Did the 1918 Influenza Pandemic Affect International Trade?

Emma Axelsson & Madeleine Lindblad
Department of Economics

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Supervisor: Maria Persson

Abstract

The aim of this study is to contribute to the existing literature by investigating what to our knowledge is a previously unexplored area, namely if the 1918 Influenza Pandemic - the Spanish flu - had an effect on global trade. The Spanish flu is estimated to have killed 17-100 million people between 1918-1920 (CDC NCIRD, 2018; Roser, 2020). However, the macroeconomic impact of one of the deadliest pandemics in modern history is scarce. In order to capture how severe the flu was across countries we measure how the intensity of the flu, in terms of change in life expectancy as well as mortality rates, varied internationally between 1918 - 1920. These indices are then applied in two differently compiled datasets. The empirical analysis is carried out using the gravity model. Based on our results no apparent conclusion can be drawn about the effects on international trade caused by the Spanish flu.

Keywords: Spanish Influenza, Trade, Fixed effects, Gravity Model, Life expectancy, Mortality, Pandemics, Poisson

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Abbreviations

COVID-19: Coronavirus Disease 2019

IV: Instrumental Variable

OLS: Ordinary Least Squares

Spanish flu: 1918 Influenza Pandemic

WWI: World War I

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1. Introduction

The outbreak of the coronavirus disease 2019 (COVID-19) has sparked urgent interest about the impact of viral diseases. The COVID-19 pandemic is one of the most serious global health crises since 1918 and is set to become the most economically costly (Boissay & Rungcharoenkitkul, 2020). However, it is not the first time in modern history that a virus disease is depressing our world. There have been several epidemics and pandemics such as the Asian flu, SARS, Ebola and COVID-19. However, the death toll from these diseases combined is not even close to the one caused by the Spanish flu outbreak.

The 1918 influenza pandemic, commonly known as the Spanish flu, is estimated to have killed between 17 – 100 million people during 1918 – 1920 (CDC NCIRD, 2018; Roser, 2020). From an economic point of view, Barro et al. (2020) states that the macroeconomic shock generated by the Spanish flu was the fourth most severe world economic crisis in modern history. Despite this, research concerning the economic impact of the Spanish flu is scarce and seems to have landed in the shadow of other historical disasters, such as World War I (WWI) and the Great Depression (Barro & Ursúa, 2008; Garrett, 2007).[1] As Garrett (2007) argues, the economic consequences of such a deadly disaster as the Spanish flu should be closely examined, not just for its historical significance, but also for valuable knowledge for future pandemics.

The aim of this essay is therefore to investigate the following question: *Did the 1918 influenza pandemic affect trade?* To our knowledge, there is little previous literature of macroeconomic effects that tangents the case of the Spanish flu, especially on a global level. Hence, this paper seems to be the first to specifically examine international trade effects of the Spanish flu.

It is frequently stated that it is a challenge to capture the severity of the Spanish flu, due to limitations in morbidity and mortality quantifications (Arnold & Monto, 1987). Therefore, this essay will measure how the intensity of the flu varied across countries during 1918 – 1920 in two ways: by estimates of excess mortality data and by the change in life expectancy. These indices

[1] Barro & Ursúa (2008) states that the principal world economic crises ranked by importance are World War II, World War I and the Great Depression.

are then combined with standard gravity variables and analyzed through the workhorse gravity model.

Our intention is to contribute to existing literature of the Spanish flu in two ways. First, we examine an alternative way of how the severity of a pandemic can be measured by using data over life expectancy. Secondly, we present a new take on the economic consequences of the Spanish flu. Based on our finding, no apparent conclusion can be drawn about the effects on international trade caused by the Spanish flu.

The paper will be organized as follows: in the coming chapter, the Spanish flu and trade patterns in the time period of interest will be examined. Thereafter, theoretical considerations of how a pandemic can affect trade will be examined. In the fourth section, previous literature on similar topics will be presented. A chapter of how this study will measure the severity of the pandemic using excess mortality and life expectancy data, will be introduced and discussed in the fifth section. Empirical strategy, including regressions specifications and estimation issues, will be provided in chapter six and following, the data will be presented in section seven. Regression results are presented and briefly discussed in chapter eight and lastly this paper is summarized, and conclusions are outlined in chapter nine.

2. Background

2.1. The Spanish Flu Outbreak

In 1918 a new disease called the Spanish flu started to spread across the globe. The Spanish flu was a deadly influenza caused by an H1N1 virus and is believed to have originated from avian genes (CDC NCIRD, 2019).[2] The disease eventually became a pandemic, meaning that the illness spread over a wide geographic area and affected a vastly high proportion of the world population (WHO, 2010). War and diseases have been linked throughout history and WWI is thought to have fostered the pandemic. Unfairly the influenza outbreak was named “the Spanish flu” solely because Spain was neutral in WWI and hence the first to report on the severity of the disease

[2] In 2009 a milder form of the same virus caused the Swine flu pandemic (WHO, 2010).

(Roser, 2020). Researchers have not yet been able to pinpoint the pandemic's exact origin, however, Byerly (2010) and Olson et al. (2005) suggests that the influenza originated in the U.S. and spread as hundreds of thousands American soldiers crossed the Atlantic in May 1918.

The flu has been estimated to have infected one third of the population in 1918, resulting in between 17 to 100 million deaths (CDC NCIRD, 2018).[3] The exact mortality rate as a consequence of the pandemic has been difficult to establish due to the fact that countries participating in WWI censored their media (Roser, 2020). The difficulty in uncovering accurate figures of the pandemic is also due to contemporary limitations in technology and communication (O'Neill, 2020). However, researchers have been able to conclude that the Spanish flu killed more people than WWI (Kettle, 2018).

The flu occurred during three episodes between 1918 to 1920 and spread from the northern hemisphere to eventually all remaining parts of the world (Martini et al., 2019). In the first wave, which took place in the spring of 1918, the illness was seen as a relatively mild flu-like disease. The second wave, occurring in August 1918, was however the deadliest of the three outbreaks, where the overwhelming cause of death was bacterial pneumonia secondary to the influenza (Martini et al., 2019). This was due to the aggressiveness of the Spanish flu, where the virus did not only attack the bronchus, but also the lungs (Morens & Fauci, 2007). The final wave surfaced during the winter 1919 where fewer people got infected, however is believed to have had the same mortality rate as the second wave (Taubenberger & Morens, 2006). It is unknown which exact feature of the virus that caused the disease to reoccur twice after the first outbreak, however a large share of the world population was indigent, undernourished and lacked basic sanitation, contributing to the spread of the influenza. In addition, many countries were weakened by WWI, antibiotics were not yet invented in 1918 and compared to today, health systems and living conditions were poor (Radusin, 2012; Roser, 2020).

A unique characteristic of the pandemic was that - unlike when regular strains of influenza circulate the world - the majority of the Spanish flu victims were young and healthy people (Radusin, 2012). The reason why there were so many deaths among the younger population is

[3] However, most literature estimate the mortality rate to be around 50 million.

unknown, however one theory is that a robust immunological response to the virus in younger individuals resulted in enhanced tissue damage (Morens & Fauci, 2007). Compared to other influenza viruses, the Spanish flu pandemic thus generated a W-shaped mortality age profile, where the local maximum in mortality is observed over the age interval 15 – 40 (Noymer & Garenne, 2000). Normally, an influenza exhibits a U-shape in the mortality distribution over age groups, where it is most common that the very young and very old are hit the hardest. The difference is visible in *Figure 1*. This mortality pattern naturally resulted in a labour supply shock (Karlsson et al. 2014).

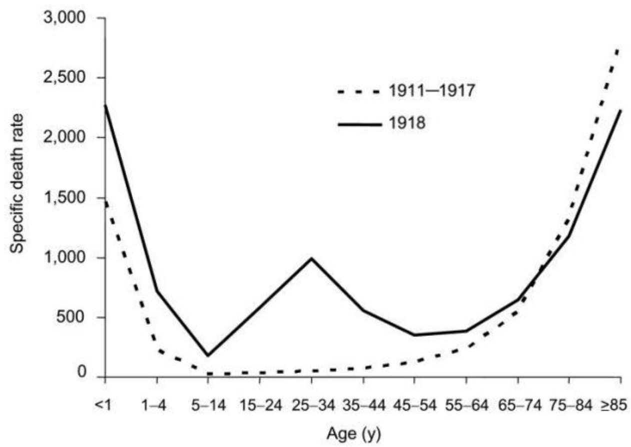

Figure 1. The mortality age-distributions of the 1918 influenza epidemic compared to normal influenza- and pneumonia-specific death rates between 1911-1917.[4] (*Source:* Taubenberger & Morens, 2006)

Further from an economic point of view, evidence implies that some areas which were severely affected by the Spanish flu, faced a sharp decline in real economic activity. In addition, a negative correlation between the 1918 flu mortality and the growth in manufacturing employment has also been found which indicate that higher mortality during the 1918 flu is associated with lower economic growth (Correia et al. 2020). Moreover, the effects of the Spanish flu on trade and the economy as a whole are unclear which to some extent might be due to the scarcity of economic data. Some argue that despite its severity the influenza pandemic was short-lived and hence many

4 Combined influenza and pneumonia mortality in the United States, by age at death, per 100 000 persons in each age group.

societies recovered quickly (Garrett, 2007). Other studies emphasize that the negative effect on the economy was substantial (Correia et al, 2020; Barro et al. 2020; Karlsson et al. 2014).

2.2 Trade Patterns in the Early 1900s

From the middle of the 1800s until the outbreak of WWI the so-called *first wave of globalization* took place (Jacks et al., 2008; Ortiz-Ospina & Beltekian, 2014). This was a period triggered by the industrial revolution and characterized by the expansion of trade, capital and technology flows (WTO, 2013). During this time transportation costs plummeted, information flows accelerated, tariffs fell, empires expanded, and economic and political stability was largely the norm (Meissner, 2015). In 1913 the share of trade in GDP reached its top and was not surpassed since after the two world wars (WTO, 2013).

Breakthroughs in transport technologies were especially important in order to open up national economies to international trade and thereby "shrinking" the world economy. According to Jacks et. al. (2008) trade costs decline explains roughly 55 percent of pre-WWI trade boom, where trade costs can broadly be defined as the resource costs of shipping and trading commodities across international borders (Meissner, 2015). This fall in trade costs can in turn be attributed to declining freight rates and tariffs as well as increasing adherence to the gold standard (Jacks et al., 2008). A significant fraction of the growth in trade was also due to the export of new goods and the opening up of new markets (Meissner, 2015). However, this expansion of international trade and industrialization spread unevenly and the economic gap between a raw-material supplying south and fast-industrializing north was wide (WTO, 2013).

WWI marked the end of an era and international trade was massively disrupted (Ortiz-Ospina & Beltekian, 2014). The gold standard collapsed, and economic controls and restrictions increased (WTO, 2013). The war accounted for about 16 million deaths and destroyed a large amount of physical capital (Gowa & Hicks, 2017). Comparing actual trade with a "no war" scenario where trade levels are assumed to be persistent at their 1913 benchmark, total trade fell by approximately 30 percent during each of the five wartime years.[5] The negative effect on global trade from WWI

[5] Comparing predicted aggregate wartime trade to counterfactual peacetime level in 1913. Glick & Taylor (2010) studied the effects of war on bilateral trade flows using the Gravity model and found large and persistent impacts of wars on trade.

has also been found to be persistent some years after its end (Glick & Taylor, 2010).[6] For the countries involved in the war, trade patterns shifted when trade between belligerents decreased while trade between countries of the same coalition increased (Glick & Taylor, 2010; Gowa & Hicks, 2017).[7] As a consequence of the war many country borders were also redrawn.

After WWI ended, in November 1918, recovery was slow partially due to lack of global economic leadership and cooperation. In October 1929 the economy plunged into the Great Depression and the value of international trade declined sharply (WTO, 2013).

3. How a Pandemic Affects Trade: Theoretical Considerations

For this study it is important to understand how a pandemic can affect global trade. The effect can be divided into three channels; i) an effect on supply ii) a rise in trade costs; iii) an effect on demand; (Bekkers et al., 2020). Further, we will separately describe these effects of a pandemic/epidemic in general and discuss their relevance for the Spanish flu.

i) *A supply effect* can be caused by trade linkages that breaks down and interrupts the flow of intermediate inputs in production (Jonung & Werner, 2006). Moreover, supply is also affected by a general reduction in labour supply. This partially occurs due to the fear of being exposed to the epidemic, which may prevent healthy people from going to work (Jonung & Werner, 2006). Labor supply is also reduced due to those that cannot work because they are sick,[8] ultimately there is also a share that actually dies from the epidemic and hence reduces the labour supply (Bekkers et al., 2020). The loss of workforce was particularly prominent in the Spanish flu due to the high mortality in the prime working ages (Boissay & Rungcharoenkitkul, 2020).

6 Glick and Taylor (2010) estimated the effects of WWI on trade to be persistent for four years after the end of the war. Quareshi (2013) found that regional conflicts, in general, also have a spillover effect on neighboring states and that this is persistent for 3-5 years. In contrast Oneal et al. (2003) finds that conflicts normally affect trade for one or two years after its end.

7 Glick and Taylor (2010) found that trade between belligerents decreased by 96% and trade between belligerents and neutrals decreased by 42%. Gowa & Hicks (2017) found that trade between Entente members increased by 40% and between Central Powers by 76%. Hence, Gowa & Hicks (2017) highlights that the wartime years led to a rerouting in trade, rather than a total breakdown in trade.

8 Or have someone in their household that is sick.

ii) *A rise in trade costs* can be explained by increased border controls and restrictions on personal travel. Trade costs *inter alia* include transportation costs, policy barriers, and legal and regulatory costs (Anderson & Wincoop, 2004). In modern times, travel restrictions have been imposed due to the COVID-19, which have had effects on transportations costs. This has amongst other things caused the price of air cargo to increase (Bekkers et al., 2020). Two studies, Jacks et al. (2008) and Estevadeordal et al. (2003), examined global trade since the 1870s and explained much of the "trade busts" through the rise in trade costs in the interwar period, however neither of the studies mentions the Spanish flu. Estevadeordal et al. (2003) mainly explains the increase in trade costs after WWI by increased protectionism. Hence the possible effect on trade costs due to the Spanish flu and no other factors might be especially difficult to distinguish.

iii) *A demand effect* due to an epidemic can arise because people are afraid of catching the virus when purchasing consumption goods. The reduction in labour supply is also likely to cause the households to lose income. Thus, people reduce their consumption and henceforth causes a demand effect (Eichenbaum et al., 2020). A fear of being exposed to an epidemic also has a negative effect on all types of transport, community, social and personal services (Jonung & Werner, 2006). In addition, a worry that financial markets will be negatively affected can increase the negative effect on demand. This psychological effect was evident during the SARS epidemic which only had a small effect on supply but strongly affected consumption (Jonung & Werner, 2006).

Both demand and supply effects are substantially worse in sectors most affected by containment measures (Jonung & Werner, 2006). In similarity with COVID-19, social distancing measures were introduced during the Spanish influenza pandemic. These interventions varied considerably and there were no synchronized stops in economic activity (Boissay & Rungcharoenkitkul, 2020). The supply effect together with the demand effect due to a pandemic, is believed to cause a persistent economic downturn (Eichenbaum et al., 2020).

4. Previous Research

To the best of our knowledge, there is no previous study that has investigated if international trade was affected by the Spanish flu. This goes in line with McKibbin (2004) and CBO (2005) who highlight that the effects of pandemics generally seem to have been under-researched within economics. This section will therefore more widely investigate, not just trade, but previous research concerning the general macroeconomic consequences of pandemics.

4.1. Macroeconomic Effects of the Spanish Flu

A study which estimates the mortality and economic contraction from the Spanish flu in order to derive a plausible upper bound for the economic outcomes of COVID-19 is Barro et al. (2020). Among other things, the author uses annual estimates for 48 countries of flu-related deaths between 1918-1920. These countries combined constituted 92 percent of the estimated world population in 1918. In order to account for WWI, the ratio of military combat death to total population is also estimated for countries in the data set which were involved in the war. Several panel least squares regressions are carried out where the explanatory variables are the flu and war death rates, which are treated as exogenous shocks, while the other explanatory variables are constants. The results imply that, for a “typical country”, the Spanish flu reduced real per capita GDP by 6,2 percent. This can be compared with WWI which is estimated to have reduced real per capita GDP by 8,4 percent (Barro et al. (2020).

Another study which uses the Spanish influenza in order to make projections for a pandemic is James & Sargent (2006).[9] Among other things, monthly data on retail sales from NBER as well as detailed data over rail passenger and subway traffic in New York are used in order to study the demand effects of the 1918 pandemic in the U.S. The authors motivate that monthly data is a necessity since half of the deaths caused by the pandemic in the U.S occurred in October 1918. Further their results show that the effects on exports were stable while the effects on the imports declined modestly during the peak pandemic month. Hence, James & Sargent (2006) conclude that the impact of the 1918 pandemic on sensitive sectors was ranging between indiscernible and modest, and thus dismiss prior claims that the pandemic would have “disrupted trade flows”.

[9] This study covered pandemics which occurred in 1918, 1957 and 1968, in order to make a projection of the economic consequences of a future pandemic.

Frequently cited Brainerd & Siegler (2003) and Correia et al. (2020) are two studies which also have examined the economic effects of the Spanish influenza in the U.S. Both investigate the effect on economic growth, but their results differ. Brainerd & Siegler (2003) use a sample of U.S. states between 1919-1930 and run several regressions, controlling for differences between states.[10] The authors find evidence that the Spanish flu actually had a large and robust positive effect on economic growth in the U.S.[11] The authors highlight that this might sound counterintuitive but some of the growth from 1919-1921 to 1930 is not a change in trend, but a return to trend after this large temporary shock.[12] In contrast to this, Correia et al. (2020) found that areas which were more severely affected by the Spanish flu outbreak were exposed to a sharp and persistent decline in real economic activity. In addition, the authors conclude that the economic downturn was driven by both supply and demand-side channels, where the pandemic is estimated to have reduced manufacturing output in the U.S. by 18 percent (Correia et al., 2020). Nevertheless, Correia et al. (2020) emphasize the empirical difficulty to analyze their results, since areas with higher exposure to the pandemic may simultaneously be more exposed to other economic shocks.

A paper which also discusses the national economic consequences of the influenza pandemic, but in the case of Sweden, is Karlsson et al. (2014). In order to estimate the economic effects of the substantial health shock, Karlsson et al. (2014) use an extension of the standard difference-in-differences estimator to exploit the differing mortality rates across Swedish regions. The authors treat the influenza outbreak as a large labour supply shock and, among other things, find that the pandemic led to an increase in poverty rates and that capital returns were negatively affected. Furthermore, the authors claim that it is possible to gain additional insights if the consequences of Spanish flu are studied in a trade theory framework. Thus, Karlsson et al. (2014) plot total Swedish exports alongside key trading partners during 1910-1930. Moreover, the authors motivate that Sweden is an especially suitable country to focus on regarding the economic impacts of the Spanish

10 Such as differences in urbanization, levels of income per capita, climate, populations density, geography, human capital accumulation, the sectoral composition of output and the legacy of slavery.

11 One more death per thousand resulted in an average annual increase in the rate of growth of real per capita income, over the next ten years, of at least 0.15 percent per year.

12 One reason for the positive association between flu deaths and economic growth is that the epidemic caused substantial business failures which caused the economy to go below its trend between 1919 and 1921.

flu since Sweden did not participate in WWI. Hence, the risk of confounding effects of the pandemic with disturbances related to the war is reduced.

4.2 Macroeconomic Effects of Other Pandemics and Epidemics

In the current climate of the COVID-19 pandemic, the economic effects of a disease outbreak have become more essential to study and even if pandemics generally may be considered an under-researched topic there is a great amount of recent literature.[13] The United Nations Conference on Trade and Development (UNCTAD, 2020) published a report in spring 2020 regarding the economic consequences of COVID-19. The report highlights that China's Manufacturing Purchasing Managers Index (PMI) fell approximately 22 points in February 2020. The PMI is highly correlated with exports and a decline in the index thus implies a reduction in export of circa two percent on an annualized basis. Moreover, the report illustrates how other economies are impacted by China's reduction of exports in intermediate inputs. It can for example be observed that in the sectors machinery, automotive and chemicals, the European Union has lost circa 9000 US$ millions due to the two percent decline (UNCTAD, 2020).

Jonung & Roeger (2006) estimate the cost of a hypothetical pandemic or epidemic outbreak. The authors approximate the likely macroeconomic effects of a pandemic using a quarterly macro-model as a response to the H5NI bird flu virus spread. Jonung & Roeger (2006) focus on the impact on sectors that are expected to be most severely hit, tourism and trade, in the EU and conclude that a pandemic is not likely to cause major trade problems for the EU State Members. Furthermore, the authors argue that under a scenario such as that of the Spanish flu, the macroeconomic cost in Europe would be high, however not equivalent with an economic disaster. In line with Jonung & Roeger (2006), Bloom et al., (2005) estimated the short-run potential economic consequences of the Avian flu pandemic in 2005. By analyzing previous flu outbreaks of SARS, using the Oxford Economic Forecasting model, the authors were able to incorporate how the demand and supply side adjust after a health shock.

13 Due to the actuality of COVID-19, the interest and demand of information regarding the pandemic has highly increased. As a consequence, many papers have not yet been peer reviewed according to the normal formalities. Therefore, published papers from 2020, should be read with carefulness.

In summary, previous literature does not give a clear picture of the general effects of pandemics or how the topic should be examined. However, for the case of the Spanish flu most agree that its economic impact was extensive. Limited previous research of the economic consequences of the Spanish flu can in some extent be attributed to data limitation. Further, when looking at studies of other pandemics, none of the previous literature has focused exclusively on the impacts on international trade (e.g McKibbin, 2004; Obukohwo, 2016). Hence, studies of pandemics which use the gravity model as a main model framework have not been found. Also, when looking at macroeconomic consequences of a pandemic in general there is not a model which seems to be favored over another.

5. How to Measure the Severity of the Spanish Flu

Since this essay examines how the Spanish flu pandemic affected trade, one must estimate how severe the pandemic was across countries. However, despite the recognition of influenza activity, it is still difficult to quantify the total influenza-related mortality and morbidity (Arnold & Monto, 1987). Morbidity rate data is found to be especially hard to affirm. Thus, excess mortality rate data as well as life expectancy data will be used as proxies for the intensity of the Spanish flu.

5.1. Excess Mortality

In order to provide estimates of the mortality rates associated with a flu, excess deaths are usually calculated and attributed to the ongoing influenza (Arnold & Monto, 1987). Henceforth, the excess mortality might also capture mortality caused by other events at the time. However, when it comes to the Spanish flu, Barro et al. (2020) points out that statistics for countries that reported yearly estimates of death rates from the influenza and pneumonia as well as all-cause excess mortality between 1918-1920, were much alike.

Furthermore, important to note is that data on excess mortality does not reflect the number of infected individuals across countries since both the risk of infection and the mortality rate given infection varied due to social factors (Quinn & Kumar, 2014). This is supported by the fact that a negative inverse relationship between the Spanish flu and prior level of GDP have been found and is likely to be reflected in a country's health care (Barro et al. 2020). This is also evident since death rates during the Spanish flu differed between high-and low-income countries, where for example the mortality rate was 20 times higher in some South American countries than in Europe (Mamelund, 2017).

Mortality rates due to the Spanish flu, have been estimated on a local, national and regional level, however only a few studies have compiled mortality rates on a global level (e.g Patterson & Pyle, 1991: Johnson & Mueller, 2002).[14] By combining multiple sources of data, the two comprehensive studies have gathered the number of deaths for both countries and continents. Though, the numerous used sources of the data entail that the numbers compiled are derived differently and hence the available data differs in both coverage and reliability (Johnson & Mueller, 2002).[15] Therefore, these figures can neither be considered complete nor fully comparable on a country level basis.

However, Barro et al. (2020) gather and use data on excess mortality rates from 48 countries which is partially based on the study by Johnson & Mueller (2002),[16] but also from more recent studies which enables comparisons between countries. The figures composed by Barro et al., (2020) represents excess mortality rates from the Spanish flu. In addition, the researchers have collected estimates of excess mortality caused by the WWI for the same set of countries. This enables one to control for death rates due to the war, which is useful since for some countries both WWI and the Spanish flu were prominent in 1918. Hence, we consider the estimates on excess mortality composed by Barro et al. (2020) to be relevant to use in order to approximate the severity of the flu.

5.2 Life Expectancy

Life expectancy is based on excess mortality rates and measures the average number of years a newborn would live if the pattern of mortality in the given year were to stay the same.[17] Life expectancy as a measurement has come to be of interest for this study due to its extensive coverage, with data over 100 countries compiled by Gapminder (2014). In addition, the Spanish flu outbreak

14 Johnson & Mueller (2002) published an updated upward revision of the figures originally compiled by Patterson & Pyle (1991), since recorded statistics of influenza mortality are likely to be a significant understatement.
15 Methods used include revisiting official records and recompiling the recorded numbers, calculating "excess" deaths from recorded mortality for influenza, respiratory causes or all causes (Johnson & Mueller, 2002)
16 Sources include Murray, et al. (2006) who used all vital registration data available worldwide from 1915 to 1923.
17 The full name of the measurement is *period life expectancy at birth.*

in 1918 marked the most striking global sudden decline in life expectancy (Roser, 2020).[18] An example of how this drop occurred across the globe is shown in *Figure 2*. To our knowledge, this measure has not previously been used to estimate the severity of a pandemic across countries.

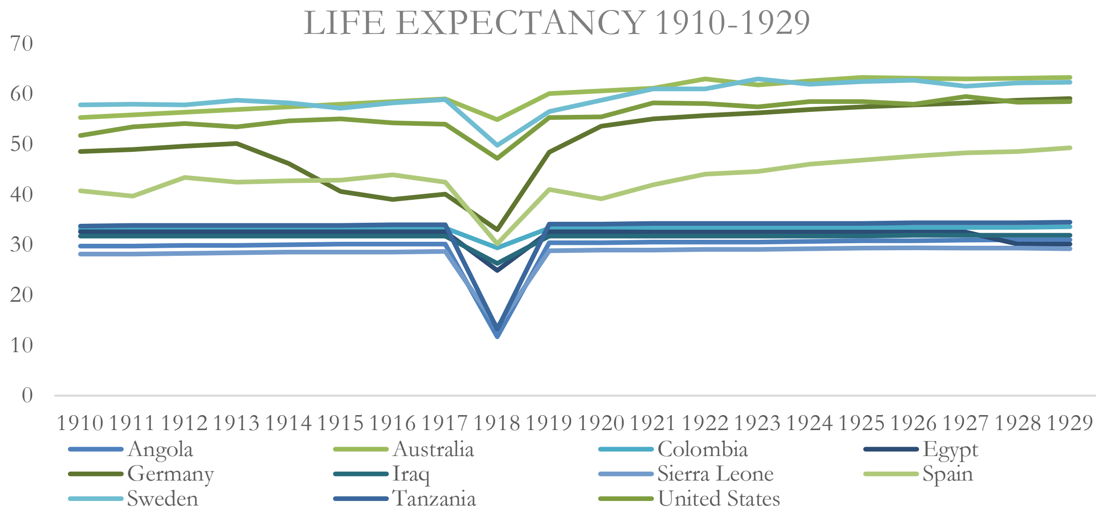

Figure 2. Life expectancy 1910-1929 for eleven arbitrarily chosen countries (*Source: Personal Collection)*

Life expectancy differs significantly by geographic location, ethnicity, sex, age, etcetera, and is therefore a commonly used measurement for specific categories (Bezy, 2013). Due to the fact that the Spanish flu was particularly critical for the younger part of the population and differed in severity across the globe, life expectancy as an indicator for how grave a country was affected by the pandemic can be considered a relevant factor. In addition, in May 2020 University of Bocconi (2020) recognized a paper by Ghislandi et al. (2020) which considered the decline in life expectancy to be the most reliable measure of the human cost of the COVID-19 epidemic. Focusing on the five most severely hit provinces in Italy, the authors conclude that these have experienced the largest decline in life expectancy since the 1918 influenza pandemic (Ghislandi et al., 2020).[19]

Nevertheless, the use of life expectancy as measurement is not unproblematic. In addition to assumptions and challenges that have already been brought up about excess mortality estimates,

18 An overview of life expectancy for several countries can be found in Appendix B.
19 The authors used death registration for Italian provinces in order to calculate excess mortality in 2020 and then estimate life expectancy for the year 2020.

the life expectancy measure also adds some uncertainty about interpretation and reliability. First of all, the interpretation of a change in life expectancy is complex since it is limited by the human lifespan. Thus, future possible changes in life expectancy depends on the already achieved level of life expectancy (Arriaga, 1984). Secondly, the data on life expectancy is compiled by Gapminder which is a Swedish data source that is more consistent over time than many other sources. However, this comes with the cost of higher uncertainty of the data quality since estimates are used more frequently than in other data sources. Therefore, Gapminder states that their data may not be appropriate for statistical inference (Johansson & Lindgren, 2014). Thus, much of the data during the time period of interest comes with a degree of uncertainty. One of the main difficulties when studying past outbreaks is that the data may be inconsistent and of questionable validity, accuracy and robustness (Johnson & Mueller, 2002). However, we believe that it is better to use the information available and recognize its limitations. For this reason, the life expectancy measure will only be used to classify whether changes in life expectancy during 1918 – 1920 were small or large.

Box 1. Gapminder's Compilation of Life Expectancy

The compilation and estimation of life expectancy

Life expectancy data from Gapminder (2014) consists of a number of different sources. Where data is missing, either estimations or so called "guesstimations" (informed guesses) are constructed by Gapminder. Guesstimations are used when life expectancy differs from the "normal" life expectancy, i.e for disasters such as the Spanish flu (Johansson & Lindgren, 2014). This means that the scraps of information available for a specific disaster, both from qualitative and quantitative sources, are used to estimate how much life expectancy dropped (Lindgren,2014b). The influenza pandemic in 1918 is treated as a special disaster category for which guesstimates are calculated.

To calculate life expectancy Lindgren (2014a) emphasizes that the relationship between crude death rate (CDR) (i.e number of dead per year per 1000 people) and life expectancy is of crucial importance. This depends on factors such as the age distribution of the population and of the dead. For the calculations of life expectancy during the period of the Spanish influenza outbreak, the model average life expectancy was estimated by Lindgren (2014a) using the following formula:

$$\text{Life expectancy}_{\text{model}} = \text{Life expectancy}_{\text{baseline}} * \exp\left(-\beta * CDR_{excess\ per\ year}\right)$$

Where Life expetancy$_{\text{baseline}}$ is the existing Gapminder figure for the year before the incident. $CDR_{excess\ per\ year}$ has been collected by Gapminder using available data on excess mortality[1], and where this data was not available extrapolation from regional or neighbor averages was used. The *beta* in the model describes the relationship between CDR and log life expectancy. Its value is based on quantitative information from countries where both data over life expectancy and excess CDR from the Spanish flu was available (Lindgren, 2014a).

In summary, to capture the severity of the flu across countries we use two measurements: the change in life expectancy and excess mortality rates. The life expectancy measure enables us to include an extensive number of countries, but the measure has not been used before in this context. The excess mortality estimate enables us to use more detailed information and to separately control for WWI, but is however less covering

6. Empirical strategy

In this thesis, the gravity model, which is considered the workhorse in international trade theory, is used for our empirical analysis and is carried out for the importer side and exporter side separately. We believe that the Spanish flu, captured by a decline in life expectancy and an increase in mortality rate, generated a negative effect on trade.

6.1 Model Specification

The gravity equation was first elaborated by Tinbergen (1962). The researcher describes how the size of bilateral trade flows between two countries is related to proximity, GDP, and other factors that affect trade barriers. Due to the equation's stability, it has been viewed as empirically successful within economics. However, it was for a period of time considered to lack theoretical foundation (Anderson & Wincoop, 2003). Thus, Anderson & Wincoop (2003) presented the idea of "Multilateral Trade-Resistance" (MTR), i.e. relative trade costs. This meant that countries would have different propensities to trade with one another based on their location (Bacchetta et al., 2012). Typical MTR terms used in the gravity model are for example common language and common border.

When estimating gravity equations, one usually takes the natural logarithm of all variables since the model has a multiplicative nature. Subsequently, one attains a log-linear equation, which can be estimated by using an ordinary least square (OLS) regression (Bacchetta et al., 2012). Furthermore, the dataset of the model is usually composed as a panel,[20] which might contain time invariant factors which are unobserved. To control for these unobserved features, fixed effects can

[20] In order to use panel data, the zero conditional mean assumption must hold. It claims that the conditional distribution of the error term *u* given the explanatory variable *x* has a zero mean (Angrist & Pischke, 2009).

be added.[21] Unique for the gravity equation in this paper, is that we add a so-called "flu variable". The coefficient of this variable will reflect the impact that the Spanish flu had on trade.

In the empirical analysis, we study bilateral trade flows separately for exports and imports. The following model is specified[22]:

$$\textit{Exporters:}\; ln\, X_{ijt} = b_0 + b_1 ln\, GDP_{it} + b_2 ln\, GDP_{jt} + b_3 ln\, Dist_{ij} + b_4 ln\, Pop_{it} + b_5 ln\, Pop_{jt} \quad (1)$$
$$+ b_6 Comlang_{ij} + b_7 Colonialrel_{ijt} + b_8 Combord_{ij} + b_9 Flu_{it} + \tau_i + \gamma_{jt} + \varepsilon_{ijt}$$

$$\textit{Importers}:\; ln\, X_{ijt} = b_0 + b_1 ln\, GDP_{it} + b_2 ln\, GDP_{jt} + b_3 ln\, Dist_{ij} + b_4 ln\, Pop_{it} + b_5 ln\, Pop_{jt} \quad (2)$$
$$+ b_6 Comlang_{ij} + b_7 Colonialrel_{ijt} + b_8 Combord_{ij} + b_9 Flu_{jt} + \varphi_j + \theta_{it} + \varepsilon_{ijt}$$

The gravity equation aims to illustrate how bilateral trade flows, X_{ijt}, from a6n exporter-country *i* to an importer-country *j* for a given year *t* is a function of countries' economical size, GDP, as well as the distance, $Dist_{ij}$, between them. Countries' economical size is measured as the gross domestic product (GDP) where it is expected that a mass of factors of production supplied in country *i,* is attracted to a mass of demand for factors of production in country *j* (Anderson, 2011). However, this potential trade flow is disrupted by the distance between, where countries located further away from each other face higher relative trade costs (Anderson & Wincoop, 2003). Thus, GDP is expected to have a positive effect on trade while the distance is believed to have a negative effect.

Moreover, the demographic size, $POP,$ of the countries is usually included in the gravity model. If a country's export rate decreases as they become larger, the population size is expected to have a negative effect on exports. Nevertheless, population size may have a positive effect on exports if the export rate increases as the population size grows, and thus attain economies of scale (Walsh,

21 In order to use fixed effects, the strict exogeneity assumption must hold. The strict exogeneity assumption is a version of the zero conditional mean assumption and says that the part of the error term that is allowed to vary over time must be unrelated to the value of the treatment indicator or other control variables in any time period (Angrist & Pischke, 2009).

22 A list of all variables and their sources is specified in Appendix A.

2006). In the specified model, it is believed that an increase in the population size generates a positive effect on bilateral trade flows.

Control variables added to the regression specification is common language,$Comlang_{ij}$, and colonial relationship,$Colonialrel_{ijt}$, which are considered as cultural institutional factors. The latter variable is time-varying since colonial relationships between countries changed over time.[23] It is believed that a common language between two countries declines potential communicational costs, and that two countries with a colonial relationship are thought to have similar institutions. In addition, a common border,$Combord_{ij}$, is expected to entail greater trade flows between the country-pair. These control variables operate as dummy variables and thus take the value 1 if the variable is true for the country-pair. All the coefficients of the control variables are expected to have positive signs.

The variable Flu is our main variable of interest and has the purpose to capture the intensity of the Spanish flu across countries. It is believed that the coefficients of this variable will have a negative effect on trade flows. As presented in the previous section, the flu-variable is measured in two ways:

1) as the excess mortality rate during the time-period 1918 – 1920. It is believed that an increase in the mortality rate has a negative impact on trade flows.

2) as the negative change in life expectancy. It is expected that a decrease larger than ten percent in life expectancy during the time-period 1918 – 1920 has a negative impact on trade flows.

The excess mortality of the flu is expressed relative to the total population. It takes the value 0 for all years except 1918-1920. Since the logarithm of zero is not defined, the value 1 is added to all mortality observations in order to generate logarithmic values.[24] Moreover, life expectancy is

[23] The variable for colonial relationship takes the value 1 if a country-pair is in a colonial relationship during a given year. In retrospect we have found that using a constant variable i.e. "countries that have ever been in a colonial relationship" might have been more suitable.

[24] Creating a dummy variable is an option but then valuable information would be lost and hence adding 1 to all values is considered more suitable.

captured in two different binary dummy variables which represent a “small” respectively “large” change in life expectancy during the influenza.[25] A small change implies that the negative percentage change in life expectancy for 1918 – 1920, compared to the year before, was between 10 percent to strictly less than 30 percent. A large change implies that the negative percentage change was 30 percent or greater. Hence each dummy takes the value 1 for a given year if the country’s negative change in life expectancy is in the given intervals.

Fixed effects are added to the specified regression. A rich fixed effects structure can account for a large series of omitted observable and unobservable variables (Olivero & Yotov, 2012). However, it is important that the fixed effects do not capture the question of interest, in this case the flu-effect. In order to control for country specific factors that are unobserved, and time invariant, country-fixed effects are added to the regression for the direction which is examined. These fixed effects can capture geographical, political, cultural and institutional factors which are specific to the country and constant over time. In the regression these effects are represented by τ_i for the exporter and φ_j for the importer. Further Olivero & Yotov (2012) suggest that in order to properly control for the unobservable multilateral resistance term, gravity-data should be obtained with time-varying country fixed effects. Thus, due to the characteristics of these effects they also absorb other country-specific variables which vary over time, such as *GDP*, *POP* and *Flu*. Hence these country-time specific variables will be included for the direction, which is not of interest for the specific regression, represented by θ_{it} for the exporter and γ_{jt} for the importer. Lastly an error term, ε_{ijt}, is included in the model.

6.2 Method of Estimation

There are several estimators to choose from in order to apply the gravity model. Researchers are not in unity of which one is favored, and the most suitable option depends on the question of interest and the characteristics of the data used. In this study the conditional fixed effects Poisson model is chosen as the main estimator, further referred as Poisson estimator. Moreover, this section aims to discuss some of the most common issues which arise in the use of the gravity model and present the methodology of our empirical analysis.

[25] This division has no theoretical anchoring and is arbitrarily chosen by the authors.

One estimation issue which is intensively discussed in the gravity literature is that bilateral trade flows can take the value zero. This tends to be a problem since the logarithm of zero is not defined and when applying an OLS estimator the natural logarithm of trade must be used (Santos Silva & Tenreyro, 2006; Shepherd, 2016). A trade flow where zero is reported may actually represent that the countries do not in fact trade with each other. However, it may also reflect shipments that fall below a threshold above zero or it may be missing observations, which may or may not reflect true zeros (Anderson, 2010). The zeroes generate issues both regarding the appropriate specification of the economic model and regarding the appropriate specification of the error term (Anderson, 2010). Helpman et al., (2008) states that studies which disregard zero trade flows give up important information and produce biased estimates. In order to account for zero trade flows a popular method is to estimate the multiplicative nature of the gravity equation instead of taking the logarithm. This approach can among other estimates be carried out with the Poisson estimator which enables one to keep the bilateral trade flow in its actual value and all of the other variables in their logarithmic forms.

Endogeneity is an important and serious issue to take into account. Endogeneity occurs when an explanatory variable is correlated with the error term. In the context of this thesis, potential endogeneity may occur since there are reasons to believe that causality between the influenza and trade work both ways. This means that the influenza pandemic might have spread to new countries via trade. Ideally one would like to use a nonlinear instrumental variable (IV) to account for this issue but a suitable instrument for the influenza is difficult to find (Winkelmann, 2008). Using pair fixed effects is also a way of dealing with this issue and to account for any observable time invariant trade cost component (Yotov et al. 2016). However, as Anderson (2010) and Winkelmann (2008) emphasizes, there is an upper bound of the number of fixed effects imposed by a typical econometric package. Hence, in the trade-off between including many observations or using pair fixed effects, we have chosen not to include the pair fixed effects in our main regressions. Thus, in the robustness analysis endogeneity is controlled for by one-period lagged explanatory variables for the flu and in addition an OLS regression,[26] with pair fixed effects is

[26] Which absorbs multiple levels of fixed effects.

carried out (Li et al., 2011; Chang & Zhang, 2013). However, these operators might not solve the endogeneity problem and one must hence be aware of this possible issue.

Further, a difficulty when gravity data follows a panel set-up is potential heteroscedasticity. Heteroscedastic data implies that the variance of the disturbance term is not constant and hence the parameters of log linearized models estimated by OLS produces biased estimates (Santos Silva & Tenreyro, 2006). Thus, the Poisson estimate is consistent in the presence of heteroscedasticity. Further the Poisson estimator is reasonably efficient in large samples and, as stated above, it can account for zero trade flows (Burger et al., 2009). Both the Poisson estimator, the negative binomial and zero-inflated model, and the Poisson Pseudo-Maximum-Likelihood model have been suggested for bilateral trade analyses (e.g Santos Silva & Tenreyro, 2006; Burger et al. 2009). However, the Poisson estimator is considered most suitable for this study and will hence be used for the empirical analysis. In addition to this method an OLS estimator with robust standard errors is carried out in order to compare the results (Head & Mayer 2013).

In order to check the robustness of the gravity equations described in this thesis, the two estimates, Poisson and OLS, will be carried out in two different datasets.[27] One which is smaller, containing data over excess mortality and change in life expectancy. The other set of data is more extensive and does solely capture the flu effect by the change in life expectancy.[28] With the use of these two bodies of data, one is able to compare the outcome results when the specifications are applied in a smaller versus larger range. The smaller dataset also serves the purpose to control if the two different measures of the flu are unanimous.

Furthermore, WWI has proved to affect trade. In order to make sure that this effect is not captured by the flu variable, the excess mortality due to the war will be added to the regression.[29] These figures were compiled by the same authors which constructed the numbers for excess mortality,

27 If a model is robust it means that several approaches and estimation methods have been applied to the regression, and the outcome results for each procedure are still comparably similar.

28 Countries included in the larger dataset are found in Appendix D.

29 The war intensity for countries that participated in WWI in 1918 are approximated as the ratio of military combat death to total population. The mortality due to the war takes the value 0 for all years except 1918 (which is the overlapping year between the war and the flu). Since the logarithm of zero is not defined, the value 1 is added to all war observations in order to generate logarithmic values.

namely Barro et al. (2020). Thus, in order to make the war-effect and flu-effect comparable, the war-variable will only operate in the smaller dataset in the regression where the flu-variable is measured in excess mortality rates.

Finally, when investigating to what extent the countries in the smaller dataset were affected by the Spanish flu, only eight countries faced a large change. In order to avoid biased estimates steered by these eight countries, the large change in life expectancy is chosen to not be estimated in this dataset.

7. Data

In order to examine the possible effect of the Spanish flu on trade, yearly data between 1900-1929 is used. The end date of 1929 is chosen in order to exclude the Great depression[30]. The observations mainly consist of data from *Centre d'Etudes Prospectives et d'Informations Internationales* (CEPII) (CEPII, 2016). The variables gathered from CEPII are frequently used in gravity equations and are presented in Appendix A.

In the dataset by CEPII (2016) there are more observations on bilateral trade flows than over GDP. Thus, in the larger dataset the GDP variable is replaced with more extensive GDP data collected from a number of different sources which are compiled by Gapminder (2018). Hence GDP data in this dataset is complete for all observations while there are missing GDP observations in the smaller dataset. The availability of data on trade flows are presented in *Figure 3*,[31] where the time period of interest is marked with dashed lines. Noteworthy is the difference in observed zero trade flows and unobserved trade flows. The unobserved trade flows, which are likely to be zero, are not included in this study.

30 As reasoned by Gowa and Hicks (2017) and Barro et al. (2020).
31 For all 319 "countries" originally included in the CEPII TRADHIST data set.

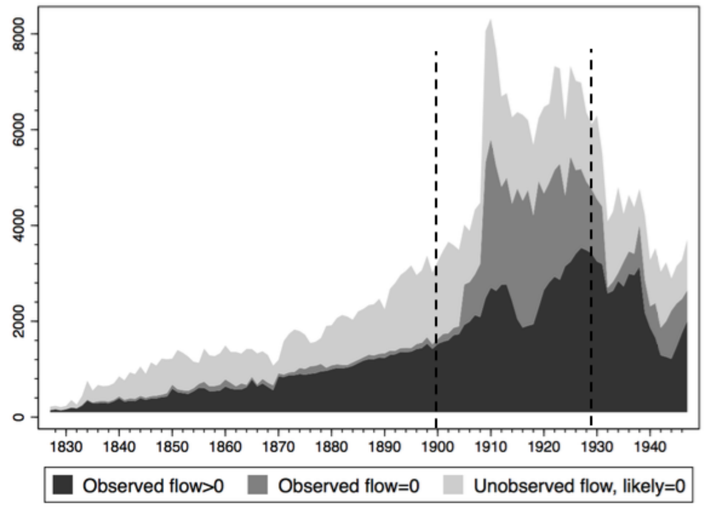

Figure 3. Number of bilateral trade observations (*Source:* Fouquin & Hugot, 2016)

Moreover, the two different datasets which have been put together in this study consists of countries from different continents and have been matched with corresponding present-day country borders. An overview of the countries included in these datasets are found in Appendix C and Appendix D. The first dataset contains 33 countries with measurements of both excess mortality and life expectancy, while the second dataset is composed of 134 countries, containing only the life expectancy measure.

As previously stated, the negative change in life expectancy is divided into two batches. In *Figure 4*, the frequency of the countries in the two batches is separately presented for each dataset. From *Figure 4*, one can further observe that the number of countries does not fully correspond to the number of countries in the datasets. This is due to the fact that some countries faced a smaller negative change in life expectancy than 10 percent.

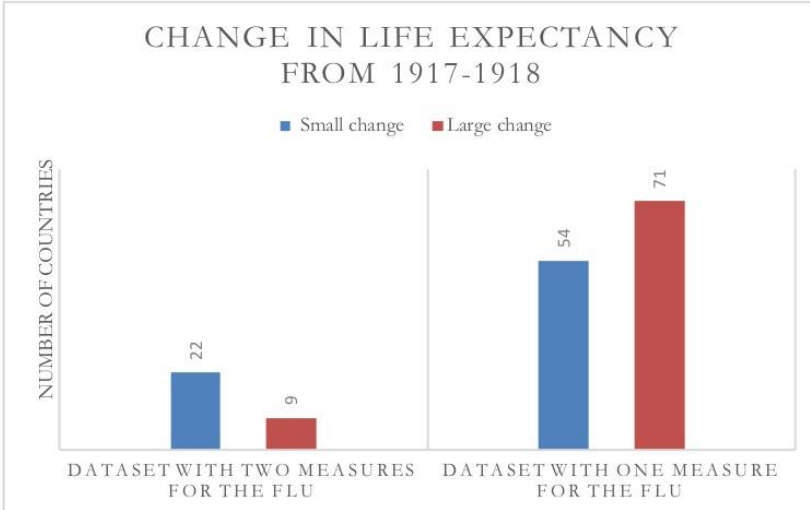

Figure 4. Negative change in life expectancy. (*Source: Personal Collection)*

8. Regression Results

The specified model is fitted with aggregated export and import data respectively, using the Poisson estimator and OLS estimator. The life expectancy measure is estimated in both datasets, while the mortality measure is only used in the smaller dataset.

8.1 Exporter Side

The regression results where the Poisson and OLS estimator has been applied for the exporters are found in *Table 1*. The estimate of life expectancy in this table refers to the small change in life expectancy and the large change is displayed in Appendix E, since these results are in line. The estimated coefficient for the flu variable measured by life expectancy, displays an insignificant sign for both estimators. However, when measured by mortality rate, the coefficient of the flu variable exhibits a negative two-star significant sign when the Poisson estimator is used. When the OLS estimator is applied, the coefficient of the flu variable measured in mortality rate displays an insignificant sign.

Further, the coefficient of the war variable shows a negative sign on a three-star significance level for both estimators. The coefficients for the excess mortality from the pandemic and the mortality from WWI exhibit large numbers since their values are "blown up" by one. Moreover, regardless of estimator and dataset, the coefficients of the GDP variable show a positive, significant sign and the coefficient for the variable distance show a negative significant sign. In addition, the coefficients of the control variables – common language, common, border and colonial relationship – exhibit positive and significant signs, as expected. However, the coefficient for the population size variable in the larger dataset exhibits an insignificant sign. This is not consistent with the result generated from the smaller dataset, in which the coefficient for the population size shows a positive significant sign.

Notably for all OLS estimates, is that the R-square generates a value between 0.657 and 0.678, and thus these regressions seem to have similar degrees of explanation.

Table 1. Regression Results: Exports

	Poisson *Small dataset*		Poisson *Large dataset*	OLS *Small dataset*		OLS *Large dataset*
	Life expectancy	Mortality	Life expectancy	Life expectancy	Mortality	Life expectancy
GDP_{it}	0.577***	0.564***	0.970***	0.536***	0.504***	1.112***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
POP_{it}	0.539***	0.573***	-0.127	1.039**	1.073**	-0.132
	(0.003)	(0.002)	(0.611)	(0.018)	(0.014)	(0.725)
$Dist_{ij}$	-0.200***	-0.201***	-0.309***	-0.474***	-0.473***	-0.734***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$Comlang_{ij}$	0.246***	0.245***	0.405***	0.808***	0.809***	0.882***
	(0.000)	(0.000)	(0.000)	(0.002)	(0.002)	(0.000)
$Combord_{ij}$	0.956***	0.959***	0.797***	0.454	0.456	0.370
	(0.000)	(0.000)	(0.000)	(0.175)	(0.172)	(0.164)
$Colonialrel_{ijt}$	1.028***	1.034***	1.558***	1.790***	1.789***	2.028***
	(0.000)	(0.000)	(0.000)	(0.008)	(0.008)	(0.000)
Flu_{it}	0.217	-67.347**	0.157	0.224	-15.502	-0.242
	(0.157)	(0.016)	(0.380)	(0.403)	(0.491)	(0.141)
War_{it}		-141.476***			-402.031***	
		(0.000)			(0.000)	
Constant				-3.428	-3.090	-7.735*
				(0.396)	(0.415)	(0.075)
Observations	16,281	16,272	32,968	15,654	15,645	31,358
R^2				0.676	0.678	0.657
Imp FE	No	No	No	No	No	No
Exp FE	Yes	Yes	Yes	Yes	Yes	Yes
Imp-time FE	Yes	Yes	Yes	Yes	Yes	Yes
Exp-time FE	No	No	No	No	No	No

Robust p-value in parentheses *** p<0.01, ** p<0.05, * p<0.1

The results of the large change in life expectancy are presented in the Appendix E.

8.2 Importer Side

The regression results where the Poisson and OLS estimator has been applied for the importers are found in *Table 2*. The estimate of life expectancy in this table also refers to the small change in life expectancy and the large change is displayed in Appendix E. When the Poisson estimator is applied, the coefficient of the flu variable measured by life expectancy, exhibits a negative, three-star significant sign when fitted in the smaller dataset (-0.388). When the OLS estimator is applied in the more covering dataset estimated as the large change in life expectancy, the coefficient of the flu variable also exhibits a negative one-star significant result (-0.389). In remaining estimates of the flu variable, the coefficients display insignificant signs.

The coefficient of the war variable does not show any significant sign when estimated with any of the estimators in contrast to the exporter side. Furthermore, regardless of estimator, the coefficients of the variables GDP, distance, common language and colonial relationship, all exhibit expected and significant signs on the importer side. However, the coefficients of the population size variable, do not display significant signs for neither Poisson nor OLS, when estimated in the smaller dataset. In the more extensive dataset however, the coefficient of the population variable shows a positive significant sign for both of the estimators. Moreover, the coefficients of the control variable common border show a positive and significant sign when the Poisson estimator is used. Though, in both datasets, insignificant coefficient signs are displayed for the same variable when the OLS estimator is applied.

Consistent with the regression results on the exporter side, the R-square takes similar values when the OLS estimator is used. On the importer side the R-square generates a value between 0.667 and 0.684, and thus these regressions also seem to have similar degrees of explanation.

Table 2. Regression Results: Importers

	Poisson *Small dataset*		Poisson *Large dataset*	OLS *Small dataset*		OLS *Large dataset*
	Life expectancy	Mortality	Life expectancy	Life expectancy	Mortality	Life expectancy
GDP_{jt}	0.809***	0.808***	0.312***	0.837***	0.837***	0.487**
	(0.000)	(0.000)	(0.005)	(0.000)	(0.000)	(0.011)
POP_{jt}	-0.225	-0.226	0.430*	0.049	0.041	0.650**
	(0.427)	(0.428)	(0.078)	(0.893)	(0.911)	(0.031)
$Dist_{ij}$	-0.217***	-0.217***	-0.317***	-0.476***	-0.475***	-0.733***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
$Comlang_{ij}$	0.228***	0.228***	0.400***	0.790***	0.789***	0.858***
	(0.000)	(0.000)	(0.000)	(0.002)	(0.002)	(0.000)
$Combord_{ij}$	0.917***	0.917***	0.772***	0.457	0.457	0.384
	(0.000)	(0.000)	(0.000)	(0.167)	(0.168)	(0.146)
$Colonialrel_{ijt}$	1.173***	1.171***	1.717***	1.713**	1.712**	2.054***
	(0.000)	(0.000)	(0.000)	(0.017)	(0.017)	(0.000)
Flu_{jt}	-0.388***	30.123	0.117	-0.351	-14.374	0.240
	(0.000)	(0.133)	(0.618)	(0.106)	(0.404)	(0.188)
War_{jt}		0.751			29.168	
		(0.981)			(0.753)	
Constant				-0.105	-0.032	0.402
				(0.973)	(0.992)	(0.917)
Observations	16,277	16,268	32,993	15,655	15,647	31,363
R^2				0.684	0.684	0.667
Imp FE	Yes	Yes	Yes	Yes	Yes	Yes
Exp FE	No	No	No	No	No	No
Imp-time FE	No	No	No	No	No	No
Exp-time FE	Yes	Yes	Yes	Yes	Yes	Yes

Robust p-value in parentheses *** p<0.01, ** p<0.05, * p<0.1

The results of the large change in life expectancy are presented in the Appendix E.

In summary, when comparing exporters and importers the variable of interest – flu – only exhibits a negative significant sign in the smaller dataset. On the exporter side, the coefficient of the flu variable only displays a negative significant sign when it is measured with *mortality rates*. On the importer side, the coefficient of the flu variable only exhibits a negative significant sign when measured with *life expectancy*. Hence, these two results indicate that if trade was affected by the flu, it was affected negatively. Since significant coefficients were only displayed in the smaller collection of data, it can be questioned whether this dataset is representative for international trade. Furthermore, the regression results are not consistent and therefore the Spanish flu's effect on trade cannot be established. As motivated by James & Sargent (2006), monthly data might have been more suitable for this analysis. Broadly, the control variables exhibit expected signs or in a few cases insignificant signs.

As previously discussed in *Method of Estimation* a suitable IV-regressor has not been found in order to test for endogeneity and more specifically reversed causality. To test for this issue, we use one-period lagged variables for the flu. The lagged variable results are presented in Appendix F and Appendix G and are not consistent with our main estimates when it comes to the coefficient of the flu variable. Thus, one cannot cancel out that endogeneity may be present.

Moreover, we also run an OLS regression with pair-fixed effects in order to control for endogeneity. The results from these regressions are presented in Appendix H.[32] The coefficient for the flu variable shows negative results with a three-star significance in all regressions, regardless of which dataset is used. Notable is also that the R-squared is between 0.841 - 0.862, which is substantially higher than in the prior regressions. These results emphasize the importance of which fixed effects are included. By only observing this table one might conclude that the Spanish flu had a negative and substantial effect on trade. However, we have previously discussed the limitations of the linear OLS estimator and hence these results alone are not trustworthy, nevertheless they might emphasize the use of country-pair fixed effects.

Lastly, as a final robustness check we examine the boundary values of the equation by dropping all zero values. Since zero trade flows only are considered for the Poisson estimate these results are not carried out with the OLS. The results are slightly different, but the significant values are still in line with the previously presented results.

9. Summary and conclusions

The aim of this thesis is to examine the question: *Did the 1918 influenza pandemic affect trade?* The workhorse gravity model where the conditional fixed effects Poisson is the main estimator, is applied. We find that the effect of the flu on trade is mostly insignificant but when significant the

[32] Due to the pair-fixed effects, variables which are specific for a country pair and do not vary over time drops, i.e distance, common language and common border. The control variable for colonial relationships does not drop since this, in contrast to the others, is varying over time

coefficient of the flu is negative. Hence, we conclude that if the Spanish flu affected trade, this effect was negative for both importers and exporters However, the regressions results cannot be enhanced by the robustness analysis. Therefore, based on our findings no apparent conclusion can be drawn about the effects on international trade caused by the Spanish flu.

In order to capture the severity of the flu across countries we use two measurements: the change in life expectancy and excess mortality rates. The life expectancy measure enables us to include an extensive number of countries but has not been used before in this context. The excess mortality measure enables us to use more detailed information and to separately control for WWI, however, is less covering. We find that the consistency of life expectancy as an estimator for the Spanish flu cannot be established. It is further noticeable that the significance between the two measurements of the flu are not always unanimous.

To the best of our knowledge this paper seems to be the first to specifically examine if international trade was affected by the Spanish flu. Our contribution to the existing literature can hence be considered twofold: We have presented and examined an alternative way of how the severity of a pandemic can be measured by the use of life expectancy. Furthermore, we have investigated and presented results over a new topic. In conclusion, further research on this subject is suggested in order to resolve still rather unexplored enquiries regarding the Spanish flu’s effect on trade.

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11. Appendix

Appendix A. Variable list

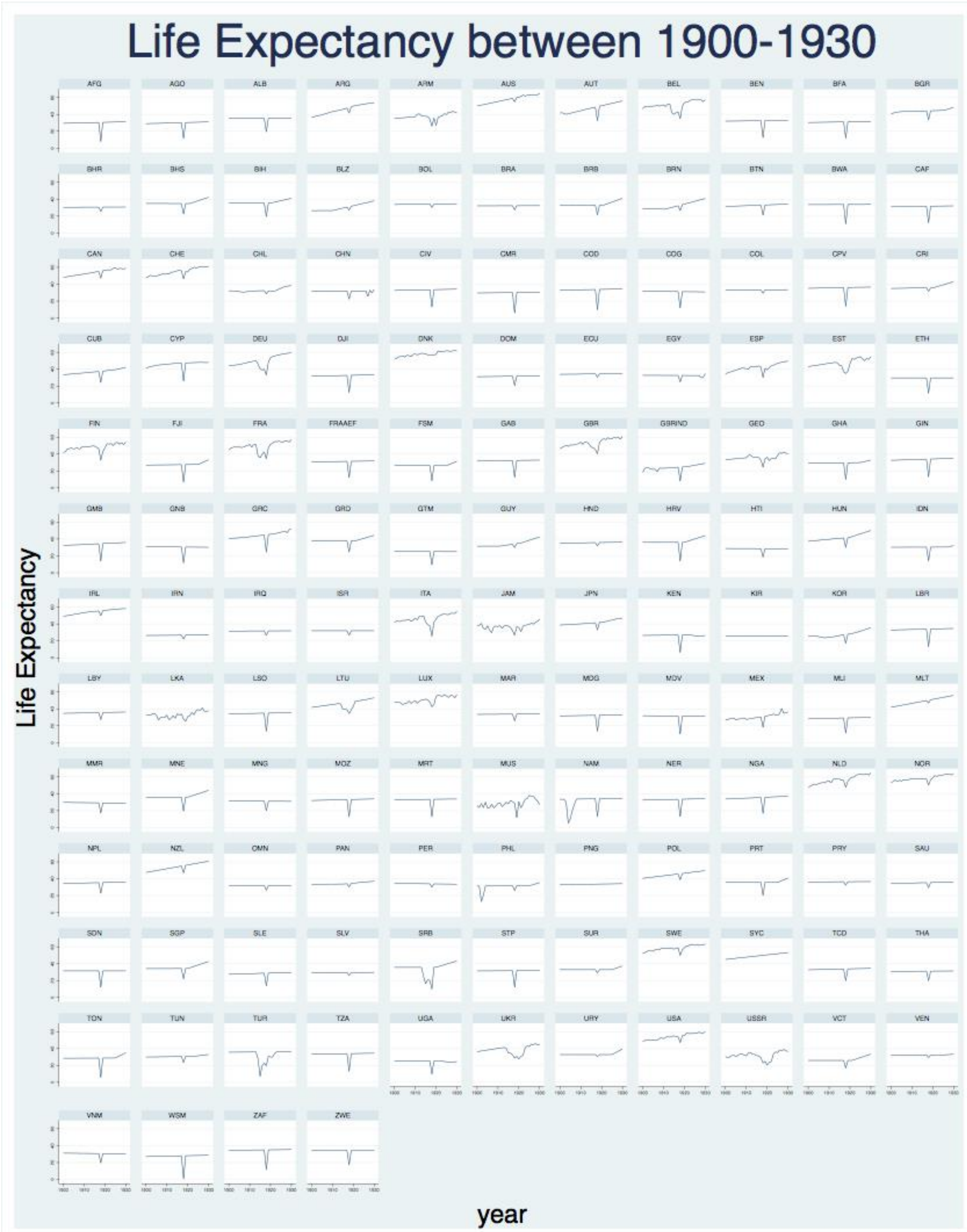
VARIABLE	FULL NAME	SPECIFICATION	SOURCE
FLOW	Bilateral trade flow	British pound sterling	CEPII
GDP (S)*	Gross domestic product	British pound sterling	CEPII
GDP (L)*	Gross domestic product	International dollars, PPP adjusted	Gapminder**
*POP**	Population		CEPII
DIST	Bilateral distance	Population-weighted-great-circle distance, in km	CEPII
COMLANG	Common language	Dummy set to one if at least one language in spoken by more than 9% of the population in both countries	CEPII
COMBORD	Common border	Dummy set to one if the countries are contiguous	CEPII
COLREL	Colonial relationship	Dummy set to one if the origin and destination country are in a colonial relationship a given year	CEPII
WAR (S)*	Mortality from WWI * (S)	War death rates from the military in combat during WWI. Expressed relative to population in 1918. Zero all other years	Barro et al., 2020
FLU	"Flu effect"	Defined by the following four measurements:	
	• *Small change in life expectancy**	Dummy set to one if there is a negative change in life expectancy compared to the year before, greater than 10% but strictly less than 30%. Can only take the value one in 1918-1920. Zero all other years	Gapminder**
	• *Large change in life expectancy**	Dummy set to one if there is a negative change in life expectancy compared to the year before equal to or strictly greater than 30%. Zero all other years	Gapminder**
	• *Mortality from pandemic* (S)*	Excess mortality of the flu expressed relative to the total population between 1918-1920. Zero all other years	Barro et al., 2020

* Direction specific variable. Further defined with *i* for exporter and *j* for importer

** Compiled by Gapminder from several different data sources

(S) = variable only included in the smaller dataset
(L) = variable only included in the more covering, larger dataset

Appendix B. Life expectancy between 1900-1930



Appendix C. Countries included in the smaller dataset

Argentina	Chile	Germany	Italy	Norway	Spain
Australia	China	Greece	Japan	Portugal	Sweden
Austria*	Colombia	Hungary*	Mexico	Russia	Switzerland
Belgium	Denmark	India	Netherlands	Singapore	Taiwan
Brazil	Egypt	Indonesia	New Zealand	South Africa	United Kingdom
Canada	France	Italy			

***** *Part of Austria-Hungary until the end of WWI in 1918. The same war death rates, based on numbers for Austria-Hungary, apply to each country.*

Appendix D. Countries included in the more covering dataset

Afghanistan	Switzerland	France	Israel	Mauritania	Serbia
Angola	Chile	Micronesia, Fed. Sts.	Italy	Mauritius	Sao Tome and Principe
Albania	China	Gabon	Jamaica	Namibia	Suriname
Argentina	Cote d'Ivoire	United Kingdom	Japan	Niger	Sweden
Armenia	Cameroon	India[33]	Kenya	Nigeria	Seychelles
Australia	Congo, Dem. Rep.	Georgia	Kiribati	Netherlands	Chad
Austria	Congo, Rep.	Ghana	Liberia	Norway	Thailand
Belgium	Colombia	Guinea	Libya	Nepal	Tonga
Benin	Cape Verde	Gambia	Sri Lanka	New Zealand	Tunisia
Burkina Faso	Costa Rica	Guinea-Bissau	Lesotho	Oman	Turkey
Bulgaria	Cuba	Greece	Lithuania	Panama	Tanzania
Bahrain	Cyprus	Grenada	Luxembourg	Peru	Uganda
Bahamas	Germany	Guatemala	Morocco	Philippines	Ukraine
Bosnia and Herzegovina	Djibouti	Guyana	Madagascar	Papua New Guinea	Uruguay
Belize	Denmark	Honduras	Maldives	Poland	United States
Bolivia	Dominican Republic	Croatia	Mexico	Portugal	Russia[34]
Brazil	Ecuador	Haiti	Mali	Paraguay	St. Vincent and the Grenadines
Barbados	Egypt	Hungary	Malta	Saudi Arabia	Venezuela
Brunei	Spain	Indonesia	Myanmar	Sudan	Vietnam
Bhutan	Estonia	Ireland	Montenegro	Singapore	Samoa

[33] Defined by CEPII as "GBRIND" (Great Britain India), have been matched with India in Gapminder
[34] Defined by CEPII as "USSR" (Russian Empire), have been matched with Russia in Gapminder

Botswana	Ethiopia	Iran	Mongolia	Sierra Leone	South Africa
Central African Republic	Finland	Iraq	Mozambique	El Salvador	Zimbabwe
Canada	Fiji				

Appendix E: Results for a Large Change in Life Expectancy

	Exporter		Importer	
	Poisson	*OLS*	*Poisson*	*OLS*
GDP	0.975*** (0.000)	1.114*** (0.000)	0.313*** (0.005)	0.491** (0.011)
POP	-0.132 (0.599)	-0.135 (0.719)	0.430* (0.078)	0.646** (0.032)
Dist	-0.309*** (0.000)	-0.734*** (0.000)	-0.317*** (0.000)	-0.733*** (0.000)
Comlang	0.405*** (0.000)	0.882*** (0.000)	0.400*** (0.000)	0.858*** (0.000)
Combord	0.797*** (0.000)	0.370 (0.165)	0.772*** (0.000)	0.384 (0.146)
Colonialrel	1.558*** (0.000)	2.027*** (0.000)	1.717*** (0.000)	2.054*** (0.000)
Flu	-0.204 (0.370)	0.174 (0.317)	-0.071 (0.777)	-0.389* (0.063)
Constant		-7.779* (0.074)		0.347 (0.929)
Observations	32,968	31,358	32,993	31,363
R^2		0.657		0.667
Imp FE	No	No	Yes	Yes
Exp FE	Yes	Yes	No	No
Imp-time FE	Yes	Yes	No	No
Exp-time FE	No	No	Yes	Yes

Robust p-value in parentheses *** p<0.01, ** p<0.05, * p<0.1

Appendix F: Lagged Flu Variable - Exporter Side

	Poisson *Small dataset*		Poisson *Large dataset*	OLS *Small dataset*		OLS *Large dataset*
	Life expectancy	Mortality	Life expectancy	Life expectancy	Mortality	Life expectancy
GDP_{it}	0.574*** (0.000)	0.540*** (0.000)	0.983*** (0.000)	0.530*** (0.000)	0.500*** (0.000)	1.022*** (0.000)
POP_{it}	0.547*** (0.003)	0.567*** (0.003)	-0.129 (0.607)	1.194** (0.011)	1.196** (0.011)	0.030 (0.940)
$Dist_{ij}$	-0.200*** (0.000)	-0.200*** (0.000)	-0.309*** (0.000)	-0.464*** (0.001)	-0.463*** (0.001)	-0.736*** (0.000)
$Comlang_{ij}$	0.245*** (0.000)	0.244*** (0.000)	0.402*** (0.000)	0.820*** (0.001)	0.820*** (0.001)	0.858*** (0.000)
$Combord_{ij}$	0.953*** (0.000)	0.955*** (0.000)	0.790*** (0.000)	0.463 (0.162)	0.465 (0.161)	0.325 (0.227)
$Colonialrel_{ijt}$	1.032*** (0.000)	1.035*** (0.000)	1.580*** (0.000)	1.733** (0.012)	1.735** (0.011)	2.016*** (0.000)
Flu_{it}	0.174 (0.240)	-33.557 (0.120)	0.071 (0.628)	0.080 (0.630)	-6.689 (0.628)	-0.267** (0.028)
War_{it}		-106.639*** (0.004)			-275.247*** (0.000)	
Constant				-4.806 (0.243)	-4.208 (0.304)	-6.908 (0.127)
Observations	15,382	15,373	30,113	14,889	14,880	28,913
R^2				0.677	0.678	0.662
Imp FE	No	No	No	No	No	No
Exp FE	Yes	Yes	Yes	Yes	Yes	Yes
Imp-time FE	Yes	Yes	Yes	Yes	Yes	Yes
Exp-time FE	No	No	No	No	No	No

Robust p-value in parentheses *** p<0.01, ** p<0.05, * p<0.1

Appendix G: Lagged Flu Variable - Importer Side

	Poisson *Small dataset*		Poisson *Large dataset*	OLS *Small dataset*		OLS *Large dataset*
	Life expectancy	Mortality	Life expectancy	Life expectancy	Mortality	Life expectancy
GDP_{jt}	0.826***	0.816***	0.288**	0.827***	0.796***	0.468**
	(0.000)	(0.000)	(0.012)	(0.000)	(0.000)	(0.019)
POP_{jt}	-0.258	-0.239	0.466*	0.025	0.032	0.611**
	(0.370)	(0.406)	(0.060)	(0.945)	(0.931)	(0.049)
$Dist_{ij}$	-0.216***	-0.216***	-0.316***	-0.465***	-0.465***	-0.735***
	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)	(0.000)
$Comlang_{ij}$	0.226***	0.227***	0.395***	0.802***	0.802***	0.832***
	(0.000)	(0.000)	(0.000)	(0.002)	(0.002)	(0.000)
$Combord_{ij}$	0.913***	0.913***	0.768***	0.465	0.464	0.337
	(0.000)	(0.000)	(0.000)	(0.156)	(0.157)	(0.207)
$Colonialrel_{ijt}$	1.156***	1.156***	1.735***	1.668**	1.668**	2.035***
	(0.000)	(0.000)	(0.000)	(0.022)	(0.021)	(0.000)
Flu_{jt}	-0.191**	23.215*	0.132	-0.331**	-12.060	0.370***
	(0.011)	(0.068)	(0.435)	(0.015)	(0.328)	(0.005)
War_{jt}		-19.126			-206.682***	
		(0.550)			(0.000)	
Constant				0.261	0.816	1.357
				(0.937)	(0.25)	(0.738)
Observations	15,378	15,369	30,124	14,890	14,881	28,923
R_2				0.684	0.685	0.671
Imp FE	No	No	No	No	No	No
Exp FE	Yes	Yes	Yes	Yes	Yes	Yes
Imp-time FE	Yes	Yes	Yes	Yes	Yes	Yes
Exp-time FE	No	No	No	No	No	No

Robust p-value in parentheses *** p<0.01, ** p<0.05, * p<0.1

Appendix H: Results using OLS with pair-fixed effects

	OLS *Small dataset*				OLS *Large dataset*	
	Life expectancy	Life expectancy	Mortality	Mortality	Life expectancy	
GDPit	0.372*** (0.000)	0.385*** (0.000)	0.377*** (0.000)	0.403*** (0.000)	1.486*** (0.000)	1.523*** (0.000)
GDPjt	0.677*** (0.000)	0.681*** (0.000)	0.730*** (0.000)	0.693*** (0.000)	1.061*** (0.000)	1.059*** (0.000)
POPit	1.426*** (0.000)	1.378*** (0.000)	1.342*** (0.000)	1.338*** (0.000)	0.218 (0.525)	0.160 (0.640)
POPjt	0.263 (0.328)	0.255 (0.342)	0.146 (0.590)	0.183 (0.500)	0.378 (0.162)	0.362 (0.178)
Distij						
Comlangij						
Combordij						
Colonialrelijt	0.469*** (0.000)	0.470*** (0.000)	0.453*** (0.000)	0.469*** (0.000)	0.601** (0.045)	0.594** (0.047)
Fluit	-0.831*** (0.000)		-55.502*** (0.001)		-0.563*** (0.000)	
Flujt		-0.959*** (0.000)		-97.545*** (0.000)		-0.438*** (0.000)
Warit			-462.346*** (0.000)			
Warjt				-137.057* (0.097)		
Constant	-23.527*** (0.000)	-23.335*** (0.000)	-22.776*** (0.000)	-22.897*** (0.000)	-55.116*** (0.000)	-55.283*** (0.000)
Observations	15,659	15,659	15,650	15,651	31,334	31,334
R_2	0.862	0.863	0.865	0.862	0.841	0.8410
Imp FE	Yes	Yes	Yes	Yes	Yes	Yes
Exp FE	Yes	Yes	Yes	Yes	Yes	Yes
Imp-time FE	No	No	No	No	No	No
Exp-time FE	No	No	No	No	No	No
Pair FE	Yes	Yes	Yes	Yes	Yes	Yes

Robust p-value in parentheses *** p<0.01, ** p<0.05, * p<0.1