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Impact of Terrorism on Economic Growth

Bachelor thesis

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Abstract

The negative market atmosphere resulting from terrorism may potentially affect key macroeconomic variables and be reflected in economic growth both immediately and with time lags. This thesis utilizes quarterly data on variables related to terrorism and key macroeconomic metrics for the time period 1970–2017 and establishes the effect of terrorism on economic growth. Furthermore, it elaborates on the change of general perception of terrorism after the 9/11 2001 attack and assesses the difference of its effect before and after this key violent act. In general, it has been found that the deaths and wounds resulting from terrorism affect economic growth with lags. Furthermore, following the 9/11 2001 terrorist attack, the time layout of the effect of deaths resulting from terrorism has changed.

Keywords

terrorism, economic growth, panel data analysis, fixed effects model, macroeconomic metrics

Abstrakt

Negativní tržní atmosféra vznikající důsledkem terorismu potenciálně ovlivňuje klíčové makroekonomické proměnné a může se negativně projevit na ekonomickém růstu, přičemž daný efekt může být okamžitý i zpožděný. Tato bakalářská práce využívá čtvrletní data týkající se specifik terorismu a klíčových makroekonomických metrik pro časovou periodu 1970–2017 a stanovuje dopad terorismu na ekonomický růst. Dále zkoumá změnu obecného vnímání terorismu po útoku 11. září 2001 a posuzuje rozdíl vlivu terorismu před a po této klíčové události. Bylo zjištěno, že smrti a zranění vzniklá důsledkem terorismu ovlivňují ekonomický růst se zpožděním. Dále také, že po útoku 11. září se změnilo časové rozložení vlivu smrtí vzniklých důsledkem terorismu na ekonomický růst.

Klíčová slova

terorismus, ekonomický růst, analýza panelových dat, pevný efekt, makroekonomické metriky

Declaration of Authorship

I hereby proclaim that I wrote my bachelor thesis on my own under the leadership of my supervisor and that the references include all resources and literature I have used.

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Prague, 1 May 2019

Signature

Acknowledgment

I would like to express my gratitude to RNDr. Michal Červinka, Ph.D. for his expertise and help throughout the process of writing the thesis. Furthermore, I would like to express gratitude to my family and to my closest who have always been supportive of my studies.

The Bachelor's Thesis Proposal

Author: Jakub Siegl

Supervisor: RNDr. Michal Červinka Ph.D.

Topic: Impact of Terrorism on Economic Growth

Description

Using fear as an instrument to achieve ideological, political or financial objectives impacts economy in both developed and developing countries. In this thesis we shall establish the effect of terrorism on various market segments and subsequently determine the relationship between economic growth and extent of the attacks. Special emphasis will be placed on the effect in developed countries. The thesis shall provide a complex analysis of this issue, putting together the already conducted researches assessing the impact of specific attacks at short-time periods. So far, it has been proved that an effect of this sort exists, however, it has not been quantified. The main contributions are therefore the investigation of the issue from broader perspective and the comparison of its development over time.

In the practical part of the thesis, we shall determine key market parts affected by terrorist acts and simultaneously influencing economic growth. Subsequently, using the data from Global Terrorism Database and The World Bank, we shall apply regression analysis to investigate the described relationships and their development over time.

Outline

1. Introduction and literature review
2. Economic growth determinants and role of terrorism
3. Regression model of influence of terrorism on macroeconomic variables
4. Data description and numerical results
5. Conclusion

Main literature

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Contents

1 Introduction

The use of violence in order to promote ideological objectives has become a largely debated topic, especially in today's era of massive globalization. Furthermore, arguably as a consequence of increased general sensitivity to the occurrence of terrorism after the 9/11 2001 attack, the potential of those acts to affect economies have increased. This influence does not necessarily need to result solely from the immediate effects of terrorist attacks. It may also be reflected indirectly in economy-affecting factors and have an effect on the economies with time lags. The establishment and quantification of those indirect macroeconomic effects requires deeper analysis of the data related to both terrorism and key macroeconomic metrics.

This thesis focuses on the assessment of the effect of terrorism on economic growth. So far, a lot of research assessing this effect from various perspectives has been conducted. Generally, those share the conclusion that terrorism negatively impacts economic growth (eg. Blomberg, Hess and Orphanides 2004). The main contribution of this thesis is the assessment of this effect over a long period of time (1970–2017), using quarterly panel data for OECD countries. None of the research which has so far been conducted makes use of quarterly data while simultaneously analyzing time period of such length. Use of this data allows us to account even for rather subtle consequences of terrorism. Furthermore, the thesis strives to evaluate the effect of not only terrorism-related deaths, but also of the sole occurrence of the acts. This is due to the fact that, as further established in the thesis, the potential effects of terrorism are a consequence of its strive to address wide audience and do not necessarily need to be linked solely to the amount of deaths resulting from it.

Another factor, which has until now been assessed only on a short-time period is the effect of the 9/11 2001 attack on general perception of terrorism and its subsequent effect on economic-related specifics. This thesis utilizes the entire dataset for the period 1970–2017 to investigate the change in the effect of terrorism-related variables on economic growth after the 9/11 attack. Furthermore, it considers potential reasons for the change of those effects and provides discussion on the role of government in this change.

The thesis starts by reviewing the already existing literature assessing the effect of terrorism on key macroeconomic variables. Then, it establishes potential determinants of economic growth using both theory and empirics. Subsequently, it elaborates on the concept of terrorism and presents potential links of terrorism to the established economic growth affecting factors. Furthermore, it elaborates on quantitative logic behind the widespread fear and potential effect of terrorism. Then, it presents both basic and advanced econometric methods used for panel data analysis. Afterwards, it describes the data used for this analysis. Next, econometric models to carry out the assessment of the effect of terrorism on economic growth are constructed. Subsequently, the results yielded by the estimation of those models are presented, interpreted and on the basis of those results, an extension of one of the models is provided. This extension allows for the assessment of the development of the effect of terrorism after the 9/11 2001 attack.

2 Literature review

This chapter establishes research which has so far been conducted and investigates the relationship of terrorism and main macroeconomic variables. It is important to note that for the purposes of this thesis, not only research which implicitly investigates the links between terrorism and economic growth is relevant. In fact, studies elaborating on the relationship between terrorism and other key macroeconomic metrics are of big importance since those are generally assumed to be subsequently reflected in the GDP growth.

To begin with, a paper Blomberg, Hess and Orphanides 2004 investigates macroeconomic implications of terrorism using an unbalanced panel dataset with annual data for the period 1968–2000 and observations on 177 countries. In the paper, it has been established that terrorism has a statistically significant negative effect on economic growth, however, that this effect is lower than in case of wars or other forms of conflict. It also points out that in OECD countries, the incidence of terrorism is more frequent in comparison to the analyzed non-OECD countries, however, its effect on economic growth is estimated to be smaller. Similar are findings of Hamida, Lassoued and Hadhek 2018 in which, using a combination of panel data and simultaneous equations, it is established that terrorism negatively affects economic growth in both developed and developing countries. Furthermore, the paper finds a negative relationship between unemployment and terrorism. Paper Gaibulloev and Sandler 2008, which analyses the effect terrorism in 18 Western European countries for the period 1971–2004 using panel data approach, finds that this negative effect exists and that even the act itself, regardless of whether it has claimed any victims, is estimated to have a significant negative impact on economic growth. It further differentiates between domestic and transnational terrorism, concluding that transnational terrorism is estimated to have twice the effect of the domestic one on the economic growth. Gaibulloev and Sandler 2009 which investigates the impact of terrorism on economic growth levels in Asia for the period 1970–2004 using panel data analysis finds that every additional terrorist act per million people results in the decrease of GDP per capita growth by 1.5 %. The paper further states that developed countries display better ability to offset adverse economic shocks resulting from terrorism.

Apart from the research which used datasets with cross-country frameworks in order to investigate the effect of terrorism, there have been many studies assessing the link between GDP growth and terrorism within one country. Implications of such research are useful since this approach may help to avoid heterogeneity bias. Example of such paper is Öcal and Yildirim 2010, which investigates effect of terrorism on economic growth in Turkey for the time period 1987–2001 and finds that terrorism slows down economic progress. According to Abadie and Gardeazabal 2003, terrorism in Basque Country in the 1960s was responsible for 10 % decline of GDP per capita. Furthermore, the study finds that subsequent decrease in terrorist activity led to increased situation of businesses activities of some companies into Basque Country. Shahzad et al. 2016 finds that, in case of Pakistan for the time period 1973–2010, a long-run relationship between terrorism and GDP growth exists.

This thesis also utilizes studies investigating the rationality of terrorist acts. Enders and Sandler 2011 states that the cost-efficiency of terrorist acts is the main reason for their execution. It also establishes the increased interest of politicians in encountering terrorism after the 9/11 2001 attack. For its analyses, the book utilizes Global Terrorism Database.

This thesis is inspired by the approach of the mentioned papers. It uses panel data analysis to investigate the effect of terrorism in OECD countries. In the model, several variables on terrorism are included and comparison of their effects is made. Furthermore, a change in the effect of terrorism after the 9/11 2001 attack is established.

3 Economic Growth and its Determinants

This chapter establishes potential determinants of economic growth. Firstly, it introduces key macroeconomic variables and explains them in the way in which they are used in the thesis. Secondly, it provides theory behind economic growth. Lastly, it discusses empirical findings of various research which partially builds upon the established theory and strives to identify economic growth affecting factors.

3.1 Key Macroeconomic Variables

Firstly, I shall define four key macroeconomic variables. The main reason behind this is that for some of those variables, there are various slightly distinct interpretations and ways of measurement. Therefore, I shall define them the way in which this thesis uses them. Furthermore, I discuss potential problems of using those variables. This section is mainly inspired by Mankiw 2006 and Mankiw 2010.

Gross Domestic Product (GDP)

Gross domestic product provides the information about the country's overall income and expenditure on the output of its goods and services. In this thesis, the data used for GDP is in line with the System of National Accounts 2008 issued by the International Monetary Fund. Furthermore, any estimation of hardly quantifiable factors such as production resulting from shadow or black market activities is disregarded.

Consumer Price Index (CPI)

This metric needs to be explained since it is subsequently used as part of technical definition of inflation. Consumer price index determines the over-time change in the prices of goods and services which are bought by a typical consumer. This is usually done on the basis of the price of a typical basket of goods and services, which is a fixed combination of goods and services. Mostly, this basket includes housing, food and beverages, transportation, recreation, medical care, clothes, education, communication and other. Each is assigned its weight in regard to its importance. Then, the overall cost of those goods and services in the given year is calculated. In order to compute the index for the given years, one of those needs to be selected as a base year. The price of the base year basket is then used as the divisor for all the years for which we are interested in the CPI.

There has been some research elaborating on the problems which may occur with CPI. According to Manser and McDonald 1988, example of such problem could be the fact that the index does not take into account the possibility of consumers opting for different goods as a consequence of the price change. This phenomenon is referred to as "substitution bias". Similar issue may occur when utterly new goods are introduced and when those become preferred by the typical customers in the next year. Another problem could result from the overall change of the quality of a good or service in the basket. This is due to the fact that distinct quality changes are often followed by price increase. However, by its definition, the basket cannot take into account this quality change.

In spite of the described possible issues, CPI is generally considered to be a reliable metric for the cost of living measurement and for the identification of price level change over time.

Inflation Rate

Inflation indicates the change in the country's currency purchasing power. On the basis of CPI, the inflation rate between years A and B is calculated as follows

$$\text{Inflation rate between } A \text{ and } B = \frac{\text{CPI in year } B - \text{CPI in year } A}{\text{CPI in year } A} \cdot 100.$$

There are other ways to measure inflation. Apart from this CPI-based calculation, a common metric is GDP deflator. According to Church 2016, selection of proper method of measurement may sometimes be dependent on the purpose of the analysis, as those metrics differ in some aspects, such as the amount of goods and services used for the calculation, location of their production or the price information aggregation. However, for our purposes, these slight distinctions do not make any difference, mostly since the resulting values from the measurements are very similar. Mankiw 2006 proves this on the basis of the data on those two metrics for the USA. However, the same is true for other regions, such as the European Union. To briefly illustrate the validity of the statement that the two metrics are similar, let us take the data for the USA and the European Union on the CPI-based inflation and GDP deflator over time. For the GDP deflator, we shall take the data from the World Bank and for the CPI-based inflation, we use the OECD data. The data for USA contain observations for years 1961–2017 and the data for the European Union contain observations for years 1997–2017. The correlation coefficient between the GDP deflator and CPI-based inflation is 0.96 for the USA and the data is displayed in Figure 1. For the European Union, the correlation coefficient is 0.81 and the data is displayed in Figure 2. Both those results indicate a strong direct positive relationship between the two assessed variables. Furthermore, the values for each year are similar, as can be observed from the two charts.

Unemployment Rate

Unemployment rate depicts the share of people wanting to work who currently do not have jobs. Generally, the formula for its calculation is the following

$$\text{Unemployment Rate} = \frac{\text{Number of Unemployed}}{\text{Labour Force}} \cdot 100.$$

Here, the "Number of Unemployed" refers to the amount of people who are available in the work market but report not having a job. Labour force is the sum of the amounts of the employed and unemployed workers. Important fact here is that in this thesis, we do not consider people who do not have a job and are not taking active steps towards acquiring new job to be part of the labour force. Therefore, if unemployed people give up looking for a new

Figure 1: CPI and GDP Deflator-based Inflation Measurement in the USA 1961–2017

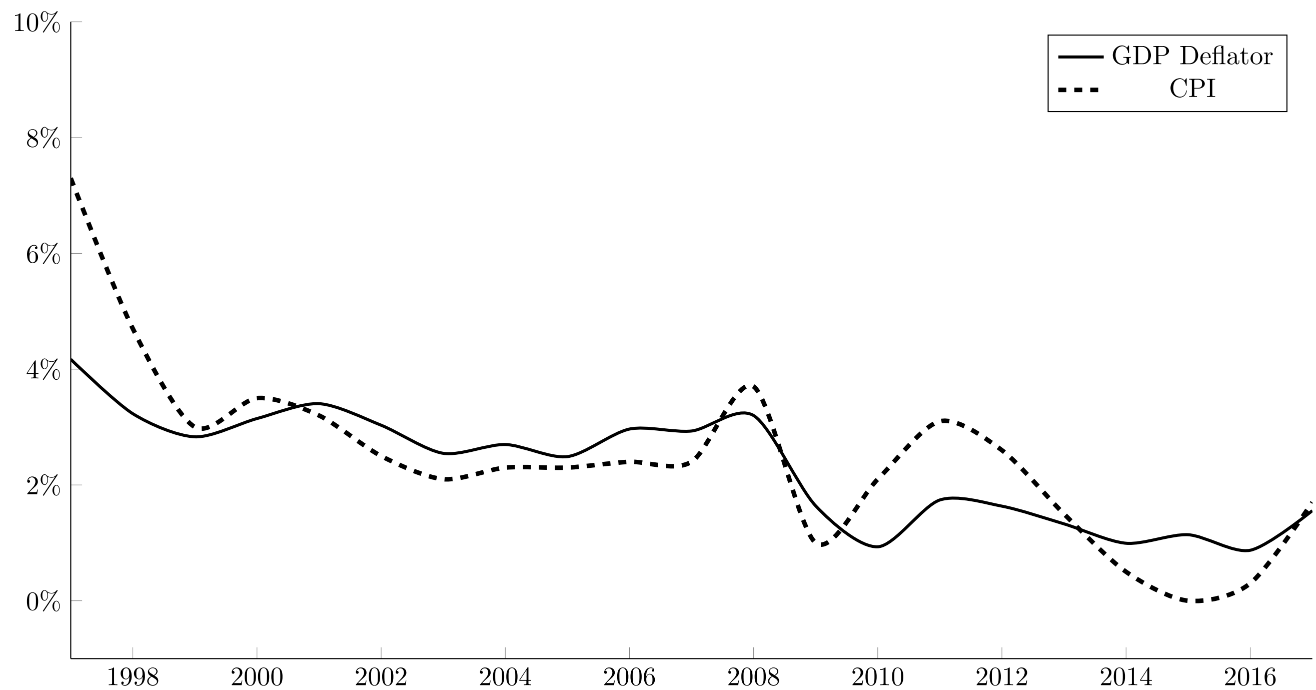

Figure 2: CPI and GDP Deflator-based Inflation Measurement in the EU 1997–2017

job, this may actually lead to a decrease in the unemployment rate. This measurement technique is uncommon in case of the Czech Statistical Office. However, international data is often reported on the basis of this calculation.

3.2 Economic Growth Theory

This section introduces the theory of economic growth called Solow-Swan model, which is a model invented in 1956 by two economists working independently. Therefore, this section is based on the papers Solow 1956 and Swan 1956.

To outline a model determining potential reasons behind long-run growth, we need to use extended Solow-Swan model to which technological progress is incorporated. We shall apply and slightly extend the derivation procedure which is explained in Mankiw 2010 to a production function taking technological progress, labour and capital into account (for the outline of theory provided in Mankiw 2010 as well as the extended model derivation, please see Appendix). To ensure generality and interconnection of the macroeconomic model with microeconomics, we use Cobb-Douglas production function

$$Y(t) = K^{\alpha}(t)\left(A(t)L(t)\right)^{1-\alpha}, \qquad 0 < \alpha < 1,$$

in which t stands for time, $Y(t)$ stands for total production, $K(t)$ for the amount of capital, $A(t)$ for the level of technology, $L(t)$ for the amount of labour force and $A(t)L(t)$ for the effective amount of workers. Furthermore, α denotes the elasticity of output with respect to capital. On the basis of the Cobb-Douglas production function, the Solow-Swan model explains the long-run economic growth per worker by the following function

$$h(t) = A(t)\left(\frac{s}{n+g+\phi}\right)^{\frac{\alpha}{1-\alpha}},$$

where s represents the share of income people save, n the population growth rate, g the steady-rate at which productivity of labor increases and ϕ the depreciation rate of capital, $s,\ n,\ g,\ \phi \in [0,\ 1]$. The function implies that, upon reaching the steady-state, the long-run growth is determined by the technological progress. Furthermore, factors like levels of interest rate, savings or investment and population growth may also affect the overall economic growth.

3.3 Empirical Assessment of Economic Growth Determinants

This section presents empirical assessment of the factors which may affect economic growth. Some of those shall subsequently be used as independent variables in the constructed econometric model.

On the basis of the model, it can be stated that higher investment rate may positively affect economic growth. This has been supported by Mankiw, Romer and Weil 1992. In fact, the research found that the importance of investment rates may be much more essential for the economic growth than originally suggested by Solow 1956 and Swan 1956. This is due to the fact that, on the basis of empirical evidence, Mankiw, Romer and Weil 1992 argues that the convergence towards the steady-state is slower than it was claimed by the previous research.

The established model further suggests indirect relationship between the population and economic growth rates. This, however, is subject to debate among economists. According to Mankiw, Romer and Weil 1992, this claim is well supported by data. Nevertheless, Lucas and Robert 1988 states that there is no such pattern and that it cannot be concluded that there is a simple linear relationship between those two factors. On the other hand, Peterson and Wesley 2017 implies that low population growth rates may prove detrimental for the overall economic growth rates in developed countries as a consequence of the rising shares of elderly people.

On the basis of the provided theory, it has been argued that the main long-term economic growth determinant is technological development. In other words, technological development, as a long-run economic growth driver, should be in direct causal relationship with the economic growth rates. This is supported by a lot of research (eg. Lipsey and Bekar 1995) and is used as an assumption by many economists in their further research (eg. Carlaw and Lipsey 2003).

According to Fischer 1993, on the basis of cross-sectional and panel data analysis, another factor closely related to economic growth is the inflation rate. The analysis shows that high inflation rate negatively affects overall economic growth and attributes this occurrence to decreased productivity levels resulting from inflation increases. Similar conclusion was drawn in Barro 2013, which, on the basis of a sample of more than 100 countries, found that, on average, a 10 % increase in inflation leads to approximately 0.2–0.3 % decrease in GDP growth rates. The paper further argues that there is likely to be a causal impact of inflation on the GDP growth rates. The negative impact of inflation on GDP is also supported in Ghosh and Phillips 1998 which focuses on the assessment of this relationship in case of moderate inflation changes, assuming that the relationship is clearly negative for high inflation rates, and finds that there is an indirect causal relationship even for milder inflation increases. On the other hand, however, the research Easterly and Bruno 1999 opposes the view that lower inflation rates can be linked to decreased economic performance. It states that inflation is damaging to economic growth only in case its rate is higher than 40 %.

It is a very common perception that economic growth and unemployment rates are negatively related. This has been first described by Arthur Okun and has later become referred to as Okun's law. According to this law, a 1 % increase in unemployment results in 2 % decrease in GDP. The validity and reliability of this simplification is subject to further debate. Some economists argue that empirics often violates this law (eg. Knotek and Edward 2007). However, those disputes do not question the validity of this indirect relationship in general, but rather the precision of the quantification it provides. Generally, it remains agreed that high unemployment rate negatively affects economic growth, which coincides with pure logic that increased unemployment rates are likely to decrease productivity in the given area.

4 Role of Terrorism

This chapter provides definition of terrorism the way it is used in this thesis. Furthermore, it elaborates on economic and quantitative logic behind terrorism and potential widespread fear to which this phenomenon leads. Last, it discusses potential relationship of terrorism with the already established factors which potentially affect economic growth.

4.1 Definition of Terrorism

Over time, government agencies have adopted various definitions of terrorism as part of their legal frameworks. Generally, it has not been agreed what the exact definition of terrorism is and many papers striving to establish it came to the conclusion that it is hardly possible to unify this definition (eg. Schmid 2011). This opinion divergence is not a consequence of disagreements on broad aspects of the acts defining terrorism. Rather, the definitions mostly differ in subtle specifics, such as whether attacking a person engaged in war-related acts should be regarded as terrorism or whether an attack requires political motivations in order to be classified as terrorist. This thesis shall adhere to a combination of definitions introduced by Pinkerton Global Intelligence Service (PGIS) and Global Terrorism Database. As PGIS puts it, terrorist attack is:

> *the threatened or actual use of illegal force and violence by a non-state actor to attain a political, economic, religious, or social goal through fear, coercion, or intimidation.*

Pinkerton Global Intelligence Service simultaneously requires the fulfillment of the following three properties:

- Willfulness of the act – The attack is a deliberate action.
- Potential or actual violence is part of the act – The attack uses violence or threat of violence.
- The offenders are subnational – State-level actions are not regarded as terrorism.

For the purposes of this thesis, however, apart from the criteria defined by PGIS, we require at least two of the following three criteria to be fulfilled for the act to be considered terrorism:

- The purpose of the action is an achievement of other than purely harm-causing objective – The act cannot be driven by superficial aims. In other words, it needs to display elaborate pursuits.
- There exists evidence that the purpose of the action goes beyond a simple act of violence and that the act strives to address broader audience – The individuals carrying out the act do not necessarily need to be aware of its intended impact as long as there is any planner behind the attack (who not always participates in it directly).
- The act violates International Humanitarian Law – The acts does not abide the rules set by IHL which are meant to protect non-combatants in case of war-related conflicts.

This extension is introduced due to the fact that the majority of available data on terrorism (eg. Global Terrorism Database) is collected utilizing this extension of the definition of terrorism.

4.2 Economic and Quantitative Logic Behind Terrorism

This section looks at possible economic logic behind terrorism. It elaborates on death causes throughout the world. Furthermore, it evaluates variables on terrorism which may potentially be used as part of the econometric analysis in this thesis.

The extent to which terrorism is effective in the achievement of its objectives is unclear. Essentially, there are two main views on this matter. The first one argues that terrorism is effective policies and public views influencer, especially in the era of massive globalization. This has been examined on broad merit in Pape 2006, which concludes that terrorist attacks may potentially harm democracy. More specific research is done in Gould and

Klor 2010, which finds that terrorism pushed Israelis to make concessions to Palestinians. The other view proposes that the majority of terrorist acts is unsuccessful in achieving their objectives. According to Cronin 2009, this can be supported by the fact that terrorist groups usually fall apart within 5–9 years on average and due to it are unable to stick to their initial, mostly long-term, plans. Furthermore, there are papers (eg. Abrahms 2006) which disprove overall strategic sensibility of terrorism. Abrahms 2006 also argues that the terrorist attacks intending to harm civilians, which are more common, hardly attain their goals.

Terrorism is said to be a rather uncommon cause of death around the world in comparison to some other, more frequent causes of death. This fact is often used as a supporting argument for the claim that the fear of terrorism is irrational. The data of Institute for Health Metrics and Evaluation (2017) breaking down the causes of deaths in 2016 are depicted in Figure 3. The chart displays that terrorism-related deaths accounted for only 0.06 % of all deaths in 2016. This means that in case of dying, the likelihood that the cause of death was a terrorist attack is rather low. This could imply that the fear of terrorism is irrational and a much higher fear should steam from occurrence of health-related potential death causes. Furthermore, for example, road accidents, which accounted for 2.45 % of deaths in 2016, as opposed to the 0.06 % for which terrorism accounted, may at first seem much more dangerous.

However, the mentioned statistic does not take into account the volatility of the amount of deaths related to the given causes. Let us now take the Global Terrorism Database data on yearly amount of casualties of terrorist attacks in the USA and the National Highway Traffic Safety Administration data on yearly deaths from traffic accidents, both for period 1970–2017. This data is in logarithmic form depicted in Figure 4 (the years in which there were no casualties as a consequence of terrorist attacks assume value zero). The

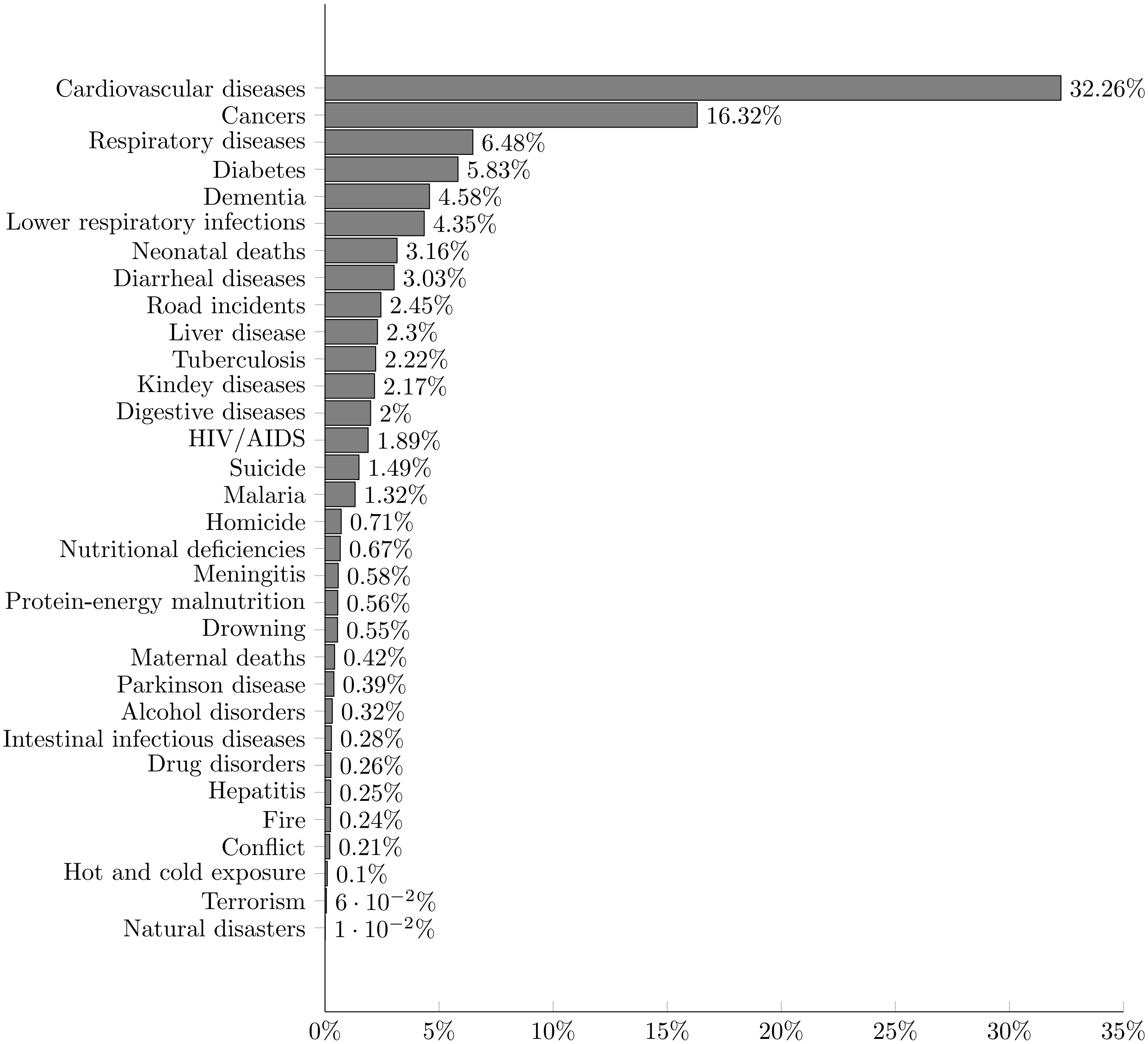

Figure 3: Share of deaths by cause in 2016

logarithmic form allows us to better observe and compare individual volatilities of those variables. From the figure, it may be observed that terrorism deaths are much more volatile than the deaths related to road accidents. This implies that although the risk of death related to terrorism is generally low, its volatility makes this phenomenon unpredictable. In this example, it is very unlikely that the deaths in traffic accidents ever rise substantially above its all-time high and that the change from one year to another will be distinct. However, with terrorism, this cannot be concluded, because in

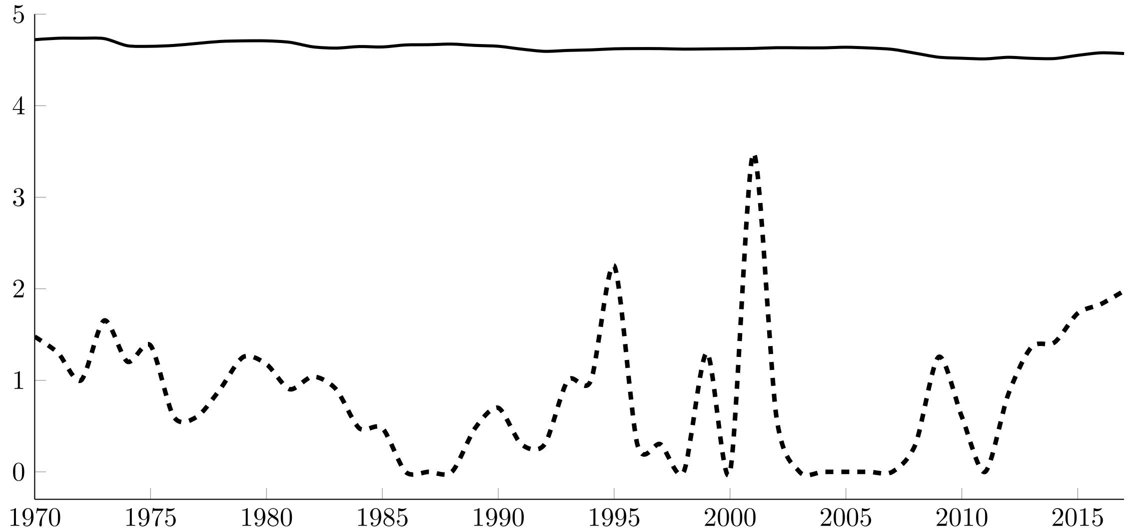

Figure 4: Deaths resulting from road accidents and terrorism volatility comparison for the period 1970–2017.

The years where there was no terrorist attack assume value 0 in the graph. The dashed line represents the deaths resulting from terrorist attacks and the full line the deaths resulting from road accidents.

2001 the amount of deaths due to terrorism was 207 times higher than the average amount of deaths between the years 1970 and 2017. The unpredictability and potential indefiniteness of terrorism may therefore result in its huge overall impact in comparison to other occurrences leading to deaths of involuntary participants.

4.3 Relationship with Economic Growth Factors

This section discusses possible relationship of terrorism with the economic growth factors which were outlined in the previous chapter. This discussion is further supported by empirical research.

Terrorism and Investment

In case of investment it is likely that foreign direct investment (FDI) is affected by terrorism. This could stem from the fact that foreign investors may lose trust in countries in which terrorist attacks take place. Enders and

Sandler 2011 assesses the impact of 9/11 terrorist attack on FDI. It finds that in case of the United States, this effect was low, however, some countries showed decreased foreign direct investment flows. The paper further applies the same analysis method to OECD countries and finds that this effect is statistically significant in case of those as well. Similar conclusion was drawn for developing countries in paper Bandyopadhyay, Sandler and Younas 2013 which finds that FDI decreases as a consequence of terrorist activities in the assessed countries.

Terrorism and Technological Development

It has been established that technological development determines long-run economic growth. However, rising overall technology levels tend to increase the country's dependency on technology. This is studied in Bijker 2006 which states that technological progress makes people more vulnerable to factors with potential to harm technology, putting this statement to the context of 9/11 attack. Logically, this may be true for two reasons. Firstly, using force, it is not difficult to disturb technology-related objects which subsequently cannot be fully utilized the way they would otherwise be. Secondly, as a consequence of the fact that technology ensures public awareness of current affairs, terrorist attacks have considerable reach which empowers their effectiveness.

Terrorism and Population Growth

Although this factor is mostly associated with terrorism in developing countries, population growth may be generally interconnected with terrorism. This is due to the fact that distinct population growth is often followed by income inequalities which result in frustration of people. According to Coccia 2018, those circumstances consequently form environment which is more susceptible to increasing occurrence of terrorist acts.

Terrorism and Inflation

The effect of inflation is similar to the effect of population growth. It is mostly observed in developing countries and results from uncertainties of future development of the economy.

Terrorism and Unemployment

Exclusion from active economic participation is believed to be strong risk factor making the related individuals more likely to engage in any sort of criminal activity. Goldstein 2005 finds that, although being responsible for only small part of it, unemployment contributes to the increase in terrorist activities. Further, it establishes that this effect is very similar for economically weak and strong countries.

5 Econometric Methods for Panel Data Analysis

This chapter briefly outlines econometric methods used for panel data analysis. It is mostly inspired by Wooldridge 2015. In case the reader is familiar with those methods, he/she can skip this chapter.

Panel data is type of data which has both cross-sectional and time dimensions. Due to this fact we can control for the effect of time when analyzing cross-sections and thus often avoid omitted variable bias. Since we have those two dimensions, panel datasets are larger by their nature. General regression for panel data analysis looks as follows

$$\begin{aligned} y_{it} = \beta_0 + \beta_1 x_{it1} + \ldots + \beta_k x_{itk} + a_i + u_{it}, \\ i = 1, \ldots, N,\ t = 1, \ldots, T. \end{aligned} \tag{1}$$

Here, i represents cross-sectional unit, t represents time period, a_i stands for time-invariant factors affecting the explained variable which are not included in the model and u_{it} contains factors which change over time, affect y_{it} and are not included as part of the independent variables in the model. We shall now discuss methods which are commonly used to analyze panel data.

Pooled Cross-Sections (Pooled OLS)

This method pools the cross-sectional observations together and subsequently uses standard OLS method on the model (1). However, it may result in biased and inconsistent estimates in case x_{itk} and a_i are not uncorrelated for all i, t, k.

First Differencing Estimation

This approach makes use of the fact that a_i is constant over time as it represents time-invariant factors. Let us assume we have two time periods ($t = 1$, 2) represented by the following models

$$y_{i2} = (\beta_0 + \delta_0) + \beta x_{i2} + a_i + u_{i2} \quad (t = 2), \tag{2}$$

$$y_{i1} = \beta_0 + \beta x_{i1} + a_i + u_{i1} \quad (t = 1). \tag{3}$$

Now, subtracting (3) from (2) yields

$$\Delta y_i = \delta_0 + \beta \Delta x_i + \Delta u_i,$$
$$i = 1, \ldots, N.$$

This is a standard cross-sectional model. The same procedure may be applied for more than two time periods, simply by differencing the adjacent periods. The key assumption here is that the idiosyncratic errors are uncorrelated with independent variables for each time period, the co-called strict exogeneity. Generally, this procedure results in loss of the first observation and does not allow for any of the variables to be constant over time since such variable would be differenced away. In case the strict exogeneity assumption is not satisfied, even profound expansion of the time periods observed does not result in increase of the consistency of the estimates.

Fixed Effects Estimation

Fixed effects estimation is the application of pooled OLS on time-demeaned model. This model is obtained by subtracting the following equation (equation (1) averaged over time for each i) from each equation of the original model

$$\bar{y}_i = \beta_0 + \beta_1 \bar{x}_{i1} + \ldots + \beta_k \bar{x}_{ik} + a_i + \bar{u}_i,$$

where

$$\bar{y}_i = T^{-1} \sum_{t=1}^{T} y_{it},\ \bar{x}_{i1} = T^{-1} \sum_{t=1}^{T} x_{it1},\ \ldots,\ \bar{x}_{ik} = T^{-1} \sum_{t=1}^{T} x_{itk},\ \bar{u}_i = T^{-1} \sum_{t=1}^{T} u_{it}.$$

This yields

$$\begin{gathered} \ddot{y}_{it} = \beta_1 \ddot{x}_{it1} + \ldots + \beta_k \ddot{x}_{itk} + \ddot{u}_{it}, \\ i = 1, \ldots, N,\ t = 1, \ldots, T, \end{gathered} \tag{4}$$

where $\ddot{y}_{it} = y_{it} - \bar{x}_i$, $\ddot{x}_{it1} = x_{it1} - \bar{x}_{i1}$, $\ldots$, $\ddot{x}_{itk} = x_{it1} - \bar{x}_{ik}$, $\ddot{u}_{it} = u_{it} - \bar{u}_i$. Model (4) can be estimated using pooled OLS, since it does not include a_i and we do not need to worry about omitted variable bias due to this unobserved effect. For FE, in case the strict exogeneity assumption is not satisfied, its bias goes to zero with increasing amount of the observed time periods.

Random Effects Estimation

Random effects estimation (RE) is the estimation of the following model using pooled OLS

$$y_{it} - \lambda\bar{y}_i = \beta_0(1-\lambda) + \beta_1(x_{it1} - \lambda\bar{x}_{i1}) + \ldots + \beta_k(x_{itk} - \lambda\bar{x}_{ik}) + (\nu_{it} - \lambda\bar{\nu}_i),$$
$$i = 1, \ldots, N,\ t = 1, \ldots, T,$$

where $\lambda = 1 - \sqrt{\sigma_u^2/(\sigma_u^2 + T\sigma_a^2)}$, $\nu_{it} = a_i + u_{it}$.

This method requires that the a_i is uncorrelated with all explanatory variables for all i and t, which is problematic in many cases. However, unlike the FD and FE method, it allows for the inclusion of time constant dummy variables.

6 Variables and Data Description

This chapter describes variables and corresponding data used for the analysis. It builds upon the chapters providing theoretical background on the ways of measurement of those variables.

In general, quarterly panel data for the period 1970–2017 ($T = 192$) is analyzed. The countries of focus are those which are members of OECD. This is for two reasons. Firstly, OECD countries may generally be considered developed which is in line with the purpose of this thesis, which analyzes the impact of terrorism mainly in developed countries. Secondly, for OECD countries, there is a lot of available reliable data on the essential macroeconomic variables. In most cases, this data is published on a quarterly basis, which allows for a rather precise estimation. Furthermore, for the key macroeconomic variables, the calculation techniques of data values are largely standardized across the OECD countries. Currently, there are 36 OECD member countries ($N = 36$), however, for some of those, observations for some quarters are missing. Therefore, we are dealing with unbalanced panel.

6.1 Data on Macroeconomic Indicators

Economic Growth Rate

In case of economic growth, OECD data on real GDP growth is used. The data measure percentage change in the gross domestic product from the previous quarter. It is seasonally adjusted and the effects of inflation are removed. Using various price indices which are updated on a regular basis and are similar for all the OECD countries, the data is converted from nominal to real which allows for its comparison over time. The comparability across countries is ensured by the fact that the calculation method of the original nominal GDP values is very similar for every OECD country, following the System of National Accounts.

Investment

Since quarterly data on investments as part of country's GDPs is very poor due to its unavailability for many OECD countries in some quarters, long-term interest rates are used as a proxy for investment. Those represent interest rate on government bonds. In case the interest rate value is low, investment is assumed to be high and vice versa. The reason for choosing long-term interest rates here is that it may potentially be less affected by inflation than short-term interest rates.

Inflation and Unemployment Rate

The quarterly data on inflation and unemployment rate is in line with the definition in chapter three. The inflation is therefore calculated on the basis of CPI. The base period is 2015. As has already been established, the subtle difference from the quarterly data on inflation measured by GDP deflator does not affect the analysis.

Technological Progress

In case of technological progress, the data on gross domestic spending on research and development (R&D) is used as a proxy. This assumes that the spending on R&D is subsequently reflected in the level of countries' technology and technological progress. The OECD data on this measure is published on yearly basis. However, it is reasonable to assume that seasonality does not affect this spending and therefore, the data is recalculated to quarterly by simple division of its values in millions of USD by 4. Subsequently, those values are divided by the respective quarterly values of gross domestic products and thus represent this quarterly spending as a percentage of GDP.

Population Growth Rate

This rate refers to the percentage change in the population from one quarter to another, mostly resulting from births and deaths in the given period.

This data is published by OECD on yearly basis which is problematic since for the analysis, we need quarterly data. Furthermore, it is unlikely that population growth rates are not affected by seasonal patterns and hence, simple recalculation of yearly to quarterly data might be insufficient in this case. Therefore, those values are recalculated to quarterly terms and then, using R-Studio, adjusted for seasonality.

6.2 Data on Terrorism

For terrorism, Global Terrorism Database is utilized. The available dataset on terrorism contains 182,439 observations for the period 1970–2017 and provides the information on at minimum 45 variables for every observation. This database is based on a large variety of media sources and the reliability of each observation is assessed by a committee before it is added to the dataset. The reason for the exclusion of year 2018 is that the data for this period is incomplete in comparison to the analyzed period. This, however, does not have any effect on the analysis. The methodology of terrorism classification follows the definition of terrorism described in chapter 5. It includes every attack which was carried out, even those where no person died or those which were unsuccessful in meeting its scope. It excludes the attacks which were uncovered and stopped before started.

It is important to determine which variables are of interest for the analysis. Extracting data for the OECD countries, we have overall 29,710 terrorist attacks with 20,750 people killed. This means that, on average, approximately 0.7 people get killed in a terrorist act. Furthermore, the average amount of kills per quarter is 3 and the average amount of attacks is 4.3. The correlation coefficient between the amount of deaths and amount of attacks for the respective quarters is 0.23 which generally does not indicate any strong relationship between the variables. From Figure 5, it can be seen that generally, the amount of attacks tends to exceed the amount of deaths in the given periods. Since the observations for the amount of deaths and

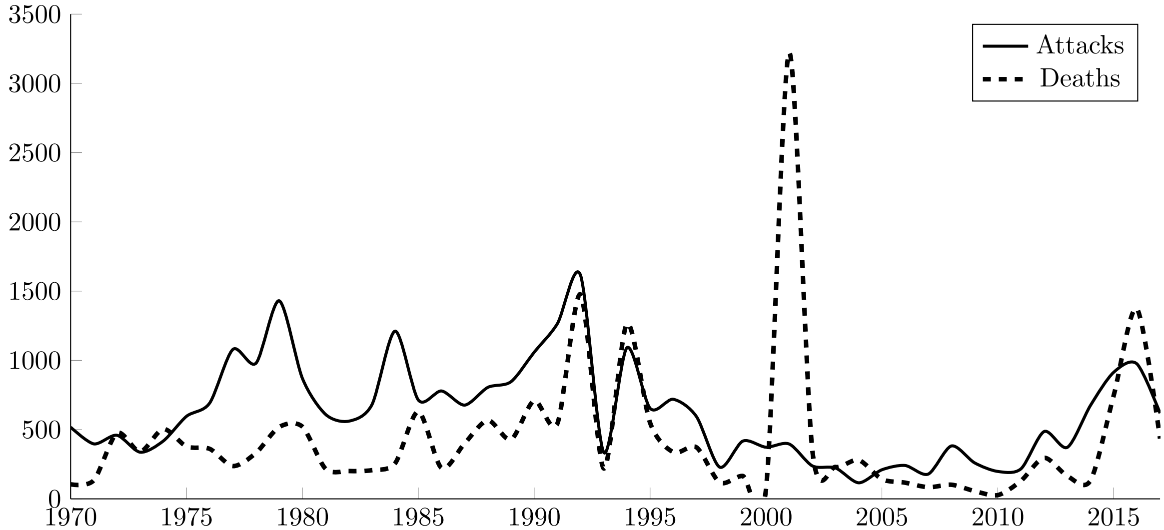

Figure 5: Annual data on amount of terrorist attacks and terrorism-related deaths for the period 1970–2017 in OECD countries

attacks are not similar, it may be a good approach to include them both in the regression. Of course, it might seem reasonable to include only the attacks which resulted in deaths of some of the victims, however, as has already been established, the intimidation and symbolic of the act is often the source of its strength. Hence, even the attacks with no deaths may have significant overall effect.

7 Regression Model of Influence of Terrorism

This chapter establishes models of economic growth which, apart from the key macroeconomic indicators, include the discussed variables on terrorism. Furthermore, this chapter evaluates fulfillment of the assumptions necessary for valid inference drawn about the models.

7.1 Model 1 - Without Technological Progress

The first constructed model excludes technological progress. This is since in case of technological progress, the majority of data is available starting from the year 1981. This could prevent the estimation from full utilization of the dataset. Therefore, the first model is constructed as follows

$$\begin{aligned} G_{i,t} &= \delta_t + \sum_{p=0}^{10} \alpha_p \cdot K_{i,t-p} + \sum_{q=0}^{10} \beta_q \cdot A_{i,t-q} + \gamma_1 \cdot I_{i,t} + \gamma_2 \cdot P_{i,t} + \\ &+ \gamma_3 \cdot F_{i,t} + \gamma_4 \cdot U_{i,t} + a_i + u_{i,t}, \qquad i = 1,\ldots,N,\ t = 1,\ldots,T, \end{aligned}$$

where δ_t represents time-fixed effects, $G_{i,t}$ stands for GDP growth, $K_{i\,t}$ for the amount of kills resulting from a terrorist act, $A_{i\,t}$ for the amount of terrorist acts, $I_{i\,t}$ for the long-term interest rate, $P_{i,t}$ for the population growth rate, $F_{i,t}$ for the inflation rate and $U_{i,t}$ for the unemployment rate, all for country i in period t.

In the model, we include all (apart from technology, which is included in the second model) the variables which were established to potentially affect economic growth and simultaneously be correlated with terrorism. This is due to the fact that it has been discussed that those variables could be correlated with the variables on terrorism both cross-sectionally and across time. Therefore, excluding them from the model could result in violation of the exogeneity assumption and the produced estimates could be biased. The lags are included since the terrorist acts may affect economic growth with lag, for example by adversely impacting tourism or trust of foreign investors in the country. Such effects may be reflected in the economic growth immediately as well as in later periods.

It is important to determine which method of panel data analysis to use. In the model, it is very likely that there are factors a_i which are correlated with some of the explanatory variables of the model. Example of those could be country-specific factors such as geographical conditions or historical aspects. Therefore, it is very convenient to use a method which eliminates this factor, like FD or FE. In this case, if we used RE, the results could be inconsistent since a_i cannot be treated as random. Furthermore, the inappropriateness of using RE can be supported by the fact that we have a relatively small N compared to T. Therefore, performing Hausman test to decide between RE and FE is unnecessary.

Since we have $T > 2$, the methods FE and FD differ in our case. In the analysis, we use FE. This is for the key reason that there are many potential factors included in the idiosyncratic error which affect the explanatory variables in the same, previous or future time periods and are correlated with the explanatory variables. As previously stated, the bias of FE depends on T and tends to asymptotically go to zero. Since we have a relatively large T in our dataset, we make use of this property. In the dataset, cross-sections for some years are missing, meaning that we are dealing with unbalanced panel. However, this is unlikely to affect the analysis since the data is missing for a random rather than systematic reasons.

We first verify that the dummy variables for each period – the time fixed effects – should be included in the model. We do so by performing Breusch-Pagan Lagrange Multiplier test for unbalanced panels. We test the null hypothesis that the time fixed effects are zero against the alternative that they are not. The test is carried out using R-Studio. The p-value is lower than 10^{-16}. This means that we can reject null at significance level very close to 0. Hence, time may be regarded as a significant contributor to GDP growth. Inclusion of the period-representing dummy variables in the model therefore enables avoidance of bias resulting from the fact that other explanatory variables may be affected by time as well.

Next, it is important to determine if heteroskedasticity and serial correlation is present in the data. This is often the case for long time-series macroeconomic data. For serial correlation, we use Breusch-Godfrey test (eg. Dimitrios and Hall Stephen 2011). This test computes test-statistics on the basis of the residuals from the model. The null hypothesis is that there is no serial correlation. Performing the test using R-Studio, we reject the null hypothesis with p-value lower than 10^{-16} and hence at significance level close to zero which implies that serial correlation is likely to be present in the model. This is likely to be a consequence of factors contained in idiosyncratic errors which are difficult to depict by variables and affect each other across time. Example of such factors could be political situation or legislative system in the given countries.

To test for heteroskedasticity, we make use of the Breusch-Pagan test which tests whether the error variance from the model regression depends on the explanatory variables. If it is the case, then heteroskedasticity is present. Performing this test via R-Studio, we reject homoskedasticity with p-value lower than 10^{-16} and hence at significance level close to zero. As previously established, the presence of heteroskedasticity and serial correlation is not uncommon for macroeconomic long time-series. However, due to it, we need to use robust test statistics.

7.2 Model 2 - With Technological Progress

The second model this thesis assesses includes technological progress. For it, we observe lower number of time periods due to poor data availability on the investment into R&D. The observations start in the first quarter of 1981 and end in the fourth quarter of 2017. The model reads as

$$\begin{aligned} G_{i,t} &= \delta_t + \sum_{p=0}^{10} \alpha_p \cdot K_{i,t-p} + \sum_{q=0}^{10} \beta_q \cdot A_{i,t-q} + \sum_{r=0}^{10} \lambda_r \cdot E_{i,t-r} + \gamma_1 \cdot I_{i,t} + \\ &+ \gamma_2 \cdot P_{i,t} + \gamma_3 \cdot F_{i,t} + \gamma_4 \cdot U_{i,t} + a_i + u_{i,t}, \quad i = 1, \ldots, N, \ t = 1, \ldots, T, \end{aligned}$$

where the new variable $E_{i,t}$ represents the investment into R&D as a percentage of GDP. The lags are included in the model since the investment into research and development is likely to be reflected in the GDP in later periods when the actual findings can be made use of or, in other words, when it is transformed into the actual technology which was established to possibly affect economic growth.

Again, we test for the significance of time fixed effects, heteroskedasticity and serial correlation using the same tests as in case of Model 1. The results of those tests are the same as in case of Model 1.

8 Numerical Results and Their Interpretation

This chapter describes and assesses the numerical results yielded by the estimation of the models described in the previous chapter.

8.1 Estimation Results

Model 1

Via R-Studio, we estimate Model 1 using fixed effects estimation method. The coefficients on time fixed effects are depicted in Figure 6 . Overall, it can be observed that the effect of time is mostly positive. This means that GDP generally tends to grow over time. The decline which can be observed at the period around 2008/2009 can be attributed to the global financial crisis. This also means that the inclusion of those variables helps to account for the effects which could otherwise be incorrectly connected to other variables in the model. Therefore, the time fixed effects also serve as a good proxy for historical events affecting world economies and for possible short-term economic fluctuations which cannot be explained by other variables included in the model.

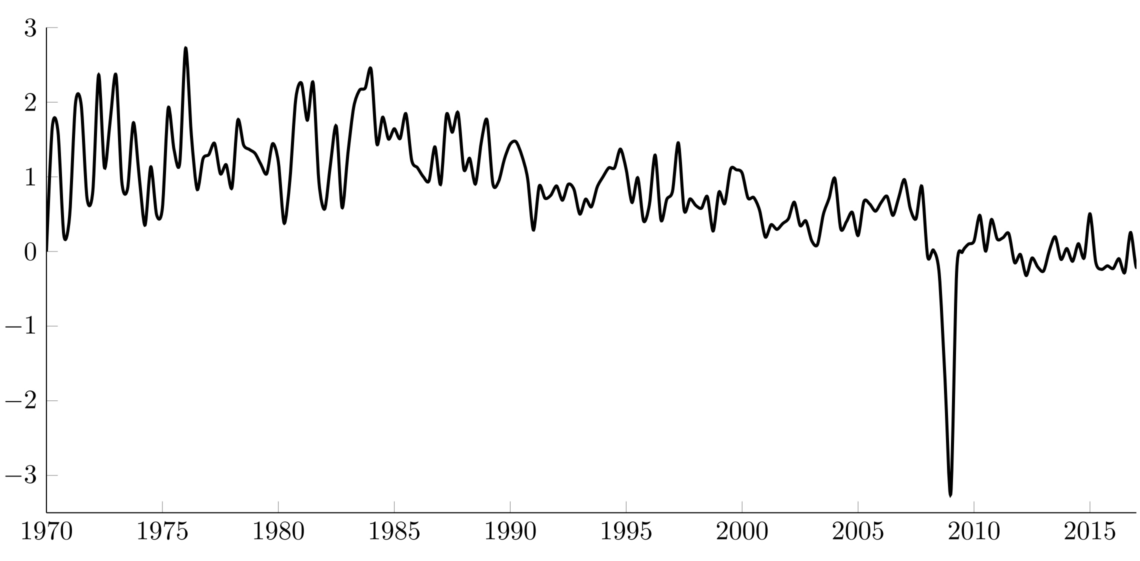

Figure 6: Quarterly time fixed effects estimation 1970/Q1—2017/Q4

The results of the estimation of Model 1 are depicted in Table 1 (the time fixed effects are excluded since those were presented by the line chart). It can be seen that the variable on the amount of terrorist attacks is not statistically significant at the 5 % significance level. Furthermore, none of the coefficient on the lags of this variable is estimated to be statistically signi-

Variable	Coefficient	Standard Error	p-value
$Kills$	−0.000118	0.000081	0.150523
$Kills_{t-1}$	−0.025299	0.026188	0.000386
$Kills_{t-2}$	0.000091	0.000053	0.089853
$Kills_{t-3}$	−0.000124	0.000065	0.057200
$Kills_{t-4}$	−0.059144	0.027100	0.029165
$Kills_{t-5}$	−0.035950	0.037182	0.000382
$Kills_{t-6}$	−0.000021	0.000075	0.778910
$Kills_{t-7}$	0.000218	0.000136	0.110454
$Kills_{t-8}$	0.057436	0.021725	$< 10^{-16}$
$Kills_{t-9}$	0.000022	0.000061	0.723896
$Kills_{t-10}$	−0.039990	0.066258	0.026478
$Attacks$	−0.001121	0.001294	0.386420
$Attacks_{t-1}$	0.001493	0.002369	0.528555
$Attacks_{t-2}$	−0.003102	0.001850	0.093709
$Attacks_{t-3}$	0.002196	0.002311	0.342023
$Attacks_{t-4}$	0.000211	0.001492	0.887522
$Attacks_{t-5}$	−0.002524	0.002072	0.223228
$Attacks_{t-6}$	−0.000621	0.001608	0.699213
$Attacks_{t-7}$	0.000078	0.002211	0.971752
$Attacks_{t-8}$	0.002614	0.001868	0.161881
$Attacks_{t-9}$	−0.002291	0.001689	0.175024
$Attacks_{t-10}$	0.001626	0.002526	0.519910
$Inflation$	−0.453278	0.196656	0.021246
$Interest\ Rate$	−0.410222	0.447567	0.000757
$Population$	−0.298343	0.369283	0.419218
$Unemployment$	−0.011793	0.011452	0.303217
R^2: 0.27			

Table 1: Estimation results – Model 1

ficant at this significance level as well. This may have many explanations. One of them is that people generally do not tend to react to attacks which did not result in the death of any of the people it directly affected. This may be caused by people's perception of those attacks, since it is possible that attacks with no deaths are not regarded as important. Another explanation could be that those attacks do not get widespread media attention and hence, society awareness of them is generally lower. It is also possible that the majority of governments and security forces do a good job regarding the suppression of the success of the main purpose of those attacks, which is to increase concerns and fears in the society and convey a message.

On the other hand, some of the lags of the variables representing amount of deaths in the attacks are very statistically significant. It can be seen that the effect in the quarter immediately after the occurrence of the deadly attack is statistically significant with p-value close to zero. The reason why the effect does not occur in the same quarter may be that the attacks and deaths happen throughout the quarter and require a few weeks before they are reflected in the GDP. It can be seen that one death in this given quarter is estimated to result in approximately 0.025 % decrease in economic growth in the next quarter. This means that 40 deaths from terrorist acts in a quarter have potential to decrease GDP growth, on average, by 1 % in the subsequent quarter. Furthermore, deaths from terrorist attacks are estimated to have a statistically significant negative effect in the fourth and fifth quarter after their occurrence. This may be caused by the overall negative atmosphere and by the impairment of market conditions which affect economic productivity and subsequently economic growth. In other words, there are some market industries which may contribute to GDP growth and are indirectly negatively affected by terrorism. Negative statistically significant effect can also be observed for the fourth and fifth quarter after the deaths from terrorism occur, with estimated effects -0.059 and -0.036, respectively.

On the other hand, a positive effect may be observed in the eighth quarter after the attack. In this quarter, one death from terrorist attack is estimated to, on average, contribute to GDP growth in the eighth quarter after this phenomenon by 0.057 %. This may be due to possible policy changes which come into existence as a consequence of those acts. Those policies may cause increased investment into defence or surveillance mechanisms in order to prevent future attacks. Those investments can be positively reflected in GDP growth.

Another variable which is statistically significant with p-value 0.021 is inflation. Its effect is estimated to be negative. This result was expected since the data on economic growth were adjusted for inflation (if this was not the case, the effect would very likely be positive). This effect, which indicates that increase in inflation by 1 % is estimated to, on average, result in decrease of GDP growth by 0.45 %, is likely to be a consequence of harmful side-effects of inflation.

Last variable which is very statistically significant is the variable on interest rate. This has generally negative effect on the GDP growth. On the basis of the estimation, a 1 % increase in the long-term interest rate results in approximately 0.41 % decrease in GDP growth. This is most likely due to the fact that higher interest rates are a reflection of unstable economic conditions. Since it has been established that this variable serves as a proxy for investments (and that the relationship between investments and interest rate is negative) it can be stated that higher investment generally leads to higher GDP growth.

Model 2

In case of the other model, we shall first examine the estimates of the coefficient on the newly added variable and its lags and then assess if their inclusion in the model affected the estimates and statistical significance of the variables representing terrorism.

Estimating the effect using R-Studio two of the lags on technology are statistically significant at the 5 % level of significance (the exact estimation results are in Appendix). One of those is the sixth lag, the coefficient on which is estimated to be 3.42 and the other is the seventh lag, the coefficient on which is estimated to be -2.68. This means that investment into research and development takes effect after six quarters, which is presumably due to the fact that after this time, the research findings and new inventions can be put into practice and therefore be reflected in the GDP. However, in the subsequent quarter, this investment contributes negatively to GDP growth. This may be a result of some further costs connected to putting the R&D findings into practice, which are reflected positively in the quarter six but the lack of those resources is then reflected negatively in the subsequent quarter.

Overall, this estimation did not change any of the coefficient estimates nor statistical significance of the terrorism variables. Therefore, further investigation of Model 2 results will be omitted.

8.2 Development after 2001 Attack

In this section, we shall further elaborate on Model 1. What has so far been found is that the amount of deaths affects (with lags) GDP growth. On the other hand, the amount of attacks was not linked to GDP growth. The variable representing amount of attacks was included since it was considered to be a good proxy variable accounting for the potential reach of terrorist acts. It may be possible, however, that reach of terrorism is not properly reflected by this variable. Therefore, a variable representing the amount of injuries in the given quarter shall be added to Model 1. This variable may be a better proxy accounting for the intimidating effects of the terrorist acts, since a high amount of wounded victims can indicate a high reach of the attack and subsequent effect on GPD. For the amount of wounded people, data from the Global Terrorism Database is used. Furthermore, we shall add an interaction variable to asses the change in the effect of deaths resulting from terrorist acts before and after the 9/11 2001 attack.

For the described elaboration on the analysis, the following extension of Model 1 shall be used

$$\begin{aligned} G_{i,t} &= \mathbf{B} + \sum_{p=0}^{10} \alpha_p \cdot K_{i,t-p} + \sum_{q=0}^{10} \beta_q \cdot D_t \cdot K_{i,t-q} + \sum_{r=0}^{10} \epsilon_r \cdot A_{i,t-r} + \\ &+ \sum_{s=0}^{10} \zeta_s \cdot W_{i,t-s} + \gamma_1 \cdot I_{i,t} + \gamma_2 \cdot P_{i,t} + \gamma_3 \cdot F_{i,t} + \gamma_4 \cdot U_{i,t} + a_i + u_{i,t}, \\ i &= 1, \ldots, N, \; t = 1, \ldots, T, \end{aligned}$$

where the new variable $W_{i,t}$ represents the amount of wounded people in the given quarter and D_t is a dummy variable taking value 1 for every quarter after the 9/11 attack (and including this quarter) and zero otherwise. Therefore, in the dataset used for this analysis, where the third quarter of 2001 corresponds to the 127$^{\text{th}}$ time period, the variable D_t assumes value 1 for every t higher or equal to 127 and value 0 otherwise. In the extended model, this variable is interacted with K_{it} and its lags. The model thus allows for the comparison of effect of deaths resulting from terrorism before and after the 9/11 2001 terrorist attack.

Estimating the model, the significance and estimates of the time fixed effects, investment, population growth, inflation and unemployment rate did not change at all or, in some cases, changed only slightly. Elaboration on those changes is not relevant for this thesis. However, the estimates and significance of variables directly related to terrorism did change. The results can be seen in Table 2. The columns represent the variables and rows their respective lags. For each coefficient estimates, its p-value is provided in brackets. Furthermore, for better comparability of the before and after 2001 effect, the column "Kills before 2001" provides the estimate of the coefficient of deaths resulting from terrorist attacks (α_d for $d = 0, 1, \ldots, 10$) and the column "Kills after 2001" includes the values of the overall effect after 2001 (which is calculated as the sum of α_d and β_d for $d = 0, 1, \ldots, 10$). The respective p-values are those of the coefficients on the interaction term.

	Kills before 2001	Kills after 2001	Wounds
t	−0.002169	−0.000094	0.000002
	(0.061369)	(0.055956)	(0.977112)
$t-1$	−0.000876	−0.000507	0.000068
	(0.249848)	(0.630568)	(0.048530)
$t-2$	0.002424	0.000120	−0.000011
	(0.000003)	(0.000180)	(0.842702)
$t-3$	−0.001806	0.000104	−0.000037
	(0.176515)	(0.182148)	(0.446353)
$t-4$	−0.000197	−0.000326	0.000043
	(0.843885)	(0.894131)	(0.408158)
$t-5$	−0.002652	−0.000058	−0.000020
	(0.044082)	(0.072358)	(0.729056)
$t-6$	−0.002640	0.000336	−0.000058
	(0.037758)	(0.011949)	(0.182218)
$t-7$	0.007334	−0.000255	0.000066
	(0.026513)	(0.022142)	(0.248085)
$t-8$	−0.000634	0.001092	−0.000139
	(0.0301758)	(0.041158)	(0.023889)
$t-9$	−0.000452	0.000963	−0.000170
	(0.670803)	(0.178278)	(0.002441)
$t-10$	0.000099	0.000120	−0.000076
	(0.924945)	(0.937197)	(0.070788)
R^2: 0.28			

Table 2: Estimation results − Extended Model 1.

The column "Kills before 2001" provides the estimate of the coefficient on deaths resulting from terrorist attacks (α_d for $d = 0, 1, \ldots, 10$) and the column "Kills after 2001" includes the values of the overall effect after 2001 which is the sum of the estimate of the coefficient on deaths with the estimate on the interaction term (calculated as the sum of α_d and β_d for $d = 0, 1, \ldots, 10$). The respective p-values are provided in brackets.

Firstly, I shall discuss the coefficients on the amount of wounds. From the table, it can be seen that some of the lags are statistically significant. There may be various reasons for why those estimates, in contrast to the estimates on the coefficient of variables representing amount of attacks, produce statistically significant results. For example, this variable may better reflect the intimidating effects of terrorist acts and be therefore subsequently reflected in the GDP. Another reason could be that governments react to terrorist attacks on the basis of their reach and consider the amount of people injured to be a good metric for the quantification of this reach.

From the table it can be seen that for every wounded person, there is a statistically significant estimated increase in GDP growth by 0.000068 in the subsequent quarter. This may be due to the fact that governments react to those attacks which caused wounds by increased spending on safety-related measures. This may be subsequently positively reflected in the GDP growth. On the other hand, however, it can be seen that those wounds affect GDP growth negatively after the eighth and ninth quarter. This may be due to the fact that the resources spent on safety measures were not invested into other, potentially growth enhancing, factors.

Interestingly, the inclusion of the variable on the amount of wounded people and of the variable allowing us to differentiate between the effect before and after the 9/11 2001 attack affected the statistical significance of the lags on the amount of deaths resulting from terrorism. Although we usually regard the variables to be statistically significant when their p-value is 0.05 or lower, due to the fact that this boundary is arbitrarily given, it may be useful to examine even the variables with slightly higher p-value. It can be seen that in the period in which the actual attacks happen, the statistical significance of the coefficients has changed. Those are statistically significant at a level only a little bit higher than 5 % (unlike in the original estimation of Model 1). It can be seen that after the 2001, this effect is estimated to be negative, however, before the 2001 attack, the negative impact was even worse. This may be due to the fact that the sensitivity of people to those attacks generally decreased, which may be explained by the fact that since the 2001 attack, there has been no other attack with so significant amount of deaths. Hence, people may regard those smaller attacks as being generally less important or dangerous.

The estimate of the coefficient on second lag of the variable representing amount of deaths, which is statistically significant with p-value close to zero, indicates more positive effect for the period preceding the 9/11 attack. This may be due to the fact that in case of the attacks preceding 2001, governments spent more resources on the implementation of safety measures after the attack immediately, possibly without much elaboration. This could also be in line with the fact that the coefficient and overall effect of the (statistically significant) sixth lag is negative for the periods before 2001 but positive for the period after 2001. In other words, it is likely that in case of the before 2001 attack period, the negative long-term effects of the immediate investments into public safety occur. The positive effect in case of the periods after 2001 may be that it is the quarter in which usually the governments come with further measures which are supposed to prevent future attacks.

The estimate for periods before 2001 is positive in case of the seventh lag and negative in case of the eight lag. For the periods after 2001, it is vice versa. All those effects are statistically significant. These fluctuations may possibly be a consequence of economic instabilities which could be caused by terrorist attacks.

The findings are in line with the main conclusion of the majority of the findings described in chapter 2 (eg. Blomberg, Hess and Orphanides 2004 or Hamida, Lassoued and Hadhek 2018). However, unlike in Gaibulloev and Sandler 2008, it has been found that the pure occurrence of the act does not affect economic growth. However, the findings in this thesis do not contradict the statement that attack which has not caused deaths of any of the people it affected has an effect on economic growth. It has been found that the amount of wounded citizens resulting from terrorism still has some effect. Hence, the findings of Gaibulloev and Sandler 2008 are more general but essentially provide a slightly different evidence for similar conclusion.

9 Conclusion

In conclusion, it was found that the occurrence of the terrorist attacks itself does not have a statistically significant effect on economic growth. This, however, could be a consequence of the fact that the amount of terrorist attacks is not a good proxy to account for the intimidating effect of those acts and for their subsequent macroeconomic impact.

On the other hand, however, the amount of deaths resulting from terrorist acts was established to affect economic growth with lags. The results of the estimates of effect of those on the GDP growth rates and their respective lags are depicted in Figure 7. This figure treats statistically insignificant variables as having zero effect and, overall, displays how the deaths resulting from terrorism affect the economic growth rate immediately and over the next 10 quarters. It has been established that the effect is mostly negative in the initial quarters, then positive, presumably as a consequence of investments into safety measures and then negative again, which is likely to be due to the fact that the money invested into safety measures was not spent on other factors which may generally better enhance economic growth in the long-term.

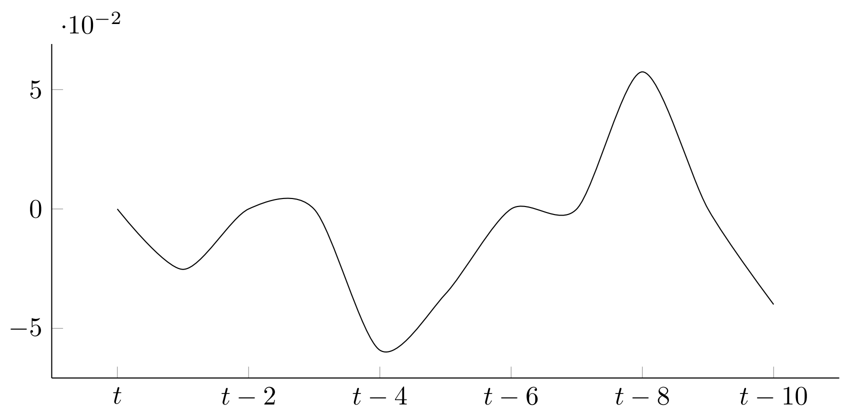

Figure 7: Estimates of the effect of the variable representing deaths resulting from terrorism and of its lags on GDP growth rate

After determining that the amount of attacks is not a good proxy for the intimidating effect of terrorism, variable on the amount of wounds was incorporated into the model. Furthermore, an interaction variable enabling the assessment of before and after 9/11 2001 effect of deaths resulting from terrorism was incorporated into the model as well.

Wounds have been found to have firstly positive effect on economic growth rate, which may indicate that those indeed represent the widespread fears resulting from terrorism as a consequence of which governments spend money on safety and further attack suppression measures. Again, however, this was negatively reflected in the economic growth rates in later quarters. Interestingly, by the inclusion of the new variables, the effects and statistical significance of terrorism-related deaths in regard to economic growth rates changed. Those are depicted in Figure 8. Overall, it was found that the immediate effects were more harming for the economic growth in the period preceding the 9/11 attack. Furthermore, the positive effects which are likely to represent implementation of safety measures, were more profound in case of this period. On the other hand, in case of the after 9/11 period, the most positive effect occurs in the sixth quarter after the attack, possibly indicating that government action is taken with more elaboration as a consequence of this phenomenon. The attack further causes general economic growth fluctuations, possibly since terrorist attacks lead to increased economic instabilities.

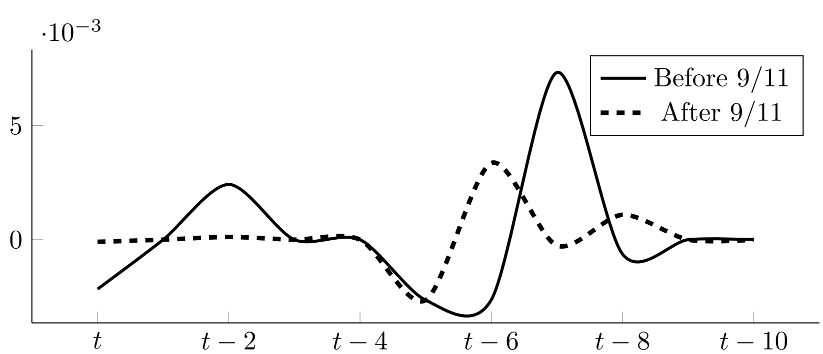

Figure 8: Estimates of the effect of terrorism-related deaths before and after 9/11 attack.

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Appendix

Solow-Swan Model Derivation

We begin by the investigation of supply and demand in relation to capital accumulation. First, let us assume fixed labour force and technology levels. The supply in the economy, represented by the production function, can generally be written as

$$Y = F(K, L).$$

where K stands for the capital stock and L for the labour force. We assume that, for any $a > 0$, the production function displays the following property

$$aY = F(aK, aL).$$

This property is also referred to as "constant returns to scale". Thanks to this property, we can examine the quantities in the economy relative to the labour force size. Setting $a = 1/L$, we get

$$\frac{Y}{L} = F\left(\frac{K}{L}, 1\right).$$

This indicates that the economy size does not affect the output and capital per worker. Hence, we can consider the quantities in per worker terms. We put $y = Y/L$ and $k = K/L$. The production function is then

$$y = f(k), \text{ with } f(k) = F(k, 1).$$

Now we turn to the demand. For the derivation of this model, we assume there is no international trade and disregard the government purchases. Therefore, we use the following national income equation which does not take into account net exports and government purchases

$$GDP = C + I.$$

and re-write it in per-worker terms ($c = C/L$ and $i = I/L$). Thus, we obtain

$$y = c + i. \tag{5}$$

Assuming people yearly save fraction s ($s \in [0, 1]$) of their income, they consume

$$c = (1 - s)y.$$

Plugging this into (5) and rearranging we get

$$i = sy = sf(k).$$

Now, let us introduce two variables ϕ and n; $\phi,\, n \in [0,\, 1]$, which denote the depreciation rate of capital and the growth rate in the number of workers, respectively. Therefore, the change in capital stock between two subsequent years can be written as

$$\Delta k = i - (\phi + n)k = sf(k) - (\phi + n)k.$$

At some level of capital, k^*, it holds that $\Delta k = 0$. This level is called steady-state and is regarded as the long-run equilibrium of the economy. This means that every economy ends up at this level in the long-run. Hence, amount of investment and population growth rate may affect the economic growth in the short run, however, in accordance with this theory, it does not cause the economic growth in the long-run.

Now we apply this outlined theory to a production function which takes the level of technological progress into account. To ensure generality and interconnection of the macroeconomic model with microeconomics, we use Cobb-Douglas production function

$$Y(t) = K^{\alpha}(t)\,(A(t)L(t))^{1-\alpha}, \qquad 0 < \alpha < 1,$$

in which $Y(t)$ stands for total production, $K(t)$ for the amount of capital, $A(t)$ for the level of technology, $L(t)$ for the amount of labour force and $A(t)L(t)$ for the effective amount of workers (this number grows at rate $(n+g)$, $n,\, g \in [0,\, 1]$). Furthermore, α denotes the elasticity of output with respect to capital. Unlike its simplified version, this functions accounts for the technological progress and its relationship with workers' production, assuming that this progress affects the overall production positively. We rearrange the equation (9) to represent output per effective worker

$$\begin{aligned} Y(t) &= K^{\alpha}(t)\,(A(t)L(t))^{1-\alpha}, \\ \frac{Y(t)}{A(t)L(t)} &= \left(\frac{K(t)}{A(t)L(t)}\right)^{\alpha}. \end{aligned}$$

Now, we put

$$y(t) = \frac{Y(t)}{A(t)L(t)}, \qquad k(t) = \frac{K(t)}{A(t)L(t)}.$$

Hence, we have

$$y(t) = k^{\alpha}(t). \tag{6}$$

Now, we assume that the change in capital stock can be described by the following equation

$$\Delta k = sk^{\alpha}(t) - (\phi + n + g)k(t).$$

Furthermore, we assume that the economy has reached a long run steady-state level of capital, k^* (the value of which is obtained by putting $\Delta k = 0$)

$$k^* = \left(\frac{s}{n+g+\phi}\right)^{\frac{1}{1-\alpha}}.$$

Plugging this into (6) and adjusting

$$\begin{aligned} y(t) &= \left(\frac{s}{n+g+\phi}\right)^{\frac{\alpha}{1-\alpha}}, \\ \frac{Y(t)}{A(t)L(t)} &= \left(\frac{s}{n+g+\phi}\right)^{\frac{\alpha}{1-\alpha}}, \\ \frac{Y(t)}{L(t)} &= A(t)\left(\frac{s}{n+g+\phi}\right)^{\frac{\alpha}{1-\alpha}}. \end{aligned}$$

Putting $h(t) = \frac{Y(t)}{L(t)}$, the output per worker can be written as

$$h(t) = A(t)\left(\frac{s}{n+g+\phi}\right)^{\frac{\alpha}{1-\alpha}}.$$

Model 2 Estimation Results

Variable	Coefficient	Standard Error	p-value
$Kills$	−0.000118	0.00008	0.13965
$Kills_{t-1}$	−0.000128	0.000038	0.000813
$Kills_{t-2}$	0.000067	0.000068	0.328148
$Kills_{t-3}$	−0.000134	0.000066	0.041203
$Kills_{t-4}$	−0.000104	0.000052	0.043224
$Kills_{t-5}$	−0.000206	0.00006	0.000594
$Kills_{t-6}$	−0.000019	0.000077	0.801364
$Kills_{t-7}$	0.00017	0.000122	0.163685
$Kills_{t-8}$	0.000325	0.000028	$< 10^{-16}$
$Kills_{t-9}$	0.000014	0.000068	0.838479
$Kills_{t-10}$	−0.000194	0.000086	0.024354
$Attacks$	0.001271	0.001778	0.474761
$Attacks_{t-1}$	0.004364	0.002506	0.081779
$Attacks_{t-2}$	−0.003163	0.00177	0.074035
$Attacks_{t-3}$	−0.000198	0.001586	0.900745
$Attacks_{t-4}$	−0.001106	0.002019	0.583659
$Attacks_{t-5}$	−0.000886	0.001662	0.594015
$Attacks_{t-6}$	0.000272	0.002074	0.895826
$Attacks_{t-7}$	−0.001932	0.003272	0.554917
$Attacks_{t-8}$	0.002036	0.002246	0.364709
$Attacks_{t-9}$	−0.00139	0.001208	0.249667
$Attacks_{t-10}$	0.001457	0.002995	0.62664
$Inflation$	−0.036599	0.01668	0.02831
$Unemployment$	−0.011053	0.012999	0.395234
$Population$	−0.317923	0.406391	0.434105
$Investment$	−0.118913	0.035496	0.00082
$Technology$	−2.877869	2.698976	0.286395
$Technology_{t-1}$	3.255323	2.372503	0.170149
$Technology_{t-2}$	−2.849473	1.568822	0.069437
$Technology_{t-3}$	1.181942	1.103611	0.284279
$Technology_{t-4}$	−1.08952	0.924151	0.238529
$Technology_{t-5}$	0.343822	1.195335	0.773648
$Technology_{t-6}$	3.420355	1.308774	0.009016
$Technology_{t-7}$	−2.677282	1.36498	0.049938
$Technology_{t-8}$	2.774185	2.200905	0.207611
$Technology_{t-9}$	−4.58965	2.708575	0.090292
$Technology_{t-10}$	2.650574	1.761818	0.132586
R^2: 0.27			

Table 3: Estimation results − Model 2

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