to a larger increase in the real economy. This is because we would expect there to be a higher marginal return on productivity per investment in countries where the development is far behind the technological frontier, renouncing the need for cutting-edge research and merely adopting existing techniques for productivity gains. For developed countries, following the same intuitions, increased stock market prices would be expected to provide a weaker relationship with the real economy. Despite this, the previous research presented in

Chapter 2 shows a weaker relationship from the stock prices to general growth in developing countries. This can be explained by cultural and structural differences, and some of these will be discussed in Chapter 3. Though the foundational assumption for this hypothesis may imply causality between stock market prices and other macroeconomic metrics, the testing of this hypothesis will be limited to evaluating whether trends between stock market prices and macroeconomic variables differ between the different types of countries.

1.2 Methodology

The objective of the thesis, as discussed in Section 1.1 is to determine if a stock index, in any way, directly or indirectly can indicate macroeconomic metrics for any country. To reach a conclusion on this objective, it is necessary to collect data for many countries and many macroeconomic variables. It will then be necessary to inspect the data for missing values and decide on how to use a potential incomplete dataset. The data transformations are important to derive the optimal fit from the independent variable to the dependent variables. Several transformations will be investigated to find the optimal solution. The data will finally be analyzed in a series of regression models to produce the results. The programming language Python, with packages statsmodels, pandas, matplotlib and seaborn, will be used for the analysis and model testing. The research methodology in this thesis will be based on the framework for design science for knowledge questions as defined by (Wieringa, 2014).

The first phase in the study is to investigate previous methods to solve the same problems and derive appropriate hypotheses for a constructive study. The previous research on the problem will elaborate on what research has been most successful, what results have they had, and what is currently unexplored. To further contribute to the research area, the unexplored analyses will be the focus of the research in this thesis. The existing research and explanations for the hypothesis will be explored in Chapter 2.

The next phase of the research is collecting the country specific data and then deciding on a method for dealing with the missing data. The method of imputation should be dependent on the statistical model. Each of the selected macroeconomic variables will be explained, in Section 4.2, along with their metrics and expected implications for the hypothesis. Each country selected will also be presented, in Chapter 3, to explain any large changes in the time series specific to that country, as financial crises and business cycles might explain large deviations in the data.

From the research phase, it is clear most previous research uses a variant of Error Correction Model (ECM) to explore the relationship from the macroeconomic variables to the stock market prices. To study the effect from the stock market prices to the macroeconomic variables, we decide a Ordinary Least Squares (OLS) regression model from the stock market prices as the explanatory variable to each of the macroeconomic variables for each of the countries. We allow the stock index time series to have a variable lag, which will give an indication of an effect from the stock market prices to the macroeconomic variables with a time delay. A one-variable input to a one-variable output in a regression model will give a result closely related to the correlation between the two, where the coefficient can be interpreted as the expected change in the dependent variable following the change in the independent variable.

The choice of a regression model allows for imputation of missing data through an interpolation method. This choice of method allows for non-contribution to additional magnitude of errors in a regression, but creates autocorrelation in each variable. This could affect the stationarity of the time series, as there will be a linear trend with no variation in the variance of the imputed data.

The choice of a OLS regression model and imputation through interpolation affects the data transformations necessary to have a close to stationary input. Different models will be proposed and tested with the imputed data to test for the best stationarity results. The research from previous steps will be taken into account when choosing a final data transformation. One data transformation model will be chosen and applied to all the time series to achieve closer to stationary series.

After the data collection, the imputation model is derived and applied, the optimal data transformation chosen, and the regression model is chosen, the research can be conducted and the results derived. The results will then be presented and discussed and their causes and potential sources of deviation will be addressed.

The thesis will conclude with an evaluation of the study along with suggestions for further research.

1.3 Outline of thesis

This thesis consists of six chapters, including this introduction.

Chapter 2 - Background presents literature and a theoretical foundation necessary for the thesis. The chapter will introduce statistical methods and considerations relevant for the models applied in the study conducted in this thesis. Furthermore, the chapter covers a variety of existing research in the space and similar studies.

Chapter 3 – Selected countries provides an overview of the economic context of each of the countries included in the study.

Chapter 4 – Research setup and inference design introduces the statistical models used in this thesis. It also presents the data used, as well as any imputations and transformations applied.

Chapter 5 – Results and discussion presents the results of the study along with discussions and analysis of said results. This chapter builds the foundation for the thesis' conclusions.

Chapter 6 – Conclusions and future work presents the overall findings of this thesis based on the results and discussions from Chapter 5. Any potential future work necessary to validate and supplement the results of this thesis will also be presented.

Chapter 2
Background

In this chapter, the statistical background for the thesis will be explained and presented. The statistical background includes linear interpolation, used for imputation of the data, and linear regression, with the extension to multiple regressions as this is the main explanatory model in this thesis. Previous research in the field will also be presented, and the methods explained and compared.

2.1 Statistical background

This section covers the statistical background on interpolation, regression, and stationarity. The interpolation can be used as a method of imputation, the regression with OLS as a method for estimation of one dependent variable using one or more independent variables and stationarity is a potential attribute of time series.

2.1.1 Linear interpolation

Interpolation is an operation for estimation of data points based on a finite set of known data points (Meijering, 2002). The method was first generalized by Newton, with Linear interpolation (Lerp) being one of the basic methods. Linear interpolation used in imputation creates the new values from the values in the immediate surroundings by joining a line (Zhang, 2016). Linear interpolation used for imputation in this thesis is given by the equation:

$$y = y_0 + (x - x_0) * \frac{y_1 - y_0}{x_1 - x_0} = \frac{y_0 * (x - x_0) + y_1 * (x - x_0)}{x_1 - x_0} \tag{2.1}$$

Lerp will be applied to the data used in this thesis as part of the preprocessing of said data.

2.1.2 Linear regression

The simple linear regression model has a mean and a variance function. The mean and variance functions are defined in Equation 2.2 and Equation 2.3 respectively. The variance is assumed to be constant and positive. As the regression is often not an exact representation of the data, en error term is included, ϵ_i. The error should be independent, Gaussian distributed and uncorrelated with the input term. (Weisberg, 2005)

$$E(Y|X = x) = \beta_0 + \beta_1 x \tag{2.2}$$

$$Var(Y|X = x) = \sigma^2 \tag{2.3}$$

The OLS estimation for a regression. The fitted value for the equation is given by the following equation, denoted $\hat{y}_i$.

$$\hat{y}_i = \hat{E}(Y|X = x_i) = \hat{\beta}_0 + \hat{\beta}_1 x_i + \epsilon_i \tag{2.4}$$

The residuals are given by the error term, and the least square algorithm attempts to minimize the error by computing the solution with the minimum amount of errors.

The assumptions of the OLS estimation are:

- The parameters in the estimation are linear.
- The sample parameters are randomly sampled.
- Conditional mean, $E(e_i|x_i) = 0$
- All errors are independent, meaning that the errors can not be computed based on the previous error term, or a combination of the other error terms. (no multicollinearity)
- Spherical errors: there is homoscedasticity and no autocorrelation

Multiple regression is, in essence, multiple OLS regressions with the same assumptions as a single regression. A combined model of one independent variable and multiple dependent variables is the accumulation of such a system of equations (Eberly, 2007).

2.1.3 Stationary

Non—stationarity defines a trend in a characteristic of a time series or the comparison between two time series (Priestley & Rao, 1969). Stationary is that the statistical properties of the process do not change over time. Stationarity is an important concept in stochastic processes. The most obvious reason is the simplification of analyzing results. There are several tests to determine the existence of non-stationarity, such as the Granader and Rosenblat (Grenander et al., 1957) test, to detect if the mean or variance of a series has a trend. Other tests estimate whether the correlation between two time series are compatible, as described by Jenkins (Jenkins, 1961). One of the problems in a time series analysis is non-stationarity as this is a common assumption for the analysis. Non-stationarity often implies a trending error term, thereby breaking an assumption of OLS. There are no tests to precisely test asymptotic stationarity and no unambiguous method for determining stationarity (Manuca & Savit, 1996).

One of the assumptions in the OLS model is, as mentioned above, that the error terms are independent and that the error terms should be normally distributed. The problem of testing if this assumption holds for the regression has been discussed in (Durbin & Watson, 1950), and further the effects of lagged dependent variables in (Godfrey, 1978). In the article (Achen, 2000) it is argued that lagged dependent variables are a part of the data generation process and including lagged dependent variables in a regression creates biased coefficients for independent error terms. This article was debated in (Wilkins, 2018), proving through a Monte Carlo simulation that the least biased estimator includes more lagged dependent variables and lagged independent variables.

One method for testing for unit roots is the Augmented Dickey-Fuller test (ADF). In the test, it is assumed that the time series has a unit root and this is the null hypothesis. If the test is significantly lower than the test statistic, we can reject the null hypothesis that the time series does not contain a unit root and is therefore stationary or trend-stationary. The method was first described by Dickey and Fuller (Dickey & Fuller, 1979).

2.2 Existing research

In this section, previous research articles on the relationship between the stock market and macroeconomic components will be presented.

In their 1998 paper, (Levine & Zervos, 1998), authors attempt to analyze the assumption that well-functioning stock markets lead to economic growth through empirical analysis. The study looks at the effects of stock markets liquidity, capitalization, volatility, and international integration on key macroeconomic indicators, mainly economic growth, productivity improvements, and savings. The study utilizes data from 47 countries in the period from 1976 to 1993. In the paper, a clear correlation between positive stock market indicators and positive economic indicators, stating that

"*This result is consistent with the view that a greater ability to trade ownership of an economy's productive technologies facilitates efficient resource allocation, physical capital formation, and faster economic growth.*" (Levine & Zervos, 1998) This paper supports hypotheses *H1* and *H2* from Section 1.1, as the stock markets lead through economic growth and productivity improvements.

The importance of international integration of capital markets on their effect on the wider economy is studied in (Obstfeld, 1992). Here it is argued that international diversification, and thus risk sharing, can lead to larger economic growth, measured here specifically as consumption. It is suggested that such integration introduce more risk willing capital into domestic markets, boosting growth. The results of the paper are, however, not conclusive.

The relationship of the stock market, the macroeconomy, and the oil prices are analyzed in the article (Filis, 2010). The article measures the macroeconomy in industrial production and Consumer Price Index (CPI). The study uses cointegration and Vector Error Correction Model (VECM) to study the data levels and use a multivariate Vector Autoregression (VAR) model to examine cyclical relationships between the component of the series. The findings suggest that the stock prices and the oil prices have a positive coefficient to the Greek CPI, indicating that if both the stock prices and oil prices increase, the Greek CPI increases. The study suggests that oil price alone are negatively affecting CPI. There is found no relationship between the stock market and industrial production.

In the article (Sharif et al., 2020), the connection between COVID-19, the oil price volatility, the stock market, geopolitical risk, and economic policy uncertainty is discussed. The article uses a wavelet-based approach for analyzing Granger Causality, to show that the association varies across time periods. The risks are observed to be different in the short and the long run. The study suggests oil price volatility is causing volatility in the stock index. Geopolitical risk is suggested based on the results to be the main reason for the volatility.

The relationship between stock market returns and macroeconomic variables is analyzed in a small open economy in the article (Gjerde & Saettem, 1999). The research uses a multivariate VAR approach on the Norwegian market and data. The article shows a link from real interest rate to stock market returns and inflation. The article also finds an accurate response by the stock market in relation to oil price changes. It further shows that the stock market has a delayed response to changes in domestic economic activity.

The link between patents and the stock market is researched in the article (Pakes, 1985). The research found a clear relationship between an increase in stock value to spending on Research and Development (R&D), the research also found a correlation from R&D to the amount of patents. Unprecedented changes in both R&D and the patents of a firm lead to a reevaluation of the firm with large changes in market value. There is a large variance in the value increase by the amount of patents, and this is assumed to reflect a dispersed distribution of the values of the patented ideas. The patents are a proxy to measure development and productivity gains from new ideas and therefore represent the new ideas formed by the R&D of a company.

The link from the macroeconomy to the stock market is attempted to be studied in the article (Humpe & Macmillan, 2009). The article compares Japan and the US, and examines a number of macroeconomic variables; CPI, money supply and interest rates. A cointegration analysis is used to compare the variables with US and Japanese stock prices. The article finds that stock prices are positively related to industrial production and negatively related to CPI and interest rates. For the Japanese market, the stock prices are positively influenced by industrial production and negatively by money supply. The Japanese industrial production is shown to be negatively influenced by CPI and the interest rate. The article argues the explanation between the stock markets might be from Japans liquidity problems in the 1990s.

The article (Wongbangpo & Sharma, 2002) analyzes the link between the stock market in the Association of Southeast Asian Nations (ASEAN) and their economies, measured by selected macroeconomic variables, i.e., Gross national product (GNP), CPI, money supply, interest rate and exchange rate. The analysis is done using Granger causality test. The article observes that stock prices are positively related to GNP and negatively related to CPI. In Singapore, the Philippines, and Thailand a negative relation is show between stock prices and interest rates. The article finds a causal relationship from the macroeconomic variables to stock prices in all the five coutries. The article also finds some relation from the stock price to macroeconomic variables, stock prices to GNP and CPI in all the five countries, and stock price to money supply and interest rate in Indonesia, Malaysia and Thailand, and from stock price to exchange rate in the the Philippines and Singapore.

The article (Cheung & Ng, 1998) uses the Johansen cointegration technique and finds a long run comovement between five national stock market indices and macroeconomic variables. The study uses real oil price, real consumption, real money supply, and real output measured in Gross domestic product (GDP) as explanatory variables for the macroeconomy. The countries compared in the article are Canada, Germany, Italy, Japan, and the US. The article further uses an augmented ECM and finds that the real return on stock indexes are generally related to deviations from the long term changes in macroeconomic variables. Increase in the real stock price leads to an increase in GDP for some countries while a decrease for other countries. The article supports hypothesis *H1* as the article finds relationship from the stock prices to macroeconomic variables. The relation from stock prices to GDP is positive in all countries except Japan, where it is slightly negative, supporting *H2*.

The article (Osamwonyi & Kasimu, 2013) examines the causal relationship between the stock market development and economic growth in Ghana, Kenya, and Nigeria. The article uses Granger Causality from the stock market capitalization, stock turnover ratio, and several other financial measures against real GDP as a measure of economic growth. The study uses data from 1898 to 2009 and shows no causal relationship between stock market development and economic growth in Ghana and Nigeria, but some causal bidirectional relationship in Kenya. This article support hypothesis *H3* as there was no relationship from the countries Ghana and Nigeria, assuming that *H1* is correct.

In the article (Choong et al., 2010) the relationships between private capital flows and investment and the economic growth in developed and developing countries are studied. The study finds that foreign direct investment has a positive impact on growth, while foreign debt and portfolio investment have a negative impact on growth in the same countries. The results further show that the negative impact of private capital flows can be transformed into a positive one if the stock market has attained a certain threshold, regardless of if the country is developed or developing. This could be because a developed stock market has a more efficient market than an underdeveloped market. The implication on *H3* are mixed as the implications are dependent on how developed the stock market is and not how developed the country is. With an assumption that the stock market is more developed in developed countries, the article could support *H3*.

The article (Hailemariam & Guotai, 2014) analyzes the development of 17 emerging markets and 10 developed economies to study the relationship between the stock market and economic growth over 12 years. The article uses a generalized method of momentum for dynamic panel data. The study finds a relationship between stock market development and economic growth. The article also suggests that the stock market can predict the future of the economy. Developed countries have higher growth effects from the investments in the article, and this is consistent with hypothesis *H3*.

Most of the existing research use a variant of ECM to compare a combination of macroeconomic variables to explain the stock price or use the stock price as an input to determine one or more of the other variables in a multivariate analysis.

As the purpose of this thesis is to use the stock price as an independent variable to determine the impact on dependent variables and only the stock price's impact, the methods of previous research are insufficient for this case. An analysis using macroeconomic variables in combination and then selecting out each of the variables' contribution to the analysis could be an alternative as this would have a higher chance of giving significant regression or model results as the error term would have a higher chance of being uncorrelated with the model. Previous research suggests a slight correlation between stock prices and some macroeconomic variables, with the implication that the macroeconomic variables mostly affect the stock price, not vice-versa. The article (Hailemariam & Guotai, 2014) further suggests that the stock market can be a prediction of the future of the economy.

In the article (Beaudry & Portier, 2006) it is argued that business cycles do not affect productivity in the short run, and therefore do not look like a standard technological shock. In the article (Berkelaar & Kouwenberg, 2009), the impact of heterogeneous loss-averse investors affects bust and boom cycles. When the wealth of investors reaches a certain point above their reference point, this pushes up equity prices. When the wealth drops below the reference point, the investors become risk-seeking, and demand for stock increases. This leads to a forced sell-off and pushes the stock market towards a bear market. The heterogeneous reference point among the investors leads to bust and boom cycles in the stock market. The article discusses the high equity premium in the stock market and high volatility. The inflation following a boom cycle is often adjusted using national interests and this will lead to a natural relationship between the interest rates, the CPI, and stock prices.

The efficient market hypothesis is discussed in the article (Malkiel, 1989), the market price in all current information in the stock prices, and any information changes will be reflected in an efficient market. An uninformed investor with a diverse portfolio will obtain a rate of return equivalent to one that can be achieved by an expert. Some market mistakes ("bubbles") are argued to be because of investors over-evaluating technological inventions. An efficient market can also be interpreted as if there exists an opportunity of greater returns with lower risk. This opportunity will be invested in as there would exist arbitrage to the point where the price would go up until the expected risk averaged return would be equivalent to any other investment.

There has been an increasing income inequality in the US from the years 1953-2008, and in the article (Rubin & Segal, 2015) it is argued that the inequality largely comes from the increasing importance of the stock market in the US economy and the use of pay-for-performance compensation for the top earners. The article (Owyang & Shell, 2016) argues that the wage gap comes from the higher earners owning more stocks, and as the stock market grows, this benefits the rich, while the middle and lower class rely on wages for income. The article (Machin & Van Reenen, 2007) argues that the wage inequality comes from lower minimum income and weaker trade unions, and that these offer the best explanation for the observed pattern. The increased financial returns can be argued to come at the cost of real wages, based on the observed trends.

There are conflicting results within the existing literature. The article (Filis, 2010) finds no relationship between the stock market and industrial production, while the article (Humpe & Macmillan, 2009) finds a positive relationship between the stock market and the production, supporting *H1* and *H2*. The article (Filis, 2010) does not support hypotheses *H1* or *H2* as the article finds no relationship between the stock market and industrial production. Geopolitical risk is discussed in (Sharif et al., 2020), and is a metric that can be applied to some countries in this thesis. The political risk and its implication for foreign investments will be discussed for the developing countries in Chapter 3. The geopolitical risk can be assumed to be higher for developing countries, and such an interpretation could explain hypothesis *H3*. The article (Gjerde & Saettem, 1999) shows the relationship from macroeconomic variables to the stock market, and this implication does not affect the hypotheses. The article (Wongbangpo & Sharma, 2002) to some extent supports *H1* as it finds relation from the stock prices to some of the macroeconomic variables, namely GNP and CPI. The article finds a positive relation from stock price to GNP, supporting *H2*. The same article finds a causal relationship from the macroeconomic variables to the stock prices. As the countries analyzed can be classified as developing countries, the article could be interpreted as negative to *H3*, but as no other countries are compared, this could be a stretch. The article (Cheung & Ng, 1998) studies traditionally considered developed countries and finds a mixed implication from the stock prices to GDP. The article (Hailemariam & Guotai, 2014) is consistent with hypothesis *H3*, where the stock market growth has a stronger relationship to the macroeconomy in developed countries.

In conclusion, the previous research provides conflicting results to all the hypotheses in this thesis. The articles that measure implications from the stock market to macroeconomic variables, imply a relationship from stock prices to GDP, while not testing other less traditional measures of the economy. Most of the literature supports hypothesis *H3*, while some find a relationship supporting *H1* and *H2*. Others do not. There are no articles in this study supporting *H1* and at the same time disproving *H2* in more than a few of the test cases. Some sources of errors in the existing literature could be a lack of efficient market in a developing economy with a small stock exchange, bust and boom cycles might overly affect the stock market due to risk-averse investors, and bust and boom cycles might affect GDP while other macroeconomic variables might be unaffected.

Chapter 3
Selected countries

Before the hypotheses and results of the regression are presented, we will, in this chapter, briefly review the selected countries. This will provide a foundational understanding about the macroeconomic context of each country, as well as an introduction to the stock exchanges and their histories. Such an understanding of the economic context of each of the selected countries will be necessary to support this thesis' hypotheses, as well as supplement the interpretation and discussion of the results.

3.1 Economic state of the countries

In this section, each country will be presented with the state of their economy in the years 2000-2020 and significant events in their political situation. Then their corresponding stock indices are presented with a short description. For all stock indices the stock index value is used, thus not including dividends.

USA The United States is the world's largest economy in terms of GDP. It has a GDP per capita of $74,035 (Worldometer, 2022). The US is one of the most technologically advanced economies and are in the front in several research areas. Most firms are private and have more freedom than in other western countries, as it is easier to lay off workers. There are several long-term problems in the US. These include stagnation of wages or lower-income households, wealth inequality, inadequate invested in infrastructure, large medical and pension costs, energy shortage and budget deficits. Since 1996 the increase in divides and capital gains have grown faster than wages and any other category of after-tax income. The sub-prime mortgage crisis in 2008 lead to a GDP contraction until late 2009. In 2009, congress provided economic stimulus to curb the contraction. (CIA, 2022t)

The stock index used, in this thesis, for the US is Standard and Poor's 500. This index includes 500 leading companies, accounting for approximately 80% of available market capitalization in the US (S&P, 2022a). The index has been operating in more or less its current form since 1957. Despite a plethora of other American indexes, the S&P 500 is largely considered to be the most synonymous with the stock market at large. (Valetkevitch, 2013)

Singapore The Singaporean economy is widely recognized for its market openness and very low levels of corruption. Its GDP per capita is $94,105 (Worldometer, 2022). The country has strong property rights and a high level of openness to trade. (The Heritage Foundation, 2022) The country has, since its rapid industrialization in the 1970s, had very a high level of economic growth. The country ranks as the best country in the world on human capital development according to the World Bank. (The World Bank, 2019)

The index used to measure stock prices in Singapore is the MSCI Singapore index. This index, consisting of 20 companies, accounts for around 85% of Singapore market capitalization. (MSCI, 2022)

China China opened its previously planned economy in 1978. Since then, it has seen nearly 10% yearly growth in GDP on average, making it one of the world's largest economies. Despite this, its GDP per capita is only $16,842 (Worldometer, 2022). Along this massive economic growth, living standards has significantly increased over this period as well. The growth in the nation's economy has largely been driven by manufacturing, though their comparative advantage of highly available low-income labor has subsided in recent years. China has imposed a one-child policy from 1980 to 2015. (The World Bank, 2022)

The index used for China is the SSE Composite, consisting of all stocks listed on the Shanghai stock exchange. (Chen, 2022c)

Germany The German economy is the fifth largest in the world in terms of Purchasing power parity (PPP) adjusted GDP, and a world leader in high-tech industry. It has a GDP per capita of $52,556 (Worldometer, 2022). The country also has a general high standard of living. The current state of the German economy was largely achieved through economic reform in the late 90s and early 2000s, aiming to combat high unemployment and low growth. In later years, the country has struggled to attract private investments, both foreign and domestic.

The index used for Germany is the DAX. DAX consists of the 40 largest companies listed on the Frankfurt stock exchange (Dax, 2022). The index accounts for approximately 80% of the market capitalization in Germany (Deutsche Börse Group, 2022).

Israel Israel has an advanced free market economy, primarily driven by high-tech industry (CIA, 2022h). The country has a GDP per capita of $38,868 (Worldometer, 2022).

For Israel, the TA 35 index is used. This index consists of the 35 largest companies on the Tel Aviv stock exchange (TASE, 2022).

Canada Canada is a developed market economy with high standards of living. It has a GDP per capita of $46,510 (World Bank Open Data, 2022). The country has seen strong growth in the last three decades, primarily due to having a high-skilled labor force and large natural resources. The country's close economic relationship to the USA, who is a major trade partner, has also been integral. (CIA, 2022c)

The index chosen for Canada is the S&P/TSX Composite. This index, launched in 1977, currently consists of 239 companies listed on the Toronto stock exchange. The index accounts for around 95% of the Canadian equity market. (TMX, 2022)

Greece Greece has a capitalist economy with a strong public sector. It has a GDP per capita of $28,583 (Worldometer, 2022). Despite being an eurozone country, the country has seen considerably lower economic growth than other nations in the cooperation. The country was hit particularly hard by the financial crisis of 2008 and the following European sovereign debt crisis. The recession caused the government to implement stringent austerity measures. (CIA, 2022f)

For Greece, the Athens General Composite index was chosen. This index has 60 constituents listed on the Athens stock exchange. (Athexgroup, 2022)

Italy Italy is the third-largest country in the eurozone. It has a GDP per capita of $40,924 (Worldometer, 2022). The country is split between the highly developed northern part of the country and the more agricultural south. This divide is reflected economically. The country has significant government debt, reaching a 131% of GDP in 2017, and high levels of unemployment, particularly among young people. (CIA, 2022i)

The index used for Italy is the Italy 40, also known as FTSE MIB. This index consists of 40 leading companies at the Borsa Italiana. (Trading Economics, 2022)

Switzerland Switzerland is a highly developed market economy. It has one of the world's the largest GDP per capita at $66,307 and low unemployment (Worldometer, 2022). The country largely relies on its service industry, primarily the finance sector, as well as high-tech manufacturing. Switzerland is widely recognized for its relaxed finance and banking regulation, along with low corporate tax levels. This has made

Switzerland a very competitive economy. Despite the country relatively quickly overcoming the immediate effects of the 2008 financial crisis, it saw a decline in GDP from 2011 to 2017. This was largely due to appreciation of the Swiss franc in this period, stemming from the volatility in other markets at the time, causing the countries export to be outcompeted.

For Switzerland, the SMI was used. This index includes the 20 largest companies on the Swiss exchange. The index accounts for more than 70% of the Swiss equity market. (SIX Group, 2022)

Poland Poland is a member of the EU. Since the collapse of the Soviet Union in the early 1990s, Poland has liberalized their economy, and is today a developed free market economy, with fairly high living standards. It has a GDP per capita of $29,924 (Worldometer, 2022). Due primarily to expansive fiscal policies, the country overcame the financial crises of 2008 without going into recession. Since then the country has seen decent levels of growth with more than 3% GDP expansion per year since 2014. The country is reliant on funds from the EU to maintain its relatively high budget deficit. (CIA, 2022o)

The index used for Poland is the WIG20. This consists of 20 large companies on the Warsaw stock exchange. The WIG20 is slightly unusual in that it allows no more than five companies from one sector. (Interactive, 2022)

Norway Norway is a rich country with a stable economy and large reserves of natural resources, primarily oil and gas and fish. It has a GDP per capita of $62,183 (Worldometer, 2022). The country has a big public sector, high living standards and extensive social welfare. Norway's economy has grown since the early 2000s, with the exception of 2009. (CIA, 2022n)

For Norway, the OBX index was used. This index consists of the 25 most traded companies on the Oslo stock exchange. (Euronext, 2022b)

Hong Kong Hong Kong is a free market economy with international trade and finance. Hong Kong has no tariffs on imports and there are no quotas. The country has a GDP per capita of $61,671 (Worldometer, 2022). It has a strong reliance on foreign trade, and its open economy makes the country exposed to global financial volatility. The Hong Kong Stock Exchange is very attractive for main land China as a stock exchange to list companies and in 2015 more than 50% of the firms listed on the stock exchange were mainland Chinese companies. These companies account for more than 66% of the exchange's market capitalization. (CIA, 2022g)

For Hong Kong, the Hang Seng Index was selected. The index consists of 50 of the largest companies on the Hong Kong stock exchange. The index accounts for around 65% of the exchange's market capitalization. (Chen, 2022a)

Japan Japan has during the last 70 years developed an advanced economy. The country has a strong work ethic and mastery of high technology. It has a GDP per capita of $42,067 (Worldometer, 2022). Measured in purchasing power parity, Japan was the fourth-largest economy in the world in 2017. Japans economy grew after 2000, but has had four recessions after 2008. (CIA, 2022j)

The index used for Japan was the Nikkei 225. This index consist of the top 225 on the Tokyo stock exchange. (Chen, 2022b)

South Korea In the 1960s, South Korea's GDP per capita levels were one of the lowest in the world. Today its GDP per capita is $38,824 (Worldometer, 2022). The economy had a rapid growth during the 1960s and 1970s and was ranked by the Organisation for Economic Cooperation and Development (OECD) to be an advanced economy in 1997. The country had a financial crisis in 1997-1998 and their GDP fell by 7%. After this, the country opened up for more foreign investment and imports, as well as other measures to recover the economy. In the 2000s, the country signed several free trade agreements with the largest economies in the world. (CIA, 2022k)

For South Korea, the KOSPI 200 index was used. KOSPI 200 consists of the largest 200 companies traded on the Korean exchange. The index represents around 70% of the value of the exchange. (Kenton, 2021)

Great Britain The UK is the third-largest economy in Europe. It has a GDP per capita of $44,920 (Worldometer, 2022). The union has a high standard of living. The 2008 financial crisis hit the financial sector of the economy hard. The economy slowed down after the decision to leave the EU in 2016, but the union still has a trade agreement with the EU. (CIA, 2022s)

The index used for Great Britain was the FTSE 100. The index consists of the 100 highest valued companies on the London stock exchange. (Young, 2022)

Brazil Brazil is the eight-largest economy in the world. It has a GDP per capita of $15,553 (Worldometer, 2022). The country has through its history been affected negatively by corruption scandals with private companies and governing officials. Brazil had a recession in 2015-2016 that was the worst in the country's history. The country has since 2016 started infrastructure projects, such as oil and gas auctions, to raise revenue. The country has also reduced the limitations on foreign investment and attempted to improve labor conditions. (CIA, 2022b)

For Brazil, the BOVESPA index was used. The index has around 84 constituents, and represents around 70% of the Brazilian market. (Hayes, 2022)

Mexico Mexico is the third-largest economy in the world and has been part of the North American Free Trade Agreement since 1994. It has a GDP per capita of $18,656 (Worldometer, 2022). Mexico has several structural issues such as low productivity, high inequality, corruption, weak laws and over half of the workforce employed in the informal sector. (CIA, 2022l)

The index used for Mexico was the S&P/BMV INMEX. It has 20 constituents and the stocks are the 20 largest stocks on the S&P/BMV IPC stock exchange. (S&P, 2022b)

New Zealand New Zealand has been transformed from an agrarian economy to an industrial free market economy in the last 40 years. It has a GDP per capita of $40,748 (Worldometer, 2022). The country has a growing per capita income for ten consecutive years from 1997-2007, while falling in the finance crisis. During the 2000s, the consumer debt increased and fueled the growth. The central bank raised its interest rates to battle the inflation and from 2004 to 2007 it had the highest interest rate in the OECD. (CIA, 2022m)

For New Zealand, the S&P midcap index is used. The index is designed to measure the performance of New Zealand's core mid-cap equity market and is rebalanced quarterly by float-adjusted market cap weight (S&P, 2022c). The index consists of 38 constituents.

Australia Australia is an open economy with an active role in major trade and political organizations in the world. It has a GDP per capita of $49,378 (Worldometer, 2022). Australia is a large exporter of natural resources, energy, and food. Large foreign investments are made in Australia because of its few limitations in trade and its richness in natural resources. For most of the 2000s up to 2017 Australia has a large benefit of its trade with low unemployment, continuous growth, low public debt and a strong and stable financial system. In 2018 growth constraints started to apply, driven by a lower global price of its exporting items, lower increase in demand from Asia and China growth decrease. (CIA, 2022a)

For Australia, the index picked is the S&P/ASX 200 index. The index is constituted by 200 eligible companies listed on the Australian Securities Exchange (ASX).

The index is designed to measure the performance of the 200 largest stocks listed on the ASX by market capitalization. (S&P, 2022e)

South Africa South Africa is an emerging market with a large supply of natural resources. It has a GDP per capita of $13,526 (Worldometer, 2022). The country has a well-developed infrastructure and the stock exchange is the largest in Africa and top 20 in the world. The economic growth has slowed the last years, and the official unemployment remain high at a 27% of the workforce. There is also a large amount of inequality and poverty in the country. South Africa is deemed as a risky investment by international credit rating agencies. (CIA, 2022q)

South Africa's index FTSE/JSE Top 40 index is designed to follow the stock market of the capital and industry segments of the South African market. The index consists of 40 companies and follows the FTSE/JSE all shares very closely, as the top 40 companies are the largest on the stock exchange. (FTSE/JSE, 2022)

Turkey Turkey is a free market economy with a large industry and service sector. Its GDP per capita is $28,002 (Worldometer, 2022). The agriculture is 25% of the employment in Turkey. In recent times, there has been political stability, while there still exists concerns about the economic outlook of Turkey. Turkey had a severe financial crisis in 2001, while reforms afterwards strengthened the economy and had an average growth of 6% annually until 2008. The economy contracted in 2009, but the well regulated financial markets and banking system helped the country rebound to 9% growth in 2010 and 2011. The economy is largely reliant on foreign investment. The Turkish currency lira has a continuing depreciation against the dollar. (CIA, 2022r)

For Turkey, the Borsa Istanbul is the main stock exchange. On this stock exchange, the BIST 100 index is used as the main index for the Borsa Istanbul Equity market. It consists of 100 selected stocks and covers the BIST 30 and BIST 50 stocks. (Istanbul, 2022)

Chile Chile has a market-oriented economy with a high level of foreign trade and strong financial institutions. It has a GDP per capita of $24,747 (Worldometer, 2022). Exports of goods and services are about one-third of GDP and commodities are 60% of the exports. In the ten years from 2003 to 2013 real growth was about 5% per year with a slight contraction in 2009 following the global financial crisis. A drop in copper price lowered Chile growth the last few years. (CIA, 2022d)

For Chile, the S&P IPSA aims to measure the performance of the largest and most liquid stocks of the Santiago Stock Exchange. The stocks are ranked by a six-month median traded value and the top 30 are picked. (S&P, 2022d)

Russia Russia is one of the world's largest producers of oil and gas and is a top exporter of various metals. It has a GDP per capita of $25,763 (Worldometer, 2022). Russia heavily relies on commodity export and commodity prices. The economy grew annually 7% from 1998-2008, and since that a diminishing growth. The protection of property rights is weak, and the state interferes continuously with the free operations of the private sector. A large part of Russia's wealth is centered in the government's hands. (CIA, 2022p)

The Russia MOEX index is a market cap weighted index based on prices of the largest stocks on the Moscow Exchange. The Index is 40% oil and gas, 20% financial sector and 18.5% metal and mining industry. (MOEX, 2021)

France The French economy is diverse in all sectors. It has a GDP per capita of $44,033 (Worldometer, 2022). France has a strong government and traditionally the government has been involved in several of the largest companies. France has privatized several of its largest companies, while the government maintains a strong residence in the power, transport, and defense sector. The unemployment rate among young people has been continuously high since 2014. (CIA, 2022e)

The CAC 40 index contain 40 companies and reflects the largest and most actively traded companies on Euronext Paris. The index is mainly weighted into Industrial Goods and services, Personal and household goods, health care and oil and gas. (Euronext, 2022a)

3.2 Country discussion

Most of the countries in this thesis are developed economies with free markets. Several of the countries were already very developed in the year 2000, while some were still growing. By and large, barring a few exceptions, most countries included in this thesis are fairly similar. This is partly due to the nature of the experiment, in that countries that has and have had stock exchanges typically have open market economies of some kind. The availability and accessibility of data was also a factor in this sample set. More developed countries typically provide more usable and easily obtainable macroeconomic data.

As previously stated, a distinction is, in this thesis, made between developing and developed countries. These terms are very unambiguous, without any strict and universally accepted definition. In the context of this thesis we will operate with a definition of developing countries being those that have a GDP per capita of less than $25,000. This is a slightly arbitrary definition, but it is useful in dividing the countries included into two groups based on a central measure of their economy.

By applying this definition the countries considered developing, in the context of this thesis, are China, Mexico, Brazil, Chile and South Africa.

Chapter 4

Research Setup and inference design

In this chapter, the research setup will be explained, and the data used for the research of the hypotheses will be gathered. The data selected for the analysis will be explained and the expected effects in the regression. The main models for data transformation will be explained and derived.

4.1 Country selection

The countries selected for the research are as diverse as the limitations allowed. Primary research for collecting metrics was not an option, and the thesis is, therefore, reliant on the data sources available to the public. The main sources for data in this thesis are the World Bank (World Bank Open Data, 2022) and the OECD database (OECD, 2022) and the data is thereby limited by the completeness of the datasets and the availability of the macroeconomic factors for each country. Both databases are dominated by data on western economies. It is assumed countries of similar economies and cultures will have a similar correlation and relationship between the factors and the stock market. The countries selected in this thesis are:

- Norway (NOR)
- Germany (DEU)
- Italy (ITA)
- France (FRA)
- Great Britain (GBR)
- Poland (POL)
- Greece (GRC)
- Switzerland (CHE)

- Russia (RUS)
- Israel (ISR)
- Turkey (TUR)
- Canada (CAN)
- USA (USA)
- South Africa (ZAF)
- Hong Kong (HKG)
- China (CHN)
- South Korea (KOR)
- Japan (JPN)
- Australia (AUS)
- New Zealand (NZL)
- Singapore (SGP)
- Mexico (MEX)
- Chile (CHL)
- Brazil (BRA)

The majority of the countries are traditionally considered western economies with a high standard of living. It could be argued a more diverse set of countries should be included. As mentioned, this bias is partly caused by the limitations of the thesis and the selected data sources. It was attempted to gather data also for developing countries, but due to the general lack of data and reporting from such countries, finding sufficient data sources proved beyond the limitations of this thesis.

4.2 Macroeconomic variables

In this section, each of the variables used as a measure of the economy of a country will be presented. For each variable, the source and its definitions will be presented. The variables are assumed to be dependent on the stock market of the respective country with a delay. The lag to be used in the regression will be explained at a later stage. The data are collected for all the countries from Section 4.1 in the period 2000-2020, if available. Although referred to as macroeconomic variables throughout this thesis, some of these metrics are not traditionally considered economic in nature. As the overall objective of this thesis is to analyze the stock markets' ability to indicate developments in the wider economy, and economy in this sense is a rather elusive concept, a large selection of metrics was included.

Traditionally of the metrics selected, GDP, household income, and unemployment are metrics to measure the economy and economic growth. From the previous research, most articles use traditional metrics, such as GDP, CPI, and interest rates as indicators. In this thesis, we argue that CPI and interest rate are dependent on national politics and national effects. The other macroeconomic variables included in this study are included to show a broad implication and measure the indirect effects of the stock market. Proxies for economic stability, human development, societal features, and equality could all show effects of improvements for the public and not only the countries' production. As the improvement in stock prices can be the result of a higher share of companies revenue going to the shareholders, wider use of macroeconomic variables is necessary to control for stock manipulation, capital gain motivation for board members, and general living standards. Bust and boom cycles are another factor that can drive both the economy and the stock market, but might not influence access to electricity, fertility rate, and education level in a country as these are wider and slower moving measures.

Number of patent The patent applications per resident with data from World Intellectual Property Organization (WIPO), collected through World Bank. The patent variable can be interpreted as a proxy for technological development and innovation, and thus efficiency gains in the economy. For most countries, the trend is flat, with the exception of China.

Gini The Gini index is collected from the World Bank. For most countries, the Gini index is stable over time and was not measured yearly before 2005. The Gini index is a measure of the inequality of wealth in a nation. Higher values for the GINI index indicate that a country has a high degree of economic equality. A characteristic considered positive for an economy in the context of this thesis.

GDP per capita The GDP per capita measured in current US$ gives an average of the national output in a nation. The data is collected from the World Bank. GDP is a central measure of the well-being of a nation's economy. GDP per capita is used as it allows for comparison of different countries.

Life Expectancy The life expectancy at birth measured in total years could give an indication of level of healthcare and public health in the country. The data is collected from the World Bank. Life expectancy, although typically not considered a macroeconomic feature, gives an indication of a country's level of development, quality of life and prosperity. It is therefore assumed in this thesis that increased life expectancy indicates a positive development of the economy.

Household Income The household income is collected from the OECD database. The measurement includes social benefits and financial income as well as security contributions. The data is adjusted for current prices and PPP. For Singapore, the data is collected from the department of statistics Singapore's website (Department of Statistics Singapore, 2022). PPP adjusted household income is an indicator of the economic well-being of a country's inhabitants. It measures households' solvency more directly than for instance GDP per capita, which measures the average economic output of each person in the country without any indication of the returns on that output, and the distribution of those returns, seen by the population.

Income share of the lowest 10% The income share held by the lowest 10% gives a measurement of the inequality in income. The data is collected from the World Bank. The measure is similar to the GINI index in that it in some way measures inequality. Whereas the GINI index broadly measures the inequality in a country across the population, income share of the lowest 10% indicates how relatively poor the absolute poorest people in a country are.

Pollution The air pollution exposure is a measure in percentage of the WHO guideline and is collected from the World Bank. The metric only has measurements every 5. years before 2010. The interpretation of the level of air pollution as an economic indicator is not necessarily trivial. Lower air pollution indicates a higher standard of living. However, increased air pollution may also indicate increased industrial, and thus economic, activity. In the data, we see that developing countries typically have higher levels of pollution. It can be argued, for such developing countries, increased air pollution might actually be a positive economic indicator. Conversely, for other countries in later development stages, decreased air pollution may indicate positive economic development. Any interpretation of this variable is therefore dependent on the context of the country studied.

Fertility The fertility rate, measured in births per woman, is collected from the World Bank. Changes in fertility are, compared to the other variables here presented, very ambiguous. It is not clear whether decreased fertility is positive or negative for a country's economic development. This will vary between countries with their level of development, age of the population, and many other factors. Thus, it is hard to generally interpret any potential findings of this variable in terms of whether changes in stock market prices indicate positive or negative economic trends. It is still included in the analysis as any potential relationship between stock market prices and fertility can indicate that the stock market is an indicator of the wider economy, even if an exact interpretation of such a relationship is not achievable.

Female Labor The female labor participation rate in percentage of female population above 15 years old. The data is collected from the World Bank. Female labor participation is a measure of gender equality and economic development. This measure is effected by a variety of cultural and political contexts. Despite this, from a purely economic standpoint, it can be argued that increased female labor participation, as with any other segment of the working population, is a positive economic development.

Unemployment The unemployment as a percentage of the total labor force. Data collected from the World Bank. Increasing unemployment is negative for a country's economic development and vice versa.

Access to electricity The access to electricity variable defines the percentage of the population in the country with access to electricity. The data is collected from the World Bank and is equal to 100% for most of the developed countries in the same period. The rationale for including the variable is that for developing countries, the variable may be a proxy for technological development and general increases in quality of life.

Energy use The energy use is measured in kg equivalent of oil per capita usage. The data is collected from the World Bank. Energy use of a country indicates its economic activity as well as its level of development. Increased energy use is thus a positive economic development.

Electric energy use The energy use is measured in kg equivalent of oil per capita usage. The data is collected from the World Bank. Similar to general energy use, electrical energy usage indicates economic activity and level of development. It can be argued electrical energy usage, compared to energy use, is a better indicator of the modernity of a country's economy and its technological sophistication. Access to electricity is also a similar variable, but this measure only accessibility as a percentage of the population, not to what level society and industry utilize electricity compared to other energy sources. Increasing electrical energy use indicates a modernization of a nation's economy and thus positive economic development.

Primary Education Primary school enrollment as a percentage. Collected from the World Bank. Education, of all types, are important indicators of a country's level of development. Higher levels of education lead to technological, industrial, and economic development. Primary education is crucial for an effective labor force, and thus increases in it indicate positive economic development.

Secondary Education Secondary education enrollment as a percentage. Collected from the World Bank. The arguments stated for primary education hold for secondary education as well. It is included as a separate variable, as countries in certain stages of development may have very high levels of primary education but lacking secondary education. These countries will provide indications as to whether the stock market can indicate the wider economy through level of education as secondary education levels change.

Tertiary Education Tertiary school enrollment as a percentage. Collected from the World Bank. Tertiary education is similar to other types of education included in its effects. Tertiary education is, however, the type of education where it can be expected to see the most dramatic changes following the trends of the overall economy. Increased tertiary education is positive for economic development.

Stock Price The historic stock indices is collected of each country's most recognized stock index. As for some countries, the most recognized stock index can be debated, and in most cases, the most common of the indices is chosen. The stock index data is collected from (investing.com, 2022). The data is collected from 2000-2020, as this was the widest range available on the source. Some indices have fewer years than the total range of 21 years, and a summary of the data is shown in Table 4.1. For each index, the end value of December for each year was selected as the yearly value. The indices are presented in Chapter 3.

4.2.1 Linear interpolation of the data

For most of the missing values in the data, a Lerp approach was used for imputation as described in Section 2.1.1. A Lerp approach to imputing missing data is considered beneficial when "*...the panel data contain a high degree of missingness...*" (Kang & Drukker, 2011), which is the case with many of the variables in the data set. An alternative to the Lerp approach to missing data is simply to ignore the missing data and perform the regression analysis without it. This approach avoids introducing false and potentially biased data points into the models, while skipping important data in time steps in a time series. Many of the variables follow long term trends (non-stationarity), for which interpolation is a better imputation method than others, such as mean/median substitution. Due to the relatively small sample size of 21 years, which is even smaller for variables with missing data, there are large spikes in the data and relatively high variance. The raw data will be transformed using a statistical model to achieve stationarity. The interpolation gives a varying variance, as the interpolated data will have less variance than real data. In the article (Isaac Miller,

Country Code	Index Name	Data range
NZL	NZX MidCap	2000-2020
KOR	KOSPI	2000-2020
AUS	S&P/ASX 200	2000-2020
SGP	MSCI Singapore	2004-2020
BRA	Bovespa	2000-2020
MEX	S&P/BMV INMEX	2000-2020
USA	S&P 500	2000-2020
ZAF	South Africa Top 40	2000-2020
TUR	BIST 100	2000-2020
ITA	Italy 40	2003-2020
ISR	TA 35	2000-2020
POL	WIG20	2000-2020
HKG	Hang Seng	2000-2020
CHN	Shanghai Composite	2000-2020
JPN	Nikkei 225	2000-2020
NOR	Oslo OBX	2000-2020
CHL	S&P CLX IPSA	2000-2020
RUS	MOEX Russia	2000-2020
GBR	United Kingdom 100	2001-2020
CAN	S&P/TSX Composite	2000-2020
CHE	SMI	2000-2020
FRA	CAC 40	2000-2020
DEU	DAX	2000-2020
GRC	Athens General Composite	2005-2020

Table 4.1: Country and stock index data overview

2010) it is suggested that Lerp may outperform omission. The same article suggests that Lerp is preferable to high-frequency omission either when the increments are random, or when the time series is moderate but stationary serial correlation is allowed in the increments. As the data will go through a transformation in a later stage, small increments of serial correlation can be assumed to be dealt with in a first difference model, but in other models the serial correlation introduced by Lerp can be the reason for a non-stationary series. As the series is time series and assumed serial correlated before the Lerp, the imputation can have an effect of increasing the non-stationarity in the data and can be a source of error in a later stage. The limitations in collecting data and limitations in the data supply make the research harder as a more advanced statistical model will be necessary to achieve stationarity in the data. is

4.3 Model decisions and regression testing methodology

The effects of applying each model as will be discussed in Section 4.4. A preprocessing of the data will affect the results of the regression, but the choice of model for achieving results will be a prerequisite to which models are valid and will therefore be presented first.

The general regression model used for the results in this thesis will be based on the OLS model. For each regression, the model will test for different lags in the data to see if a delayed effect is present. The optimal amount of lag will be decided by the AIC. By regressing each macroeconomic variable using the stock market indices with a lag, the effect from the stock market on the macroeconomic variable will be present through the regression coefficient. Based on the significance of the regression, the square of residuals, the amount of lag, and the regression coefficient, the results can be interpreted and discussed.

For the lag in the model, we will use the notation L for a lag function. The lag function takes an input x, the time series, and an input *lag* to represent the number of years to lag and t, the time input in the time series. The lagged series will then be, $L(x, lag, t) : x(t) = x(t - lag)$, representing a lag amount of shift in the time series from the time t.

The OLS model for the regression will be given by the equation:

$$var_{cnt,lag}(year) = \beta_{0,cnt,lag} + \beta_{1,cnt,lag} \cdot L(stock_{cnt}, lag, year) + \epsilon \tag{4.1}$$

where *var* represents each macroeconomic variable, *cnt* represents country, *lag* represents the number of lags in the stock index price, *stock* represents the stock index price for the respective country and L is a function with the series and the lag as an input. For each country and each variable, we will derive a regression result for each lag. From each lag, the optimal is chosen based on the lowest AIC result, and this will give the corresponding $\beta_{1,cnt,lag}$, the coefficient to give an interpretation of the effects on that country, on the respective variable from the stock index with an optimal lag.

This testing method will be run for each of the 24 countries and their respective stock indices, each of the 16 remaining macroeconomic variables, and for 10 lags. As the data is only over 21 years, 2000-2020 more than 10 lags would result in low confidence in the results as there would be few points of data left to regress.

4.4 Statistical data model

The acceptable handling of missing data points is dependent on the model to be used and the requirements of that model. The model is outlined in Section 4.3. One of the basic assumptions of linear regression is the stationarity of the time series. The stationarity is traditionally tested with unit root tests. As discussed in Section 2.1.3 unit root tests are a widely discussed subject and the accuracy of such tests must be discussed in the context of the regression and the data. As the data is not random and in a time series, it could benefit the analysis to transform the data to make the series stationary. There are several methods in making data stationary and in this thesis we will use six methods, which will be explained in this chapter, to do the minimum amount of transformations to achieve the most accurate results. For each model, the stationary solution will be decided by an augmented Dickey-Fuller test. In this thesis, we choose a weakly significant limit, $p < 0.10$, as the required significance level to reject the null hypothesis in the stationarity tests. The null hypothesis is that the time series is non-stationary — has a trending variance over time – and the rejection of the null hypothesis will be that the series is stationary. If the Dickey-Fuller statistic is less than the test statistic with confidence of p, the null hypothesis is rejected. After testing all the methods, the best-performing model will be selected. Before the regression, the best model for data transformation will be applied to all series.

The independent variable, the stock price, will also be transformed by these models to test for the optimal model. A transformation in the independent variable corresponds to an inverse transformation in the explanatory variable in a regression, and the regression result will consequently be a valid result with an adjustment in the regression coefficient. As the independent variable will be the explanatory variable, regression results will be comparable between one country. When comparing different countries, a direct comparison should include a discussion of the differences in the transformation model of the explanatory variable when using different models. For this reason, the same data transformation model will be used on all data before the regression, as described in Section 4.3.

Only one model will be chosen per variable per country (per time series) in the testing phase, and for each model, the transformation that provides the most significant result will be selected as the optimal for that time series. In the final results, one model will be selected for the regressions to create comparable results where the coefficient sizes are easily discussable. The best model will then be applied to all time series. The regression will then use the data decided by the best time series for the tests to derive the results as described in Section 4.3.

A lag in the data in the preprocessing would correspond to the same lag in a regression model. A normalization of the data was considered to make the regression results and coefficient comparable between the countries and between the macroeconomic variables, but it would affect the relative sizes of the effects and make the actual effects of a comparison less observable.

4.4.1 Model 1 – No transformation

The first model represents the no transformation of the data, the raw data directly in the stationarity test. If the data is stationary in its original form, a regression will give the most authentic and real world applicable result.

4.4.2 Model 2 – First difference transformation

The second model is the first difference model, and addresses the problem of omitted variables. For each series, the transformation derives the difference from the previous value.

$$\hat{y}_{t,i} = y_{t,i} - y_{t-1,i} \tag{4.2}$$

4.4.3 Model 3 – Base average shift model

The base average shift model is a model used to adjust the starting value in the time series. The model removes the mean from each of the series, as the change from the mean will provide a metric in the series from each effect as a change from the mean value.

$$\hat{y}_{t,i} = y_{t,i} - \bar{y}_{t,i} \tag{4.3}$$

4.4.4 Model 4 – Log first difference

The natural logarithm first difference model uses a combination of logarithms and the first difference model to give a closer to linear series with exponential differences between consecutive numbers in the series.

$$\hat{y}_{t,i} = ln(y_{t,i}) - ln(y_{t-1,i}) \tag{4.4}$$

4.4.5 Model 5 – Log first difference, lag 2

The natural logarithm first difference with two in lag skips the consecutive values and looks at the difference with a two lagged period.

$$\hat{y}_{t,i} = ln(y_{t,i}) - ln(y_{t-2,1}) \tag{4.5}$$

4.4.6 Model 6 – Log average shift model

The natural logarithm average shift model combines logarithm with the average shift model transformation and can remove the base effects of a high starting point along with making exponential trends linear.

$$\hat{y}_t = ln(y_t) - \overline{ln(y_t)} \tag{4.6}$$

Chapter 5
Results and discussion

This chapter will present the results from the studies and discuss the findings. The chapter begin by introducing the results from the model selection by the unit root test, and then continues with the results of the unit root test for the best transformation model found in the first part. Afterwards, the regression results are presented and the implications discusses. Lastly, the chapter concludes in a discussion of the empirical analysis, the data analyzed and the implications of the study on the hypotheses.

5.1 Unit root transformation results

The augmented Dickey-Fuller (ADF) unit test decides stationarity as described in Section 4.4. Stationary or weakly significantly stationary time series would be optimal for a regression with valid results. To save the space as there are over 400 time series and 7 models to test, for each of them only the transformation model and the corresponding p-value deemed as optimal is included in the results. If the ADF test give no significant p-value to reject the null hypothesis for any of the models, the log first difference model (Model 4) is chosen to show the test results. After the optimal model was selected, model 4, all series was transformed using this.

5.1.1 Model selection results

In Figure 5.1 a heatmap of the stationary variables from the unit root tests per country is shown using weak stationarity. Out of the 17 variables and 24 countries, totaling 408 time series, 290 of the series are stationary with the optimal transformation model. In the tables in Appendix A, Section A.1, the stationarity results for each combination are shown, split in country triplets for space purposes. As we can see, some variables have very few stationary series cross countries, while other, have many. Overall, none of the macroeconomic variables have no stationary series, but “Access to Electricity” is the closest. The data series of access to electricity is a dataset of mostly constant values. For most western countries in the time frame 2000-2020, the

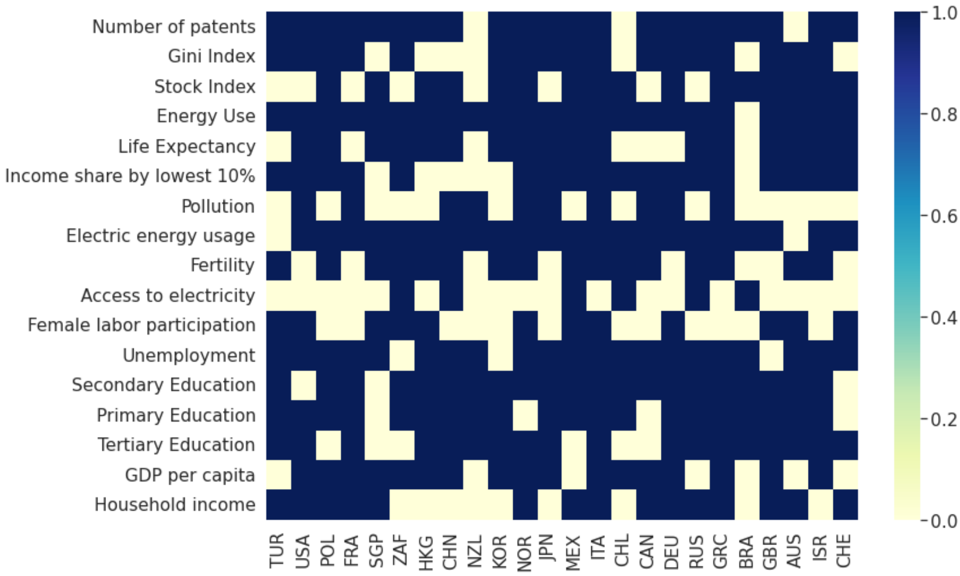

Figure 5.1: Heatmap of stationary variables from the unit root tests per country, using weak stationarity, ($p < 0.1$) with all models (1-6).

access to electricity is already 100% and a constant series will not have a noticeable effect on a variable series.

Another noticeable variable is pollution with high amounts of non-stationary trends, suspected to be from missing data that has been interpolated, with low variations in the original data. An interpolation of two equal variables will create a variable of the mean of the two variables, without varying variance in the series, causing a non-interesting series.

Energy use, unemployment, number of patents and secondary education are other noticeable variables where for almost all countries the series is stationary with their respective transformation.

The model selection is visualized in Figure 5.2. There is a large spread in models through the series, and no model can be said to dominate the data. Each model does better in some series than in others. Model 4 was selected due to model score and convenience in results interpretation. This model is also supported by the background in Section 2.2.

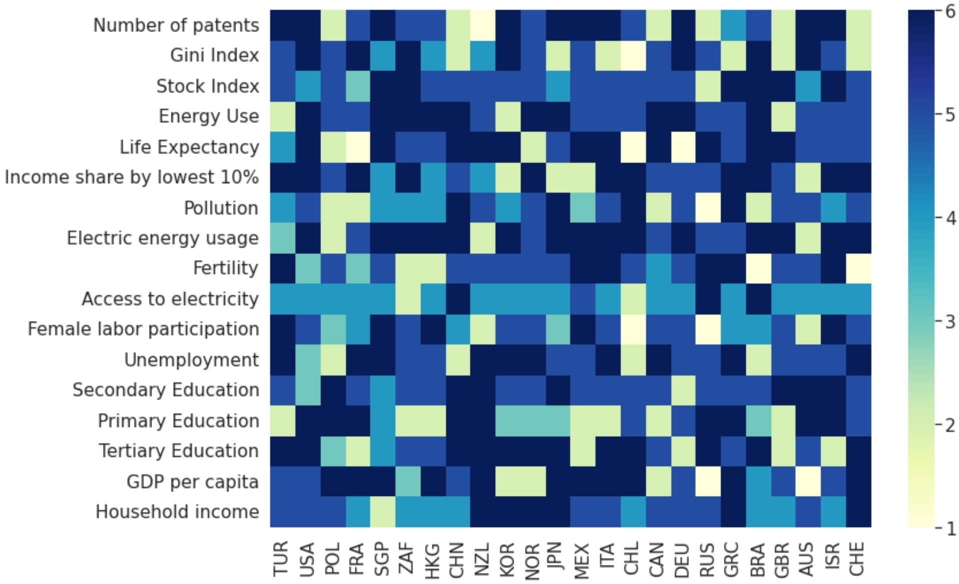

Figure 5.2: Best fit data transformation model by country and coefficient. The models are visualized by model as shown on the right label axis.

5.1.2 Final model unit root results

The final model, model 4, is described in Section 4.4.4. The results of the regression are found in Appendix A, Section A.2. Using only this model, as expected, the results are worse than using all 6 models. Out of the 408 combinations of countries and variables, 189 of them are weakly significant. The heatmap in figure 5.3 visualize the stationary series. The blue color in the figure indicates a significant stationary solution, as there we can significantly reject the null hypothesis that there exists a unit root.

5.2 Countries and omitted variables

In the regression, one of the assumptions of a time series is the stationarity condition to ensure no multicollinearity. As some countries had non-stationary stock index price, the regression results should be looked at with skepticism as the regressions potentially breaks the assumptions of OLS regression. The regressions containing non-stationary series will be a part of the combined regression results and the further discussion, even as they might not result in a strictly correct regression.

All the macroeconomic variables has at a minimum of one stationary series and one significant regression.

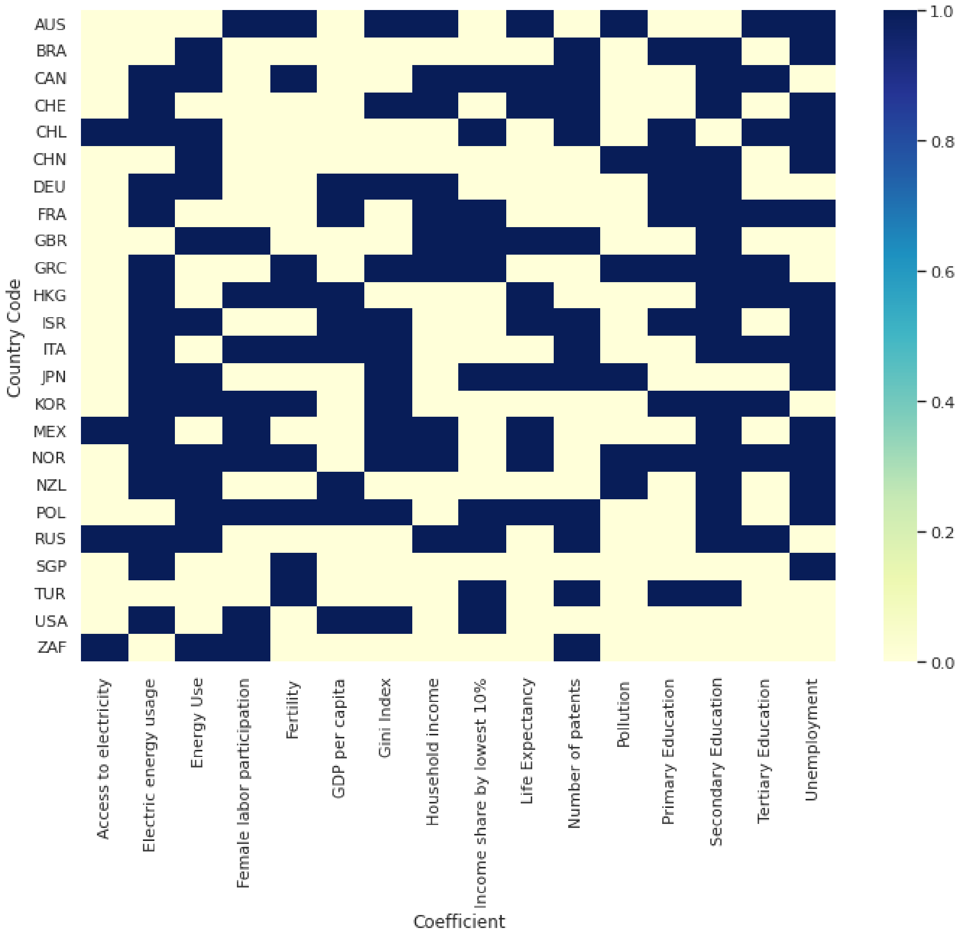

Figure 5.3: Heatmap of stationary variables from the unit root tests per country, using weak stationarity, ($p < 0.1$) with only model 4.

5.3 Regression results

The regression result tables can be seen in Appendix A.3. The regression is described in Chapter 4 with a linear regression using OLS. For each country and each macroeconomic variable, the macroeconomic variable is regressed on the explanatory variable, the stock index, for ten different lags. Only the best result, measured by AIC, is displayed in the tables in the Appendix, and only the best result, with regard to lag, will be discussed going forward, referred to as the regression result of the respective country and variable.

In the appendix, two and two countries are presented with their respective lags, macroeconomic variable coefficient, P-value and R^2 for each macroeconomic variable regression. A summary with the average coefficients for all the macroeconomic variables can be found in Table 5.1. The coefficients are visualized as a heat map in Figure 5.4. The z-axis, i.e., the color scale, in this plot is limited to the interval from -0.5 to 1 despite some results being higher or lower than this. This is done so that a few outliers does not overly extend the scale, saturating the majority of the results. Statistically insignificant results have a coefficient of 0 in this plot.

The results are also visualized in Figure 5.5 as a box plot, displaying coefficients observed for each macroeconomic variable and each country respectively. This plot show minimum, first quartile, second quartile (median), third quartile, and maximum values for the different observations. Statistically insignificant results are not included in the plot.

This section will cover all the macroeconomic variables and review their results for the different countries.

5.3.1 Macroeconomic series coefficients

Number of patents

The results from the number of patents regression models are statistically significant for 12 of the 24 countries, and have an average coefficient of -0.034632. From Figures 5.5 and 5.4 we see that the results vary considerably. There are some observations that have relatively high positive coefficients, such as Australia, Greece, Mexico, and Turkey. Other countries have an opposite but simular coefficients, such as Chile, New Zealand and South Africa. These results indicate that there is no consistent relationship between stock market prices and number of patents filed across the different countries. The average coefficient suggests a negative trend between the two, but the overall variance of the coefficients makes it difficult to decisively conclude that any universal trend exist. The fact that the countries with negative coefficient are so varied in their development, and the same is true for those with positive

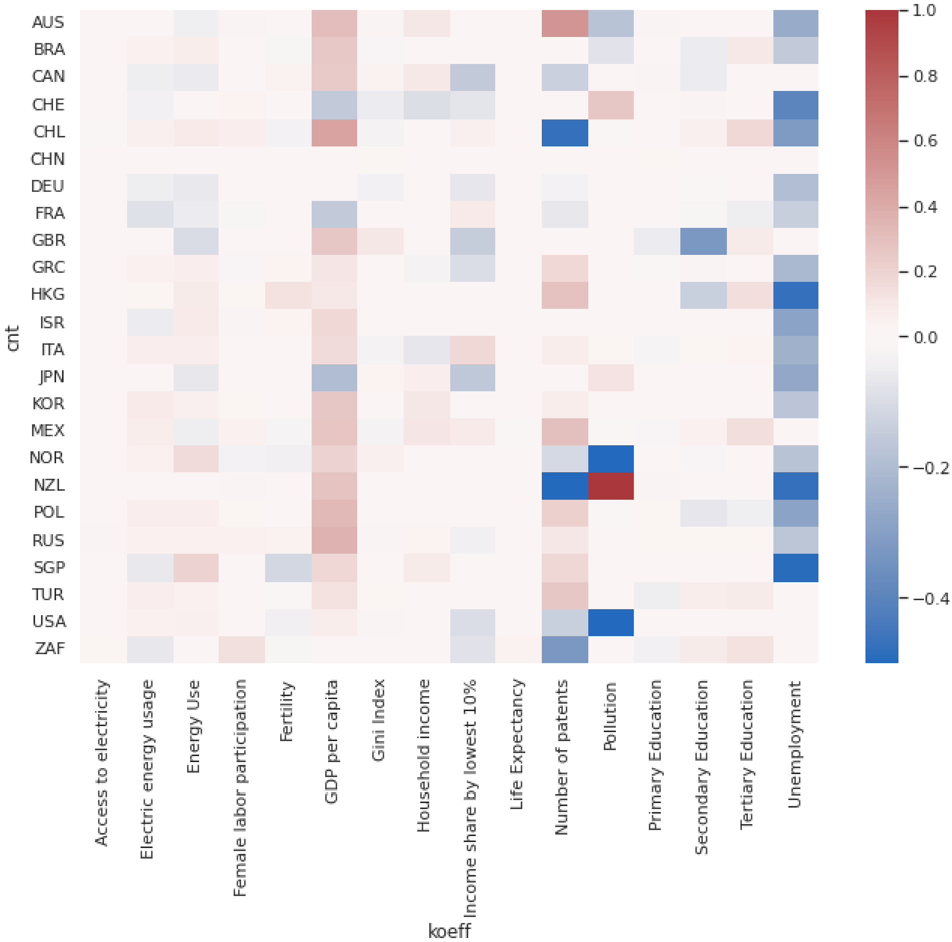

Figure 5.4: Heatmap of the coefficient values for each country and macroeconomic series. The extreme values are reduced to 1 on the positive and -0.5 on the negative to improve the visualization of the less extreme coefficients.

	Coefficient value	Significant count
Access to electricity	0.016620	2
Electric energy usage	0.025514	15
Energy Use	0.031739	17
Female labor participation	0.030634	10
Fertility	0.013724	5
GDP per capita	0.206743	12
Gini Index	0.017681	8
Household income	0.071426	5
Income share by lowest 10%	-0.027747	8
Life Expectancy	0.016227	3
Number of patents	-0.034632	12
Pollution	-0.003870	10
Primary Education	0.001437	9
Secondary Education	-0.038926	10
Tertiary Education	0.083804	5
Unemployment	-0.311569	11

Table 5.1: Coefficient averages of the macroeconomic variables. The significant count uses $p < 0.05$ as a level of significance.

coefficient, indicates that there are not different trends for developing and developed countries. Of the countries with large, both positive and negative, coefficient, many are, however, in the developing category. This suggests that number of patents are more volatile in developing countries, which is to be expected.

GINI index

The GINI index regression models are statistically significant for 8 countries, with an average coefficient of 0.017681. The results have some variance and a slightly positive trend across the different countries. Overall, there seems to be a weak but positive trend between stock market prices and GINI index. This supports the hypotheses based on the assumption that increased GINI score indicates positive economic development.

Energy use

The regression results for energy use are statistically significant for 17 of the 24 countries, with an average coefficient of 0.031739. There are variations in the results,

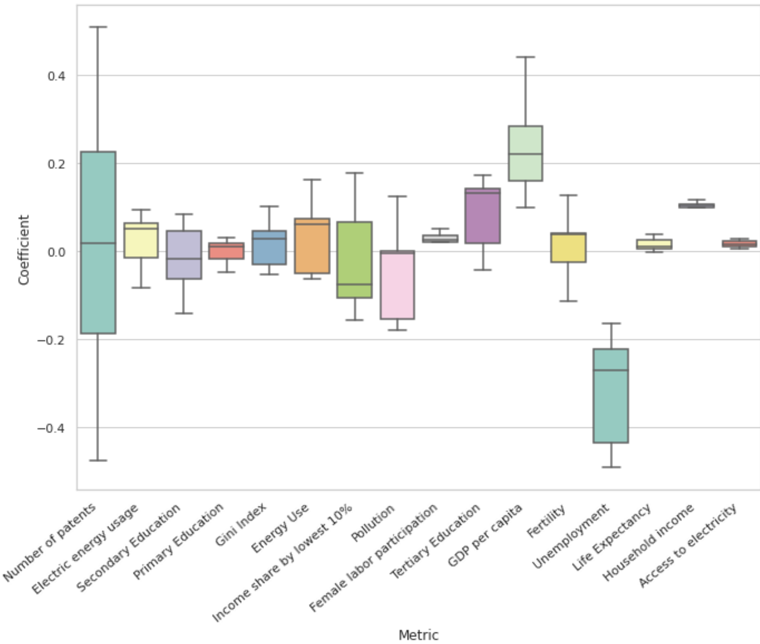

Figure 5.5: A box plot showing the distributions of coefficients for each macroeconomic variable. The plot only considers significant regressions, remaining series have been dropped.

and for many countries negative coefficients are observed. This suggests that there is no consistent trend between stock market prices and energy use across the different countries. The results do not seem to fluctuate with the level of development of countries, as both developed and developing countries see variate trends.

Life expectancy

For life expectancy, only 3 of the 24 regression models are statistically significant, with an average coefficient of 0.016227. With the very low number of statistically significant results, it is likely that most of, if not all, the observed trend is a statistical fluke. Thus, we should not infer any relationship between stock market prices and life expectancy based on these results. This is somewhat expected given the relatively short period studied, as we can expect this metric to change very slowly, barring any major catastrophe.

Income share of lowest 10%

Income share of lowest 10% have statistically significant models for 8 of the countries. The average coefficient is -0.027747. Despite the average and median results indicating a negative trend, Mexico, Italy, France, and Chile have positive coefficients. This suggests that there exists no consistent trend between stock market prices and income share of lowest 10% across the different countries.

Pollution

The results for the pollution variable are statistically significant for 10 countries, with an average coefficient of -0.003870. This in and of itself suggests a slight negative trend between stock market prices and air pollution. There are, however, some very varied results behind this average. The US, Norway and partially Australia have strong negative coefficients. The coefficients for Switzerland and particularly New Zealand, however, indicate a strong positive relationship. These diverging results makes it difficult to infer any consistent relationship between stock market prices and pollution. The observed trends can be due to other, country specific, factors, or they may be spurious correlations or other misleading results.

Electric energy usage

Electric energy usage has statistically significant results for 15 of the 24 countries. For these, the average coefficient is 0.025514, suggesting a slight positive trend. The results have some variance, as both positive and negative coefficients are observed. Thus it is not possible to infer any consistent relationship between stock market prices and electrical energy usage across the various countries.

Fertility

The results for fertility are statistically significant only for 5 countries. Of these the average coefficient is 0.013724. The only two observations here suggesting trends are for Hong Kong, for which there seems to be a positive trend, and Singapore, for which there seems to be a negative trend. These countries are fairly similar, suggesting there may be a country specific relationship. As the coefficients are opposite, however, inferring any meaningful relationship between stock market prices and fertility is difficult, based on the results.

Access to electricity

Access to electricity has statistically significant results for only 2 countries. These are Russia and Brazil which both have positive coefficients with an average of 0.016620. If we extend to weakly statistically significant ($p < 0.1$) results then South Africa, Mexico, and Chile have valid coefficients as well, thus covering all the developing countries, except for China, but including Russia. All the countries have positive coefficients except for Chile with a slight negative coefficient of -0.01463. As stated, this variable was included to specifically study developing countries. When tolerating weakly significant results, there appears to be a positive trend between stock market prices and access to electricity. The small number of statistically significant ($p < 0.05$) results, however, makes it difficult to decisively conclude on whether an actual relationship between stock market prices and access to electricity exists.

Female labor participation

Female labor participation has statistically significant results for 10 countries. For these, the average coefficient is 0.030634. The variance of these results are low, suggesting a fairly consistent trend between stock market prices and female labor participation.

Unemployment

The results for unemployment are statistically significant for 11 countries. The average coefficient is -0.311569. These results are some of the clearest findings in the regression results, suggesting a negative relationship between stock market prices and unemployment. There are some variations in the strength of the relationship across the different countries, but no observations indicate an opposite trend. The largest coefficients are observed for Singapore, New Zealand, Hong Kong and Switzerland. With the exception of New Zealand all these countries have strong financial sectors suggesting, somewhat expectedly, that in countries in which finance is one of the largest industries, the relationship between the stock market and the labor market is stronger.

Primary education

Primary education has statistically significant results for 9 countries. The average coefficient is 0.001437. The variable has some variations in its results, with some countries' coefficients suggesting a negative trend. With small coefficients compared to the variations of positive and negative results, there seems to be no decisive relationship between stock market prices and primary education.

Secondary education

Secondary education has statistically significant results for 10 countries. The average coefficient is -0.038926. These results indicate, surprisingly, that there may be a negative relationship between stock market prices and secondary education. The coefficients for Poland, Hong Kong, Great Britain, Canada, and Brazil all suggest a negative trend. There is seemingly no common characteristic of these countries that would explain this observation. Generally the results have large variations, with several of them indicating a positive trend as well. Therefore, it is difficult to decisively conclude on any consistent relationship between stock market prices and secondary education.

Tertiary education

The results for tertiary education are statistically significant for 5 countries. For these countries the average coefficient is 0.083804. There are some variations in the results, with one negative coefficient observed. Despite this, the results suggest a positive relationship between stock market prices and tertiary education. Note however that this finding is based on few results.

GDP per capita

GDP per capita has statistically significant results for 12 countries. The average of these coefficients is 0.206743. There is some variance in the results, but they largely suggest a positive trend between stock market prices and GDP per capita.

Household income

Household income has statistically significant results for only 5 countries. For these countries the average coefficient is 0.071426. The results see minor variance. Based on these results, there appears to be a positive relationship between stock market prices and household income.

5.3.2 Significance and stationarity

The regression results with significant values are visualized in Figure 5.6. A large share of the regressions provide significant results, as 142 of the 384 regressions are significant with ($p < 0.05$). With a significance of 5%, we could expect that 1 out of 20 would be significant if the sample was random. With 142 out of 384, a share of 36.98%, we can expect that the trends observed are different from a random sample. We can clearly see a trend that access to electricity is an insignificant regression in almost all cases, just as discussed is Section 5.1. The reason for this is that the data was mostly already 100% for most countries in the regression, and a constant series should not provide a significant result, assuming the compared variable, stock price, is not constant. The coefficient is still an interesting result as for the developing countries, we expect this coefficient to provide a proxy for development.

5.3.3 Optimal lag in the regression models

In Figure 5.7 we see the lags selected for each macroeconomic variable for each country. An average of lags applied per macroeconomic variable is shown in Table 5.2. Lag is selected based on the regression as explained in Section 4.3, and is optimized based on AIC. From the figure, we see that a variety of lags is applied to

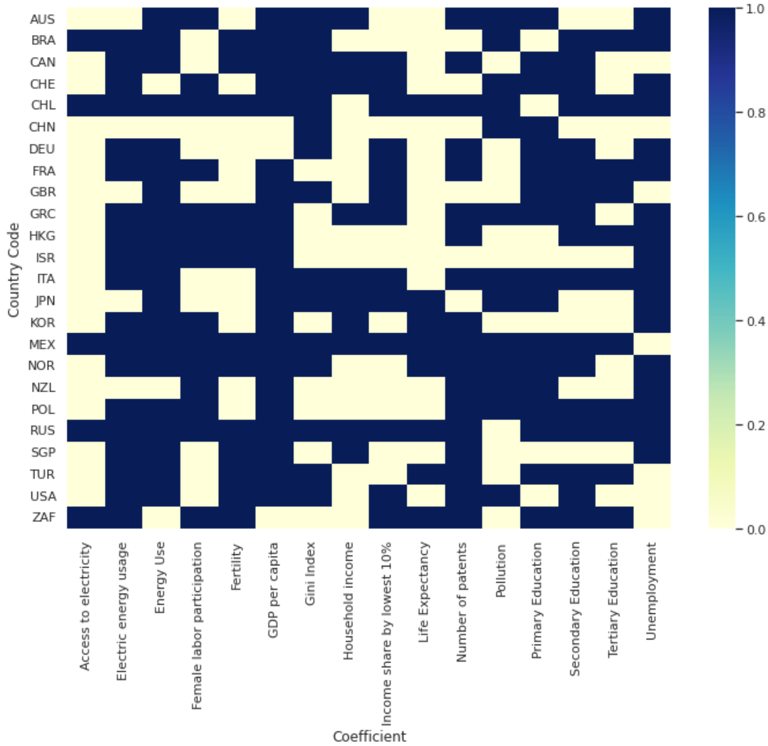

Figure 5.6: Heatmap of significant regressions results (p < 0.1). The color blue marks a significant regression result. The white color represents insignificant regression results.

different contexts, and seemingly at random. There are, however, some trends in the selection of lags. Fertility, income share of 10%, GDP per capita, number of patents, pollution, and primary education all have average optimal lags of more than four years. This indicates that stock market prices may have a delayed effect on these macroeconomic variables. For some of these variables, it can be argued this is to be expected. Variables like pollution, fertility, primary education and number of patents are expected to be slow moving variables, reacting only after economic growth in more direct terms has already been present for some years.

Similarly, there are variables that have relatively low optimal lags in the result. Access to electricity, life expectancy and unemployment stand out with less than two years lag applied. For unemployment, it can be argued rapid changes in the stock market quickly can lead to changes in unemployment. Especially in downturns, with rapidly falling stock prices, businesses can rapidly lay off workers, thus quickly having a noticeable impact on unemployment. The other two variables with notably

Macro variable	Average lag
Access to electricity	1.625
Electric energy usage	3.5625
Energy Use	3.125
Female labor participation	2.1875
Fertility	4.0625
GDP per capita	4.4375
Gini Index	3.5625
Household income	2.875
Income share by lowest 10%	4.4375
Life Expectancy	1.875
Number of patents	5.3125
Pollution	5.3125
Primary Education	6.1875
Secondary Education	3.8125
Tertiary Education	3.1875
Unemployment	1.6875

Table 5.2: Average lag per coefficient

low lags, life expectancy and access to electricity, are also the variables for which there are the fewest significant results. We know these metrics have little to no change for many of the countries over the period studied. This suggests that the low lags selected was chosen as a default with no level of lag being able to significantly decrease AIC as no good fitting model exists.

5.3.4 R^2 scores

In Figure 5.8 we see the R^2 scores for the models. Statistically insignificant models are marked as gray in this plot. By and large, the R^2 scores obtained are fairly low. This suggests that the models poorly explain the macroeconomic variables observed. This is to be expected due to the simplicity of each model, measuring only stock market prices against each macroeconomic variable. Adding control variables to each regression could increase this score. Despite the generally low scores, there are some models that achieve high R^2 scores. Most notably, access to electricity, electric energy use, and energy use in Russia have good scores suggesting a general change in energy use of various kinds have fit well with observed stock market prices in Russia

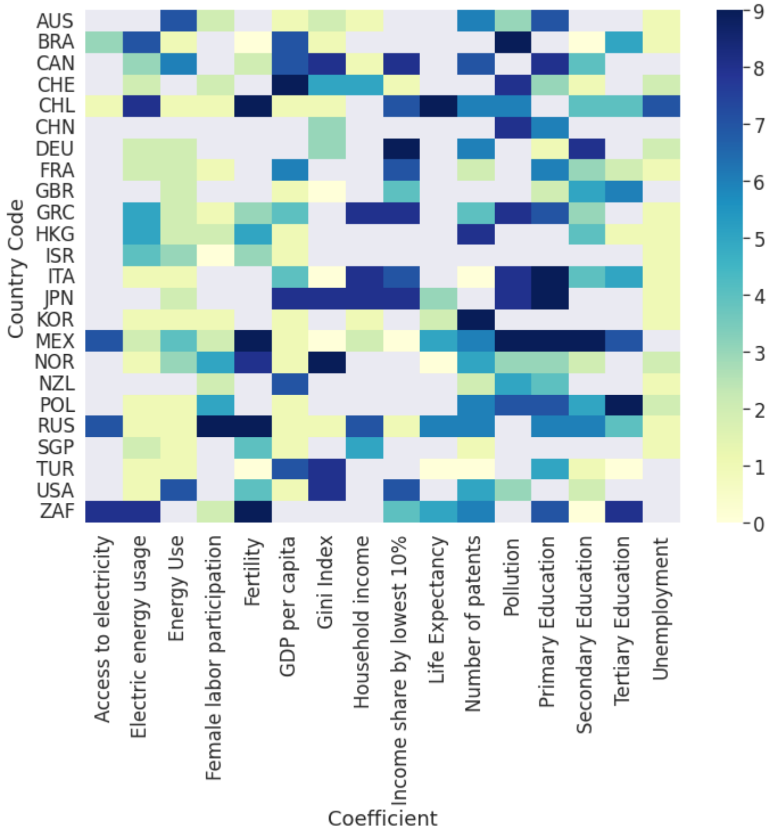

Figure 5.7: The optimal lag from each result. The optimal lag was decided from the AIC. The figure only shows the lag from weakly significant regressions ($p < 0.10$).

for the given lags. It can be argued that this is due to Russia's economy being highly dependent on energy exports.

5.4 Discussion of the results

The results suggests that relationships exists from stock market prices to certain macroeconomic variables. These relationships are observed with a lag applied to the macroeconomic variable suggesting a delay in the relationship from stock market prices to changes in the macroeconomic variables. Such relationships are observed for female labor participation, tertiary education, GDP per capita, unemployment and household income. Specifically, the results imply that a 1% increase in stock market prices lead to a 0.030634% increase in female labor participation, a 0.206743% increase in GDP per capita, a 0.071426% increase in household income, a 0.083804% increase in tertiary education and a 0.311569% decrease in unemployment. For the

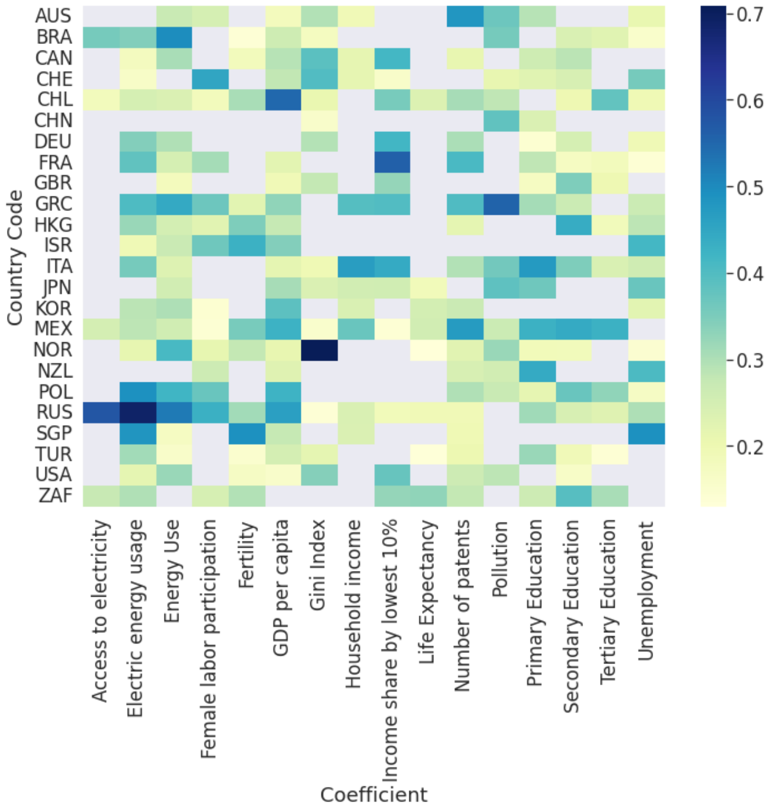

Figure 5.8: The r2 score of the regression for each country and macroeconomic series. The plot only considers weakly significant regressions, remaining series have been dropped.

other macroeconomic variables studied there appears to be no consistent trend across the various countries. Neither are there observed any such trends among developed or developing countries.

In this section the results will be discussed and the hypotheses will be evaluated. The statistical models and methods applied, as well as the overall quality of the results, will be reviewed, along with a discussion on their potential impact on the findings of this thesis.

5.4.1 Hypotheses evaluation

The results partially support *H1* — There exists a measurable relationship from the stock market prices to the macroeconomic variables — in that such a relationship is observed for five of the macroeconomic variables studied. The lag applied to the macroeconomic variables suggests that this is a directional relationship and that the trend is observable from stock market prices to the macroeconomic variables. The results imply causality between stock market prices and these variables. Such a causal relationship may exist, but would require further research to definitively confirm the causality. There may be other external factors influencing both stock market prices and the macroeconomic variables responsible for the observed relationship. These results also does not exclude the existence of opposite relationships to those observed, i.e., that changes in the macroeconomic variables leads to, but not necessarily cause, changes in stock prices. Such relationships have support in the literature, but are not studied directly in this thesis. The stock market can be interpreted as an indication of future growth and future growth expectations. Because of this, it is largely priced by the companies expected revenue, inflation and real interest in the respective market, and adjusted for political, economic and structural risk. In bust and boom cycles, the stock market has often proved to be bad at estimating structural risk, and it is argued by (Malkiel, 1989) risk averse investors might worsen the bubble's in the stock market. The future predictions of the economy are often related to GDP, while investors often have a short time perspective for their evaluations. The future expectations might be a source of error or a cause of a correlation between the stock prices and economic variables, but this would be speculation.

The macroeconomic variables for which a relationship is observed are largely the more traditional macroeconomic metrics included in this study, i.e., GDP per capita, unemployment and household income. This is in line with existing literature presented in Chapter 2, such as (Wongbangpo & Sharma, 2002) and (Levine & Zervos, 1998). Female labor participation and tertiary education are not considered traditional macroeconomic metrics, but still show such a relationship, suggesting stock market prices can be used as an indicator for a broader economic view.

For many of the macroeconomic variables studied, no consistent relationship following stock market prices was found. For some of these, such as fertility, access to electricity, primary education, pollution and life expectancy, this was expected as they are either very slow moving variables or constant for a large selection of the countries. For some of the variables, the expected change with an increase in stock market prices may also be ambiguous. As previously mentioned, this is the case for pollution and fertility. A similar argument may also hold for other variables. For instance, both GINI index and income share of lowest 10% measure, in some way, inequality. Although reduced inequality is generally considered a positive economic development, increases in stock market prices may increase inequality, even as they also trend with broader economic growth. The reasoning for this is that returns on capital, presented by increased stock market prices, may disproportionately benefit the wealthy, and thus increase inequality.

This ambiguity in expected relationship with stock market prices may explain why no relationship is observed for some of the studied variables. It may also be the case, of course, that such relationships simply does not exist, or that they are too elusive or long-term to be measured in this study.

For *H2* — Growth in stock market prices leads, over time, to positive development in other macroeconomic variables — the results support the hypothesis for those variables for which a trend is observed. Increased stock market prices seems to indicate a trend of increased female labor participation, increased tertiary education, increased GDP per capita, decreased unemployment and increased household income. These changes in the macroeconomic variables are all considered positive economic developments. *H2* is therefore partially supported in the results.

The implications of the results on *H3* — For developed countries, the stock exchange will be a better indicator for the economy than for developing countries — are harder to interpret. By and large, there seems to be little difference in the relationships observed between developed and developing countries. For many of the variables, there was too much variance in the results to conclude on any consistent relationships, and this variance was present both for developing and developed countries. Of the variables for which trends were observed, there is little to no difference in the magnitude of the trend between developed and developing countries, with exception of tertiary education. For tertiary education, the average observed coefficient is 0.11876 for developing countries and 0.056559 for developed countries, suggesting the relationship between stock market prices and tertiary education is actually stronger for developing countries. This is, however, only observed for one variable based on the results for three developing countries that had statistically significant results.

For *H3* there are no supporting results given that none of the variables studied suggests a more clear relationship with stock market prices for developed countries, than for developing countries. If anything, the results for tertiary education suggests the opposite may hold for this specific macroeconomic variable.

One possible explanation as to why no difference between developed and developing countries is observed may be that such a difference could be considered an arbitrage opportunity, and thus would not exist in efficient markets. The reason for this is that disproportionately large returns on stock market growth in certain countries in terms of economic growth, for instance measured in GDP, could be the result of large potential investments in technology with high marginal returns. The marginal returns could be assumed higher, as adopting current technology has a higher marginal return than researching new technology. If such an investment opportunity existed, investors would find this to be a high rewarding investment and invest in the developing countries until the risk adjusted return on capital would be equal to the one in developed countries. The lack of such an investment opportunity indicates efficient markets.

5.4.2 Model and methods evaluation

There are multiple issues with the statistical models and methods applied in this thesis. These issues stem partially from the overall limitations of the thesis and partially from the limitations posed by the data available. In this section, some of these issues will be discussed, along with their potential impact on the results presented.

One issue with the data used in this thesis was missing data points. For some of the macroeconomic variables studied only sporadic data was available. The available data varied greatly between countries. This made it necessary to interpolate some of the data before it could be used in the research. Such interpolation decreases the validity of the findings by essentially introducing untrue data points. These data points may bias the results, as real trends may not be observed.

Another issue with the data used in this thesis was making the various time series stationary. As outlined in Chapter 4, transformation were applied to the time series in an attempt at making the series stationary. As seen in the results, this transformation only made 189 of the total 408 time series stationary. Subsequently, a large part of the regressions performed were done using non-stationary time series. From Figure 5.1 we see the extent of this non-stationarity.

As stated, using non-stationary time series breaks an assumption of the OLS method used for regression analysis. Using such time series therefore introduces a potential problem with the obtained results, namely spurious correlation. Spurious correlations produce results that seemingly indicate a relationship between variables, despite their being no connection between them. This has, due to the high number of non-stationary time series applied, in all likelihood, biased the results obtained in this thesis. This makes any inference of causality made based on the results of the regression models, at best, weak.

5.4.3 Results evaluation

A large part of the results of the regression models are statistically insignificant. This can be, partly, because there is insufficient information in the data to support the existence of a linear relationship between the variables. It can also be the case that, for the insignificant, there are no relationship to observe. The large number of statistically insignificant results may also be due to the simplicity of each regression model. The small sample size applied in each model may also lead to insignificant results. The presence of several statistically insignificant results indicate that more research, using more extensive models and data, is necessary to better understand the relationships studied.

Across the different macroeconomic variables, we see some variance in the results. For some variables in particular, this variance is fairly large. This suggests, quite expectedly, that there are other factors than stock market prices alone that influence the macroeconomic variables. Some of this variance may also be due to spurious correlations due to non-stationary data or imputation through interpolation essentially producing untrue findings.

Chapter 6 Conclusions and future work

The assumptions foundational to this thesis, that the stock market can and should be used as an indicator of the state of the economy, has some support in the findings of this thesis. We see that for certain macroeconomic variables, the results suggests a relationship from stock market prices to the variable. These are female labor participation, tertiary education, GDP per capita, unemployment and household income. For other macroeconomic variables studied, namely fertility, income share by the lowest 10%, life expectancy, number of patents, pollution, GINI index, energy use, electrical energy usage, access to electricity, and primary and secondary education, however, no such consistent relationship can be found across the various countries. The relationships are significant to some extent, with the optimal amount of lag varying in between the variables with a varying coefficient. The lagged significant regressions with a wide support in the result suggest a causal relationship from the stock market prices to the macroeconomic variables for where this trend is observed.

More research into whether, and to what degree, the stock market can be used as an indicator of the state of the economy is needed before any conclusions can be determined. Such research should build on more complex statistical models and broader complete data set. A model using stationary time series could benefit the analysis. Other stock market indicators and their relationships to key macroeconomic indicators should also be included to generate a more complete picture. Including more than just the stock price in the regression could be beneficiary for observing the isolated effects of the stock index price's contribution to control for other variables. More extensive research into the causality of the relationships may also be explored to further understanding of the stock market as an economic indicator.

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Appendix

Appendix A

A.1 Stationarity results all models

	TUR	USA	POL
Number of patents	(6, -2.7624*)	(6, -46.6741***)	(2, -4.3359***)
Gini Index	(5, -5.668***)	(6, -2.83*)	(5, -3.4051**)
Stock Index	(5, -0.9565)	(4, -1.9221)	(5, -3.3825**)
Energy Use	(2, -9.8075***)	(6, -5.7982***)	(5, -2.7222*)
Life Expectancy	(4, 0.4463)	(6, -11.2135***)	(2, -4.9581***)
Income share by lowest 10%	(6, -3.3459**)	(6, -2.9778**)	(5, -4.6578***)
Pollution	(4, nan)	(5, -3.0603**)	(2, -0.5063)
Electric energy usage	(3, -0.7249)	(6, -10.1624***)	(2, -4.8761***)
Fertility	(6, -8.2158***)	(3, -2.1799)	(5, -20.6699***)
Access to electricity	(4, nan)	(4, nan)	(4, nan)
Female labor participation	(6, -3.8308***)	(5, -5.1824***)	(3, -2.2777)
Unemployment	(6, -4.8975***)	(3, -2.7958*)	(2, -13.2918***)
Secondary Education	(5, -2.6799*)	(3, 0.1115)	(6, -3.0761**)
Primary Education	(2, -4.3732***)	(6, -2.8982**)	(6, -3.7797***)
Tertiary Education	(6, -3.1812**)	(6, -3.9358***)	(3, -1.6225)
GDP per capita	(5, -1.0343)	(5, -3.1764**)	(6, -2.6561*)
Household income	(5, -4.5705***)	(5, -2.8428*)	(5, -4.2168***)

Table A.1: Adjusted dickey-fuller test results and model selection for Turkey, the USA, and Poland. The test statistic is listed in each result along with the model. The stationarity is ranked after the significance, from strongly significant ($p < 0.01$) denoted "***", significant ($p < 0.05$) "**" and weak significance ($p < 0.1$) "*". The table is in the format (model number, test statistic). If the test statistic did not have enough values due to duplicate or missing values, "nan" is represented in the table.

	FRA	SGP	ZAF
Number of patents	(5, -4.3183***)	(6, -4.7682***)	(5, -3.4383***)
Gini Index	(6, -2.9396**)	(4, nan)	(6, -8.5882***)
Stock Index	(3, -2.3902)	(6, -4.8112***)	(6, -1.9978)
Energy Use	(5, -2.9753**)	(6, -24.2563***)	(6, -3.7918***)
Life Expectancy	(1, -0.6151)	(6, -5.673***)	(5, -3.9452***)
Income share by lowest 10%	(6, -3.1376**)	(4, nan)	(6, -8.9822***)
Pollution	(2, -4.7304***)	(4, nan)	(4, nan)
Electric energy usage	(5, -3.2733**)	(6, -17.2068***)	(6, -4.0481***)
Fertility	(3, -1.971)	(5, -3.8183***)	(2, -48.9202***)
Access to electricity	(4, nan)	(4, nan)	(2, -4.7764***)
Female labor participation	(4, -1.7071)	(6, -3.3578**)	(5, -2.7588*)
Unemployment	(6, -8.0552***)	(6, -3.0074**)	(5, -0.9423)
Secondary Education	(5, -4.6406***)	(4, 15.8956)	(5, -3.5501***)
Primary Education	(6, -29.6123***)	(4, 8.4461)	(2, -60.5051***)
Tertiary Education	(2, -2.6182*)	(4, 11.7817)	(5, -0.8575)
GDP per capita	(6, -2.6746*)	(6, -5.1398***)	(3, -2.5824*)
Household income	(4, -7.2637***)	(2, -3.2495**)	(4, nan)

Table A.2: Adjusted dickey-fuller test results and model selection for France, Singapore, and South Africa. The test statistic is listed in each result along with the model. The stationarity is ranked after the significance, from strongly significant ($p < 0.01$) denoted “***”, significant ($p < 0.05$) “**” and weak significance ($p < 0.1$) “*”. The table is in the format (model number, test statistic). If the test statistic did not have enough values due to duplicate or missing values, “nan” is represented in the table.

	HKG	CHN	NZL
Number of patents	(5, -3.2747**)	(2, -4.3341***)	(1, 1.6458)
Gini Index	(4, nan)	(2, -1.8161)	(4, nan)
Stock Index	(5, -4.8373***)	(5, -5.4475***)	(5, -0.5559)
Energy Use	(6, -2.7434*)	(6, -11.8108***)	(5, -4.2971***)
Life Expectancy	(5, -4.1214***)	(6, -3.2391**)	(6, -2.4435)
Income share by lowest 10%	(4, nan)	(5, -1.1709)	(4, nan)
Pollution	(4, nan)	(6, -3.7314***)	(5, -3.657***)
Electric energy usage	(6, -2.9755**)	(6, -3.2133**)	(2, -4.5826***)
Fertility	(2, -5.4926***)	(5, -2.6593*)	(5, -2.1599)
Access to electricity	(4, nan)	(6, -4.4941***)	(4, nan)
Female labor participation	(6, -3.1775**)	(4, nan)	(2, -1.9889)
Unemployment	(5, -3.6266***)	(2, -4.297***)	(6, -6.7013***)
Secondary Education	(5, -3.9026***)	(6, -3.0137**)	(6, -4.5321***)
Primary Education	(2, -3.1991**)	(6, -7.9965***)	(6, -4.8355***)
Tertiary Education	(5, -9.87***)	(6, -2.874**)	(6, -2.5754*)
GDP per capita	(6, -4.5411***)	(5, -5.7884***)	(6, -2.0495)
Household income	(4, nan)	(4, nan)	(6, -2.4046)

Table A.3: Adjusted dickey-fuller test results and model selection for Hong Kong, China, and New Zealand. The test statistic is listed in each result along with the model. The stationarity is ranked after the significance, from strongly significant ($p < 0.01$) denoted "***", significant ($p < 0.05$) "**" and weak significance ($p < 0.1$) "*". The table is in the format (model number, test statistic). If the test statistic did not have enough values due to duplicate or missing values, "nan" is represented in the table.

	KOR	NOR	JPN
Number of patents	(6, -2.8802**)	(5, -4.8028***)	(6, -25.6127***)
Gini Index	(6, -3.1634**)	(5, -3.1122**)	(2, -3.4695***)
Stock Index	(5, -3.0101**)	(5, -6.5515***)	(4, -1.3548)
Energy Use	(2, -3.4705***)	(6, -3.4085**)	(6, -5.2945***)
Life Expectancy	(6, -6.3188***)	(2, -2.8348*)	(5, -6.274***)
Income share by lowest 10%	(2, -2.4146)	(6, -2.6456*)	(2, -3.5513***)
Pollution	(4, nan)	(5, -3.4964***)	(6, -6.8953***)
Electric energy usage	(6, -5.0443***)	(5, -4.1635***)	(6, -3.1711**)
Fertility	(5, -9.0609***)	(5, -11.5572***)	(5, -1.7473)
Access to electricity	(4, nan)	(4, nan)	(4, nan)
Female labor participation	(5, -1.7361)	(5, -2.7014*)	(3, -0.8454)
Unemployment	(6, -1.7802)	(6, -2.8579*)	(5, -10.0142***)
Secondary Education	(5, -2.7373*)	(5, -3.3703**)	(6, -2.6341*)
Primary Education	(3, -3.7736***)	(3, -2.1784)	(3, -3.7138***)
Tertiary Education	(6, -4.0864***)	(6, -2.9107**)	(6, -3.1177**)
GDP per capita	(2, -4.6702***)	(2, -10.9534***)	(6, -5.5677***)
Household income	(6, -2.4761)	(6, -2.696*)	(6, 0.1538)

Table A.4: Adjusted dickey-fuller test results and model selection for South Korea, Norway, and Japan. The test statistic is listed in each result along with the model. The stationarity is ranked after the significance, from strongly significant ($p < 0.01$) denoted "***", significant ($p < 0.05$) "**" and weak significance ($p < 0.1$) "*". The table is in the format (model number, test statistic). If the test statistic did not have enough values due to duplicate or missing values, "nan" is represented in the table.

	MEX	ITA	CHL
Number of patents	(6, -11.3287***)	(6, -4.6957***)	(5, -2.4307)
Gini Index	(5, -3.2054**)	(2, -3.1981**)	(1, -2.1333)
Stock Index	(5, -3.8374***)	(5, -2.8633**)	(5, -3.0852**)
Energy Use	(5, -7.1867***)	(5, -4.714***)	(5, -4.7114***)
Life Expectancy	(6, -3.1882**)	(6, -2.6277*)	(1, 0.7116)
Income share by lowest 10%	(2, -4.2672***)	(6, -11.0063***)	(6, -3.0796**)
Pollution	(3, -0.2442)	(5, -3.6827***)	(6, -0.4856)
Electric energy usage	(6, -2.5903*)	(6, -4.7782***)	(6, -2.8362*)
Fertility	(6, -16.9804***)	(6, -2.9289**)	(5, -4.3551***)
Access to electricity	(5, -5.0975***)	(4, nan)	(2, -6.8226***)
Female labor participation	(6, -3.158**)	(5, -9.8828***)	(1, -1.5657)
Unemployment	(5, -5.0079***)	(6, -5.2386***)	(2, -2.9799**)
Secondary Education	(5, -2.6198*)	(5, -4.9403***)	(5, -2.6751*)
Primary Education	(2, -3.6187***)	(2, -4.2133***)	(5, -2.7753*)
Tertiary Education	(2, -0.175)	(6, -8.6161***)	(6, -2.2956)
GDP per capita	(6, -2.0855)	(6, -16.2658***)	(6, -4.5269***)
Household income	(5, -4.2782***)	(5, -3.8011***)	(4, nan)

Table A.5: Adjusted dickey-fuller test results and model selection for Mexico, Italy, and Chile. The test statistic is listed in each result along with the model. The stationarity is ranked after the significance, from strongly significant ($p < 0.01$) denoted "***", significant ($p < 0.05$) "**" and weak significance ($p < 0.1$) "*". The table is in the format (model number, test statistic). If the test statistic did not have enough values due to duplicate or missing values, "nan" is represented in the table.

	CAN	DEU	RUS
Number of patents	(2, -4.9426***)	(6, -3.9266***)	(2, -5.175***)
Gini Index	(5, -2.6909*)	(6, -2.9468**)	(5, -4.1742***)
Stock Index	(5, -2.1195)	(5, -16.6413***)	(2, -2.0888)
Energy Use	(6, -2.8221*)	(6, -7.2238***)	(5, -3.8591***)
Life Expectancy	(6, -1.6542)	(1, -1.9686)	(6, -4.2471***)
Income share by lowest 10%	(5, -3.4435***)	(5, -5.2653***)	(5, -7.0381***)
Pollution	(2, -4.6369***)	(5, -10.0853***)	(1, -0.6453)
Electric energy usage	(5, -3.0907**)	(6, -3.3341**)	(5, -4.4737***)
Fertility	(4, -2.6515*)	(5, -0.3894)	(6, -15.9126***)
Access to electricity	(4, nan)	(4, nan)	(6, -4.4721***)
Female labor participation	(5, -1.3027)	(5, -2.7243*)	(1, 0.4536)
Unemployment	(6, -2.9919**)	(5, -3.4977***)	(5, -4.3604***)
Secondary Education	(5, -3.4532***)	(2, -2.8951**)	(5, -2.8615*)
Primary Education	(2, -2.5629)	(5, -3.6507***)	(6, -3.3833**)
Tertiary Education	(5, -0.1234)	(2, -4.0062***)	(6, -5.1494***)
GDP per capita	(2, -3.0809**)	(5, -3.0105**)	(1, -1.9513)
Household income	(5, -3.0375**)	(5, -2.8817**)	(5, -3.9443***)

Table A.6: Adjusted dickey-fuller test results and model selection for Canada, Germany, and Russia. The test statistic is listed in each result along with the model. The stationarity is ranked after the significance, from strongly significant ($p < 0.01$) denoted "***", significant ($p < 0.05$) "**" and weak significance ($p < 0.1$) "*". The table is in the format (model number, test statistic). If the test statistic did not have enough values due to duplicate or missing values, "nan" is represented in the table.

	GRC	BRA	GBR
Number of patents	(4, -3.1252**)	(5, -3.2198**)	(2, -3.479***)
Gini Index	(2, -2.7622*)	(6, -1.1913)	(2, -5.8205***)
Stock Index	(6, -3.5005***)	(6, -3.3726**)	(6, -2.9786**)
Energy Use	(5, -20.2481***)	(6, -1.5441)	(2, -5.8888***)
Life Expectancy	(5, -5.7822***)	(6, -1.6959)	(6, -2.6037*)
Income share by lowest 10%	(6, -3.5175***)	(6, -2.2074)	(5, -28.7796***)
Pollution	(6, -17.6121***)	(2, -2.4238)	(5, -1.9798)
Electric energy usage	(5, -5.5132***)	(6, -2.6152*)	(6, -4.2017***)
Fertility	(6, -7.2645***)	(1, -2.0745)	(5, -2.1061)
Access to electricity	(4, nan)	(6, -11.6755***)	(4, nan)
Female labor participation	(4, -2.3622)	(4, -1.397)	(5, -3.0546**)
Unemployment	(6, -2.7798*)	(2, -3.0898**)	(5, -1.2157)
Secondary Education	(5, -2.9641**)	(5, -2.8903**)	(6, -2.7141*)
Primary Education	(6, -10.3619***)	(3, -4.2049***)	(2, -4.0318***)
Tertiary Education	(5, -45.1101***)	(6, -3.9923***)	(2, -3.566***)
GDP per capita	(6, -2.8877**)	(4, -2.4169)	(5, -2.595*)
Household income	(6, -7.7153***)	(4, nan)	(4, -3.6191***)

Table A.7: Adjusted dickey-fuller test results and model selection for Greece, Brazil and Great Britain. The test statistic is listed in each result along with the model. The stationarity is ranked after the significance, from strongly significant ($p < 0.01$) denoted "***", significant ($p < 0.05$) "**" and weak significance ($p < 0.1$) "*". The table is in the format (model number, test statistic). If the test statistic did not have enough values due to duplicate or missing values, "nan" is represented in the table.

	AUS	ISR	CHE
Number of patents	(6, -2.3887)	(6, -5.9597***)	(2, -4.3202***)
Gini Index	(6, -2.8397*)	(5, -10.0147***)	(2, -2.5138)
Stock Index	(4, -2.8536*)	(6, -3.3657**)	(5, -3.3575**)
Energy Use	(5, -5.8982***)	(5, -4.0379***)	(5, -5.349***)
Life Expectancy	(5, -3.7631***)	(5, -2.91**)	(5, -3.6849***)
Income share by lowest 10%	(2, -10.7198***)	(6, -3.8337***)	(6, -3.6533***)
Pollution	(5, -2.3601)	(4, nan)	(5, -1.8722)
Electric energy usage	(2, -1.2287)	(6, -2.6095*)	(6, -2.6614*)
Fertility	(5, -3.3243**)	(6, -3.4197**)	(1, 0.3189)
Access to electricity	(4, nan)	(4, nan)	(4, nan)
Female labor participation	(2, -3.692***)	(6, -1.6186)	(5, -4.2731***)
Unemployment	(5, -2.7461*)	(5, -3.6732***)	(6, -3.0342**)
Secondary Education	(6, -2.6338*)	(6, -3.467***)	(5, -1.4513)
Primary Education	(6, -3.503***)	(6, -2.9629**)	(5, -2.2354)
Tertiary Education	(5, -2.8278*)	(2, -3.3638**)	(6, -3.8832***)
GDP per capita	(1, -1.5136)	(5, -3.8005***)	(6, -2.0498)
Household income	(5, -3.0974**)	(4, nan)	(6, -3.3125**)

Table A.8: Adjusted dickey-fuller test results and model selection for Australia, Israel, and Switzerland. The test statistic is listed in each result along with the model. The stationarity is ranked after the significance, from strongly significant ($p < 0.01$) denoted "***", significant ($p < 0.05$) "**" and weak significance ($p < 0.1$) "*". The table is in the format (model number, test statistic). If the test statistic did not have enough values due to duplicate or missing values, "nan" is represented in the table.

A.2 Stationarity results final model

	TUR	USA	POL
Number of patents	(4, -3.7245***)	(4, 0.7971)	(4, -4.1167***)
Gini Index	(4, -2.3565)	(4, -2.8606*)	(4, -3.5623***)
Stock Index	(4, -5.2063***)	(4, -0.3006)	(4, -4.0303***)
Energy Use	(4, 2.5559)	(4, -1.6361)	(4, -5.6178***)
Life Expectancy	(4, 3.0872)	(4, -1.9176)	(4, -5.2684***)
Income share by lowest 10%	(4, -4.3946***)	(4, -4.9927***)	(4, -2.7601*)
Pollution	(4, nan)	(4, 1.4393)	(4, 12.0204)
Electric energy usage	(4, 1.3815)	(4, -5.178***)	(4, 1.0215)
Fertility	(4, -3.2564**)	(4, -1.1765)	(4, -2.695*)
Access to electricity	(4, nan)	(4, nan)	(4, nan)
Female labor participation	(4, -0.366)	(4, -3.4106**)	(4, -2.9758**)
Unemployment	(4, -0.8617)	(4, -1.5563)	(4, -3.382**)
Secondary Education	(4, -4.4809***)	(4, 1.5653)	(4, -7.9232***)
Primary Education	(4, -4.6902***)	(4, -2.2784)	(4, -2.3364)
Tertiary Education	(4, 2.9798)	(4, 11.7266)	(4, -1.5548)
GDP per capita	(4, -1.2693)	(4, -2.5776*)	(4, -5.5409***)
Household income	(4, -2.0889)	(4, -1.7886)	(4, -1.0655)

Table A.9: Adjusted dickey-fuller test results and model selection for Turkey, USA, and Poland. The test statistic is listed in each result, for this statistic all variables use model 4. The stationarity is ranked after the significance, from strongly significant ($p < 0.01$) denoted "***", significant ($p < 0.05$) "**" and weak significance ($p < 0.1$) "*". The table is in the format (model number, test statistic). If the test statistic did not have enough values due to duplicate or missing values, "nan" is represented in the table.

	FRA	SGP	ZAF
Number of patents	(4, -0.8554)	(4, 1.8414)	(4, -2.8802**)
Gini Index	(4, -1.8022)	(4, nan)	(4, -0.7683)
Stock Index	(4, -1.7288)	(4, -5.3993***)	(4, -0.7104)
Energy Use	(4, -1.7453)	(4, 0.2232)	(4, -6.5843***)
Life Expectancy	(4, 0.1318)	(4, 0.1116)	(4, -1.1139)
Income share by lowest 10%	(4, -2.9973**)	(4, nan)	(4, -0.8755)
Pollution	(4, 2.9741)	(4, nan)	(4, nan)
Electric energy usage	(4, -7.3549***)	(4, -3.553***)	(4, -1.5264)
Fertility	(4, -1.5059)	(4, -3.8916***)	(4, -1.8599)
Access to electricity	(4, nan)	(4, nan)	(4, -4.5203***)
Female labor participation	(4, 1.4515)	(4, 0.1627)	(4, -4.2532***)
Unemployment	(4, -3.1787**)	(4, -4.4813***)	(4, -2.5124)
Secondary Education	(4, -6.5415***)	(4, 16.7463)	(4, -1.6945)
Primary Education	(4, -14.0975***)	(4, 8.9158)	(4, -1.9929)
Tertiary Education	(4, -2.6869*)	(4, 12.4149)	(4, 0.1387)
GDP per capita	(4, -3.0103**)	(4, -0.1042)	(4, -1.1729)
Household income	(4, -5.4537***)	(4, -0.4759)	(4, nan)

Table A.10: Adjusted dickey-fuller test results and model selection for France, Singapore, and South Africa. The test statistic is listed in each result, for this statistic all variables use model 4. The stationarity is ranked after the significance, from strongly significant ($p < 0.01$) denoted "***", significant ($p < 0.05$) "**" and weak significance ($p < 0.1$) "*". The table is in the format (model number, test statistic). If the test statistic did not have enough values due to duplicate or missing values, "nan" is represented in the table.

	HKG	CHN	NZL
Number of patents	(4, -2.3763)	(4, 0.5293)	(4, 0.3504)
Gini Index	(4, nan)	(4, -1.1782)	(4, nan)
Stock Index	(4, -5.2746***)	(4, -5.784***)	(4, -3.0636**)
Energy Use	(4, -0.9379)	(4, -5.6049***)	(4, -4.31***)
Life Expectancy	(4, -9.0516***)	(4, 0.0451)	(4, 1.1979)
Income share by lowest 10%	(4, nan)	(4, -0.5873)	(4, nan)
Pollution	(4, nan)	(4, -5.1594***)	(4, -3.4019**)
Electric energy usage	(4, -5.1275***)	(4, -0.5899)	(4, -4.6323***)
Fertility	(4, -4.9965***)	(4, -2.0001)	(4, -0.5152)
Access to electricity	(4, nan)	(4, -1.9912)	(4, nan)
Female labor participation	(4, -3.7725***)	(4, nan)	(4, -2.1309)
Unemployment	(4, -2.667*)	(4, -4.2108***)	(4, -2.758*)
Secondary Education	(4, -6.3617***)	(4, -2.7346*)	(4, -5.8479***)
Primary Education	(4, -1.7203)	(4, -2.7209*)	(4, -1.7849)
Tertiary Education	(4, -3.8119***)	(4, -2.5008)	(4, 1.9901)
GDP per capita	(4, -2.7749*)	(4, -2.1306)	(4, -3.1692**)
Household income	(4, nan)	(4, nan)	(4, 0.6647)

Table A.11: Adjusted dickey-fuller test results and model selection for Hong Kong, China, and New Zealand. The test statistic is listed in each result, for this statistic all variables use model 4. The stationarity is ranked after the significance, from strongly significant ($p < 0.01$) denoted "***", significant ($p < 0.05$) "**" and weak significance ($p < 0.1$) "*". The table is in the format (model number, test statistic). If the test statistic did not have enough values due to duplicate or missing values, "nan" is represented in the table.

	KOR	NOR	JPN
Number of patents	(4, -1.5751)	(4, -2.3422)	(4, -4.4611***)
Gini Index	(4, -5.5362***)	(4, -4.5482***)	(4, -3.5726***)
Stock Index	(4, 1.3759)	(4, -4.0766***)	(4, -0.6153)
Energy Use	(4, -3.6104***)	(4, -7.1986***)	(4, -6.1597***)
Life Expectancy	(4, -1.49)	(4, -3.1979**)	(4, -3.0236**)
Income share by lowest 10%	(4, -2.4823)	(4, -1.3376)	(4, -3.6101***)
Pollution	(4, nan)	(4, -5.6809***)	(4, -4.806***)
Electric energy usage	(4, -2.6004*)	(4, -5.8852***)	(4, -4.7429***)
Fertility	(4, -3.67***)	(4, -5.9289***)	(4, -0.5524)
Access to electricity	(4, nan)	(4, nan)	(4, nan)
Female labor participation	(4, -4.7217***)	(4, -4.0593***)	(4, 0.7397)
Unemployment	(4, 2.0761)	(4, -4.9276***)	(4, -3.3876**)
Secondary Education	(4, -2.9784**)	(4, -4.3934***)	(4, 1.9902)
Primary Education	(4, -2.8465*)	(4, -2.9514**)	(4, 2.3505)
Tertiary Education	(4, -3.0881**)	(4, -4.3917***)	(4, 2.8075)
GDP per capita	(4, -2.3813)	(4, -0.52)	(4, -1.3861)
Household income	(4, -1.6091)	(4, -4.3176***)	(4, 0.5023)

Table A.12: Adjusted dickey-fuller test results and model selection for South Korea, Norway, and Japan. The test statistic is listed in each result, for this statistic all variables use model 4. The stationarity is ranked after the significance, from strongly significant ($p < 0.01$) denoted "***", significant ($p < 0.05$) "**" and weak significance ($p < 0.1$) "*". The table is in the format (model number, test statistic). If the test statistic did not have enough values due to duplicate or missing values, "nan" is represented in the table.

	MEX	ITA	CHL
Number of patents	(4, -1.0419)	(4, -8.9517***)	(4, -2.5796*)
Gini Index	(4, -2.8859**)	(4, -20.2588***)	(4, 0.2863)
Stock Index	(4, 0.0469)	(4, -4.6066***)	(4, -4.5753***)
Energy Use	(4, -2.226)	(4, -0.9397)	(4, -3.6096***)
Life Expectancy	(4, -3.1097**)	(4, -1.4241)	(4, 1.9472)
Income share by lowest 10%	(4, -2.2798)	(4, -1.1952)	(4, -2.6175*)
Pollution	(4, 2.8216)	(4, -1.4671)	(4, 1.9829)
Electric energy usage	(4, -3.9654***)	(4, -3.7197***)	(4, -2.7871*)
Fertility	(4, 2.2208)	(4, -3.453***)	(4, -2.4958)
Access to electricity	(4, -7.8451***)	(4, nan)	(4, -8.8699***)
Female labor participation	(4, -2.9565**)	(4, -4.4157***)	(4, 1.21)
Unemployment	(4, -2.5723*)	(4, -6.0731***)	(4, -2.7319*)
Secondary Education	(4, -2.952**)	(4, -3.2838**)	(4, -2.2734)
Primary Education	(4, -0.2678)	(4, -1.3656)	(4, -2.7583*)
Tertiary Education	(4, -0.5218)	(4, -10.8427***)	(4, -5.5167***)
GDP per capita	(4, 3.3775)	(4, -6.4404***)	(4, -1.4773)
Household income	(4, -3.0322**)	(4, -1.9071)	(4, nan)

Table A.13: Adjusted dickey-fuller test results and model selection for Mexico, Italy, and Chile. The test statistic is listed in each result, for this statistic all variables use model 4. The stationarity is ranked after the significance, from strongly significant ($p < 0.01$) denoted "***", significant ($p < 0.05$) "**" and weak significance ($p < 0.1$) "*". The table is in the format (model number, test statistic). If the test statistic did not have enough values due to duplicate or missing values, "nan" is represented in the table.

	CAN	DEU	RUS
Number of patents	(4, -4.9483***)	(4, -0.8431)	(4, -5.3719***)
Gini Index	(4, -0.946)	(4, -4.7548***)	(4, -2.4339)
Stock Index	(4, -2.8127*)	(4, -2.7033*)	(4, -0.5632)
Energy Use	(4, -3.736***)	(4, -9.7704***)	(4, -4.7656***)
Life Expectancy	(4, -2.6972*)	(4, -0.2048)	(4, -2.0211)
Income share by lowest 10%	(4, -3.872***)	(4, -2.3777)	(4, -6.0705***)
Pollution	(4, -1.4266)	(4, 1.3169)	(4, 3.2588)
Electric energy usage	(4, -4.3575***)	(4, -5.263***)	(4, -5.3325***)
Fertility	(4, -2.654*)	(4, -0.0543)	(4, -1.4296)
Access to electricity	(4, nan)	(4, nan)	(4, -7.3485***)
Female labor participation	(4, -2.3571)	(4, -1.0926)	(4, 3.0541)
Unemployment	(4, -2.3057)	(4, -2.222)	(4, -2.1137)
Secondary Education	(4, -4.1933***)	(4, -2.8564*)	(4, -2.7124*)
Primary Education	(4, -2.2994)	(4, -3.3974**)	(4, -1.8076)
Tertiary Education	(4, -4.0981***)	(4, -2.1638)	(4, -9.2807***)
GDP per capita	(4, -0.4647)	(4, -3.7947***)	(4, -0.412)
Household income	(4, -2.6872*)	(4, -4.2175***)	(4, -2.9834**)

Table A.14: Adjusted dickey-fuller test results and model selection for Canada, Germany, and Russia. The test statistic is listed in each result, for this statistic all variables use model 4. The stationarity is ranked after the significance, from strongly significant ($p < 0.01$) denoted "***", significant ($p < 0.05$) "**" and weak significance ($p < 0.1$) "*". The table is in the format (model number, test statistic). If the test statistic did not have enough values due to duplicate or missing values, "nan" is represented in the table.

	GRC	BRA	GBR
Number of patents	(4, -1.5584)	(4, -3.3351**)	(4, -4.0253***)
Gini Index	(4, -2.7612*)	(4, -0.7658)	(4, 4.2009)
Stock Index	(4, -0.5943)	(4, -1.9919)	(4, -4.7856***)
Energy Use	(4, -1.6324)	(4, -5.9178***)	(4, -6.1793***)
Life Expectancy	(4, -2.004)	(4, 1.5133)	(4, -3.6675***)
Income share by lowest 10%	(4, -2.5952*)	(4, 2.1605)	(4, -6.6121***)
Pollution	(4, -13.4054***)	(4, 1.7249)	(4, 0.7852)
Electric energy usage	(4, -3.2796**)	(4, 0.3673)	(4, -1.0706)
Fertility	(4, -6.0011***)	(4, -1.4211)	(4, -0.618)
Access to electricity	(4, nan)	(4, -1.5232)	(4, nan)
Female labor participation	(4, 1.3303)	(4, -0.6041)	(4, -5.8913***)
Unemployment	(4, -2.2063)	(4, -3.4001**)	(4, -0.3771)
Secondary Education	(4, -3.0906**)	(4, -5.0504***)	(4, -3.5482***)
Primary Education	(4, -4.1955***)	(4, -2.665*)	(4, -1.057)
Tertiary Education	(4, -5.0434***)	(4, -0.5965)	(4, 5.4696)
GDP per capita	(4, -2.3503)	(4, -2.3225)	(4, -1.9414)
Household income	(4, -3.6464***)	(4, nan)	(4, -3.9456***)

Table A.15: Adjusted dickey-fuller test results and model selection for Greece, Brazil and Great Britain. The test statistic is listed in each result, for this statistic all variables use model 4. The stationarity is ranked after the significance, from strongly significant ($p < 0.01$) denoted "***", significant ($p < 0.05$) "**" and weak significance ($p < 0.1$) "*". The table is in the format (model number, test statistic). If the test statistic did not have enough values due to duplicate or missing values, "nan" is represented in the table.

	AUS	ISR	CHE
Number of patents	(4, -2.0269)	(4, -3.0866**)	(4, -3.1554**)
Gini Index	(4, -10.2999***)	(4, -6.3089***)	(4, -3.127**)
Stock Index	(4, -2.3925)	(4, -1.478)	(4, -4.2536***)
Energy Use	(4, -2.3776)	(4, -3.9359***)	(4, -0.7159)
Life Expectancy	(4, -3.2745**)	(4, -3.4681***)	(4, -3.3248**)
Income share by lowest 10%	(4, -1.3403)	(4, -0.8593)	(4, -2.2635)
Pollution	(4, -4.3146***)	(4, nan)	(4, -1.6645)
Electric energy usage	(4, -2.1466)	(4, -3.7483***)	(4, -5.6348***)
Fertility	(4, -9.8532***)	(4, 2.4152)	(4, 0.3169)
Access to electricity	(4, nan)	(4, nan)	(4, nan)
Female labor participation	(4, -4.051***)	(4, 2.0816)	(4, -2.0473)
Unemployment	(4, -2.9324**)	(4, -2.9189**)	(4, -3.8669***)
Secondary Education	(4, 2.2269)	(4, -3.1994**)	(4, -2.9431**)
Primary Education	(4, -1.8737)	(4, -2.759*)	(4, -1.879)
Tertiary Education	(4, -2.8216*)	(4, -2.0749)	(4, 5.0654)
GDP per capita	(4, -0.0978)	(4, -3.2929**)	(4, 1.4111)
Household income	(4, -4.5341***)	(4, nan)	(4, -2.8676**)

Table A.16: Adjusted dickey-fuller test results and model selection for Australia, Israel, and Switzerland. The test statistic is listed in each result, for this statistic all variables use model 4. The stationarity is ranked after the significance, from strongly significant ($p < 0.01$) denoted “***”, significant ($p < 0.05$) “**” and weak significance ($p < 0.1$) “*”. The table is in the format (model number, test statistic). If the test statistic did not have enough values due to duplicate or missing values, “nan” is represented in the table.

A.3 Regression results

	ISR	CHE
Number of patents	(0, 0.09188, 0.34834, 0.04408)	(0, 0.09171, 0.14046, 0.10539)
Gini Index	(0, 0.00373, 0.73508, 0.00585)	(5, -0.05279, 0.00642, 0.40021)
Stock Index	(0, 1.0, 0.0, 1.0)	(0, 1.0, 0.0, 1.0)
Energy Use	(3, 0.08699, 0.02301, 0.26861)	(0, -0.01061, 0.79253, 0.00354)
Life Expectancy	(0, 0.00176, 0.55045, 0.01811)	(0, -0.00436, 0.34283, 0.04508)
Income share by lowest 10%	(0, -0.0259, 0.382, 0.03842)	(1, -0.0713, 0.07116, 0.16127)
Pollution	(0, 0.0, nan, nan)	(8, 0.25812, 0.09703, 0.2126)
Electric energy usage	(4, -0.05129, 0.06782, 0.1934)	(2, -0.03848, 0.07694, 0.16357)
Fertility	(3, 0.03777, 0.00232, 0.42958)	(0, 0.01399, 0.6028, 0.01379)
Access to electricity	(0, 0.0, nan, nan)	(0, 0.0, nan, nan)
Female labor participation	(0, 0.02494, 0.00288, 0.36539)	(2, 0.0372, 0.0012, 0.45049)
Unemployment	(1, -0.2861, 0.00162, 0.41514)	(2, -0.39486, 0.00536, 0.35757)
Secondary Education	(0, -0.00672, 0.3369, 0.04617)	(1, 0.02432, 0.02317, 0.24302)
Primary Education	(0, -0.00038, 0.94866, 0.00021)	(3, 0.0115, 0.0392, 0.22695)
Tertiary Education	(0, 0.0146, 0.61383, 0.01297)	(0, -0.00675, 0.86188, 0.00155)
GDP per capita	(1, 0.17705, 0.0053, 0.34269)	(9, -0.15253, 0.06326, 0.27947)
Household income	(0, 0.0, nan, nan)	(5, -0.09173, 0.06033, 0.21574)

Table A.17: Multiple regression results of the stock indices of Switzerland and Israel against the presumed dependent variables. The results are in the format of (Optimal lag, Regression Coefficient, P-value, R squared).

	CHL	CAN
Number of patents	(6, -0.47479, 0.02586, 0.30729)	(7, -0.13474, 0.08388, 0.21232)
Gini Index	(1, -0.02863, 0.03737, 0.20866)	(8, 0.03986, 0.01716, 0.38893)
Stock Index	(0, 1.0, 0.0, 1.0)	(0, 1.0, 0.0, 1.0)
Energy Use	(1, 0.09297, 0.0242, 0.23994)	(6, -0.05854, 0.02631, 0.30578)
Life Expectancy	(9, 0.00414, 0.0937, 0.23433)	(0, 0.00285, 0.32218, 0.049)
Income share by lowest 10%	(7, 0.05849, 0.01907, 0.35508)	(8, -0.15524, 0.01299, 0.41433)
Pollution	(6, -0.00723, 0.03454, 0.28136)	(0, -0.00477, 0.99322, 0.0)
Electric energy usage	(8, 0.06085, 0.07018, 0.24766)	(3, -0.04942, 0.07096, 0.17916)
Fertility	(9, -0.03333, 0.05059, 0.30445)	(2, 0.04577, 0.06089, 0.18173)
Access to electricity	(1, -0.01463, 0.05368, 0.18213)	(0, 0.0, nan, nan)
Female labor participation	(1, 0.06657, 0.05319, 0.18281)	(0, 0.0001, 0.99387, 0.0)
Unemployment	(7, -0.31261, 0.09764, 0.1968)	(0, 0.06243, 0.74452, 0.00543)
Secondary Education	(4, 0.05931, 0.06377, 0.19865)	(4, -0.05084, 0.02229, 0.28574)
Primary Education	(0, -0.0011, 0.94121, 0.00028)	(8, 0.02353, 0.06087, 0.2628)
Tertiary Education	(4, 0.17279, 0.00649, 0.37946)	(0, 0.03493, 0.26665, 0.06129)
GDP per capita	(1, 0.43995, 0.00012, 0.54877)	(7, 0.24532, 0.03828, 0.29017)
Household income	(0, 0.0, nan, nan)	(1, 0.09857, 0.03377, 0.21602)

Table A.18: Multiple regression results of the stock indices of Chile and Canada against the presumed dependent variables. The results are in the format of (Optimal lag, Regression Coefficient, P-value, R squared).

	DEU	RUS
Number of patents	(6, -0.03388, 0.02706, 0.30326)	(6, 0.10305, 0.0907, 0.1908)
Gini Index	(3, -0.03731, 0.01642, 0.29422)	(1, 0.02419, 0.09749, 0.13786)
Stock Index	(0, 1.0, 0.0, 1.0)	(0, 1.0, 0.0, 1.0)
Energy Use	(2, -0.0606, 0.01293, 0.29719)	(1, 0.04838, 0.0002, 0.52477)
Life Expectancy	(0, 0.00136, 0.66671, 0.00946)	(6, 0.00825, 0.0897, 0.19186)
Income share by lowest 10%	(9, -0.07, 0.01719, 0.4166)	(1, -0.04146, 0.05005, 0.18729)
Pollution	(0, -0.00711, 0.65418, 0.01023)	(0, -0.00098, 0.76687, 0.0045)
Electric energy usage	(2, -0.05018, 0.00655, 0.34416)	(1, 0.05088, 0.0, 0.68961)
Fertility	(0, 0.01076, 0.58632, 0.01507)	(9, 0.04027, 0.04778, 0.31074)
Access to electricity	(0, 0.0, nan, nan)	(7, 0.02775, 0.00105, 0.57516)
Female labor participation	(0, 0.01381, 0.17502, 0.08997)	(9, 0.05124, 0.01461, 0.43222)
Unemployment	(2, -0.19515, 0.0514, 0.19481)	(1, -0.16434, 0.00999, 0.30113)
Secondary Education	(8, -0.0144, 0.07036, 0.24738)	(6, 0.02324, 0.05248, 0.24279)
Primary Education	(1, 0.01308, 0.09038, 0.14349)	(6, 0.01705, 0.02431, 0.31276)
Tertiary Education	(0, 0.01831, 0.39243, 0.0368)	(4, 0.0171, 0.04344, 0.2311)
GDP per capita	(0, -0.03205, 0.68054, 0.00865)	(1, 0.36349, 0.00069, 0.46273)
Household income	(0, -0.01012, 0.76042, 0.00476)	(7, 0.03546, 0.06282, 0.24152)

Table A.19: Multiple regression results of the stock indices of Germany and Russia against the presumed dependent variables. The results are in the format of (Optimal lag, Regression Coefficient, P-value, R squared).

	GBR	AUS
Number of patents	(0, -0.03833, 0.52276, 0.02183)	(6, 0.50802, 0.00293, 0.47986)
Gini Index	(0, 0.10168, 0.01393, 0.27854)	(2, 0.02769, 0.01317, 0.29583)
Stock Index	(0, 1.0, 0.0, 1.0)	(0, 1.0, 0.0, 1.0)
Energy Use	(2, -0.09959, 0.06982, 0.18047)	(7, -0.04498, 0.04651, 0.27128)
Life Expectancy	(0, 0.0051, 0.30498, 0.05527)	(0, 0.0038, 0.25458, 0.06437)
Income share by lowest 10%	(4, -0.14489, 0.01686, 0.32511)	(0, 0.03276, 0.32388, 0.04866)
Pollution	(0, -0.03608, 0.54634, 0.01947)	(3, -0.17968, 0.00598, 0.36701)
Electric energy usage	(0, -0.00501, 0.88633, 0.0011)	(0, 0.0196, 0.42192, 0.03252)
Fertility	(0, -0.00841, 0.81354, 0.003)	(0, -0.01341, 0.64911, 0.01056)
Access to electricity	(0, 0.0, nan, nan)	(0, 0.0, nan, nan)
Female labor participation	(0, 0.00026, 0.97523, 5e-05)	(2, 0.02512, 0.02499, 0.24934)
Unemployment	(0, 0.02582, 0.87469, 0.00134)	(1, -0.25587, 0.03689, 0.20961)
Secondary Education	(5, -0.32786, 0.01615, 0.34805)	(0, 0.02705, 0.50681, 0.02234)
Primary Education	(2, -0.05432, 0.07761, 0.17186)	(7, 0.03115, 0.03797, 0.29096)
Tertiary Education	(6, 0.07837, 0.09616, 0.19837)	(0, 0.03848, 0.33036, 0.04741)
GDP per capita	(1, 0.26117, 0.05324, 0.1921)	(1, 0.31138, 0.05416, 0.18147)
Household income	(0, -0.02978, 0.55213, 0.01892)	(1, 0.10632, 0.04662, 0.19251)

Table A.20: Multiple regression results of the stock indices of Great Britain and Australia against the presumed dependent variables. The results are in the format of (Optimal lag, Regression Coefficient, P-value, R squared).

	GRC	BRA
Number of patents	(4, 0.17808, 0.02014, 0.40107)	(0, 0.06037, 0.17644, 0.08941)
Gini Index	(0, 0.00323, 0.81224, 0.00388)	(1, -0.01605, 0.05905, 0.1751)
Stock Index	(0, 1.0, 0.0, 1.0)	(0, 1.0, 0.0, 1.0)
Energy Use	(2, 0.06368, 0.00654, 0.4457)	(1, 0.07328, 0.00037, 0.49591)
Life Expectancy	(0, -0.00328, 0.16763, 0.12294)	(0, 0.00477, 0.11319, 0.12067)
Income share by lowest 10%	(8, -0.09688, 0.06816, 0.39871)	(0, -0.07275, 0.11829, 0.11754)
Pollution	(8, 0.0, 0.02114, 0.55567)	(9, -0.07609, 0.03142, 0.35575)
Electric energy usage	(5, 0.04773, 0.0262, 0.40453)	(7, 0.05084, 0.02177, 0.34308)
Fertility	(3, 0.03503, 0.0878, 0.22349)	(0, -0.02282, 0.08796, 0.1386)
Access to electricity	(0, 0.0, nan, nan)	(3, 0.00549, 0.00683, 0.35779)
Female labor participation	(1, -0.01615, 0.01265, 0.36847)	(0, 0.00828, 0.69092, 0.00807)
Unemployment	(1, -0.20764, 0.04051, 0.26679)	(1, -0.15599, 0.07599, 0.15639)
Secondary Education	(3, 0.0252, 0.05939, 0.26541)	(0, -0.05094, 0.01986, 0.24264)
Primary Education	(7, -0.00883, 0.09489, 0.30951)	(0, -0.0262, 0.39355, 0.03663)
Tertiary Education	(0, -0.04062, 0.12507, 0.14962)	(5, 0.09663, 0.05283, 0.22758)
GDP per capita	(4, 0.1112, 0.04029, 0.32932)	(7, 0.25756, 0.05101, 0.26221)
Household income	(8, -0.02898, 0.07017, 0.39432)	(0, 0.0, nan, nan)

Table A.21: Multiple regression results of the stock indices of Greece and Brazil against the presumed dependent variables. The results are in the format of (Optimal lag, Regression Coefficient, P-value, R squared).

	HKG	CHN
Number of patents	(8, 0.28265, 0.0916, 0.21888)	(0, -0.01296, 0.91989, 0.00052)
Gini Index	(0, 0.0, nan, nan)	(3, 0.01794, 0.09293, 0.15712)
Stock Index	(0, 1.0, 0.0, 1.0)	(0, 1.0, 0.0, 1.0)
Energy Use	(2, 0.08492, 0.02389, 0.25267)	(0, 0.02028, 0.56188, 0.0171)
Life Expectancy	(0, 0.00233, 0.50104, 0.02294)	(0, 0.00038, 0.86042, 0.00158)
Income share by lowest 10%	(0, 0.0, nan, nan)	(0, -0.00973, 0.72937, 0.00612)
Pollution	(0, 0.0, nan, nan)	(8, 1e-05, 0.0185, 0.38192)
Electric energy usage	(5, 0.01976, 0.01792, 0.32011)	(0, 0.02957, 0.54603, 0.01851)
Fertility	(5, 0.12768, 0.01282, 0.34715)	(0, 0.00036, 0.85583, 0.00169)
Access to electricity	(0, 0.0, nan, nan)	(0, -8e-05, 0.94532, 0.00024)
Female labor participation	(2, 0.02197, 0.03404, 0.22622)	(0, 0.0, nan, nan)
Unemployment	(1, -0.47655, 0.01285, 0.28408)	(0, -0.01157, 0.8069, 0.00306)
Secondary Education	(4, -0.14043, 0.00278, 0.43789)	(0, 0.01031, 0.559, 0.01735)
Primary Education	(0, 0.00065, 0.94599, 0.00024)	(6, 0.01599, 0.05479, 0.23875)
Tertiary Education	(1, 0.14599, 0.05117, 0.18566)	(0, 0.02539, 0.7282, 0.00617)
GDP per capita	(1, 0.09982, 0.01462, 0.27524)	(0, -0.00591, 0.93932, 0.0003)
Household income	(0, 0.0, nan, nan)	(0, 0.0, nan, nan)

Table A.22: Multiple regression results of the stock indices of Hong Kong and China against the presumed dependent variables. The results are in the format of (Optimal lag, Regression Coefficient, P-value, R squared).

	MEX	ITA
Number of patents	(6, 0.30134, 0.00326, 0.47235)	(0, 0.07181, 0.0161, 0.29572)
Gini Index	(0, -0.02834, 0.07185, 0.153)	(0, -0.02902, 0.05679, 0.19724)
Stock Index	(0, 1.0, 0.0, 1.0)	(0, 1.0, 0.0, 1.0)
Energy Use	(4, -0.04989, 0.03161, 0.25743)	(1, 0.06912, 0.04299, 0.23197)
Life Expectancy	(5, -0.00118, 0.03825, 0.25598)	(0, -0.00207, 0.69159, 0.00949)
Income share by lowest 10%	(0, 0.08952, 0.08673, 0.13961)	(7, 0.17687, 0.01815, 0.44305)
Pollution	(9, -0.00091, 0.07085, 0.26659)	(8, 0.0194, 0.05027, 0.3618)
Electric energy usage	(2, 0.07756, 0.0154, 0.2847)	(1, 0.06331, 0.00889, 0.3565)
Fertility	(9, -0.02379, 0.0316, 0.35516)	(0, -0.02559, 0.21582, 0.08861)
Access to electricity	(7, 0.00971, 0.05783, 0.24977)	(0, 0.0, nan, nan)
Female labor participation	(2, 0.04712, 0.09993, 0.14319)	(0, -0.0116, 0.51947, 0.02482)
Unemployment	(0, 0.17869, 0.11835, 0.1175)	(1, -0.23484, 0.03074, 0.25972)
Secondary Education	(9, 0.05127, 0.01322, 0.44161)	(4, 0.01583, 0.02046, 0.34874)
Primary Education	(9, -0.01678, 0.01506, 0.42931)	(9, -0.0269, 0.02744, 0.47518)
Tertiary Education	(7, 0.14241, 0.00808, 0.42868)	(5, 0.03751, 0.07377, 0.2423)
GDP per capita	(1, 0.27213, 0.00134, 0.4258)	(4, 0.15731, 0.07825, 0.21938)
Household income	(2, 0.1159, 0.0042, 0.37346)	(8, -0.06798, 0.02036, 0.4674)

Table A.23: Multiple regression results of the stock indices of Mexico and Italy against the presumed dependent variables. The results are in the format of (Optimal lag, Regression Coefficient, P-value, R squared).

	NOR	JPN
Number of patents	(5, -0.1063, 0.05328, 0.22682)	(0, -0.03303, 0.36738, 0.04079)
Gini Index	(9, 0.06143, 0.00031, 0.70794)	(8, 0.03419, 0.07573, 0.23949)
Stock Index	(0, 1.0, 0.0, 1.0)	(0, 1.0, 0.0, 1.0)
Energy Use	(3, 0.16192, 0.00308, 0.4114)	(2, -0.0634, 0.02322, 0.25479)
Life Expectancy	(0, 0.00373, 0.09967, 0.12971)	(3, 0.00538, 0.06433, 0.18714)
Income share by lowest 10%	(0, 0.00914, 0.75084, 0.00516)	(8, -0.16063, 0.06431, 0.25697)
Pollution	(3, -1.15982, 0.01154, 0.32029)	(8, 0.12429, 0.01826, 0.38316)
Electric energy usage	(1, 0.05076, 0.03473, 0.21398)	(0, 0.03166, 0.23341, 0.0702)
Fertility	(8, -0.04194, 0.05329, 0.27681)	(0, -0.01353, 0.48578, 0.0246)
Access to electricity	(0, 0.0, nan, nan)	(0, 0.0, nan, nan)
Female labor participation	(5, -0.03373, 0.06177, 0.21363)	(0, 0.01332, 0.18094, 0.08766)
Unemployment	(2, -0.17723, 0.09618, 0.14618)	(1, -0.26937, 0.00329, 0.37275)
Secondary Education	(2, -0.01678, 0.05875, 0.18449)	(0, 0.00146, 0.47942, 0.02531)
Primary Education	(3, 0.00508, 0.06427, 0.18722)	(9, 0.00417, 0.02872, 0.36511)
Tertiary Education	(0, 0.03196, 0.10921, 0.12321)	(0, 0.00452, 0.78706, 0.00373)
GDP per capita	(1, 0.19636, 0.03525, 0.21291)	(8, -0.19656, 0.03972, 0.30716)
Household income	(0, 0.01153, 0.75068, 0.00516)	(8, 0.06761, 0.06502, 0.2558)

Table A.24: Multiple regression results of the stock indices of Norway and Japan against the presumed dependent variables. The results are in the format of (Optimal lag, Regression Coefficient, P-value, R squared).

	POL	FRA
Number of patents	(6, 0.21327, 0.02907, 0.29688)	(2, -0.06307, 0.00244, 0.40785)
Gini Index	(0, -0.02139, 0.27798, 0.05854)	(0, -0.03174, 0.23533, 0.06964)
Stock Index	(0, 1.0, 0.0, 1.0)	(0, 1.0, 0.0, 1.0)
Energy Use	(1, 0.06594, 0.0015, 0.41941)	(2, -0.05098, 0.02506, 0.24913)
Life Expectancy	(0, -0.00244, 0.49464, 0.02363)	(0, -0.00097, 0.8427, 0.00202)
Income share by lowest 10%	(0, 0.06577, 0.23805, 0.06887)	(7, 0.08623, 0.00131, 0.56111)
Pollution	(7, -0.00018, 0.04628, 0.27176)	(0, -0.00942, 0.83123, 0.00233)
Electric energy usage	(1, 0.06402, 0.0004, 0.491)	(2, -0.08403, 0.00369, 0.38176)
Fertility	(0, 0.01914, 0.53529, 0.01951)	(0, -0.0016, 0.90972, 0.00066)
Access to electricity	(0, 0.0, nan, nan)	(0, 0.0, nan, nan)
Female labor participation	(5, 0.0193, 0.00916, 0.37337)	(1, -0.0198, 0.00876, 0.30996)
Unemployment	(2, -0.28679, 0.07075, 0.1701)	(1, -0.14298, 0.09462, 0.14008)
Secondary Education	(5, -0.06653, 0.00924, 0.37275)	(3, -0.02265, 0.07893, 0.17048)
Primary Education	(7, 0.0198, 0.08021, 0.21688)	(6, 0.00936, 0.03391, 0.28303)
Tertiary Education	(9, -0.04394, 0.04057, 0.32858)	(2, -0.04862, 0.05927, 0.18381)
GDP per capita	(1, 0.32164, 0.0014, 0.42364)	(6, -0.15455, 0.06556, 0.22182)
Household income	(0, -0.03313, 0.53238, 0.01979)	(0, -0.05277, 0.17541, 0.08982)

Table A.25: Multiple regression results of the stock indices of Poland and France against the presumed dependent variables. The results are in the format of (Optimal lag, Regression Coefficient, P-value, R squared).

	SGP	ZAF
Number of patents	(1, 0.18094, 0.07472, 0.1965)	(6, -0.32804, 0.03597, 0.27767)
Gini Index	(0, 0.0, nan, nan)	(0, 0.02218, 0.12286, 0.11485)
Stock Index	(0, 1.0, 0.0, 1.0)	(0, 1.0, 0.0, 1.0)
Energy Use	(1, 0.19834, 0.0985, 0.17142)	(0, -0.01959, 0.62979, 0.01184)
Life Expectancy	(0, 0.00199, 0.56223, 0.02142)	(5, 0.0392, 0.01576, 0.33059)
Income share by lowest 10%	(0, 0.0, nan, nan)	(4, -0.07901, 0.01369, 0.32396)
Pollution	(0, 0.0, nan, nan)	(0, 0.0, nan, nan)
Electric energy usage	(2, -0.06042, 0.00278, 0.48373)	(8, -0.06282, 0.04318, 0.29864)
Fertility	(4, -0.11331, 0.00534, 0.48962)	(9, -0.02187, 0.05506, 0.29505)
Access to electricity	(0, 0.0, nan, nan)	(8, 0.02073, 0.05505, 0.27339)
Female labor participation	(0, 0.00231, 0.88814, 0.00127)	(2, 0.13349, 0.02576, 0.2471)
Unemployment	(1, -0.49115, 0.00174, 0.49043)	(0, 0.04419, 0.51843, 0.02115)
Secondary Education	(0, 0.0006, 0.90362, 0.00095)	(0, 0.08444, 0.00177, 0.39377)
Primary Education	(0, 0.00051, 0.72544, 0.00792)	(7, -0.03693, 0.05053, 0.26314)
Tertiary Education	(0, -0.00183, 0.89337, 0.00116)	(8, 0.13066, 0.0403, 0.3057)
GDP per capita	(1, 0.18689, 0.0308, 0.27471)	(0, 0.22591, 0.19502, 0.08247)
Household income	(5, 0.08344, 0.0904, 0.2385)	(0, 0.0, nan, nan)

Table A.26: Multiple regression results of the stock indices of Singapore and South Africa against the presumed dependent variables. The results are in the format of (Optimal lag, Regression Coefficient, P-value, R squared).

	TUR	USA
Number of patents	(0, 0.26111, 0.0366, 0.20057)	(5, -0.13939, 0.03524, 0.26312)
Gini Index	(8, 0.02036, 0.0918, 0.21864)	(8, 0.02952, 0.02837, 0.34089)
Stock Index	(0, 1.0, 0.0, 1.0)	(0, 1.0, 0.0, 1.0)
Energy Use	(1, 0.04717, 0.07289, 0.15949)	(7, 0.06171, 0.02772, 0.32078)
Life Expectancy	(0, 0.00541, 0.09548, 0.13276)	(0, 0.00282, 0.31117, 0.05122)
Income share by lowest 10%	(0, -0.02621, 0.32811, 0.04784)	(7, -0.09443, 0.0153, 0.37463)
Pollution	(0, 0.0, nan, nan)	(3, -0.89519, 0.01858, 0.28494)
Electric energy usage	(1, 0.07015, 0.00865, 0.31074)	(1, 0.05228, 0.03248, 0.21882)
Fertility	(0, -0.0124, 0.07356, 0.15133)	(4, -0.04243, 0.09015, 0.16896)
Access to electricity	(0, 0.0, nan, nan)	(0, 0.0, nan, nan)
Female labor participation	(0, -0.02569, 0.39526, 0.03637)	(0, -0.0106, 0.198, 0.08143)
Unemployment	(0, 0.07334, 0.37764, 0.03911)	(0, -0.09643, 0.73497, 0.00586)
Secondary Education	(1, 0.07148, 0.04827, 0.18996)	(2, 0.00959, 0.07854, 0.16198)
Primary Education	(5, -0.04784, 0.01781, 0.32063)	(0, 0.00063, 0.8918, 0.00095)
Tertiary Education	(0, 0.07986, 0.08615, 0.14009)	(0, 0.00076, 0.95737, 0.00015)
GDP per capita	(7, 0.12763, 0.05792, 0.24962)	(1, 0.07687, 0.0739, 0.15847)
Household income	(0, 0.01057, 0.74186, 0.00555)	(0, 0.02344, 0.59466, 0.01441)

Table A.27: Multiple regression results of the stock indices of the USA and Turkey against the presumed dependent variables. The results are in the format of (Optimal lag, Regression Coefficient, P-value, R squared).

	NZL	KOR
Number of patents	(2, -0.91004, 0.0272, 0.24305)	(9, 0.07523, 0.07025, 0.26756)
Gini Index	(0, 0.0, nan, nan)	(0, -0.00401, 0.34567, 0.04456)
Stock Index	(0, 1.0, 0.0, 1.0)	(0, 1.0, 0.0, 1.0)
Energy Use	(0, 0.01395, 0.62464, 0.0122)	(1, 0.05904, 0.01001, 0.30101)
Life Expectancy	(0, 0.00334, 0.33477, 0.04657)	(2, 0.01066, 0.02363, 0.2535)
Income share by lowest 10%	(0, 0.0, nan, nan)	(0, 0.00292, 0.81731, 0.00273)
Pollution	(5, 2.15519, 0.03831, 0.25585)	(0, 0.0, nan, nan)
Electric energy usage	(0, -0.00093, 0.95661, 0.00015)	(1, 0.09287, 0.0122, 0.28761)
Fertility	(0, -0.01706, 0.72897, 0.00614)	(0, -0.01142, 0.85836, 0.00163)
Access to electricity	(0, 0.0, nan, nan)	(0, 0.0, nan, nan)
Female labor participation	(2, 0.02903, 0.02065, 0.26339)	(1, 0.01903, 0.08887, 0.14475)
Unemployment	(1, -0.47523, 0.00185, 0.40735)	(1, -0.17131, 0.03075, 0.22277)
Secondary Education	(0, 0.02762, 0.46769, 0.02667)	(0, 0.00523, 0.57968, 0.0156)
Primary Education	(4, 0.03122, 0.00255, 0.44347)	(0, -0.00072, 0.93961, 0.00029)
Tertiary Education	(0, 0.012, 0.59793, 0.01416)	(0, 0.03722, 0.15952, 0.09645)
GDP per capita	(7, 0.27975, 0.07057, 0.22983)	(1, 0.26363, 0.0026, 0.38705)
Household income	(0, 0.07048, 0.1939, 0.08287)	(1, 0.10432, 0.02356, 0.24182)

Table A.28: Multiple regression results of the stock indices of New Zealand and South Korea against the presumed dependent variables. The results are in the format of (Optimal lag, Regression Coefficient, P-value, R squared).

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