Essays on Violent Crime in Mexico and the World

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Curriculum Vitae

Jessica Baier was born in Achern in 1989. After graduating from school, she studied International Economics and European Studies at Eberhard Karls Universität Tübingen, graduating with a Bachelor of Science in 2012. In 2014, she graduated from the Master of Science in Economic Development and Growth after studying at the University Carlos III in Madrid, Spain and at Lund University, Sweden. Since 2015, she has been working as research assistant at the chair of Economic History at the Eberhard Karls Universität Tübingen.

Preface

First and foremost, I would like to thank my advisor, Jörg Baten, for encouraging me to write this doctoral thesis and for giving me the opportunity to be part of his research group. He offered constant support and feedback for my work, introduced me to the community of international researchers and he encouraged me to present my work at international conferences and submit it to scientific journals. This way, I gained experience in the academic world and the general scientific practice. Furthermore, I thank my second advisor, Georg Wamser, for valuable comments on the drafts of some of the chapters and his willingness to review my thesis as co-examiner.

My occupation as assistant at the Economic History department was a great complement to my research activity: Teaching STATA courses, tutoring students and taking care of organizational issues at the department, I could acquire important work experience. I would like to thank my colleagues from the Economic History department in Tübingen, Dr. Daniel Steinberg, Dr. Nicholas Meinzer, Rima Ghanem, Tom Keywood, María del Carmen Pérez Artes and Katrin Rohland, who contributed to a productive office environment, provided feedback and were available for discussions.

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Jessica Baier
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List of Abbreviations and Symbols

#	Number
2 SLS	Two-stage Least Squares Regression
AET-ratio	Altonji-Elder-Taber-ratio
ARMA	Autoregressive Moving Average
BC	Before Christ
CIPS	Cross-sectional augmented Im-Pesaran-Shin
DP	Death Penalty
FE	Fixed Effects
GDP	Gross Domestic Product
GK	Geary-Khamis
GVA	Gross Value Added
ICD	International Classification of Diseases
IV	Instrumental Variable
L.	Lag
LIML	Limited Information Maximum Likelihood
log	Logarithm
OECD	Organization for Economic Cooperation and Development
OLS	Ordinary Least Squares
pc	Per capita
PH	Proportional Hazards Assumption
PRI	Partido Revolucionario Institucional
RE	Random Effects
UK	United Kingdom
UNO	United Nations Organization
UNODC	United Nations Office on Drugs and Crime
US	United States of America
USD	United States Dollar
VAR	Vector Autoregression
WHO	World Health Organization

A. Introduction

A.1. The Burden of Crime

Having spent a few years of my life in Latin American countries, I have directly experienced what it is like to live in an insecure environment and under the constant fear of becoming the victim of a crime. Especially in Venezuela, crime and violent crime rates are high, which is tangible in everyday life: Whenever in public, you always have to pay attention to your surroundings; identify potential threats and get inside a private space as soon as possible. After darkness, it gets too dangerous to even go outside. In Caracas, world's most violent city, people are living in a constant fear of robbery, assault, or even kidnapping. They are trying to spent the least amount of time in public spaces and leave their house only to get to work and to the supermarket. At night, you can hear gunshots throughout the streets; in the morning, you can often find blood on the walkways just outside where you were sleeping. While there is no official data, experts estimate that in a typical weekend, around 40 people are killed in Caracas alone (OSAC 2016).

These problems of high crime rates and personal insecurity are not limited to Venezuela or the Latin American continent but present in many parts of the world, and they are negatively affecting the quality of life of entire societies. Being the victim of a (violent) crime can have detrimental impacts on parenting skills, occupational functioning and intimate relationships (Hanson et al. 2010). If a family member or friend is the victim of a crime, people experience grief and pain. But even if the individual is not a direct victim of a crime, living in circumstances of high crime incidence and insecurity can have negative consequences. Living in a context of constant threat of crime and violence is nerve-wracking, exhausting and detrimental for human well-being. The fear of crime is a major social problem and its impacts range from detrimental psychological changes to suboptimal reactions and behavioral adaptations (Doran and Burgess 2012). The sheer fear of crime can erode social capital by disrupting neighborhood cohesion, creating interpersonal distrust and breaking down social relations and attachment (Doran and Burgess 2012, Spelman 2004, Ross and Mirowski 2000). Many of these phenomena are consequences of the protective and avoidance behaviors that people adopt when confronted with high crime rates and insecurity.

Apart from these intangible, personal costs, crime and insecurity also have direct measurable costs for the entire economy. A significant part of resources is spent on preventive measures and precautions, that could otherwise be used to generate additional income and welfare. Direct expenses to prevent and clear up criminal incidents are for example used for police protection, correction and prosecution. Further costs arise due to the losses and medical treatment of the victims, crime prevention and deterrence measures (Anderson 1999). For the case of the US, the aggregate burden of crime is estimated to around 11.9% of GDP, or an annual $ 4,118 per capita (Anderson 1999). In Latin America, the cost of crime is even higher: Londoño and Guerrero (1999) estimated the social cost of only the violent crimes to be as high as 14.3% of GDP on average in Latin American countries. In some countries, such as El Salvador, costs of violence account for even a quarter of annual GDP.

According to Detotto and Otranto (2010) however, these sums still considerably understate the total impact of crime on society, since they do not account for the detrimental effect crime has even on the legal economic activity. The environment of uncertainty and inefficiency created by high crime rates discourages investments and reduces the competitiveness of firms, consequently slowing down overall economic growth and imposing an even higher cost on the entire population (Detotto and Otranto 2010). Goulas and Zervoyianni (2012) show that in uncertain environments, a 10% increase in crime can reduce annual GDP per capita growth by up to 0.62 %.

Given these figures, it is evident that crime has the potential to paralyze the way of life and development of entire countries. In order to act against it, scholars and politicians have been attempting to identify the main drivers of crime for decades – with mixed results. Due to my own experience with high crime rates and insecurity and knowing about the detrimental impact on society, I dedicated my thesis to the research on violent crime and its determinants to add valuable insights to the existing literature. This thesis examines the determinants of violent crime in certain contexts and by taking a look at the interaction of violent crime and punishment. It looks at violent crime because it is the more severe form of crime incidence. An overview of the definitions and theories used in this context in the following subchapter will set the basis for the subsequent analysis.

A.2. Violent Crime – Definition, Theories and Measurement

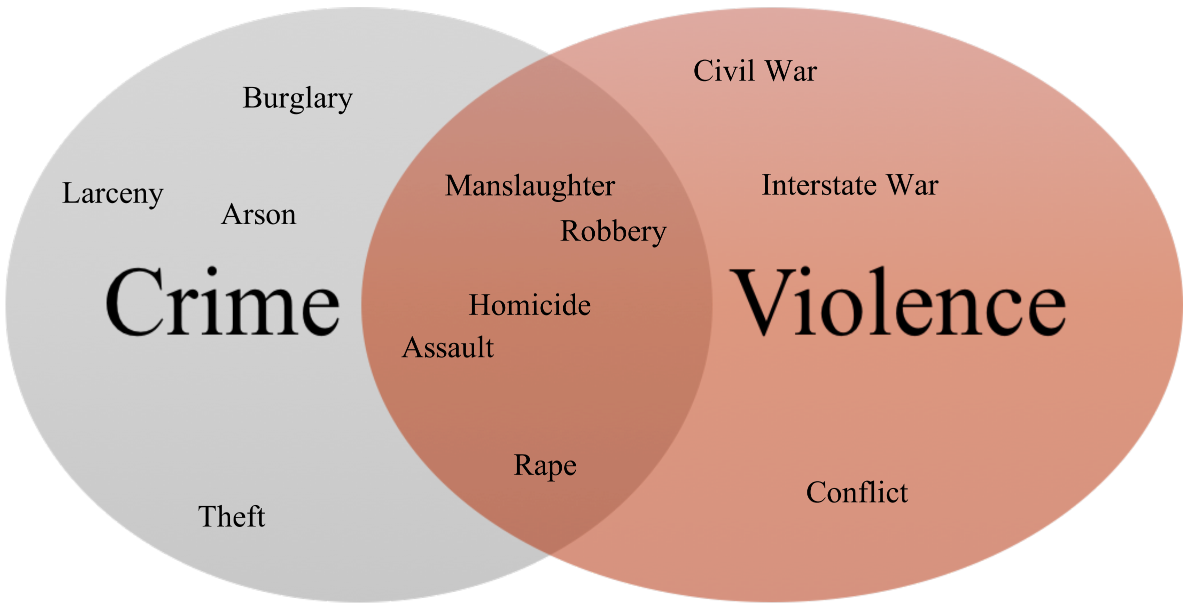
Crime can be divided into two main forms: property crimes and violent crimes[1]. Property crime includes burglary, larceny, theft and arson; hence all the forms of crime that do not intend, threat or use physical violence against the person and have the object of taking money or property (US Department of Justice 2016). Violent crime includes homicide, manslaughter, aggravated and simple assault, rape, sexual assault and robbery. These offenses involve the use or the threat of force. Among the violent crimes, there are two different types of violence involved: While some

[1] In criminology, two more forms of crime are to be distinguished, namely the white-collar crime and organized crime.

of the offenders want to harm the victim (e.g. assault, homicide), others do not care (e.g. robbery, rape) (Felson 2009).

Violence is defined by the WHO as "the intentional use of physical force or power, threatened or actual, against oneself, another person, or against a group or community, which either results in or has a high likelihood of resulting in injury, death, psychological harm, maldevelopment or deprivation" (WHO 2002, p. 5). Violence also appears in two main forms: collective violence, such as interstate wars and civil wars, and interpersonal violence, mostly between unorganized individuals, such as homicide (WHO 2002).

Figure A.1: Crime and Violence



Violent crime is situated in the intersection between crime and violence (see Figure A.1). Crime involves the breaking of rules, while violence is the "intentional harm-doing using physical means" (Felson 2009, p.24). Some violent acts are not crimes, which are for example violence in self-defense, violence exerted by government institutions such as police force or executions on death row in certain jurisdictions, and violence during war time. Since violent crime has a more severe impact on society than property crime, this thesis focuses on the determinants and interactions of violent crime.

Crime has always been present in human societies, and scholars have been attempting to explain the reasons behind crime occurrence for centuries. After the beginning of the 20th century, scholars from the disciplines of sociology and psychology started to study crime as a mainly psychological problem: Until the late 1960s, scholars were convinced that individuals that engage in criminal behavior are fundamentally different from “normal”, law abiding people (Cook et al. 2013). Delinquents, especially killers, were assumed to be “vicious, depraved or psychologically disturbed individual[s]” (Cook and Laub 2002, p. 14). An increase in criminal activity was therefore associated with an especially high prevalence of this anomalous type of human being (Cook and Laub 2001).

The economist Gary Becker revolutionized this notion of crime in 1968 by moving the focus away from the individual and towards contextual factors such as the social, economic and political environment that can impact crime incidence. He developed an economic rational choice model of crime that showed that a criminal activity can be a rationally optimal decision, depending on the individual’s preferences and the expected utility of crime. The utility is determined by the return of the crime, the probability and severity of punishment as well as opportunity costs such as foregone income, hence the contextual factors in the society (Becker 1968). Even though the preferences of potential criminals might be different from non-offenders, both groups equally react rationally to changing incentives. This notion had important implications for crime-prevention policies. One consequence is the possibility of deterrence: By increasing the severity or the probability of the punishment, the expected utility of crime is reduced and hence might be lower than the expected utility of legal options (Cook et al. 2013). Secondly, by altering the opportunity costs, for example by increasing the legal earning opportunities, it should be possible to divert potential delinquents from criminal behavior.

Apart from the economic theory of crime, other disciplines such as biology, sociology and criminology have developed new theories and explanations since the 1960s. Especially in the field of violent crime, these disciplines can offer a valuable amendment to the rational choice theory. Biology and psychology can explain violent and criminal behavior with genetic preconditions that result in impulsive behavior, attention deficit or lower levels of self-control, or with psychological disorders (Marsh and Melville 2006). While these explanations are helpful in the singular, individual case, they cannot explain why some societies are more violent than others. Sociological theories focus on the social circumstances that are conducive to criminal behavior. The strain theory by Robert Merton (1968) assumes that social blocks and obstacles make it impossible for some individuals to achieve the culturally defined goals (for example wealth), which creates strain and pushes these individuals into using illegal methods in order to succeed. The social disorganization theory refers to the inability of a community to maintain effective social controls due to residential instability and ethnic heterogeneity (Shaw and McKay 1942).

Finally, there are two theories that describe the development of crime over time or over the course of economic development. The modernization theory states that a transition from an agricultural to an industrial and the related division of labor weakens solidarity and the social norms that stabilized the society before the transition (Shelley 1981). After an initial upswing, crime is then expected to decline again. One of the most famous theories on crime and violence is the hypothesis of the civilizing process, first established by the German sociologist Norbert Elias in the 1930s and further developed by Eisner (2001) and Pinker (2011). These scholars assume that humanity is experiencing a dramatic change of the nature of human interaction regarding violence, sexual behavior and manners. The more sophisticated the division of labor becomes, the more dependent individuals are on each other, which makes it necessary to establish common rules, coordinate actions and adopt self-control. Physical force is monopolized by the government, resulting in a long term decrease of crime and violence. This theory might explain the long-term decline in violence experienced in Europe: A tenfold to fiftyfold decrease in homicide rates between the middle ages and 1900 (Pinker 2011). However, it cannot explain short term fluctuations in crime. All the mentioned theories of crime are summarized in Table A.1.

Table A.1: Overview Theories of Crime

Theory	**Determining Factors**
Economic Theory	Expected Utility of Crime
Biological and Psychological Theories	Genes, Psychological Disorders
Sociological Theories	
Strain Theory	Inequality, Social Barriers
Social Disorganization	Ethnic Heterogeneity, Residential Instability
Theories Describing the Development of Crime over Time	
Modernization Theory	Crime increases with Industrialization
Civilizing Process	Crime decreases in the Long-Run

The research presented in this thesis contributes to the explorations of long-term trends in violent crime using one of the most prominent and widely used indicators: homicide rates. Homicide is considered one of the most serious crimes since it involves the taking of a human life. Due to its severity and because the definition of homicide is relatively stable and unequivocal across cultures and time, homicide data are more accurate than those for other crimes such as robbery or rape (see van Zanden et al. 2014 and chapters B.2.2 and C.3.1 for more details). After this introduction to the concepts of crime, violence and violent crime and an overview over the existing theories, the following subchapter will introduce the structure of the thesis at hand.

A.3. Outline of the Thesis

This thesis comprises three chapters, of which some are intended for publication. Therefore, I refer to the chapters as papers or studies. Together, the studies aim to add to the literature on the determinants of crime and the interrelationship of crime with a potential determinant, the capital punishment.

The first aim of the studies is to identify determinants of crime by looking at specific contexts in which crime rates have been observed to be especially high. The first paper of the thesis presents a case study on the country of Mexico, a country that is notorious for its high prevalence of violence and crime. Especially in recent years Mexico has caught the attention of the international public due to its spectacular increase in murder rates. The paper reconstructs the development of crime back until the beginning of the 20^{th} century and then examines the driving forces behind this development. While looking at some of the general determinants that have been identified in a global framework as drivers of crime, the study also looks at factors that are specific to the Mexican case.

The second chapter, the result of a cooperation with my supervisor, Jörg Baten, shifts the focus away from the single country-case towards a worldwide perspective. Using a newly assembled global data set, the paper takes a look at the impact of valuable natural resources, a factor that has been known to increase the risk of collective violence such as interstate war and civil conflict. The paper shows that the presence of valuable silver resources can also be a main driver of violent crime, by altering the incentives in an economy.

Deterrence is the hypothesis that the threat of a severe punishment can decrease the expected utility of a crime substantially, which results in fewer crimes. While often used as anti-crime measure, the efficacy of deterrence has not been proven reliably. One fact that complicates the matter is that the relationship between crime and punishment is not clear-cut. Societies might react to changes in crime rates and adjust punishment accordingly, hence there is the potential of reverse causation. With the newly assembled data set and hand it was possible to model the complex interactions between homicide rates and the capital punishment and to test the deterrence hypothesis as well as the hypothesis that crime levels determine the severity of punishment. Finally, the concluding remarks in chapter E. summarize the joint findings of the studies and give an outlook on future research and potential policy implications.

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B. Explaining the Great Decline of Homicide Rates in 20th Century Mexico

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Abstract

Over the last decade, Mexico has gained notoriety for being extraordinarily violent. Since the alarming increase of homicide rates after the launch of the "war on drugs" in 2008, the Mexican case has received broad international media coverage as well as the attention of scholars, attempting to explain this unexpected development. Meanwhile, the origins of Mexican violence and the previous development of homicide rates remain largely unexplored. This paper has the goal to shed light on Mexico's past by reconstructing the homicide rates back until the 1930s. The data, compiled using information from statistical yearbooks of the National Archive, reveals an impressive decrease in violence levels from over 60 homicides per 100,000 in the 1930s to less than 10 in the year 2000. What caused this sustained decrease in violent crime? While the rapid economic growth during the Mexican Miracle, improved schooling and institutional quality certainly contributed to this development, they cannot explain it entirely. Other, less apparent factors must play a role and they are probably unique to the Mexican case. Did the improvement in the Mexican justice system deter crime? Or did the abolition of the death penalty lead to a less violent society? Did even the Pulque, the traditional Mexican alcohol beverage, have an impact?

B.1. Introduction

On the 13th of July of 1930, Luciano González Medina was drinking Pulque, the traditional Mexican alcoholic beverage in a bar in the center of Mexico City. After a disagreement, he ended up killing one of his companions with a pocket knife in the street just outside the bar. He was arrested by the police and sentenced to a six-year prison sentence (Cetina 2016). This case is nothing extraordinary, but rather typical for the Mexican society in the 1930s. According to Cetina (2016), violence in the public space was a day-to-day phenomenon. It characterized the entire Mexican history, at least until 1940, not only in the form of political violence and assassinations of political candidates, but also in generally high crime rates (Knight 1997). In most of the reports, the delinquents are reported to have been under the influence of alcohol, and many even claimed not to remember anything about the crime they committed due to their intoxicated state. Pulque, the traditional Mexican beverage that is made from the fermented sap of the agave, is mentioned especially often. Already in historical reports[2] authors complained about the detrimental impact of Pulque consumption on society, however, little is known about Mexico's experience with violence, and if factors like the Pulque consumption had an impact. Even after the outbreak of the "drug war" in the past decade, while Mexico has caught the attention of international media as well as the interest of scholars scrutinizing the recent events, hardly anyone has looked at Mexico's past. Apart from descriptive reports, crime data for Mexico for the period before 1990 had not been available.

This paper aims to fill this existing gap by shedding some light on the historic development of Mexico's crime rates. The first part of the paper presents recently collected data on homicide rates in Mexico and the data reveals that the recent outbreak of violence was

[2] Found in the Archivo General de la Nación, Fondo Tribunal Superior de Justicia del Distrito Federal, Expediente 343700.

preceded by an almost century-long decline. Up until the 2000s, crime rates have been steadily falling and Mexico seemed to be on a path towards political stability, low crime rates and sustained economic growth. The second part of the paper is dedicated to identifying the driving forces behind this century-long reduction in crime rates. After a review of the theoretical explanations that might potentially explain the striking decrease in violence, empirical tests are used to test the significance of single determinants. While the experience of rapid economic growth and improved education certainly impacted the development of the homicide rates, there must be additional factors. One possibility is the improved justice and police system, that might have had a deterrent effect on crime. Maybe even the Pulque, the alcoholic beverage mentioned often in the context of homicides did play a role in determining Mexico's crime rate.

The motivation behind understanding the underlying dynamics of crime is evident, since personal security is an important component of well-being (van Zanden et al. 2014). The detrimental impact of crime and violence on society has been well documented and seems to be especially high in the Latin American region (see for example Prillaman 2003/ van Zanden et al. 2014 for an overview). The negative consequences of crime and violence start with the intangible personal costs like the constant fear and strain experienced when living in an unsecure environment, followed by the grief and pain experienced after the loss of a family member or friend. On a macroeconomic level, high crime rates cause measurable direct costs: the expenses on prevention and deterrence like police work, correction and prosecution as well as the medical treatment of the victims (Anderson 1999). However, the costs of crime are not limited to these direct costs, since crime also has a detrimental effect even on the (legal) economic sector. Uncertainty and inefficiency created by high crime rates deter investment activity, tourism and reduce the competitiveness of local businesses, reducing overall economic activity (Detotto and Otranto 2010). Londoño and Guerrero (1999, p. 26) estimate that in the time from 1980 until

1995, the social costs of only the violent crimes were as high as 12.3 % of GDP in Mexico.

B.2. The Data Set: Crime in 20th Century Mexico

All throughout the 20th century, Mexico experienced what seemed to be an exemplary development towards macroeconomic stability and political order. After being torn apart by a violent revolution, the entire structure of the economy was changed by political and social reforms and direct economic forces (Reynolds 1970). Over the course of the century, "the national market has been unified, a third of the population has moved to the cities, the level of living has quadrupled and the economy […] achieved[d] one of the most rapid rates of growth in the hemisphere" (Reynolds 1970, p. 20). Up to now, little had been known about how the crime rates in Mexico responded to this "Mexican Miracle". While the homicide rate development of the recent decades after 2000 has received broad media coverage, the past remained unexplored. The newly collected data set at hand enables us to look for the first time at the long-term development of Mexican homicide rates, and it reveals that during the 20th century, the country experienced an impressive decline in violent crime rates: from 60 murders per 100,000 inhabitants in 1930 to less than 10 in 2000. The US murder rate was reduced in the same period by only 3, from 9 to 6 (Bureau of Justice Statistics 2015). Unfortunately, it is not possible to compare the reduction of crime to the experience of other Latin American countries, since there is no data available before 1960.

This section will give an overview over the Mexican historical political and economic context in which this striking fall of violence occurred. A short introduction of the concepts and definitions used to measure violent crime follows, before the data set is presented in descriptive statistics.

B.2.1. Historical Background Mexico

The time period covered in this study stretches from the end of the Mexican Revolution in up to the late 1980s. The Mexican Revolution started in 1910, ending the rule of Porfirio Díaz, who had been in power since 1877. His autocratic style government enforced law, order and discipline with a centralized system: It suppressed all kinds of violence and crime, using both the military and the federal police (Miller 1985). Under his rule, Mexico improved its infrastructure and Díaz encouraged the modernization of the economy as well as foreign investment in the country.

In 1910, oppositional groups led by Francisco Madero violently overthrew the Díaz regime. This revolution was followed by a ten-year civil war in which around 2 million Mexicans died. In 1917, a new constitution was established, weakening the property rights that had before been protected under Díaz and expropriations were not uncommon (Miller 1985). After the governance of two different presidents between 1920 and 1929, the Partido Revolucionario Institucional (PRI) was elected and remained in power until the year 2000 - during the entire period covered by this study (1930-1990). Even though the PRI was always elected and reelected in regular and free elections, the fact that one single party ruled the country during 70 years illustrates that Mexico cannot be characterized a fully democratized country during this period (Beer 2005, Greene 2007). The PRI was very powerful: it "held the majority in Congress until 1997, won every governorship until 1989 and controlled the vast majority of municipalities" (Greene 2007, p. 1). This one-party rule favored the emergence of close links between the government and criminal organizations and corruption was commonplace.

Economically, Mexico experienced a period of sustained economic growth and expansion after the revolution. During World War II, Mexico was a strong ally of the United States and provided metals as well as guest workers. This strengthened Mexico economically, establishing wealth and political stability throughout the country. The subsequent rapid economic progress has been titled the "Mexican Miracle" (Reynolds 1970). The PRI promoted a strategy mainly based on import substitution, oil exports and state-owned industrial companies. The population grew rapidly and urbanization advanced, the middle class almost doubled between 1940 and 1980 (Miller 1985). When oil prices fell in the 1980s, the country experienced a debt crisis that was counteracted by privatization of the economy and a renewed inflow of foreign investment. Today, Mexico's most important export source are the assembling plants known as maquiladoras that have been introduced by foreign investors in the 1980s. Beforehand, Mexico's most important income source had been agriculture, cultivating mainly wheat, soybeans, rice, beans, cotton, coffee, fruit, sugar, and tomatoes. Livestock farming was also prevalent. Mining, the extraction of minerals including silver, copper, gold, lead, zinc, and natural gas was an important factor as well (Miller 1985). In the 1990s, Mexico experienced another economic crisis with the collapse of the peso. In 2000 Vicente Fox was elected president and Mexico experienced the first democratic transition to a president from a different party after a 70-year rule of the PRI.

A summary of Mexico's historic development would be incomplete without mentioning drug trafficking and corruption. Crime, drugs and corruption have a long standing and intertwined history in Mexico (Morris 2012). According to Lupsha (1991, p. 41) it is "impossible to identify a beginning date for corruption in Mexico, for it is as eternal as the Aztec sun". From the beginning of the 20th century, Mexico was a country of contraband of semi-legal products such as patent drugs, alcohol and marihuana flowing north from the Central American countries. During the prohibition between 1919 and 1933 in the US, Mexico was the main supplier of illicit alcohol (Watt 2012); smuggling routes were established and illegal contraband organizations were formed.

After the Mexican revolution, the central government was worried about turmoil and instability in the regions and therefore gave the states quasi-autonomous powers to deal with this threat on their own. Especially the northern states were cut-off from the central government, allowing their governors to abuse their position to make a fortune from prostitution, gambling and smuggling contraband to the US. The US Border Patrol was installed in 1924, but it resulted impossible to efficiently police the massive border that cuts through mainly remote terrain between Mexico and the US (Watt 2012). Smugglers benefited from the corruption within the police force and the political system and used the vast number of poor citizens with no legal alternatives as cheap labor force. Corruption was already a socially perceived problem in the 1940s, which led Mexican presidents to promote “anti-corruption campaigns”, making the public believe that corruption is an “individual problem of certain officials rather than a systematic problem” (Morris 1991, p. 78). Under this shield of public deception, organized crime collaborated with officials ever since the beginning of the century.

Opium poppy was introduced to Mexico in the 1930s. The Mexican favorable mild climate, allows farmers to get two harvests per year instead of one which makes opium poppy cultivation a very profitable alternative, especially compared to legal crops. Nevertheless, up until the 1970s, Mexico was mainly a transit country for Colombian cocaine. Several families from Sinaloa engaged in moving the large amounts of cocaine they received from Colombian and other Central American traffickers to the US. Culiacan, a city in the state of Sinaloa, became the capital of the Mexican drug trade. The famous Sinaloa Cartel and its head Felix Gallardo were based in the city. Later, due to conflicts with the state, the activities were shifted to Guadalajara in Jalisco (Osorno 2011). The Colombian Cartels continued to be in control of the drug trade until 1981, when Reagan became president of the US and started a major crack-down in Florida, the Caribbean and Colombia. While the international community was focusing on the Colombian Cartels, the Mexican drug traffickers seized the opportunity (Quince and Phillips, 2014) and took control of the Inter-American cocaine and heroin market. After this transition, heroin was still produced in Colombia, however, now Mexican Cartels were in control, organized transport and sales and reaped the profits. The high profitability of the drug trade increased the ability of the Mexican drug cartels to buy protection from the state as well as weapons, technique and training (Piccato 2012). Today, Mexico is said to be the world's second largest opium poppy producer after Afghanistan, and the primary supplier of heroin to the United States (Office of National Drug Policy, 2015). The presence of illegal drug business is inevitably connected to the presence of violent crime. In illegal sectors, there is no enforcement of laws or property rights by governmental institutions, hence violence is used as a substitute. The following section introduces the topic of violent crime, the definitions and concepts related as well as the variables used to measure violent crime in this study.

B.2.2. Crime: Forms and Measurement

Crime has been present across all cultures and periods of human history and almost every person is victim of a bigger or smaller offense at least once in life. Crime appears in a variety of forms that can be divided into two major categories: offenses against the person, also known as violent crime, (homicide, assault, robbery, kidnapping or sexual assault) and offenses against property (theft, robbery, burglary, fraud, forgery, etc.).

Regarding the social cost of crimes, violent crime has the most detrimental overall impact on society (Prillaman 2003). It does not only slow down economic development but also undermines the strength and credibility of democracy and its institutions. When violent crime rates are extraordinarily high, voters turn to extremist and populist candidates that promise a "hard hand" against crime. Many times, these anti-crime strategies also involve the military (as in the case of Mexico's recent drug war) and citizens might engage in vigilante justice and mob lynching, which weakens the monopoly on the use of force by the state. In many Latin American countries, private security forces outnumber the police force (Prillaman 2003). Jointly, these factors lead to the fading of public faith in democratic institutions, courts and the police force and ultimately weaken democracy.

In the literature, homicide rates are the most prevalent proxy of violent crime or even of overall crime rates (Neapolitan 1997, Nivette 2011, Fajnzylber et al. 2002). A homicide is defined as “unlawful death deliberately inflicted on one person by another person” (OECD, 2011) per 100,000 people. This study also uses homicide rates as proxy for violent crime in Mexico.

Data on crime of “notoriously poor” quality, since crime is inherently clandestine and difficult to measure (Prillaman 2003, p. 4). The biggest drawback is the problem of underreporting (Fajnzylber et al. 2000). The victim might not report the crime, which happens mostly in the case of minor offenses or in cases of domestic violence and rape. A change in a crime rate could always reflect a change in the information-gathering technique, the reporting behavior of the society, corruption or the way crime records are aggregated. Another source of bias is that government agencies or police officials especially in less democratic countries tend to artificially lower crime rates to mask their inability to cope with crime.

Homicide rates, however, are least affected by underreporting and measurement error: First, the definition of murder is very clear cut and stable over time and across cultures and legal systems, which is especially important in studies including a variety of countries or a large time horizon (van Zanden et al. 2014). Since the scope of this study is Mexican regions, definitions of homicide do not vary substantially across observational units. Secondly, homicides are drastic events that are most likely reported and recorded. Soares (2004) finds that underreporting is severe for property crimes and for crimes with social stigma such as rape. In the case of homicide however, measurement error is not substantial (Levitt 1995b). These factors make homicide rates a superior crime indicator that is less affected by measurement error than other crime indicators (OECD 2011, Neapolitan 1997, Fajnzylber et al. 2000, Fox and Zawitz 2000).

Secondly, the data used was assembled by health authorities that obtained the information from hospitals and morticians. The authors of these sources were physicians and medics or undertakers that were concerned about the sanitary causes of death such as infectious diseases. Hence, they had no direct incentive to artificially reduce crime rates, as would for example police officials, politicians or personnel of the judicial branch. Van Zanden et al. (2014) confirm that health statistics are a lot less likely to underestimate the actual number of homicides than for example criminal records and police statistics. Using data from health authorities further reduces the probability of underreporting.

Another advantage of this analysis is the fact that the scope of the data is limited to the Mexican regions and the focus is on the variation between the states and over time, not the level of the homicide rates. Within this extent, reporting behavior can be assumed to be similar across states and constant over time. The portion of the reporting bias that stable over time in one state is captured by the state fixed effect introduced in the empirical analysis. Even though single, specific numbers might not be flawless, the analysis of trends and changes is possible without the risk of severe bias.

B.2.3. Descriptive Statistics

Up to now, historical data on crime in Mexico went back only until 1990, except for homicide data on the Federal District that was presented by Piccato (2013). The data used in this section is completely new and reveals the overall development of the homicide rate in Mexico over the course of the 20th century for each of the 32 Mexican regions for the years between 1930 and 1988. The data set was compiled using statistical yearbooks found in the Archive of the National Institute of Statistics and Geography (INEGI) in Mexico City (see appendix B.9.1 for further details on the data sources).

Figure B.1 presents the annual homicide rate for Mexico from 1935 until 2005. The massive decline from a very high level of more than 60 homicides per 100,000 inhabitants in 1935 to around 15 in the 1970s is striking. This consistent, downward trend of at least 30 years coincides with the period of political stability and economic growth that began in the 1940s, triggered by the increased foreign demand for Mexican exports during World War II. In the 1970s, the homicide rate stabilizes at a level of around 17 to 20 homicides per 100,000 until around 1990. During this period, the economic growth in Mexico slowed down. After 1990 the homicide rates experience another drop that lasts for around 15 years, until 2005. The recent increase of homicide rates in the 2010 during Mexico's drug war is not part of this study, and therefore not pictured in this graph. To sum up, the development can be divided into three phases: A 30-year sustained decline from the 1930s until the 1970s, a period of stabilization between 1970 and 1990, followed by another drop after that. Since the development of homicide rates mirrors the economic situation of the country, one could jump to the conclusion that the improvement of the overall living conditions reduced the incentives to commit violent crime. This is one of the hypothesis that will be empirically tested in the subsequent analysis.

Looking at the development of the homicide rates in the single states shows that most of the 32 states mirror the trend visible for entire Mexico. They experience a long and sustained decrease over the first 30 years, with homicide rates moving almost parallel. This suggests that important factors on the national level affected the homicide rates in all the states, a fact that needs to be taken into account when estimating an empirical econometric model. After the 1970s, the homicide rate stabilizes or increases again.

Some exceptions to this general rule are for example the two parts of Baja California (North and South), where the homicide rates follow a different pattern (Figure B.2). In the Northern part, the homicide rate drops already at the beginning of the period and then remains relatively stable over time until increasing again in the 1980s. In the Southern part, the overall level does not change over time. In Aguascalientes (Figure B.3), the homicide rate does not follow a decreasing trend but rather remains on one level from 1940 to 1960, then drops rapidly to a lower level.

Some states that display an especially high homicide rate are Colima and Morelos, two of the smallest states both in terms of area and population. In both states, homicide rates started on a very high level in the 1930s (well over 100 homicides per 100,000 inhabitants), but then rapidly decreased and reached the level of the rest of Mexico in the 1970s (Figure B.4). This particular pattern could partly be caused by measurement error in the earlier periods, since in these states with a very small population, a small overstatement of the absolute number of homicides results in a very high value of the homicide rate. Other states that display a persistently high homicide rate are Guerrero, Michoacán and Oaxaca (Figure B.5). These three pacific states also represent the states with the highest mean homicide rate in the period contemplated, and they are some of the states with the lowest income levels. Even though the level of the homicide is higher than in the rest of Mexico throughout, they follow a similar pattern of decrease until 1970 followed by a stable phase until 1990 and another decline.

For Mexico City, the longest time period of homicide rate data is available. There are some data points for the 1880s, displaying a level between 20 and 30 homicide rates per 100,000. In the 1920s, the homicide rate then increased slightly, however fell back to the previous level by 1930. After another wave of increase violence, the homicide rate in the Federal district enters a sustained decline until the end of the 1970s, when it starts increase again. On average, the homicide rate in the capital is not higher than in the remaining states, as is for example in other Latin American countries such as Venezuela or Colombia.

Figure B.7 presents the average homicide rates per state in the period from 1930 to 1990. Surprisingly, the northern states that have direct contact to the US-border (Baja California Norte, Sonora, Chihuahua, Coahuila, Nuevo Leon and Tamaulipas) and are the focus of the smuggling and drug trafficking business, experienced on average a very low homicide rate during the contemplated period (less than 20 homicides per 100,000). The same can be observed for the southern periphery (Tabasco, Campeche, Yucatán and Quintana Roo).

While the smuggling and trafficking takes place in the states neighboring the US, the production of the drugs is said to be situated in the so called "Golden Triangle" formed by the sates of Sinaloa, Durango and Chihuahua (Vinson 2009). These three states are known to be the major heroin and marijuana producers today; however, these states did not experience extraordinarily high homicide rates during the 20th century.

Comparing the development of the homicide rates in the Golden Triangle to the rest of Mexico (Figure B.8), it is evident that for the most part of the century, the developments are parallel and not too different in levels. In the "Golden Triangle" states, the homicide rate started on a higher level in the 1940s, decreased rapidly and then stayed below the level of the rest of Mexico up until 1960. Afterwards, the homicide rate in the Golden Triangle states experiences several waves of short increases and decreases, while the rate in the rest of Mexico remains stable. This development coincides with the rise of the Sinaloa cartel in the 1970s and the start of the drug business in the Triangle states. At the end of the 70s, due to the antidrug campaign, activity of drug cartels was slightly suppressed; they recovered however in the 1980s. The development of the homicide rates seems to mirror the activity level of the drug cartels and the counter-activities of the government.

Figure B.9 to Figure B.12 plot the temporal development of the homicide rates. While in 1930, a high homicide rate (>40 homicides per 100,000) was prevalent in almost all Mexican states, in 1950 most of the Northern states were already able to decrease the homicide rates in their territories. Homicide rates remained high in the pacific and southern states and the center of

Mexico. By 1970, Guerrero was the only state left with a homicide rate higher than 40, however homicide rates remained high in most of the southern pacific states. In 1990, Oaxaca was the only state with a homicide rate higher than 40, but Sinaloa, Durango, Michoacán, Guerrero and the central states still display a medium high rate. This pattern underlines the counterintuitive fact, that those states expected to be most violent due to drug production and trafficking consistently display the lowest homicide rates.

This illustrates that while some of the patterns visible in the descriptive analysis can be related to events and developments in Mexican history, others are completely unexpected and need further empirical exploration. On the one hand, the long and sustained decline from levels of over 60 homicides per 100,00 at the beginning of the 20th century to levels of around 10 homicides per 100,000 by the year 2000 has certainly been fostered by the Mexican Miracle, the improvement is schooling and the overall increase in living standards. Likewise, the homicide rate development in some of the states known for drug trafficking can also be related to historical facts about the emergence of drug cartels and the government counteractions. On the other hand, the especially high homicide rates in the pacific states (Michoacán, Guerrero, Oaxaca) are not as easily explained, just as the low levels of the southern periphery (Yucatán, Quintana Roo, Campeche). The following chapter will turn to economic and sociological theory to find potential explanations for these differences in levels and trends.

For the subsequent empirical analysis of the homicide development in 20th century Mexico it is important to keep in mind two things that were evident in the descriptive analysis: First, it will be necessary to estimate the model including state-fixed effects in order to capture the differences in the level of homicide rates that are persistent over time and caused by time-invariant characteristics of each state. Secondly, there is considerable correlation between the homicide rate trends in the different states, which implies the existence of cross-sectional correlation. Since the data includes all 32 states of the same country, it is plausible to expect that there exist common shocks that affect all states equally, as for example national policy measures, economic crises or interrelations due to interactions between states.

B.3. Theories of Crime in the Mexican Context

The causes of crime are multidimensional and intertwined. Over the course of the past century, a variety of theories from the fields of biology, psychology, sociology and economics have been developed, attempting to explain crime incidence. In search of potential causes, this section reviews the major theories of crime and discusses their implications for the Mexican case. The economic theory as well as sociological concepts offer potential factors that can have an impact on crime rates. In the unique case of Mexico, the consumption of alcohol and the presence of drug cartels needs to be considered as well.

B.3.1. The Economic Theory of Crime

Regarding crime theories, one can distinguish between theories that focus on the individual perpetrator and theories, that focus on the society and the conditions surrounding the perpetrators. Up until the late 1960s, sociologists and psychologists tried to explain crime incidence by focusing on the character of the individual perpetrator (Cook et al. 2013). Criminals were assumed to be fundamentally different from a "normal", law abiding person. Delinquents, especially killers, were said to be "vicious, depraved or psychologically disturbed individual[s]" (Cook and Laub 2001, p. 14). An increase in criminal activity was therefore explained by an (exogenous) increase in the prevalence of these anomalous individuals (Cook and Laub 2001; Bennett, DiIulio and Walters 1996).

In 1968, Gary Becker revolutionized this view of criminality when presenting an economic approach to crime, shifting the focus away from the time-stable characteristics of the criminal individual towards the situational factors such as the social, economic and political conditions in which crime occurred. He applied the economic rational choice model to the context of criminal activity, pointing out that crime is an option open to everyone and that it can be a rational choice under certain circumstances. An individual is most likely to choose the criminal behavioral option if the expected return of the crime exceeds the return from his legal earning opportunities, even when taking into account the likelihood of apprehension and conviction and the severity of the punishment (Becker 1968).

While certain aspects of the human character, the individual preferences do play a role when explaining criminal behavior, the focus of Becker's theory is on the circumstances that determine the expected return from crime (Eide, Rubin and Shepherd 2006; Cook et al. 2013). The circumstantial factors defining the utility of a crime can be summarized in three groups:

1) Factors that increase or decrease the costs of committing the crime (direct and indirect costs)
2) Factors that determine the revenue generated by the crime
3) Factors that determine the probability of apprehension and the severity of the punishment

The first group of factors, the overall costs of crime, consist of the direct and indirect costs. Direct costs are for example the actual work the delinquent must put in to commit the crime and potentially the costs of supplies necessary for the criminal act. The second part are indirect costs, such as for example opportunity costs. These are mainly defined by the employment status, income level (e.g. wages, education) and/or existing wealth (e.g. consumption). While the direct costs of the crime can be slightly increased by implementing preventive and security measures, it is much more effective to increase the opportunity costs of a crime. The economic theory predicts that an increase in opportunity costs, as for example by improving the legal earning opportunities, would translate into a lower crime rate. This could be done via the general income level or wages (GDP, real wages), a reduction of unemployment or by higher education, which improves the earning opportunities of the individual in the legal sector. Several studies have shown that these implications are valid and can be observed empirically (Trumbull 1989, Machin and Meghir 2000). The employment status has been shown to be of less importance (Ehrlich 1973 and Freeman 1999), even though there seems to be a significant and positive relation between unemployment and crime. What seems to be a very important factor is education. On the individual level, there is a significant negative effect of education on crime (Witte and Tauchen 1994).

In Mexico, the general income level has grown at an average rate of 2% from 1940 until 1995 (see Figure B.13), triplicating the income in this period (Esquivel 1999), which could be one of the factors contributing to the falling crime rate. As legal income sources improved, individuals did not turn to criminal behavior to generate income. Regarding the cross-sectional distribution of income, it is striking that some of the poorest states in the country also display the highest homicide rates (Oaxaca, Michoacán, Guerrero), while the Northern states that experienced lower homicide rates have higher income levels. This negative correlation might help to explain the extraordinarily high homicide rates in the Southern states.

In the field of education, Mexico made fundamental improvements in the contemplated period. The constitution of 1917 stipulated compulsory, free basic education. Consequently, the number of schools as well as the number of enrolled students increased rapidly. In 1930, there were only around 11,000 primary schools in Mexico, but this number had already doubled by 1940 (Alvarez Mendiola 1994). Even though the educational system was mainly controlled by the central government, the disparities across regions were still very high. Access to schooling was easier for the urban population, whereas the rural and indigenous population was mainly neglected.

After World War II, the government put additional focus on the education of the indigenous and rural population and the reduction of illiteracy (Alvarez Mendiola 1994). Education continued to improve and these achievements are clearly visible in the data. For example, the percentage of the school-age population not receiving education has been reduced significantly from 36 % in 1970 to only 13% by 1990. The illiteracy rate fell from around 45% in the 1920s to 10% in the 1980s (see Figure B.14). However, it is important to note the striking differences among states – especially the southern periphery was still lagging behind in 1990. For example, in Chiapas, in 1950 only 35% of the total population was able to read and write, in 1990 it was already 70% - a level clearly lower than the national average of 90%. In the framework of Becker's crime theory, these improvements in education and living standards are expected to promote a reduction in crime rates, since the opportunity costs of potential delinquents all over the country have been improved. Piccato (2013) already observed that crime rates and literacy rates were negatively correlated in Mexico in the 20th century.

The second group of factors in Becker's model consists of the aspects related to the potential revenue generated by a crime. Most importantly, the income level could also play a role here. The higher the overall income level, the higher the value of the pickings from an assault against a random individual or a robbing of a random home. Hence, increasing income does not only increase the opportunity costs for potential delinquents but also increases the potential revenue obtained from a crime. The direction of the impact of income levels on crime is therefore ambiguous.

In the last decade, another aspect of Becker's crime model has caught the attention of researchers: the effect of inequality. In unequal societies, the high income differential makes criminal activity especially attractive for individuals at the bottom end of the income distribution since it combines high expected revenue from crime directed against the wealthier part of society with low opportunity costs. Numerous studies have shown a robust positive link between inequality and crime incidence (see for example Machin and Meghir 2000, Ehrlich 1973; Demombynes and Özler 2002; Chiu and Madden 1998, Bourguignon 1999, Hsieh and Pugh 1993). In Latin American countries both crime rates and inequality are high, which is why many blame high inequality as driving force behind crime rates. On the other hand, higher inequality could also be linked to lower crime rates, when including the possibility of protection against crime into the model. Wealthy individuals living in an unequal society will spend high sums on private protection from crime that can range from a simple guard dog or bars on the windows to electric fences, alarms systems and armed private security companies that offer police services. This implies that in an unequal society, it is incredibly hard if not impossible for a person from the poorer part of society to steal from a wealthy individual. Consequently, "increasing inequality can actually lead to less crime if […] richer people spend a higher proportion of their income on protection (i.e. protection is a superior good)" as in the model developed by Heufer (2011).

In Mexico, cross-regional inequality is substantially more pronounced than intra-regional inequality (Moreno Brid and Ros 2009). For example, in 1940, the per capita income in the Federal District was almost 10 times as high as in the poorest state, Oaxaca (Esquivel 1999, p.13). In 1995, this coefficient had been reduced to 5.4, but these interregional disparities are still very pronounced in international comparison (for example in Colombia 3.3, USA 1.2) (Esquivel 1999). Esquivel also describes that there is some rigidity among states, such that in the period from 1940 to 1995, the poorest states remained poor and the states at the top part of the income distribution also managed to stay there. All throughout this time period, the capital states (Federal District and Mexico State) as well as the Northern states have been at the top of the income distribution, whereas the states in the south (Chiapas, Guerrero, Michoacan and Oaxaca) have maintained their position at the bottom. Esquivel (1999) identifies the unequal access to education as one of the most important reasons behind these cross-regional disparities. When it comes to intra-regional income inequality, there is no reliable data available for Mexico. Several sources suggest that inequality was falling at least until the 1980s. Hanson and Harrison (1999) for example calculate the ratio of white-collar to blue-collar wages in Mexican manufacturing plants and show that the wage gap was steadily falling until 1985. Felix (1977) however claims that income inequality in Mexico was rising from 1940 until 1975. Moreno Brid and Ros (2009) emphasize that intra-regional inequality is linked to urbanization, as rural areas lag behind the industrialized cities.

With the newly collected data, it was possible to construct an alternative inequality indicator, using the ratio of the minimum wage to GDP per worker hour, both measured in 1995 Mexican pesos:

$$Inequality = 1 - \frac{real\ minimum\ wage\ (unskilled)}{GDP\ per\ worker\ hour}$$

The higher the inequality, the lower the ratio between the real minimum wage of an unskilled laborer and the average wage, represented by the GDP per worker hour. The ratio moves between 0 and 1, since the minimum wage is never higher than the GDP per worker hour. To be able to interpret the ratio as an indicator of inequality, it was subtracted from 1, so that an increase in the indicator now represents an increase in inequality.

The development of this inequality indicator (Figure B.15) suggests that inequality has increased throughout the 20th century. This means that the average income (GDP per worker hour) has increased faster than the minimum wage. Interestingly, inequality increased mainly between 1930 and 1940 and stayed the same afterwards. The empirical analysis will show if the inequality can help to explain the trajectory of the homicide rates.

B.3.2. The Deterrent Effect of Punishment

The third implication from Becker's theory of crime, the possibility of deterrence, is a long debated idea. Since the potential criminals are assumed to respond rationally to a change in the return from crime, crime rates could be reduced using an aggravation of the potential punishment and/or a higher probability to be caught (Cook et al. 2013), according to the theory. Deterrence has two dimensions, first, the probability of getting punished and secondly the severity of the punishment. The severity of the punishment is mainly determined by the legal system and the jurisdiction, whereas the probability of the punishment is determined by the efficiency of the legal system and the police force.

In Mexico, the legal system has its roots in the Colonial law of the 16th century but was reformed by the 1917 constitution which was the main source of Mexican law for the remaining of the 20th century (Reynolds 1970). The Judicial Power is vested in the Supreme Court, but every state has its own state supreme court that applies the state laws. On the state level, there are also courts of first instance which are the ones dealing with cases of the "common law" (fuero común), the kind of offenses that only affect the victim of the act directly, such as robbery, theft, rape, bodily injury and most importantly homicide (Procuraduría General de la República 2011).

One proxy that can gauge the severity of the punishment and has been used in previous studies is the death penalty, since it is "assumed to be an indicator of the overall severity of [the] legislation regarding the punishment of offenders" (Fajnzylber et al. 2000, p. 249). If the death penalty has a deterrent effect is however widely debated. Ehrlich (1975) for example shows that the death penalty has a major impact on crime rates, while others found no evidence for deterrence (Donohue and Wolfers 2006, Mathieson and Passell 1976, Levitt 1995a and 1997).

In Mexico, the death penalty has been abolished by each state independently in the period between 1924 (Michoacán) and 1975 (Sonora) (Gonzalez Mariscal 2011). This variation can be used to examine if the abolition of the death penalty had an impact on homicide rates. One problem with measures of severity of the punishment is that they might suffer from endogeneity, since the severity of the punishment can react to the development of the country's crime rate. Countries with higher crime rates also tend to have tougher legislation, whereas states with low crime rates might abolish the death penalty first. Hence, observing a positive coefficient of the death penalty might be caused by endogeneity.

The second dimension of the deterrence apart from the severity of the punishment is the probability of receiving the intended punishment after committing a crime. Even the most severe punishment will not have any deterrent effect if it is not enforced. Proxies that capture the probability of getting punished are for example indicators of efficiency of the police force and the jurisdiction system, such as the clear-up rate. In Mexico, the probability of punishment seems to be unbelievably low: Per Cascante (2013), around 98.2% of all killings went unpunished in 2012.

The newly assembled data set contains information about the number of persons accused of homicide as well as the number of convictions for homicide. Figure B.16 compares the development of these to the homicide rate, each indicator measured as rate per 100,000. In 1940, the first year for which all three variables are available, a big gap between the number of homicides, the number of persons accused and the number of persons convicted is noticeable. There are more than 60 homicides per 100,000 inhabitants, however there were only around 33 persons accused of homicide and only 14 convicted. This translates in a probability of punishment of only around 23%. The clear majority of murderers never had to face punishment. Over the course of the century, the three rates converged significantly, reaching almost the same level in the 1970s (17 homicides and 12 sentenced) and hence a clear-up rate of 70%. While homicide rates remained stable in the 1970s and 1980s, the number of people accused and sentenced continues to decrease. This insinuates that these additional murderers successfully evaded punishment. It is possible that the violence emerging in these decades was mainly drug related, hence inflicted by illegal organizations that were successfully evading apprehension, mainly through corruption. Due to this impunity, the gap between the number of homicides and people convicted for murder widened again until 1988 (17 homicides vs. 7 sentenced), reaching again a lower clear-up rate of only 40%, however this value is still far away from the abovementioned clear-up rate of only 1.8% in 2012.

The presence of widespread impunity weakens the public trust in legal institutions and consequently their deterrent ability. Owens (2013) shows that the main impact of police on crime is through deterrence and not through the actual detention of criminals. If the probability of punishment is very low however, then the police force loses this deterrent function, which might be the case in Mexico. Hence it is not clear, if it is possible to find a deterrent effect of the legal institutions or the death penalty. The empirical analysis will show, if any of the two dimensions of the deterrent effect, the severity of the punishment as well as the probability of receiving the punishment, did significantly reduce the homicide rate in 20^{th} century Mexico.

Since the 1960s, the results of numerous studies have supported Becker's theory and shown that crime is indeed determined by the economic conditions such as income levels, education, inequality and deterrent factors, and probably not as much by the individual's character (for example Cook and Laub 1998; Eide, Rubin, Shepherd 2006; Dezhbakhsh et al. 2003). These mechanisms have been proven especially in the field of property crimes. In the field of violent crime however, especially for severe crimes like rape, homicide and hate crimes, the "rational choice theory" is sometimes not sufficient to explain crime incidence. Sociological theories offer some additional insights using more a wider range of potential influence factors.

B.3.3. Sociological Theories

One of the most influential sociological theories on crime is the strain theory developed by Robert Merton in 1938. If social obstacles make it impossible for certain individuals to achieve a culturally defined goal (such as wealth for example), the strain experienced by these individuals pushes them into using illegal methods to succeed, since the importance of the goal might outshine the means (Merton 1968). Even though plausible, this theory is especially difficult to test, since strain is a quite subjective concept that is hard to measure. One example for an empirical study can be found in Agnew and White (1992) who used questionnaire data of US adolescents to test the impact of strain on delinquency and found significant results. General inequality has also been used to capture at least part of the strain levels experienced by the poorer part of society. For example, Kelly (2000) finds that inequality has an important impact on violent crime, whereas it does not influence property crimes. This would indicate that inequality impacts crime rather through the strain-channel than through the higher payoff channel suggested by Becker.

Another theory focusing on the social environment as key determinant of crime is the social disorganization theory. Social disorganization is defined as “the inability of a community structure to realize the common values of its residents and maintain effective social controls” (Sampson and Groves 1989, p. 777). In their classic work, Shaw and McKay (1942) found that the three structural factors low economic status, ethnic heterogeneity and residential instability weaken the social bonds within a community, which encourages more individuals to choose illegal alternatives.

In the case of Mexico, the population is made up of two main ethnical groups: the descendants of Spanish immigrants and the indigenous population. This fractionalization of the society could impact the homicide rates, hence it might be illustrative to control for the presence of each ethnic group as well as a to introduce a measure of ethnic fractionalization, when explaining the variation in homicide rates. The share of indigenous population in total decreased over the 20th century, starting at 6% in the 1930s and reaching only 2% by 1988. The variation between states is however much more pronounced. The lowest shares are found in the central and northern states such as Aguascalientes, Guanajuato, Chihuahua and Baja California (<1%). The Southern periphery states are then ones with the highest shares of indigenous population as for example Oaxaca (17%), Quintana Roo (10%), Chiapas (12%) and Yucatán (13%).

Another proxy that partly captures the trust, norms and networks present in a society is religion. Freeman (1999) found a strong relation between church attendance and arrest probability. In Mexico, the predominant religion is Catholicism, and the percentage of population reported to be catholic has always been above 90%, it increased slightly during the 1940s and 1950s, reaching almost 99%, but decreased again afterwards down to 90% in 1988. Other religions present in Mexico are Protestantism and indigenous religions. Among the states with the lowest share of Catholics are the southern states Chiapas (90%), Quintana Roo (86%) and Tabasco (87%).

The phenomenon of residential instability is equally hard to measure; however, it might be related to the pace of urbanization. Already in the 19th century, Emile Durkheim realized that during the transition from an agricultural to an industrial economy, the increasing division of labor, urbanization and residential unsteadiness weaken the social bonds and norms that in a rural society traditionally help to restrict criminal behavior. The consequence of this was an increase of crime in Europe during industrialization (Rogers 1989; Clinard and Abbott 1973).

Also in Latin America, it has been found that crime is mainly an urban phenomenon (except for Columbia, Prillaman 2003). Urbanization also could reduce the direct costs of criminal behavior, since “a large degree of urbanization can facilitate the development of social interactions between criminals and would-be criminals" (Fajnzylber et al. 2000, p. 252). Several studies found a significant impact of urbanization and population density on property crime, however not on homicide (Fajnzylber et al. 2000, Gaviria and Pages 2002, Glaeser and Sacerdote 1996).

For the case of Mexico, high homicide rates seem to be a rather rural phenomenon, just as in Colombia. The correlation between urbanization and homicide rates is -0.54 and significant at all commonly used significance levels, indicating that states with higher urbanization display on average a lower homicide rate. Mexico experienced a rapid urbanization during the 20th century. In the 1930s, only 30% of the Mexican population lived in cities; however, this number increased rapidly over the course of the century, reaching 61% in the 1980s. The state with the highest urbanization rate is the capital, Mexico City, with 95%, followed by Aguascalientes (60%), Baja California Norte (65%) and Nuevo León (63%). Among the most rural states are the Pacific states Guerrero (26%), Oaxaca (23%), e.g. two of the states with the highest mean homicide rates.

Norbert Elias (1939) stated that as a country develops, it experiences a "civilizing process" which includes a dramatic change of the forms of human interaction, for example in the fields of violence, sexual behavior and customs. The more specialized the division of labor, the more dependent the individuals are on each other, what makes it necessary to establish common rules, exert self-control and coordinate actions. Physical force is monopolized by the government, which results in a long term decrease of crime and violence (Eisner 2001, Pinker 2011). Here, the size of the public sector might play a role, since a bigger government might be able to more efficiently control and punish criminal behavior. Also, an increase in education might change how individuals deal with strain and frustration, leading to lower violence among them.

Cultural aspects in general have also been suspected to cause especially high or low crime rates. In Japan, the "shame culture" seems to be the reason why the country modernized relatively crime free (Leonardsen, 2004). Contrarily, in Latin America, the "cultural values conducive to violence [that] have evolved out of the history of colonization and subjugation" have been blamed for causing the high homicide rates throughout the continent (Neapolitan 1994, p. 4). As for most of the sociological factors that might impact homicide rates, it is hard to find proxies, especially when contemplating historical data. In the subsequent analysis, indicators of strain, social disorganization and the civilizing process include inequality, education, ethnic heterogeneity, religion, population density, urbanization and the share of workers employed in the agricultural sector.

B.3.4. Alcohol Consumption and its Impact on Violent Behavior

Cetina (2016) examines crime in post-revolutionary Mexico City between 1920 and 1940 and he emphasizes that one of the most common crimes between 1920 and 1940 was the "homicidio en riña", a homicide induced by quarrel, which typically occurred between two males in the surroundings of canteens, pulquerías or bars (Cetina 2016, p. 156). In these spaces of "masculine encounters", quarrels and disputes due to rivalries, offenses against the honor and these disputes often escalated into open violence. The persons included in the quarrels were often acquaintances that lived in the same neighborhood or visited the same pulquería. Just as in a Wild West movie, people challenged each other to duels, that often ended with death (Cetina 2016). In most of these events, the delinquents and their victims were under the influence of alcohol, and afterwards claimed that they could not remember anything, due to their drunkenness (p. 161).

Already in the statistical yearbook of Mexico City of the year 1899 (found in the National Archive of Mexico), reports of drunken violence can be found. The (unknown) author describes that the reason for most of the violent crimes can be found in the consumption of alcoholic beverages. A cheap price combined with a growing number of bars and canteens (expendios de alcohol) is responsible for the offense against the person, in the opinion of the author. Over five pages, he describes how alcohol stimulates the temperament of the drinkers, awakens the instincts and reveals the individual wishes and passions. These illustrations show that alcohol consumption might have been a serious problem in 20^{th} century Mexico, which in turn increased the incidence of homicides. The effect of alcohol consumption on violence has already been shown in other contexts. Mehlum et al. (2006) show that in 19^{th} century Bavaria, higher rye prices led to higher beer prices, which in turn resulted in a drop in alcohol consumption and consequently reduced violent crime. Markowitz (2005) found that higher beer taxes led to lower violent crime in the 1990s in the US. In a meta-analytic review covering nine countries, Kuhns et al. (2014) conclude that on average 48% of the homicide offenders were under the influence of alcohol at the time of the offense.

The most prevalent alcoholic beverage in Mexico is Pulque, a traditional liquor made from fermented sap of Agave. Pulque always had an important place in the Mexican society. Already during colonial times, the "excessive consumption of pulque caused serious problems in public health and order" (Garine 2001, p. 171). Pulque is even considered as the "center of whole ways of life", at least in the regions in which it is produced. Pulque is almost exclusively drunk in special bars known as pulquerías (see Figure B.17) (Garine 2001), that were the center of the (male) social life in 20^{th} century Mexico (Cetina 2016). Still after the colonial period, the excessive consumption of pulque as well as the extraordinarily high number of Pulquerías in the cities was considered public nuisance. Cetina (2016) describes that the pulquerías were known for scandals, fights, quarrels and violent behavior. Rancaño (2000) reports that at the beginning of the 20th century, newspapers were filled with news about fights, injuries and assassinations that happened in the surroundings of pulquerías and many were complaining about the general turmoil caused by the presence of pulquerías. In Mexico City 1,311 pulquerías existed, while the city had only 400,000 inhabitants, which corresponds to one pulque bar for every 305 persons. For comparison, there was only one bakery for every 11,764 inhabitants. The Newspaper "El Imparcial" then concluded that Mexicans consumed more pulque than meat. Since the presence of so many pulquerías led to social disorder and turmoil, the municipality of Mexico City decided to impose clear regulations. While until 1906 there was one pulquería every 60 meters, afterwards there had to be a minimum distance of 100 meters between two pulquerías in any direction (Rancaño 2000). Also in other cities, following incidents of social disorder, pulquerías were closed or the number of pulquerías admitted was reduced. These facts illustrate how severe the impact of the consumption of pulque was in the Mexican society. Whenever pulquerías are mentioned in the literature, quarrels, disputes, violence, duels and assassinations are mentioned as well. This leads to the hypothesis, that the consumption of pulque might have significantly augmented the number of homicides in Mexico.

Because of these circumstances revolving around the pulquerías, the number of pulquerías was precisely documented in every state all throughout the 20th century. The statistical yearbooks that are the basis of the data set used in this study also contained data on the number of pulquerías per state. Fortunately, the variation in this variable is substantial. In some cases, the number is reduced by 10 pulquerías from one year to next, probably caused by an incident of social disorder and the subsequent closing of the bars. Additionally, the number of cervecerías, the bars selling beer, is also reported, even though beer has been less influential in the Mexican society.

To obtain an indicator that gauges the intensity of pulque consumption in every state-year observations, the number of pulquerías is divided by the total population of the state. The underlying assumption is that the size of pulquerías stays roughly the same and that each pulquería can serve roughly the same number of people. This assumption is reasonable, since pulquerías are usually small to medium sized bars.

Figure B.18 depicts the geographical patterns of the pulquerías per capita indicator. While the northern states as well as the southern periphery are characterized by a low density of pulquerías, they were omnipresent in the center of Mexico. The highest average density of pulquerías was present in Tlaxcala, followed by Puebla, Mexico, Querétaro, Hidalgo and Mexico City.

B.3.5. Drug Cartels, Corruption and State Capacity

Mexico is notorious for its drug cartels and their role in the international drug trade and hence a search for the determinants of crime would not be complete without the mention of organized crime. In general, the presence of illegal drug production or consumption is thought to be linked with higher crime rates and lethal violence, especially among youth (Grogger and Willis 1998). Fajnzylber et al. (2000, p. 250) suggest that the presence of illegal drug business is a "potentially important determinant of crime, not only because the drug trade is highly profitable but also because it uses a very violence-intensive technology". Violence is a tool used on both the supply and the demand side of the drug market. On the supply side, drug cartels use violence to enforce agreement and property rights in the illegal environment that lacks other enforcement mechanisms. On the demand side, juveniles with low opportunity costs use criminal activity to generate the income they need to purchase the drug, since drugs have a very low elasticity of demand (habit forming good). Therefore, property crimes appear mostly on the demand side, and violent crimes on the supply side. Since in Mexico the single most important illegal industry is the drug production and trade, it is probably not surprising that homicide rates are especially high. The presence of profitable criminal industries and the geographical pre-condition for such could be providing an important incentive to commit crimes.

Furthermore, the presence of illegal drug business is inevitably related to corruption. Without corruption, organized crime would not be able to operate (Morris 2012) and this form of government involvement in illegal activity is common in Mexico (Piccato 2013): During the 20th century, "everyone knew that policemen, prosecutors and judges could be bought" (Piccato 2013, p. 112). The reasons for this weak rule of law can be found mainly in poor training of officials, insufficient resources, inefficient procedures, official corruption, abuse of authority, limited transparency and even the involvement of police officers in criminal activity (Shirk and Cazares, 2007). When it is possible for criminals to bribe police officials and consequently walk free, the overall probability of punishment is very low which makes criminal activities more attractive. Especially in a money-spinning illegal business such as drug trafficking, most delinquents have the financial capacity to buy protection from the law. The possibility of collusion between police and criminals undermines the potential deterrence mechanisms by decreasing the probability of punishment (Bowles and Garoupa 1997). This way, corruption is expected to increase crime. One consequence is that drug cartels and other forms of organized crime might choose the state in which they operate depending on the willingness of the government and police force to cooperate. Drug cartels move their operations to regions in which government officials are especially easy to bribe and consequently bribery costs are low, and avoid regions in which law enforcement is relatively strict.

The obvious problem with corruption or criminal organizations is that there is no official data on their activity. However, it is possible to gather information on the presence of drug cartels for the states by decades: Per Valdés Castellanos (2013), drug cartels started to operate in Mexico in the 1970s and their activity was concentrated in the following states: Tamaulipas, Tabasco, San Luis Potosí, Nuevo Leon and Veracruz (Gulf Cartel); Sonora, Sinaloa, Baja California, Jalisco, Durango and Chihuahua (Guadalajara Cartel); Oaxaca (Oaxaca Cartel) and Michoacán (Milenio Cartel). The drug cartel activity was limited to these states until the end of the 1980s. Afterwards, the existing cartels expanded their area of influence and new cartels arose. See

Figure B.19 for an overview of the geographical distribution of the drug cartels in the year 1977. Based on this information (see also narcodata.animalpolitico.com (2016)), a dummy variable indicating the presence of an active drug cartel in the respective state in the respective decade was created and can be included in the subsequent empirical analysis.

Regarding corruption, there is a variable that has been used to gauge the extent to which corruption is present, especially in settings of not fully democratized countries: the size of the public sector. Inflated government budgets are associated with more corruption. The argumentation is that "regulations and other forms of intervention typically associated with and facilitated by larger public sectors distort competition and introduce opportunities for rent-seeking" (Montinola and Jackman, 2002). Goel and Nelson (1996) show that government spending has a strong positive influence on corruption in the US. Kotera and Okada (2012) show that this relationship is especially true in partially democratized countries, which tend to have a higher level of corruption generally (Montinola and Jackman 2002). In dictatorships and mature democracies however, corruption tends to be low and bigger public sectors are not linked to higher corruption. Mexico in the 20th century displays the characteristics of a partially democratized country, emerging from a dictatorship but not having reached the status of a full democracy yet (one-party system). Hence the government size might be a proxy of corruption and inefficient governance. The channel through which corruption can affect crime is the probability of punishment. The higher the overall corruption level, the more likely a criminal can bribe a police officer into refraining from executing his duties, and consequently the lower is the probability of punishment.

On the other hand, a larger public sector could also indicate a more powerful government and a higher effectiveness in fighting crime. A government that has the power to appropriate and consequently spend more resources should be more capable and effective at maintaining order and enforce the law (Richani 2010). Savolainen (2006) predicts that a country with strong institutions of social protection (welfare states) can even counteract the homicidal effects of economic inequality. Other studies found links between (low) state capacity and general violence levels (Huntington 1968), civil wars (Fearon and Laitin 2003) and genocide (Heldring 2014).

To measure state capacity, a wide range of proxies has been used ranging from GDP per capita to road density and census frequency (Soifer 2012). More common are measures of the state's extractive ability (Soifer 2012). In the data set at hand, the government spending per capita in 1995 Mexican pesos is used to gauge the capacity of the state. On the one hand, it measures the state's power to extract revenue, and at the same time it quantifies the amount of government revenue that is spent on public goods, services, administration and social programs. Due to the theoretical models explained above, the effect of this variable could be in either direction: Higher government spending could increase homicide rates due to increased possibilities for corruption and rent-seeking behavior. It could however also decrease homicide rates, via a more effective prevention of crime, via social protection or via law enforcement and improved institutional quality.

B.4. Empirical Strategy

After theoretically identifying the factors that might have impacted the homicide rate in Mexico, the goal of the subsequent empirical analysis is to check which of them has a significant impact and hence could cause the remarkable decline in violent crime. The focus will be, apart from the rather obvious economic factors such as income levels, education and inequality on the impact factors that might be unique to Mexico: The consumption of alcohol in the form of Pulque, or rather a high density of pulquerías per capita as well as the presence of drug cartels. Furthermore, the analysis will check if there is evidence for a deterrent effect.

The analysis is based on the newly created panel data set containing information about homicide rates and numerous control variables for the 32 federal entities of Mexico. The observations range from the 1930s until the 1980s. For the homicide rates as well as some of the explanatory variables, yearly observations are available. However, for other variables, the information was only available every five or every ten years.

For some of the analysis, yearly observations will be used, however, to introduce more control and explanatory variables, the bulk of the regressions is done with decade averages. This results in six decades from 1930 to 1980 for each of the 32 regions, e.g. a strongly balanced panel with a total 192 observations. Due to the strongly balanced nature of the data, there is no risk of selection bias, since all federal entities are observed in all the time periods. Further advantages of using decade averages are the ruling out of short term fluctuations and the prevention of spurious regression, since the time dimension is reduced to six observations.

The model to be estimated is based on the theoretical framework developed by Becker:

$$\log\,(Homicide\ Rate)_{i,t} = \beta' X_{i,t} + u_{i,t}$$ [3]

with i = state, t = year and X the vector of control variables that might have an impact on crime rates. In the baseline model, proxies for the most common determinants of homicide rates (as shown by cross-country studies, e.g. Fajnzylber et al. 2000) are included:

1) Income level: log(GDP per capita), in 1995-Mexican Pesos (Esquivel 1999)[4]
2) Education/Human capital: illiteracy rates (percentage of the population that is not able to read and write)
3) Inequality: $1 - \frac{real\ minimum\ wage\ (unskilled)}{GDP\ per\ worker\ hour}$

When using panel data, there are factors that affect crime rates on the state level but do not

[3] Due to the extremely skewed distribution of the homicide rates, the logarithmic transformation is used for all regressions. The same holds for GDP per capita.
[4] Summary statistics for all included variables can be found in appendix B.9.2.

change over time. Examples are geographical conditions (location relative to the border/US, suitability of poppy seed cultivation), certain demographic, ethnic and cultural features that are roughly constant over time (for example presence of indigenous population), crime reporting behavior, attitudes towards crime and historically grown institutions and customs (judicial system of each state). It is well known that OLS-estimates are biased in the presence of these unobserved fixed effects. By controlling for fixed effects in the regression, it is possible to allow for (the likely) correlation between geography and historical factors and the time-variant regressors such as income, education and inequality. Even though necessary, there is one caveat of including state fixed effects, namely that it is not possible to analyze the impact of time constant geographical conditions, as for example the presence of poppy seed cultivation or the location at the border. In the regression, time fixed effects will also be included to capture common time trends or events that affected all states in the same way, like national political reform.

With time and state fixed effects, the model is as follows:

$$\log\,(Homicide\ Rate)_{i,t} = \beta' X_{i,t} + f_t + \eta_i + u_{i,t}$$

An additional challenge when estimating this model is that traditional panel data methods are all based on the assumption of cross-sectional independence, which in this case is an assumption that is not easy to maintain. Since the data stems from the 32 states of Mexico, the time series are likely correlated across cross-sections due to common unobserved and observed factors, as for example similar geographical and climate conditions, federal policy measures that affected some of the regions as well as the interrelations of drug cartels and commerce between states. Time fixed effects do account for some of the cross-sectional dependence; however, they assume a very simple form of dependence, imposing the same coefficient for all the cross-sections. The Pesaran (2004) test for cross-sectional independence on the variables as well as on the residuals of the baseline model reject the Null hypothesis of cross-section independence (see Table B.1). This indicates that there is still considerable cross-sectional dependence present in the panel even when controlling for time fixed effects, (as indicated by the graphical analysis). To accommodate both time- and cross-sectional fixed effects and cross-sectional dependence, Driscoll and Kraay (1998) standard errors will be used. These are robust to all forms of (spatial) cross-sectional dependence and temporal dependence.

B.5. Empirical Results: What explains the Great Decline?

Following the methodology of Fajnzylber et al. (2000), the first step is to estimate the baseline model including the proxies of the three most important determinants of crime identified by cross-sectional studies: General income level, education and inequality. Subsequently, the baseline model is extended along four dimensions (deterrence, sociological factors, alcohol consumption and drug cartel activity).

B.5.1. Baseline Model

The results of the baseline estimation are presented in Table B.2. Column (4) shows the standard fixed effects regression, not taking into account the cross-sectional dependence. However, the Pesaran (2004) test for cross-sectional dependence on the residuals (Table B.1) results in a rejection of the independence hypothesis, indicating that even when including time-fixed effects, there is still considerable cross-sectional dependence present.

Consequently, Driscoll-Kraay standard errors are used that are robust to all kinds of cross-sectional dependence, and the result is presented in columns (1) to (3). In the first two regressions, the GDP per capita has a significant positive effect on homicide rates, indicating that higher income levels result in higher violence. This counterintuitive result is probably a result of omitted variable bias, since the income levels are positively correlated with inequality (coefficient of correlation 0.82), which in turn is expected to increase homicide rates. Indeed, when including the inequality indicator in column (3), the sign of GDP per capita turns negative, and the effect is insignificant. Inequality however has a positive, significant impact on homicide rates, just as expected. This connection could work through various channels, first through the higher spread between the income of the poor and the rich part of society which increases the expected utility of crime for the poorer part of society and furthermore also through sociological channels such as strain and social heterogeneity that are supposed to drive individuals into criminal behavior. The share of illiterate population does not have a significant impact. The time fixed effects are jointly significant (p=0.000) and all negative, revealing an overall downward time trend that is common in all the 32 states of Mexico.

The results of the baseline regression identified inequality as crime-increasing factor. Since inequality increased over the contemplated period, it cannot account for the decrease in homicide rates in 20th century Mexico. Maybe the improvements in the judicial and police system had a deterrent effect on crime?

B.5.2. Is there Evidence for Deterrence?

Becker's theory of crime predicts a negative impact from the probability of being convicted and the severity of the punishment on crime rates. The death penalty has been used as proxy for the severity of punishment, since it captures the overall harshness of the penal system (Fajnzylber et al. 2000). Since in Mexico there is substantial variation in the abolition of the death penalty across states, it is possible to analyze the impact of the death penalty on homicide rates even with state and time fixed effects included in the model. The earliest state to abolish the death penalty was Michoacán in 1925, the latest Sonora in 1975 (Gonzalez Mariscal 2011). The abolition dummy takes on the value 1 if the death penalty was still in place in a certain decade (in most of the years), and it takes on value 0 if the death penalty was already abolished.

One problem with the inclusion of the death penalty as control variable is that it might suffer from endogeneity; since it is expected to react to the country's crime rate. Countries or states with higher crime rates could have tougher legislation, and the death penalty might be abolished only when the crime rates are already quite low. Finding a positive coefficient on the death penalty variable could imply that its crime reducing impact does not offset the positive bias caused by reverse causality.

Apart from the severity of the punishment proxied by the death penalty, measures of the probability of being convicted will be included. The two following indicators were constructed using the data about the number of persons accused and convicted of homicide.

1) $Police = \frac{\#\ of\ persons\ accused\ of\ homicide}{total\ \#\ of\ homicides}$

   This indicator measures the number of people that have been caught by the police and accused of homicide. It is a measure of the efficiency of the police force, if the police is able to find and arrest the delinquent. However, it remains to mention that in the historic data at hand, especially in the states with a smaller population, there are sometimes more persons accused of homicide than occurred murders in some years. One explanation for this could be that the delinquents that committed murder in one year might have been apprehended and accused only in the following year, or that more than one suspect was arrested and accused in a single murder case. Therefore, in some cases the police indicator exceeds the value one.

2) $Jurisdiction = \frac{\#\ of\ persons\ convicted}{\#\ of\ persons\ accused\ of\ homicide}$

   This indicator is the percentage of persons accused that are convicted subsequently. It is a measure of the efficiency of the judicial system, e.g. if it can prove the guilt of the delinquent and enforce the sentence.

Both variables could be subject to measurement error, since it is indeed possible that the police catch the wrong person and consequently the judicial system is not able to prove the person guilty. Furthermore, if the police apprehend an innocent person, it is still counted as successful apprehension by this indicator. It is assumed that the number of these erroneous incidents is relatively small, and therefore the indictor is still able to capture the efficiency of police and justice system to some extent. Table B.3 presents the results of the regression analysis. In column (1), only the death penalty indicator is included, displaying no significant effect, as does the jurisdiction indicator in column (2). The police indicator (column (3)) however, has a significant and negative impact, indicating that a more efficient police work leads to a decrease in the homicide rates. This effect is robust to including the other deterrence indicators in column (4).

These results indicate that while there is no evidence for a deterrent effect of the severity of the punishment, the probability of the punishment might indeed influence crime rates, especially in the form of more efficient policing. The effect of the police indicator is also quite substantial in magnitude. An increase of one standard deviation of the police leads to a reduction in homicide rates by around 16%. Regarding the level of 60 homicides per 100,000 in 1930, this corresponds to a decrease of 10.

B.5.3. Sociological Theories

The next section examines the importance of various sociological phenomena related to crime. As illustrated above, theories from the field of sociology predict an impact of factors such as population growth, urbanization rate ethnic composition or religion on crime. The results of the inclusion of these variables are shown in Table B.4. The first column includes the percentage of indigenous population living in the respective state. A high percentage of indigenous population decrease or increase social cohesion in the society, or it could proxy some kind of underreporting in the indigenous population. Viqueira and Palerm (1954) for example observed that in various indigenous communities, homicide due to vengance or honor is not seen as a crime and hence is usually not reported to the authorities. The indicator does however not have a significant impact on homicide rates, hence no such effects are present.

The second column, introduces the share of catholic population into the regression and it has a positive and significant effect. This might indicate that the religious communities were able to construct a social barrier against violent crime. The urbanization rate is included as additional control variable in column (3), mainly to check for the implications of the social disorganization theory that predicts higher violent crime due to weakening social bonds with increasing urbanization. However, the results indicate that there is no significant effect. The same results when including the population density in column (5). A further control related to the social disorganization theory is the share of workers employed in the agricultural sector. In industrializing society, hence when the share of agricultural workers decreases, violent crimes might increase. Column (4) however shows that the opposite is the case. Homicide rates are higher in settings with a high share of agricultural workers, and more industrialized states experience lower homicide rates.

B.5.4. The Role of Pulque Consumption

Due to the excessive consumption of pulque and the social disorder and problems revolving around it, a higher density of pulquerías is expected to increase the homicide incidence. And indeed, column (1) of Table B.5 shows the highly significant impact of the pulquería density on homicide rates. An increase of the pulquería density by one standard deviation leads to an increase of the homicide rate by 8%. This effect even increases in magnitude when including the covariates that also significantly determine the homicide rate (column (2)). Here, an increase of pulquerías per capita by one standard deviation increases the homicide rate by 12%. The decrease in the pulquería density from 1930 to 1980 accounts for a decrease in homicide rates of roughly 5 homicides per 100,000.

In contrast, the number of cervecerías per capita as well as the total number of alcohol selling points (columns (3) and (4)) do not have a significant impact. This suggests that not the alcohol consumption per se, but rather the social dynamics surrounding the traditional pulquerías is responsible for the increasing effect on homicide rates.

B.5.5. Drug Cartels and State Capacity

The history of Mexico in the 20th century is inevitably intertwined with the presence of drug cartels. Even though the impact of these illegal organization is not the focus of this study, the regressions should still control for the presence of a drug cartel in the respective state. Including the drug cartel dummy in the regression model results in a positive and significant coefficient as expected (Table 4, column (1)). The homicide rate is expected to increase by 17 to 27% if a drug cartel is present. Even though this effect was not visible in the descriptive analysis, the data suggests that the presence of drug cartels is an important determinant of homicide rates.

Column (3) includes the indicator of real government spending per capita and the result suggests that a bigger public sector is not linked to higher homicide rates via corruption, but that the government spending is successfully used to combat crime. However, this effect is not very robust, as evident from column (4).

Up to now, the empirical analysis has revealed a total of five factors that have a significant and robust impact on the homicide rates. Inequality as well as the presence of drug cartels have a crime-increasing effect. Since both phenomena experienced an increase over the observed period, they cannot explain the decline in homicide rates, but have rather hampered an even more pronounced decline in homicide rates. The factors that can account for the decline are the share of catholic population (increased over time and has a crime-reducing effect), the police indicator of efficient prosecution of delinquents (indicator improved over time and has a crime-reducing effect as well) and the pulquería density (decreased over time, and less pulquerías are associated with less homicides). Together, these five variables can account for roughly 50% of the total variance in the homicide rate. Including state fixed effects, the amount of explained variance reaches even 77%, which is substantial. Nevertheless, there might be factors that do have an impact on violent crime, but the effect is not visible in the decade averages. Since for many variables, yearly observations are available, it is meaningful to exploit the yearly variations in these indicators to identify additional driving forces.

B.5.6. Exploiting Yearly Variation

With the yearly observations, instead of the decadal averages, the panel still contains the 32 cross-sectional units, however the time period is extended to between 40 and 80 observations per state. According to Eberhardt (2011), any panel with more than 20 time periods is a macro panel with higher risk of variable non-stationarity. Before conducting further empirical analysis, the series need to be pre-tested for the presence unit roots to make sure the results are not spurious. The results of the Pesaran (2004) unit root test that is applicable in the presence of cross-sectional dependence are shown in Table B.7. The null hypothesis of a non-stationarity can be rejected for the specifications with up to 2 lags. Given the stationarity of the homicide series, standard panel procedures can be applied, however the standard error must be corrected for cross-sectional correlation and time fixed effects should be included (Eberhardt 2011).

The results are presented in Table B.8. The analysis based on yearly observations corroborates the previous findings for the pulquería density as well as for the policing indicator. Both have the same sign as in the previous analysis and are highly significant. The yearly regressions introduce an alternative measure of income level, sugar consumption per year per capita in kilograms, since GDP per capita is only available on decade level (Esquivel 1999). Sugarcane production in Mexico has a history of almost 500 years, and is the most important agricultural industry after corn (Aguilar-Rivera et al. 2012). Also, the fact that its consumption has been documented over the entire century indicates, that sugar had an important standing in Mexican society. A higher sugar consumption could hint towards an increase in income levels. A higher consumption in one year could indicate a particularly good crop, which would also increase overall income levels, especially in the first half of the century, where the agricultural sector was still the most important in the Mexican economy: In 1940, still around 60 % of the total workforce was employed in the primary sector.

Including this alternative income indicator, sugar consumption per capita, into the regression, results in a negative and significant coefficient, indicating that higher consumption levels decrease violence levels. This is the effect that was in fact expected for GDP per capita, however GDP per capita did not have any significant impact. Unfortunately, in this yearly regression it is not possible to control for inequality, since that indicator is only available for the decades. One explanation that the GDP per capita is not significant is that the impact is averaged out by the decadal averages, and hence not visible. Another reason might be measurement error, since the GDP per capita variable is based on estimations by Esquivel (1999), and no real GDP data is available for Mexico for that period. A third explanation could be that the sugar consumption is a better proxy of the living standards directly experienced by the households than GDP per capita.

In any case, the negative impact of sugar consumption on crime supports the predictions by the economic rational choice theory of crime by Becker (1968). Higher income levels increase opportunity costs, and hence make criminal behavior less attractive, compared to the legal earning opportunities. This suggest that the “Mexican Miracle”, the increase in income levels between 1940 and 1970 could have had a crime-decreasing effect, even though this is not visible when using GDP per capita as income indicator.

B.6. Summary of the Findings and Conclusions

This paper contributed to the historical literature on Mexico by reconstructing the homicide rates for all federal entities back until at least 1930. Up to now, data on homicide rates had only been available until 1990. The data reveals that the recent increase in homicide rates since 2008 in Mexico is indeed alarming, since it breaks with an almost century long trend of decreasing homicide rates. While the recent outburst of violence has been identified as the result of the break of an agreement between the drug gangs and the government, in which criminal organizations could buy protection from the government (Piccato 2012, p. 52), and the subsequent war on drugs, the past development of homicide rates pre-2000 remained unexplored.

Therefore, the second goal of this study was to identify the factors that have contributed to the century-long decline of homicide rates in Mexico revealed by the recently compiled data. One of the main results is that the indicator of inequality used in this study is significantly increasing homicide rates. This confirms the findings of the previous literature on general determinants of crime (for example Fajnzylber et al. 2002). However, since inequality increased during the 20th century in Mexico, it cannot explain the great decline in homicide rates.

The analysis did not offer any support to the deterrence hypothesis, namely that the severity of the punishment, measured by the presence of the death penalty, decreases crime. Nevertheless, there is a significant deterrent impact from a newly developed policing indicator. It measures the percentage of homicide perpetrators that were arrested and accused of the crime they committed. The higher the probability of getting caught, the lower the expected utility from a crime, and hence the less attractive the criminal behavioral option. The jurisdiction indicator, the percentage of the persons accused of homicide that were in fact convicted of the crime, did not have any deterrent power. These findings suggest that in order to effectively deter crime it is not necessary, to increase the severity of the punishment. An improvement in the criminal prosecution system that results in a higher probability of apprehension and conviction seems to be a lot more effective in deterring crime.

Among the cultural and socioeconomic factors such as ethnic diversity, religion, urbanization rate, the importance of agriculture as well as population density, only the share of Catholic population was found to have an impact on homicide rates. This confirms the findings of Fajnzylber et al. (2002) who found a negative link between Christianity and violence levels.

One surprising and novel result is the influence the number of establishments that sell and serve alcohol, in particular the pulquerías, have on the homicide rate. While there is a multitude of reports on violence revolving around pulquerías, it is remarkable that this effect is visible in the data. The effect is very robust to including different cofounding factors, and hence it is possible to conclude that the historical reports on the problems and turmoil revolving around pulquerías are not an overstatement of a few incidents, but accurately describe the real experience Mexico had with pulquerías. The decision of the government to regulate and restrict the number of pulquerías during the 20th century did have a pacifying effect on the social life.

The presence of drug cartels seems to have hampered the decreasing trend of homicide rates, and it is safe to assume that without the activity of the drug cartels in the regions, violence levels would have declined even more. Regarding income levels, the results of this study are twofold. First, there was no evidence for an impact of GDP per capita on homicide rates. This fact is hard to believe, since income levels have been proven to be important in most of the previous literature. Potential reasons are the reduction of variation due to decadal averaging and the fact that the GDP data are estimates, not real statistical data. Secondly, when using the yearly consumption of sugar per capita as income proxy, a crime-reducing effect is found. This result indicates that the growing income level in Mexico throughout the 20th century was at least to some extent causing the century-long reduction in violent crime.

Overall, the factors identified as driving forces behind Mexican homicide levels are very similar to the ones found by previous research. Alcohol consumption has been hypothesized to be conducive to violent behavior beforehand, however the significant correlation between the number of alcohol sales points and violence even when controlling for cofounding factors found by this study is novel. It remains to clarify that these results are probably of quite limited external validity, since Mexico is an individual case.

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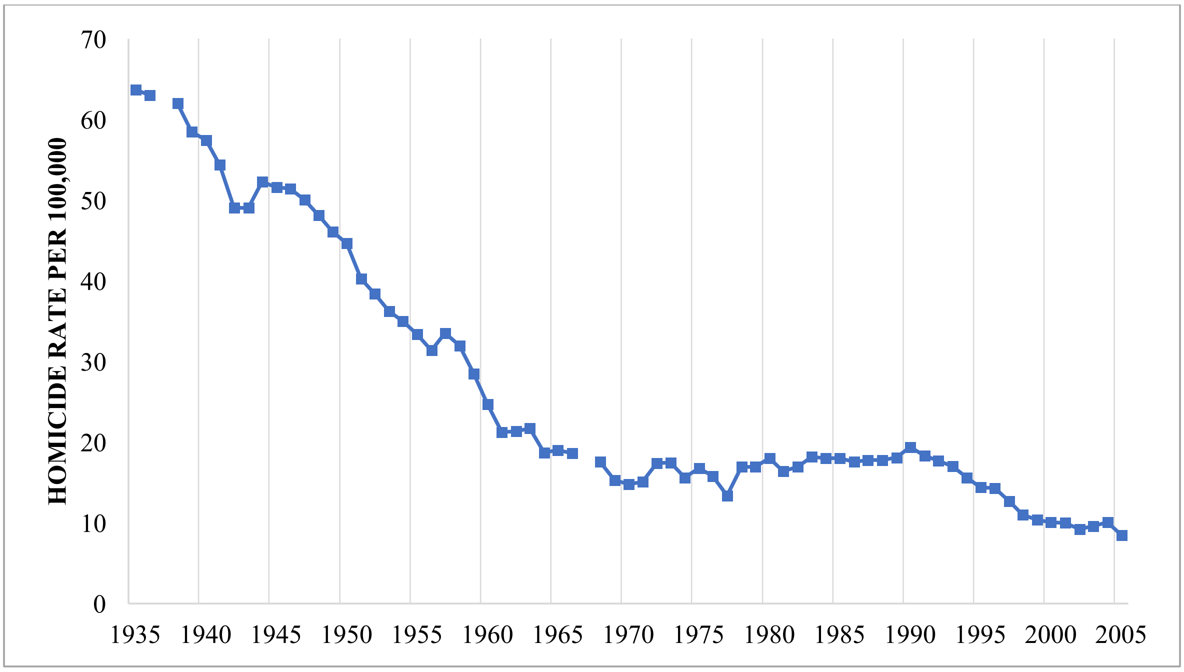
B.8. Figures and Tables

B.8.1. Figures

Figure B.1: Homicide Rate in Mexico, 1935 - 2005[5]



[5] In all of the following graphs, the data before 1988 stems from the assembled data set. The data from 1988 to 2005 was obtained from UNODC 2017.

Figure B.2: Homicide Rate in Baja California

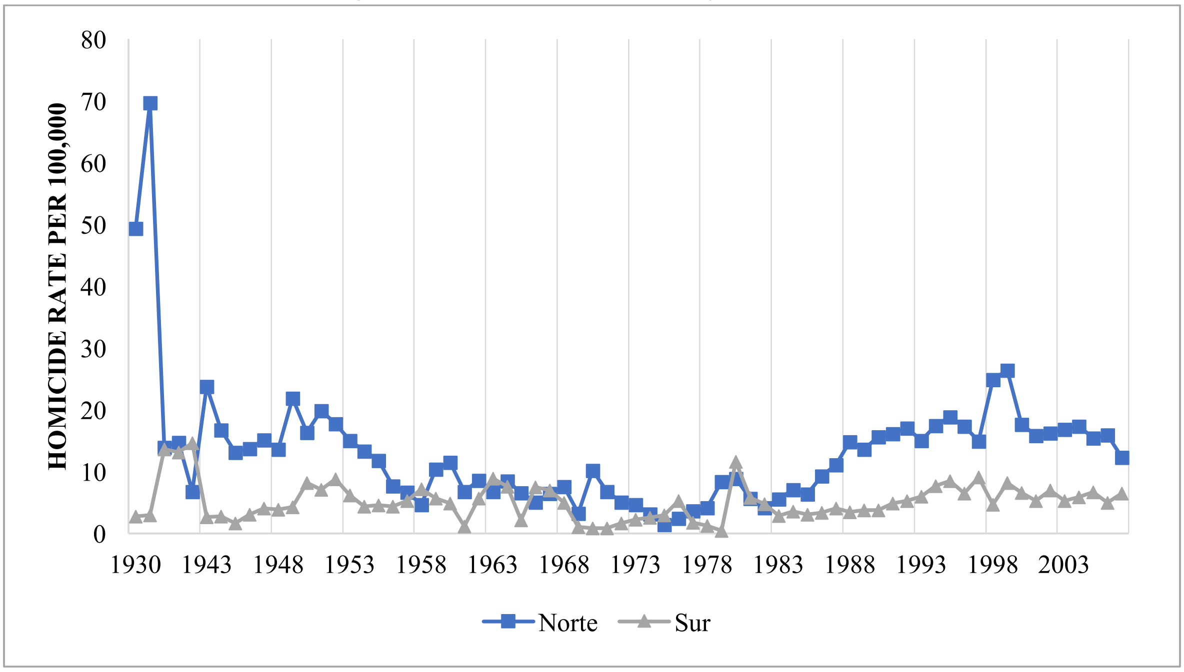


Figure B.3: Homicide Rate in Aguascalientes

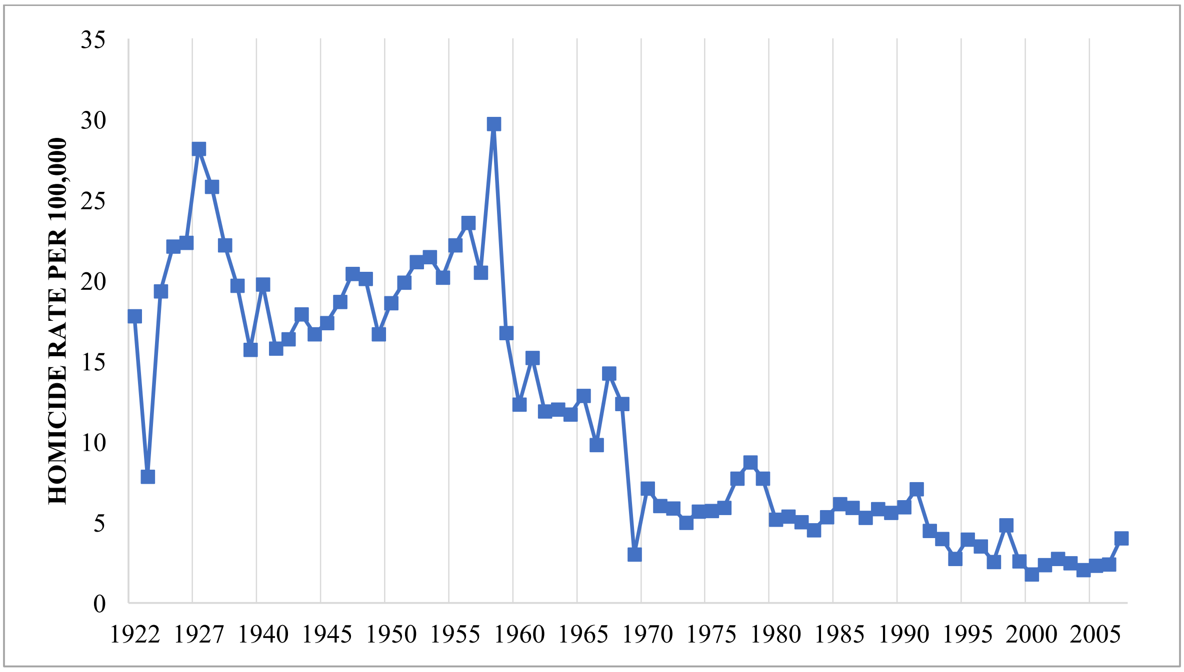


Figure B.4: Homicide Rate in Colima and Morelos

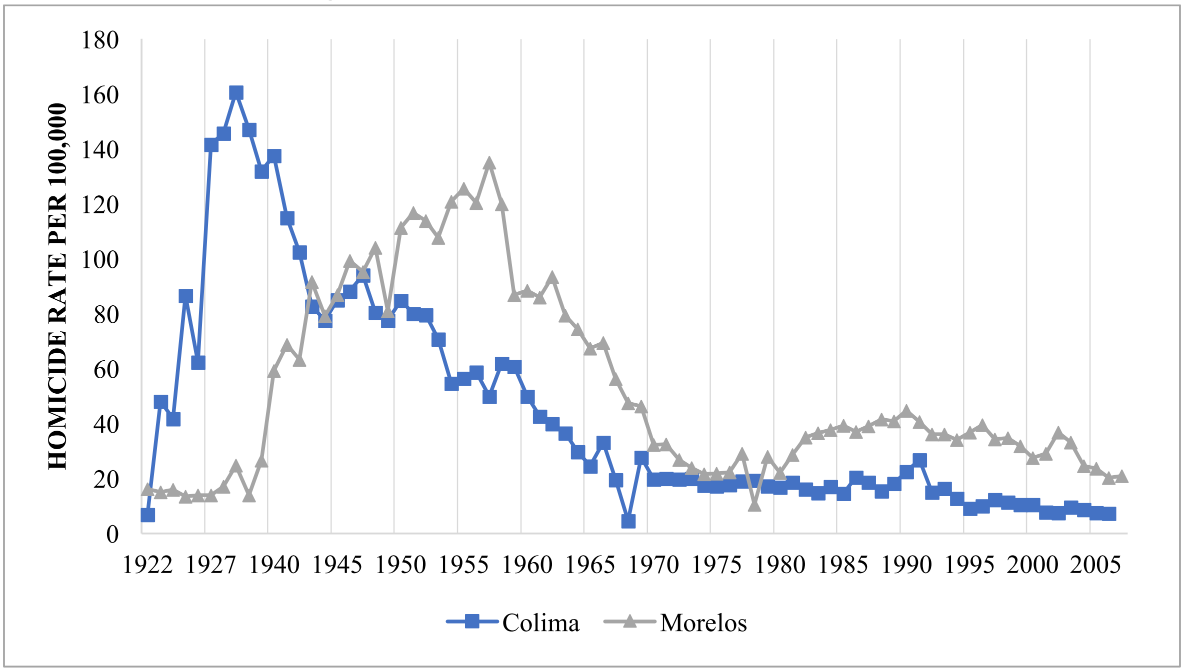


Figure B.5: Homicide Rate in Guerrero, Michoacán and Oaxaca

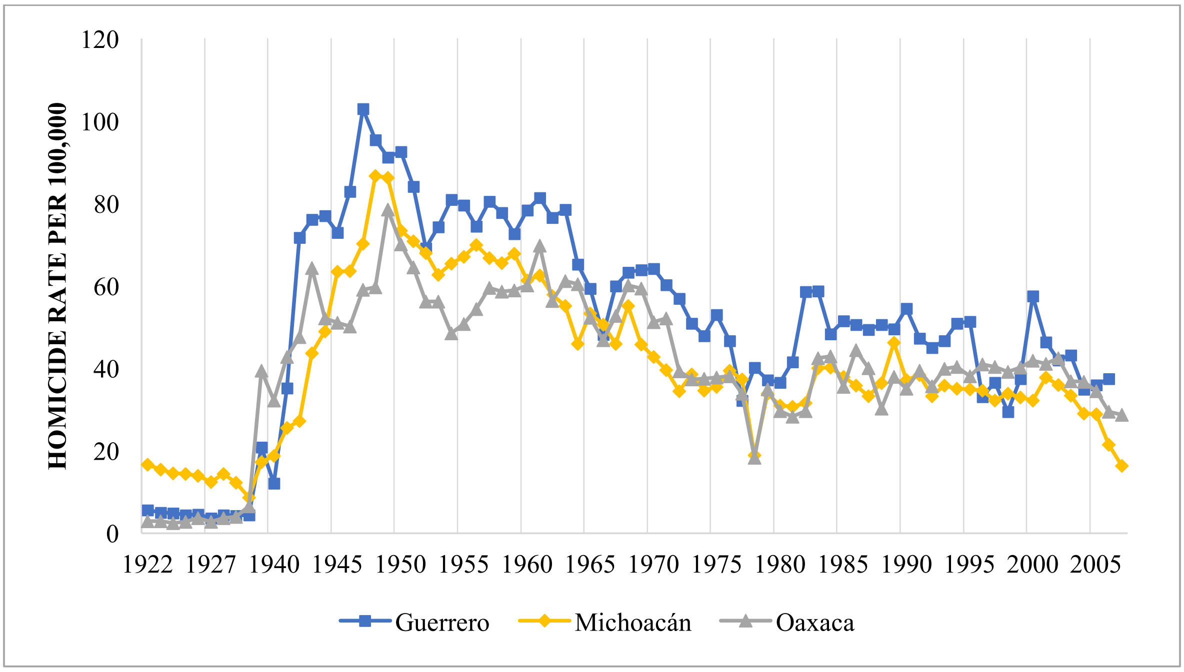


Figure B.6: Homicide Rate in Mexico City

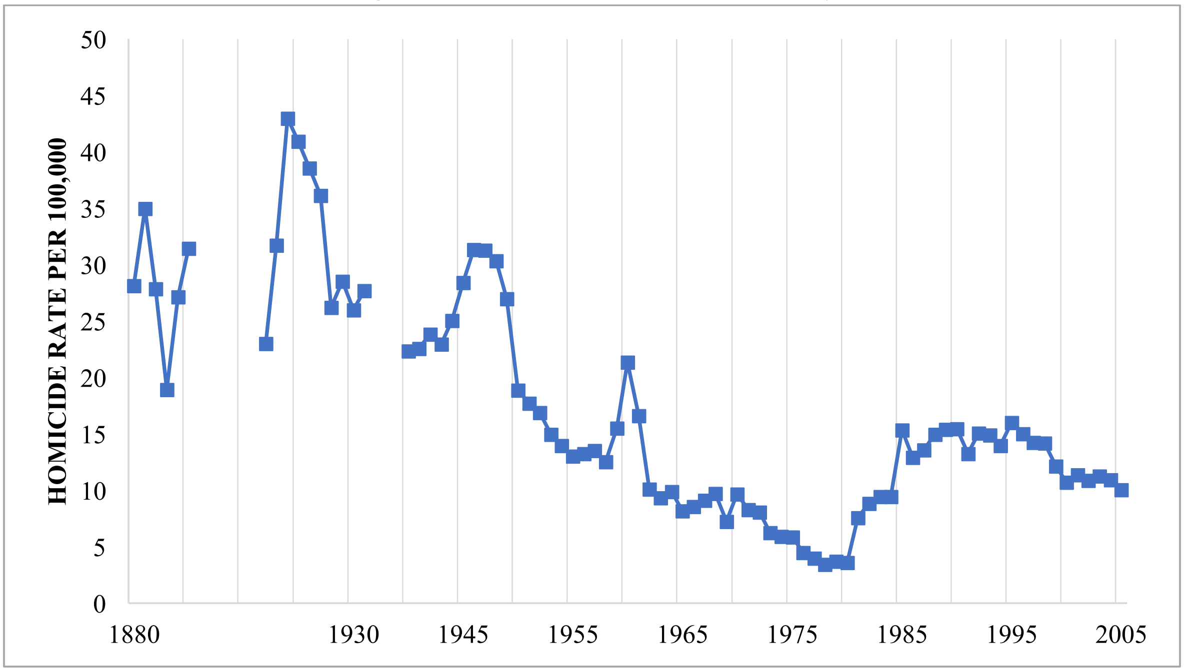


Figure B.7: Mean Homicide Rate by State from 1930 to 1990

Figure B.8: Homicide Rate in the Golden Triangle vs. the Rest of Mexico

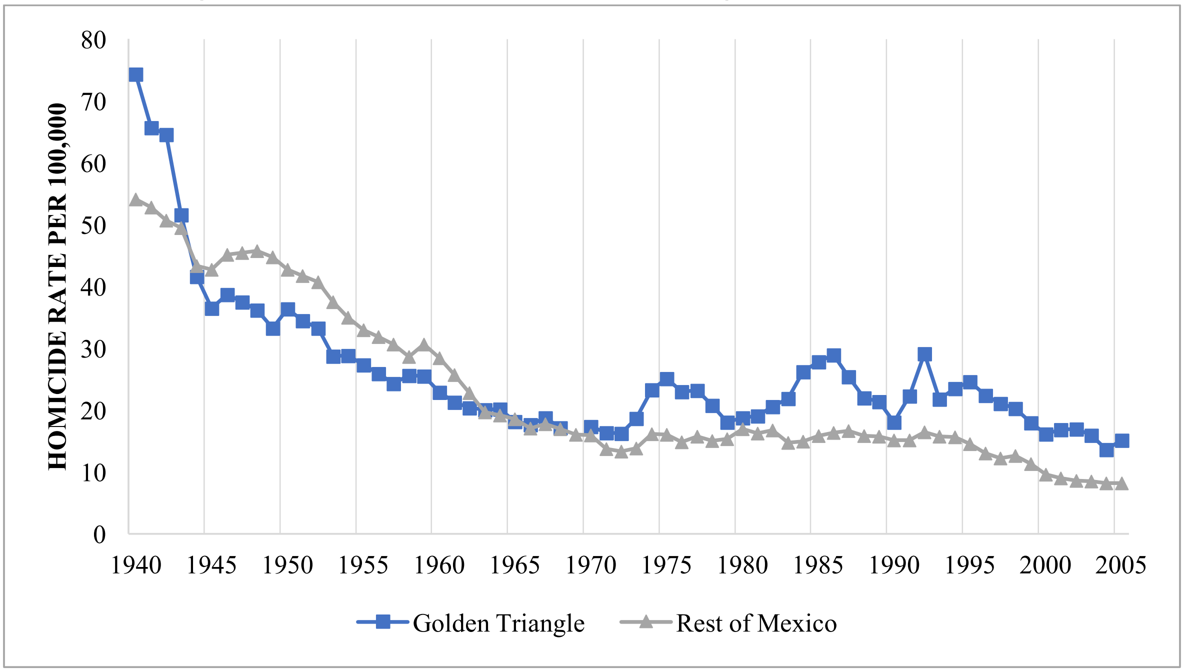


Figure B.9: Homicide Rate in 1930 by State

Figure B.10: Homicide Rate in 1950 by State

Figure B.11: Homicide Rate in 1970 by State

Figure B.12: Homicide Rate in 1990 by State

Figure B.13: GDP per capita (Source: Esquivel 1999)

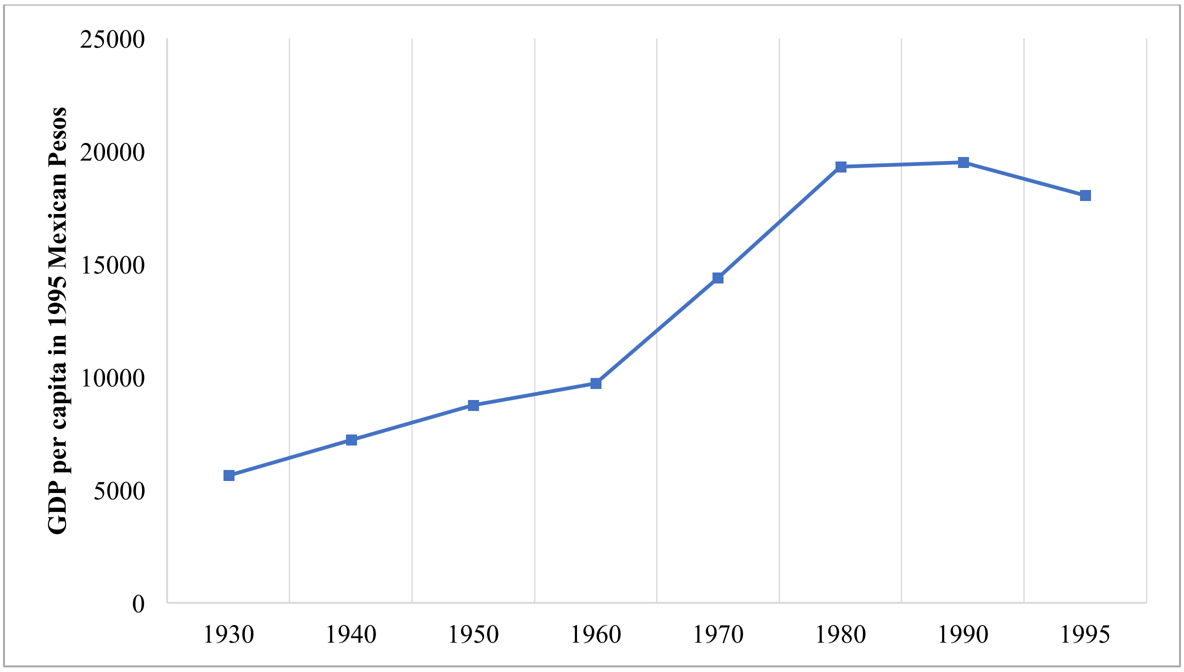


Figure B.14: Illiteracy Rate

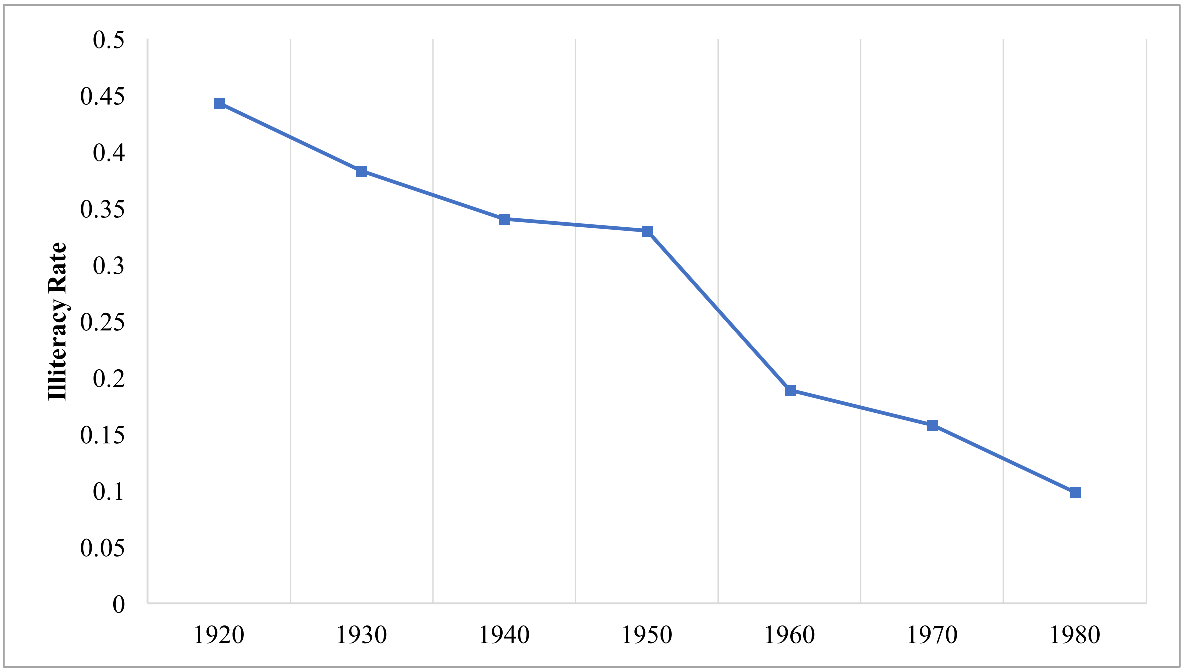


Figure B.15: Inequality Indicator

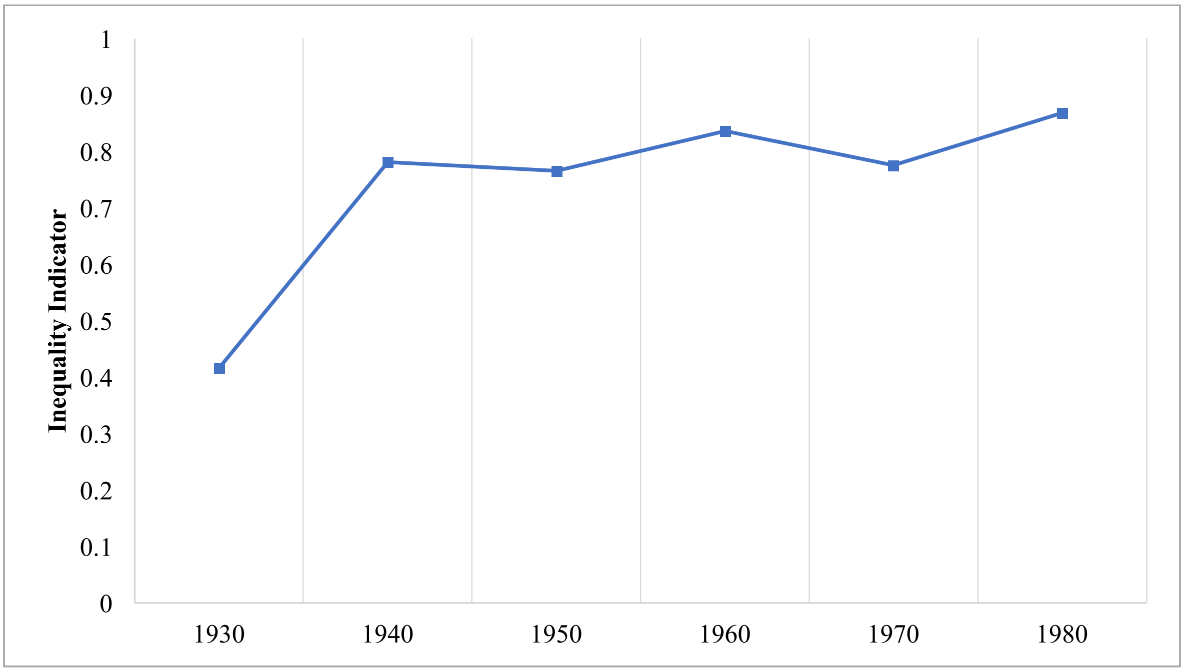


Figure B.16: Homicide, Accused and Convicted Rate (per 100,000 inhabitants)

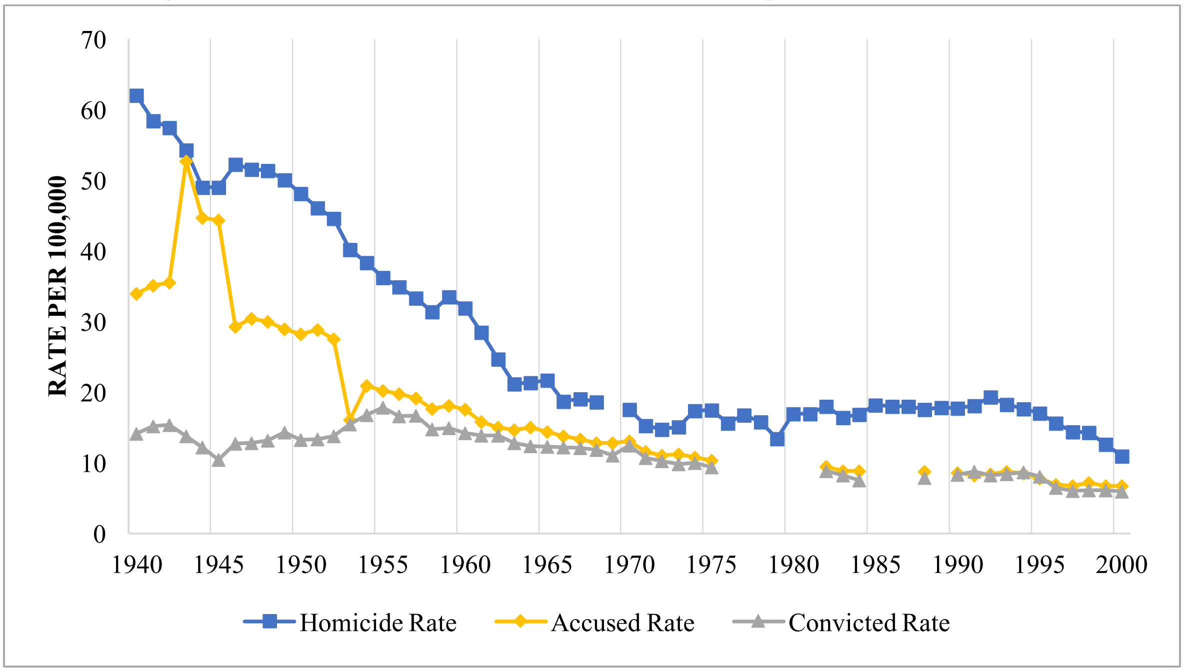


Figure B.17: Picture of a Pulquería in 1930

(Source: relatosehistoria.mx)

Figure B.18: Number of Pulquerías per capita (Average 1930 – 1990)

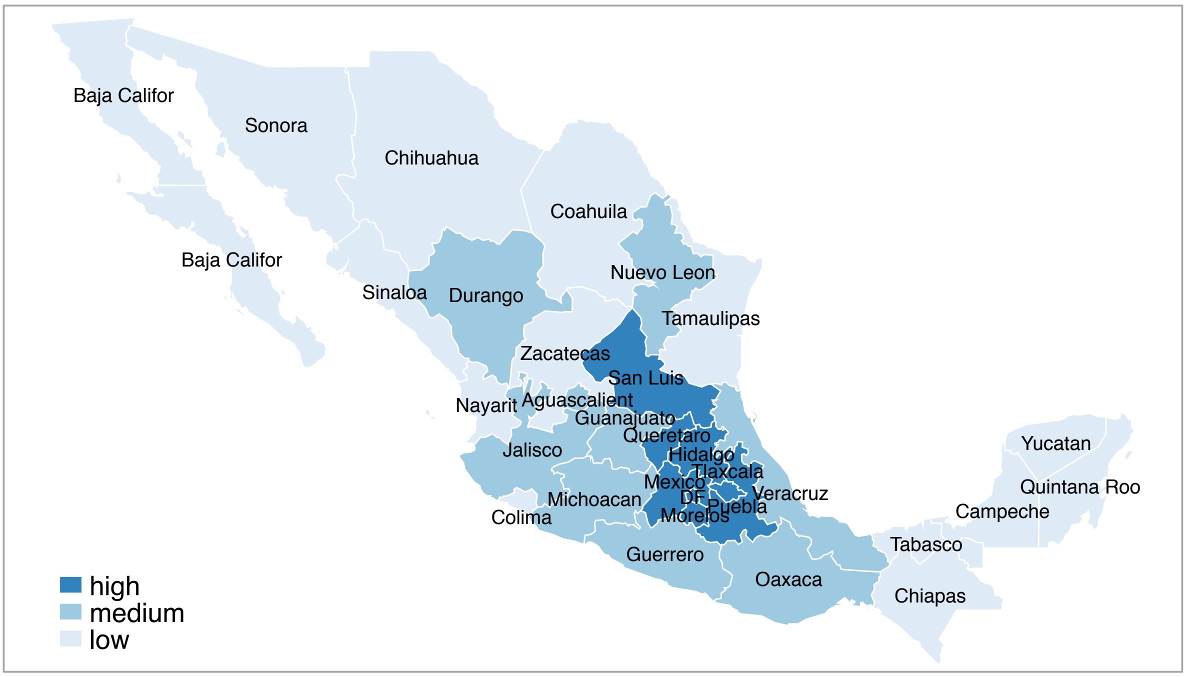


Figure B.19: States with Presence of Drug Cartels in 1977 (red)

B.8.2. Tables

Table B.1: Pesaran (2004) Test of Cross-Sectional Dependence

# of States	32		
Average # of Observations	6		
Variable	CD-test	p-value	Average Correlation
log(Homicide Rate)	38.041	0.000	0.697
log(GDP per capita)	45.051	0.000	0.826
Residuals of Regression (4) of Table B.2	13.490	0.000	0.247

Table B.2: Regressions of Log(Homicide Rate) – Baseline

	(1)	(2)	(3)	(4)
Log(GDP per capita)	**0.148*****	**0.160*****	-0.0715	-0.0715
	(0.034)	(0.031)	(0.061)	(0.094)
Inequality Indicator			**0.895****	**0.895*****
			(0.234)	(0.294)
% Illiterate		0.792	0.823	0.823
		(0.397)	(0.454)	(0.687)
Constant	2.629***	2.248***	3.735***	3.735***
	(0.278)	(0.313)	(0.279)	(0.746)
Observations	192	192	192	192
# of States	32	32	32	32

Driscoll- Kraay standard errors in parentheses, time and state fixed effects included.

*** p<0.01, ** p<0.05, * p<0.1

Table B.3: Regressions of Log(Homicide Rate – Deterrence

	(1)	(2)	(3)	(4)
Log(GDP per capita)	-0.0764	-0.0795	**-0.0837***	-0.0655
	(0.0643)	(0.068)	(0.041)	(0.038)
Inequality Indicator	**0.881****	**0.906****	**0.865*****	**0.862*****
	(0.221)	(0.236)	(0.159)	(0.174)
Death Penalty Dummy	0.0391			0.102
	(0.058)			(0.055)
Jurisdiction Indicator		-0.0923		-0.134
		(0.057)		(0.067)
Police Indicator			**-0.159*****	**-0.169*****
			(0.034)	(0.032)
Constant	4.050***	4.131***	4.276***	4.112***
	(0.421)	(0.472)	(0.266)	(0.244)
Observations	192	192	192	192
# of States	32	32	32	32

Driscoll- Kraay standard errors in parentheses, time and state fixed effects included.

*** p<0.01, ** p<0.05, * p<0.1

Table B.4: Regressions of Log(Homicide Rate) – Sociological Factors

	(1)	(2)	(3)	(4)	(5)	(6)
Log(GDP per capita)	-0.083	-0.077	-0.064	-0.070	-0.086	-0.065
	(0.066)	(0.071)	(0.077)	(0.068)	(0.070)	(0.074)
Inequality Indicator	**0.875*** **	**0.874** **	**0.826** **	**0.862** **	**0.919** **	**0.849** **
	(0.212)	(0.235)	(0.252)	(0.226)	(0.247)	(0.245)
% Indigenous	-0.657					
	(0.404)					
% Catholics		**-0.531*** **				**-0.523*** **
		(0.125)				(0.111)
Urbanization Rate			-0.006			
			(0.005)			
% of Workers in Agriculture				**0.187** **		**0.174***
				(0.053)		(0.069)
Population Density					0.001	
					(0.000)	
Constant	4.172***	4.577***	4.193***	3.906***	4.135***	4.369***
	(0.453)	(0.580)	(0.453)	(0.448)	(0.465)	(0.607)
Observations	192	192	192	192	192	192
# of States	32	32	32	32	32	32

Driscoll- Kraay standard errors in parentheses, time and state fixed effects included.

*** p<0.01, ** p<0.05, * p<0.1

Table B.5: Regressions of Log(Homicide Rate) – Alcohol Consumption

	(1)	(2)	(3)	(4)
Log(GDP per capita)	-0.043	-0.026	-0.085	-0.082
	(0.061)	(0.036)	(0.068)	(0.067)
Inequality Indicator	**0.551****	**0.437*****	**0.882****	**0.887****
	(0.201)	(0.102)	(0.229)	(0.224)
Pulquería Density	**0.293****	**0.460*****		
	(0.090)	(0.090)		
Police Indicator		**-0.216*****		
		(0.028)		
% Catholics		-0.366***		
		(0.073)		
% of Workers in Agriculture		0.102		
		(0.060)		
Cervecería Density			0.063	
			(0.119)	
Alcohol Sales Points Density				0.009
				(0.011)
Constant	3.888***	4.248***	4.134***	4.110***
	(0.437)	(0.385)	(0.463)	(0.455)
Observations	192	192	192	192
# of States	32	32	32	32

Driscoll- Kraay standard errors in parentheses, time and state fixed effects included.

*** p<0.01, ** p<0.05, * p<0.1

Table B.6: Regressions of Log(Homicide Rate) – Drug Cartels and State Capacity

	(1)	(2)	(3)	(4)
Log(GDP per capita)	-0.088	-0.049	-0.060	-0.034
	(0.068)	(0.033)	(0.060)	(0.027)
Inequality Indicator	**0.888*****	**0.477*****	**0.866*****	**0.463*****
	(0.213)	(0.078)	(0.208)	(0.069)
Drug Cartel Dummy	**0.172*****	**0.251*****		**0.273*****
	(0.028)	(0.025)		(0.016)
Pulquería Density		**0.342****		**0.303****
		(0.106)		(0.109)
Police Indicator		**-0.231*****		**-0.232*****
		(0.031)		(0.029)
% Catholics		**-0.304*****		**-0.271*****
		(0.043)		(0.036)
Log(Government Spending per capita)			**-0.092***	-0.070
			(0.040)	(0.049)
Constant	4.174***	4.462***	4.435***	4.679***
	(0.464)	(0.337)	(0.508)	(0.382)
Observations	192	182	192	182
# of States	32	32	32	32

Driscoll- Kraay standard errors in parentheses, time and state fixed effects included.

*** p<0.01, ** p<0.05, * p<0.1

Table B.7: Pesaran (2004) Unit Root Test of the Yearly Homicide Rate Series

# of States	32	
Average # of Observations	42	
# of Lags	Zt-bar	p-value
0	-8.701	0.000
1	-5.104	0.000
2	-3.161	0.001

Table B.8: Regressions of Log(Homicide Rate) Based on Yearly Observations

	(1)	(3)	(4)
Sugar Consumption per capita	**-0.012*** **	**-0.011*** **	**-0.012*** **
	(0.003)	(0.003)	(0.004)
Pulquería Density	**0.726*** **	**0.688*** **	
	(0.201)	(0.197)	
Police Indicator		**-0.199*** **	**-0.201*** **
		(0.029)	(0.030)
Constant	10.60***	11.32***	11.76***
	(0.949)	(0.759)	(0.795)
Observations	1,305	1,153	1,191
# of States	32	32	32

Driscoll- Kraay standard errors in parentheses, time and state fixed effects included.

*** p<0.01, ** p<0.05, * p<0.1

B.9. Appendix

B.9.1. Sources

Most of the variables have been obtained from the Archive of the Instituto Nacional de Estadística y Geografía in Mexico City. The information was found in statistical yearbooks that were available for the years from 1937 to 1988. The publications contained detailed and standardized information about a variety of statistical variables, disaggregated by year and state. The variables obtained include cause of death data, jurisdiction data such as the number of people accused and convicted for homicide, population, precipitation, illiteracy rates, percentage share of Catholics, indigenous population, per capita sugar consumption, number of pulquerías, cervecerías and total alcohol selling points, minimum wage, urbanization rate and the share of workers employed in the primary, secondary and tertiary sector. The yearbooks have been accessed during October and November of 2014 in the Archive of the Instituto Nacional de Estadística y Geografía in Mexico City. Figure B.20 gives an insight into the structure of the yearbooks.

Few other variables were obtained from additional sources. Since there is no official GDP data for Mexico available for before 1970, the estimated GDP series provided by Esquivel (1999) was used. Homicide data for the years after 1988 was retrieved from UNODC (2017).

Figure B.20: Statistical Yearbook of Mexican States for the Years 1963 to 1965

3.18 Defunciones por causas y entidades federativas. 1963–1965.—*Continuación*

Entidad y año	584, 585 Colelitiasis y colecistitis	590-594 Nefritis y nefrosis	640-652, 670-689 Complicaciones del embarazo, parto y estado puerperal	760-776 Enfermedades propias de la primera infancia	794 Senilidad sin mención de psicosis	780-795 Enfermedades mal definidas, excepto senilidad sin mención de psicosis	800-962 Accidentes	963, 970-979 Suicidio	964, 965, 980-999 Homicidio	Las demás causas
Baja California, T.										
1963	1	9	3	82	32	16	31	1	8	101
1964	2	8	4	76	57	21	33	2	7	128
1965	—	11	6	116	46	31	50	1	2	126
Campeche										
1963	3	15	23	201	171	149	81	5	9	230
1964	5	15	23	187	152	131	77	3	10	241
1965	5	14	22	181	171	112	88	8	14	245
Coahuila										
1963	11	115	48	1 270	744	569	366	11	78	1 395
1964	13	157	46	1 304	668	622	370	12	74	1 571
1965	11	119	54	1 192	671	558	440	20	97	1 420
Colima										
1963	1	12	8	250	109	94	187	1	76	282
1964	4	21	16	223	82	108	189	2	72	275
1965	3	23	17	306	113	110	217	1	61	284

1.—Población de los Estados Unidos Mexicanos, por Entidades Federativas, según los Censos de 1895, 1900, 1910, 1921 y 1930.

ENTIDADES FEDERATIVAS	CENSOS DE 1895	1900	1910	1921	1930
Estados Unidos Mexicanos	12 632 427	13 607 259	15 160 369	14 334 780	16 404 030
Aguascalientes	104 615	102 416	120 511	107 581	132 492
Baja California	42 245	47 624	52 272	62 831	94 469
Campeche	88 121	86 542	86 661	76 419	84 971
Coahuila	241 026	296 938	362 092	393 480	434 313
Colima	55 752	65 115	77 704	91 749	60 845
Chiapas	319 599	360 799	438 843	421 744	521 318
Chihuahua	262 771	327 784	405 707	401 622	491 893
Distrito Federal	476 413	541 516	720 753	906 063	1 217 663
Durango	295 105	370 294	483 175	336 766	895 807
Guanajuato	1 062 554	1 061 724	1 081 651	860 364	981 963
Guerrero	420 339	479 205	594 278	566 836	637 530
Hidalgo	558 769	605 051	646 551	622 241	674 674
Jalisco	1 107 227	1 153 891	1 208 855	1 191 957	1 239 484
México	841 618	934 463	989 510	884 617	978 412
Michoacán	896 495	935 808	991 880	939 849	1 014 020
Morelos	159 355	160 115	179 594	103 440	132 582
Nayarit	148 776	150 098	171 173	162 499	170 054
Nuevo León	309 252	327 937	365 150	336 412	416 173
Oaxaca	884 909	948 633	1 040 398	976 005	1 070 852
Puebla	984 413	1 021 133	1 101 600	1 024 955	1 148 286
Querétaro	228 551	232 389	244 663	220 231	234 386
Quintana Roo	... ...	... ...	9 109	10 966	12 150
San Luis Potosí	568 449	575 432	627 800	445 681	559 106
Sinaloa	258 865	296 701	323 642	341 265	385 512
Sonora	191 281	221 682	265 383	275 127	315 312
Tabasco	134 839	159 834	187 574	210 437	223 838
Tamaulipas	206 502	218 948	249 641	286 904	343 677
Tlaxcala	166 803	172 315	184 171	[illegible]	[illegible]

B.9.2. Summary Statistics

Table B.9: Summary Statistics

	# of Observations	Mean	Min	Max	Standard Deviation
Homicide Rate	2488	25.653	0.000	160.647	22.945
Log(Homicide Rate)	2487	2.854	-0.888	5.079	0.930
Economic and Deterrence Variables					
Log(GDP per capita♣)	192	9.181	2.625	10.842	0.863
Minimum Wage♣	192	29.572	0.770	180.000	46.798
Inequality Indicator	192	0.740	0	0.948	0.220
% Illiterate♠	255	0.285	0.019	0.620	0.154
Death Penalty Dummy	3012	0.304	0.000	1.000	0.460
Police Indicator	1715	1.061	0.129	24.000	1.221
Jurisdiction Indicator	1790	0.856	0.000	12.702	0.918
Sociological and Socioeconomic Variables					
% Indigenous♠	255	0.064	0.000	0.692	0.107
% Catholics♠	223	0.943	0.148	1.000	0.108
Urbanization Rate	893	41.752	0.000	100.000	18.577
% of Workers in Agriculture♠	192	0.577	0.022	1.000	0.224
Population Density	2794	156.449	0.211	6347.606	728.045
Alcohol Consumption and Government Activity					
Alcohol Sales Points Density[6]	1585	2.809	0.000	9.055	1.502
Cervecería Density[7]	1429	0.305	0.000	1.268	0.244
Pulquería Density[8]	1544	0.164	0.000	1.971	0.307
Drug Cartel Dummy	3012	0.172	0.000	1.000	0.377
Log(Government Spending per capita♣)	192	6.000	3.995	8.994	1.077
Additional Variables for yearly data					
Sugar Consumption per capita in kg	1453	29.677	2.051	143.515	15.966

♣ - in 1995 Mexican pesos
♠ - percentage share of total population

[6] Number of alcohol selling facilities per 1,000 inhabitants.
[7] Number of beer serving facilities per 1,000 inhabitants.
[8] Number of pulque serving facilities per 1,000 inhabitants.

C. Did the "Curse of Resources" impact on Homicide Rates?

Global evidence since 1890

Abstract

Does mining increase interpersonal violence? While the impact of natural resources on civil war and interstate conflict is well examined, its link to a second context of violence, interpersonal violence, is less explored. We assess the effect of silver mining on homicide rates, choosing silver because it was an important mining product for many countries over a substantial time span. We use a newly collected, global sample of countries, covering over more than 100 years between 1890 and 1990, and find that extensive silver extraction leads to heightened interpersonal violence. The effect is particularly pronounced in the interaction between silver mining and systems of autocratic governance. To rule out endogeneity, we use silver prices and silver deposit density as instrumental variables. Our key message is that economies mainly dependent on mining resources are not only prone to violent conflict, but are also at risk of amplified day-to-day violence.

This chapter is based on a paper co-authored with Jörg Baten (University of Tübingen). At the time this thesis was completed, the paper was in the peer-review process.

C.1. Introduction

Mining resources are a crucial input for modern economies. Without metals in particular, today's welfare and productivity levels could not be imagined. However, metal mining often has side effects on the societies and economies that surround it (Campbell and Roberts, 2010). Some of these side effects were most prominently hypothesized under the empirical paradox of the "Curse of Natural Resources" (Sachs and Warner 2001). Traditionally this phenomenon has been studied using national income growth (or its abatement) as the variable to be explained. But human welfare depends on a much larger vector of components which might be equally impacted.

The OECD stresses in a series of publications that personal security is an important component of living standards (for example OECD 2011). Welfare is not only reduced by deficient health, but also by serious crimes. People's well-being is certainly higher if they do not have to fear becoming a victim of crime, especially a serious crime such as homicide. Even if a crime does not happen to an individual, the victimization of a close relative or friend can have disastrous influence on the individual's welfare (van Zanden et al. 2014). A change in crime levels may also affect well-being substantially; a rise in violent crime, even if the absolute level is still relatively low, may contribute to feelings of insecurity; in particular if the increase in violence is broadly covered by the media.

Since personal security is one of the most important elements of a high living standard, here we study whether a "Curse of Natural Resources" might have a systematic impact on personal security. We use a global sample of country-specific averages over time (1890 to 2010). As a caveat, we need to mention that intra-country regional evidence would be preferable, as Fleming et al (2015) demonstrated. However, we compensate for this issue of country-averages by expanding our knowledge about resource curse effects far back in time, to the late 19th

Century.[9]

In order to study the effect of mining resources, a suitable indicator is needed. Silver is a natural resource that has always been important; and scarce. Silver coins were used as some of the first currencies in ancient times, it has always been rare and short in supply due to the limited presence of silver deposits worldwide and due to mining limitations. Thirdly, silver is distributed all across the world (Sverdrup et al. 2014). These characteristics make silver a suitable indicator of scarce resources with universal validity through time and across different cultures.

Our main hypothesis is that interpersonal violence is indeed one of the negative consequences of the resource curse of silver. To gauge the importance of country-level silver production, we use the share of gross value added by silver production relative to total GDP as our resource indicator. We measure country-level violence using homicide rates, since they have the advantage of being relatively clearly defined and the definition varies little over time and space. In contrast, other crimes have varying definitions and are sometimes counted in a different manner across nations. Hence, the degree of measurement error is usually lower for homicide rates than for other crimes. Moreover, homicide is a far-reaching crime for the offender, the victim and the public. Most societies invest a large amount of resources to prevent homicides (on all these aspects, see van Zanden et al. 2014).

We have collected and consistently coded contemporary statistical publications and archival data on homicide rates for numerous countries. These collections were supplemented with data from publicly available sources (WHO mortality database, ClioInfra, Historical Violence Database, Interpol) to construct a large unbalanced panel. The data set covers more than 65 countries, including data on Africa, Latin America, Asia. For many of these countries, a time

[9] It would not be feasible to a construct a dataset of resource curse effects on a regional level so far back in time.

span of 10 decades is covered, from the 1890s until the 1990s.

A graphical inspection of the trends of silver dependence and homicide rates gives some suggestive evidence that these two might be related, especially in Latin America: Figure C.1 shows the trends for Mexico, Peru and Chile from 1910/1920 until 2010. In the case of Mexico, we observe a small increase in silver dependence between 1920 and 1930 as the economy recovered from political conflicts during the Mexican revolution. However, after 1940, there is a consistent decline in silver dependence in Mexico. Accordingly, the homicide rate accompanied this change. On the other hand, in the figure on Peru, we can distinguish not only a decline, but also increases in silver dependence and murder. The initial decline in silver dependence around the 1930s is followed by an increase in the 1960s and a climax around the 1990s, in both silver dependence and homicide. Finally, for the case of Chile, downward trends in silver dependence and the homicide rate are visible from the early 1900s until 1960. After that period, the relationship is not as strong, since silver dependence started to increase again while the homicide rate did not. It seems that Chile was able to maintain its homicide rate at a relatively low level, in spite of its renewed dependence on silver resources.

Figure C.2 shows the average homicide rate and silver dependence values for all countries for which every decade between 1920 and 2000 was available. Aside from the first decade, declining silver dependence corresponds with declining homicides. An increase in silver dependence in the 1980s was followed by an increase in homicide rates in the 1990s.

To test this hypothesis empirically, we employ three different regression models. First, fixed effects as well as correlated random effects models are estimated. We include a number of control variables to check if the effect hinges on other mechanisms. Most prominently, GDP per capita is included. Low GDP levels might not only proxy low opportunity cost (allowing easier recruiting of young men or criminal gangs) but also an undiversified economic structure in which high silver dependence could also measure economic monoculture. By controlling for GDP per capita, we take this effect into account. Another important control variable is inequality, which might have a distinct effect as criminal gangs often arise when assets can be transferred from rich to poor in high inequality settings (Fajnzylber et al. 2002b). We also control for education, drug production and trade, violent conflicts and other factors (Fajnzylber et al. 2002a). The results show that silver dependence does in fact have a negative effect on personal security when looking at the global data set. This effect also survives the inclusion of these and other control variables.

Secondly, we also assess the interaction of silver dependence with autocratic regime types (using Polity IV data). A number of articles have hypothesized that law and order policies (which might be associated with autocratic regimes, see Chile 1970s/80s) might reduce crime and homicide (Pinker 2011). In the absence of mining resources, we actually confirm this. However, in silver mining countries, the interaction of autocracy and silver leads to further homicide, suggesting that kleptocratic behavior emerges more often in autocracies and that dissatisfaction in parts of the population is also more likely. The takeaway message is that – especially in the presence of valuable resources – the quality of the institutional landscape is crucial in avoiding violence and crime.

In a third and final step, we employ an instrumental variable approach to make sure that the results are not caused by endogeneity that might occur due to omitted variables or reverse causality: By altering the incentive structure in an economy, homicide rates might increase or reduce silver production. We use the world market price of silver as well as the number of sites in which silver occurs, per country, relative to the country size. Both variables are arguably good sources of exogenous variation that influence silver production in a country, but they cannot be impacted by the violent characteristics of a single country. The results show that the effect is even more pronounced when integrating these exogenous sources of variation. We conclude that the previous results were not artificially bolstered by reverse causality or an omitted variable, but rather that the effect might even be underestimated by OLS benchmarks. As an additional check of a potential omitted variable bias we use the methodology proposed by Oster (2017) and find that omitted variables would probably not eliminate the silver dependence effect.

The paper is organized as follows. The next section gives a summary of the existing literature on the topic and previous studies. It also provides some potential channels through which silver dependence might influence homicide rates. Section C.3 presents the data and some descriptive statistics. In Section C.4, we describe the methodology used and present our regression results. Section C.5 summarizes the findings and discusses potential policy implications.

C.2. Previous Literature and Economic Framework

The "resource curse", originally identified by Sachs and Warner (2001), is one of the most paradox and interesting phenomena in the economic growth research area. This line of research argues that the availability of natural resources does not stimulate income growth but rather reduces it, especially in the presence of suboptimal institutional setups. Windfall gains from mining resources, for example, lead to exchange rate appreciation and, hence, pressure on industrial exports. They can also lead to rent-seeking behavior, corruption and inefficient governance (see, for example, Sala-i-Martin & Subramanian, 2003).

But do resources only impact on economic performance? As human welfare depends on a multitude of factors, one should not consider economic growth rates in isolation. One important dimension of wellbeing is personal security, which might also be affected by the resource curse via an increased incidence in violence.

According to the WHO (2002), violence appears in two main forms: on the one hand, there is collective violence – which refers to any violence committed by larger groups of individuals such as interstate wars or civil wars. On the other hand, there is interpersonal violence, which mostly appears between unorganized individuals – homicide being the most prominent example.

A vast number of empirical studies have shown that the presence of valuable resources increases the probability of civil war or conflict (Collier, Hoeffler & Soderbom 2004, Fearon and Latitin 2003, Blattman and Miguel 2010, Ross 2004 and Bazzi and Blattman 2014). Elbadawi and Soto (2014) also examine the interaction of resource rents and institutional quality. They find that better political institutions (democracy, control over government decisions) decrease the incidence of conflict while the presence of resources can even dampen the potential conflict-containing effect of good institutions. Van der Ploeg (2011) summarizes various studies on the impact of natural resources and comes to a similar conclusion: "A resource boom reinforces rent grabbing and civil conflict especially if institutions are bad [and] induces corruption, especially in nondemocratic countries" (p.1). While a substantial amount of evidence has been gathered on the fact that natural resources can increase the risk of war and conflict there are only few studies that look at the effect resources can have on the second form of violence – namely day-to-day, interpersonal violence.

A couple of studies look at the grey area between conflict and individual violence, namely the emergence of organized crime groups and gangs, which usually entails higher violence levels. Angrist and Kugler (2008) show that the Colombian civil conflict is fueled by the financial opportunities that coca production provides. In 1994, rural areas were affected by increases of coca prices and the extension of cultivation. Subsequently, these regions became considerably more violent. The authors suggest that coca revenue supports rural paramilitary groups and insurgents. Similarly, the emergence of the Sicilian Mafia can be attributed to the concurrence of a lack in state property-rights enforcement, with a sharp increase in the international demand for Sulphur – Sicily's most important export commodity (Buonanno et al. 2015). This combination increased the demand for private protection and created opportunities for rent-seeking through extortion.

Interpersonal, individual violence has not been studied as extensively, mostly due to the lack of data. Only a few studies in a local context have been published. One example is a study by Couttenier et al. (2016) that exploits a natural experiment during the US gold rush. Gold was discovered in some counties after the establishment of formal police institutions and in other counties even before formal police institutions were in place. Couttenier et al. (2016) show that, in the latter case, homicide rates per capita were higher and that this effect has persisted until today. Idrobo et al. (2014) show that gold mining in Colombia is related to increased violent activity. In a recent paper, Hong and Yang (2018) look at the impact of natural resource extraction on violent incidents in Xinjiang, China. They find that for the specific Chinese context that higher natural resource extraction has a soothing effect on violence. James and Smith (2017) present another study on the US, examining the impact of resource booms on violent and property crimes. They find that towns affected by an energy boom display increasing crime rates throughout the country.

Stretesky et al. (2017) is the only cross-national study using a relatively short panel of 173 countries and 12 years. They use the revenue created by the sale of natural resources as indicator and show how excessive natural resource dependence increases homicide rates.

The previous results are mixed; however, they mostly suggest the presence of a violence-increasing effect of natural resources for regional examples and short macroeconomic panels. Since no study with global and long-term perspective has yet been conducted on the link between (mining) resources and interpersonal violence, our study adds substantial value to the literature.

The mentioned examples show that gold and silver seem to be among the resources that are particularly prone to increasing violence in society (Downey et al. 2010). Galeano (1971) noticed that gold and silver extraction in Latin America was accompanied by violence ever since colonization. Berman et al. (2015) document how – throughout Africa – the "appropriation of a mining area" (p.1) by violent groups contributes to the escalation of violence across the entire country.

The presence of mining resources might matter, especially in the absence of property rights enforcement and the rule of law. Two channels of transmission can be hypothesized:

First, in a setting with low institutional quality and the subsequently weak enforcement of property rights, individuals with a comparative advantage in violence will engage in violent behavior to appropriate a larger share of the resource surplus (Skaperdas 1992, Gonzalez 2012, Spierenburg 2006). According to Couttenier et al. (2016), this occurs "because interpersonal violence and state enforcement are substitutes for enforcing or defending property rights". Violence can be used for both direct expropriation as well as to create a reputation of being extraordinarily violent. Downey et al. (2010) state that in the presence of abundant natural resources, violence is the most efficient mechanism to prevail over others in the occurrence of conflicts. In their definition of violence, they include violence perpetrated by the military, the police as well as by mercenary and rebel forces.

The second potential channel is that resources provide financing for the formation of criminal gangs and organizations, which might have external effects on interpersonal violence.

In conclusion, if resource extraction is high and the institutional structure allows kleptocratic tendencies to arise, the presence of (abundant) silver resources might lead to an outburst in violence, since interpersonal violence is used to appropriate revenue, defend or enforce property rights, or to deter attacks revolving around the revenue generated subsequently.

C.3. Data and Descriptive Statistics

C.3.1. Measuring Interpersonal Violence: Homicide Rates

We take the homicide rate as an indicator of interpersonal violence. We follow the UNODC definition of homicide as an “unlawful death purposefully inflicted on a person by another person” (UNODC 2011). This definition makes clear that the incident has to meet 3 points: 1) there must be a killing, 2) the killing was intended by the perpetrator and 3) the killing was against the law.

Homicide rates are widely used by researchers as an indicator of interpersonal violence because they have many advantages (van Zanden et al. 2014). First, there are fewer definition issues compared to other violence statistics, since the definition of a homicide is relatively clear and is identical in most cultures. On the contrary, non-lethal violent activities are often counted in many different classification items of statistics. For example, rape was not considered a violent crime in some western societies until few decades ago if it took place between married partners. Another advantage is that for homicide rates, technological change in killing technology does not matter, since all deaths are counted regardless of how they occurred.

Certainly, homicide rates are not without problems. Among the caveats, we need to mention that during the most recent period, there was a certain degree of medical progress. This implies that nowadays, the same level of violence results in fewer lethal homicides because the victims can be saved. Mobile telephone technology has also led to a mortality reduction in a number of otherwise lethal events. Moreover, some countries did not always treat infanticide or the killing of brides or marriage partners after adultery (honor crimes) as homicide. Another major challenge is the problem of underreporting. The institutions reporting the homicide rate (for example police force, criminal justice system) might have an incentive to artificially lower the number of homicides, which might cause a downward bias. There is a large amount of research on these issues, which suggests that these caveats bias neither the cross-sectional nor the intertemporal statistics substantially (see UNODC 2011). In general, homicide research in a long-term perspective has made progress, improving the comparability between cultures and over time (for a recent review of studies, see ibid.).

Our homicide rate database was constructed using a wide variety of sources. A large amount of earlier research by social historians, legal study experts, and – for the more modern periods – UN organizations, allows us to mobilize a substantial compilation of homicide rates worldwide; and in some countries, even for early periods. Generally, there are two main sources of homicide data: criminal statistics and health statistics. Health statistics are usually less affected by underreporting since the deaths are certified by health physicians[10], and health authorities usually have no incentive to artificially lower the homicide rate. It is a great advantage that, in many cases, we had both sources available and hence, were able to minimize measurement error: When data from both sources was available (health and criminal statistics) and not concordant, priority was given to the cause-of-death data from public sources. The most important sources for our database were the WHO, ClioInfra Project, the World Bank, Interpol and the Historical Violence Database.[11]

[10] During the last decades, physicians used the WHO International Classification of Diseases (ICD) for this purpose.

[11] More information on the homicide rate data and sources can be found in appendix C.8.1.

C.3.2. Silver as Resource Indicator

Why do we study silver as indicator of resource dependence? For our analysis, we chose to focus on silver since it has a number of advantages over other mining products, first of all, universality over time and space. Silver has been important for many civilizations since ancient times, whereas gold, diamonds, or other scarce resources have been either more localized (gold, antimony and diamonds) and/or have only become important during recent decades (oil). In the case of diamonds, the top four countries (Congo (Kinshasa), Russia, Australia and Botswana) account for 91% of the total world mine production while for silver, the top four producers account for only 53% of total world mine production (U.S. Geological Survey 2018).

Silver coins were already used as a payment method in antiquity. Silver was converted into decorative items and jewelry since this period. Most nations were on a silver standard until the late 19th century. Nowadays, silver is still widely used. Due to its excellent thermal and electrical conductibility, silver is integrated in conductors, switches, contacts and fuses, as coating material in photovoltaic cells, in mirrors and in batteries. Silver is also present as jewelry and silverware, in photography and in coins. Silver deposits are also not limited to certain geographical conditions or continents. Even though the bulge of silver deposits is situated along western North, Central and South America, significant silver production can be found in all continents. Silver deposits are only rare in Northern and Central Africa (Figure C.3).

The second advantage of silver is that the law of one price is not too strongly violated. East Asia might have had slightly higher prices and a greater appreciation of silver in the early modern period but, in general, the price of silver is quite similar across countries due to its easy transportability. For this study, silver also has the advantage that it belongs to a group of resources that are easily appropriable or lootable (Van der Ploeg 2011). Other resources that have a much lower value per unit of weight, such as iron, need more consent and cooperation by the labor force to be transported and, hence, the resource curse aspects are much less obvious for iron production.

Finally, technological change matters for silver, but it was less radical than for other resources. Oil experienced an enormous increase in demand during the middle of the 20th century whereas guano, for example, was important for the 19th century. However, it became obsolete after the invention of nitrogen fertilizer. Moreover, the data availability and comparability for silver is a lot better than for other metals or natural resources (except gold), which makes it one of the best natural resource indicators. One last reason why we decided to use this single resource indicator instead of a vector including a larger set of natural resources is comparability over time and space, which would not be given if different resources with different units and volatile prices were used.

C.3.2.1. History of Silver production

Silver is a soft, white metal that occurs in nature either in native form, as an alloy with gold, or in various ores (in conjunction with minerals). The main sources of silver are ores combined with copper, lead and zinc. The silver metal is extracted by smelting or by chemical leaching. After the discovery of the Americas, vast amounts of silver were shipped to Europe, especially from Zacatecas (Mexico) and Potosí (Bolivia).

Between 1876 and 1920, worldwide silver production exploded, mostly due to technological innovations and the exploitation of new regions in Australia, Canada, USA, Africa, Japan and elsewhere. The total silver production increased from around 80 million ounces annually in the 1870s to 190 million ounces by 1920 (on all this, see silverinstitute.org). Major technological breakthroughs include “steam assisted drilling, mining, mine dewatering and improved haulage” (silverinstitute.org 2017). These new technologies were necessary to be able to separate silver from ores that contained less silver, since many of the high-ore deposits were exhausted by the end of the 19th century.

In 2015, the biggest silver mine was situated in Australia, whereas Mexico continues to be the world’s largest silver producer (189.5 million ounces). Other top silver producers are Peru, China, Russia and Australia (silverinstitute.org 2017).

C.3.2.2. Silver Data

The information on silver production was retrieved from three different sources: the ClioInfra database, the British Geological Survey and the “Historical Statistics on Silver Production” by the US Department of Commerce.[12] The production data from the different sources have all been converted to kg per capita to ensure comparability. In a second step, the average annual silver production (in kg per capita) has been calculated for each decade. Since, for our analysis, we need a variable that expresses how important silver production was for each respective country, we calculated silver dependence ratios, presented below.

The dataset employed in this paper stretches over 110 years from the 1890s to the 1990s, covering 67 countries in total. In the earliest decade, seven countries are covered (Spain, Italy, Germany, Greece, France, Sweden, Japan) while in the most recent decade, observations for 58 countries are included. The coverage is quite global, including data from all world regions (see Figure C.4 or refer to appendix C.8.3. for a more detailed discussion of the observations included in the dataset).

[12] For further information on the sources see appendix C.8.2.

C.3.2.3. Silver Dependence Ratio

To what extent does an economy depend on silver production? We construct a measure of silver dependence, the share of total GDP that was generated by silver production.

$$Silver\ Dependency\ Ratio = \frac{Gross\ Value\ Added\ by\ Silver\ Mining\ per\ capita}{GDP\ per\ capita} * 100$$

Both the gross value added (GVA) of silver mining per capita and GDP per capita are expressed in 1990 international Geary-Khamis USD.[13] We use deflators (nominal per real GDP) to convert nominal silver prices into 1990 dollars (following Földvári 2006, for details see appendix C.8.2). Using this approach, we can calculate silver dependence ratios for 90 countries. The ratios range from 0% to 6%.

According to this ratio, the most silver dependent countries that, on average, obtained more than 1% of their national income during the last centuries are Mexico, Republic of Congo (Brazzaville) and Peru. These countries are closely followed by Honduras, Namibia and Bolivia (between 0.5 and 1%). Other countries that obtain a substantial share of their GDP from silver mining (between 0.1 and 0.5%) are Chile, Australia, Colombia, Canada, Democratic Republic of Congo (Kinshasa), Zambia, Kazakhstan and the USA.

Previously, no estimations of the contribution of silver mining to GDP have been realized for most of the countries for the period under study. However, estimates for total mining per GDP exist and hence we were able to cross-check the obtained results with estimations of the contribution of the total mining sector in order to assess whether the magnitude of silver dependence in each respective country is realistic (Table C.1). We find that our estimate of silver dependence correlates with the total mining contribution to GDP that is available in some cases,

[13] Since the 1990 Geary-Khamis international USD is chosen as the currency unit of this paper, all data expressed in other currencies were converted.

and the magnitude does indeed seem plausible. Silver typically accounts for 10 -20% of total mining revenue to GDP. Also, the high dependence numbers for Mexico at the end of the 19^{th} century seem plausible, since up to 1850 Mexico was always among the largest silver producers (US Department of Commerce 1930).

C.4. Empirical Analysis

Our main hypothesis is that higher silver dependence leads to a significantly higher homicide rate. To test this hypothesis, we use the following specification:

$$\mathrm{Y}_{it} = \beta_0 + \beta_1 L.Silver\ Dependence_{i,t-1} + \beta_2 X_{it} + \delta_i + \delta_t + \varepsilon_{it} \qquad (1)$$

Y_{it} is the natural logarithm of the decadal homicide rate per 100,000 inhabitants of country *i* in decade *t*. We use decadal averages to rule out short-term fluctuations both in the dependent and in the explanatory variables and to rule out the risk of spurious regression: As described by Kao and Baltagi (2000) and Ventosa-Santaularia (2009), when dealing with macro panels with large N (Number of countries) and large T (length of the time series) rather than the usual micro panels with large N and small T, the presence of a trending mechanism can lead to spurious results. Reducing the length of the time series reduces the risk of spurious regression. Furthermore, we are not interested in the short term fluctuations in homicide rates or silver dependence, but rather in the long-term effects of how a high silver dependence can have a substantial effect on the violence levels in a society. Another argument in favor of the use of decadal observations is the availability of control variables. For many variables, data is only available every or every five years. Using decadal averages, the availability of control variables can be maximized. Nevertheless, we also report results using country-year observations in the robustness checks. δ_i and δ_t are country and time fixed effects. ε_{it} is the unexplained, idiosyncratic error.

$Silver\ Dependence_{i,t}$ is our silver dependence ratio described above. This variable enters the regression lagged by one decade. We expect the effect of resource dependence on violence not to be immediate, but it seems more realistic that distortions take a certain time to exert an influence. Lagging by one decade is a natural choice in a decadal panel, which is in line with the methodology applied by previous studies as for example Hong and Yang (2018) and Stretesky et al. (2017). Stretesky et al. (2017) show that the correlation between homicide rates and resource dependence is highest when the resource rents are lagged by 10 years. The decision to lag the silver dependence is furthermore supported by our inspection of Figure C.2, which displays a one decade lag from resource dependence to homicide.

An additional benefit is that lagging the most important explanatory variable avoids the possibility of reverse contemporaneous causation (Hong and Yang 2018, Kollias and Ali 2017).

X_{it} is the vector of control variables that includes:

1) Log (GDP per capita)
2) Gini coefficient of income inequality
3) Execution of death penalty (dummy variable)
4) Education (combined index of numeracy and enrollment rates)
5) Interstate conflict in that decade (dummy variable)
6) Autocracy (dummy variable)
7) Major drug production or trade (dummy variable)

We include GDP per capita as a proxy of the general level of income and development of each country; it acts as one of the most important control variables. Lower GDP levels might not only proxy low opportunity cost (allowing easier recruiting of individuals for criminal activity, see Fajnzylber et al. 2002a) but also an undiversified economic structure in which high silver dependencies are more pronounced. Another important control variable is inequality, measured by the Gini coefficient, which has previously been shown to be related to high levels of violence (Fajnzylber et al. 2002b). Incentives for violent expropriation are higher if assets can be transferred from rich to poor in high inequality settings.

Execution of the death penalty is a dummy variable that takes on the value 1 if the death penalty has been executed in that decade and 0 otherwise. This variable can be used as a proxy indicator for the severity of the judicial system or, more precisely, the harshness of the punishment of convicts. Deterrence of potential delinquents through severe punishments might influence the decision to engage in criminal behavior (Fajnzylber et al. 2002b) and hence, needs to be controlled for.

Education is another factor that alters the incentives of an individual to commit a severe crime by increasing the opportunity costs of criminal behavior, resulting in less violent and illegal activities. We include a combined index of education that is based on average years of schooling and is complemented by numeracy data.[14]

We include a dummy variable that indicates if a violent conflict, civil war or interstate war took place in the respective decade in the country, to control for the fact that in the years leading up to a war and during its aftermath, a society is generally characterized by unrest and turmoil. There might be externalities from wars on interpersonal violence.

We control for autocracy, using an indicator variable that takes on value 1 if the Polity IV score of the single country in each decade was lower than the world average score in that decade. Hence, it identifies whether the political setup was rather autocratic in comparison to the other countries in the world at the same time. As mentioned above, institutions play an important role in determining the specificities of the resource curse. Since the multitude of institutional regimes is impossible to capture in one single variable, we decided to opt for a dummy indicator that

[14] For a detailed description of the construction of the index refer to appendix C.8.4.

clearly discerns between “good” and “bad” institutional setups.

Finally, we include a binary variable indicating whether a country was majorly involved in drug production or trade. Due to the lack of time variant evidence, we can only include this variable in the random effects specification (see Table C.5).

Table C.2 offers descriptive statistics of the variables included in our empirical analysis.[15] Our empirical analysis follows a three-step approach: In a first step, we estimate fixed effects panel models to control for unobserved country-specific heterogeneity that is constant over time. Secondly, since we realized that the assumptions of a random effects model might be fulfilled, we estimated correlated random effects models as first suggested by Mundlak (1978) and developed by Allison (2009). This specification has the advantage that it relaxes the assumption of the pure random effects model and that it allows for the inclusion of time-invariant variables. Even more importantly, we can identify whether the resource effect is more an intertemporal or a cross-sectional feature.

Thirdly, we estimate IV regressions. Even though silver mining depends mostly on the availability of resources and the world market demand, there is always the possibility that endogeneity – due to reverse causality or omitted variables – is present in macroeconomic regression models. For example, one could imagine that homicide rates might influence silver mining by changing the incentives of investors and the overall economic climate in the country. Autocracy is less suspicious of endogeneity because of its institutional nature, which implies that it changes relatively slowly over time and is, hence, unaffected by the homicide rate, contemporaneously or in the short run. To ensure that the previous results are not influenced by endogeneity, we present IV-estimations in chapter C.4.4.

[15] For a detailed description of the control variables and their sources, please see appendix C.8.4.

C.4.1. Fixed Effects Analysis

In a first step, we examined the impact of silver dependence on homicide rates over the entire global panel[16] using a fixed effects estimation. This model identifies the effect of silver dependence on homicide rates by relying on within-country time series variation while controlling for country specific differences that are constant through time. We also include time FE (specified as half centuries controls). We clustered the standard errors at the country level to allow for both heterogeneity and intra-country correlation of errors.

The results are presented in Table C.3 and the main hypothesis is confirmed. We find a significant positive link between lagged silver dependence and homicide rates (models (1) to (4)). This effect holds even when controlling for different sets of covariates.[17] Regarding magnitude, in the case of model (4), a 1 standard deviation increase in silver dependence (0.19) roughly entails a 10% increase in the homicide rate.

In line with theoretical predictions and previous studies, we find a negative impact of GDP per capita on homicide rates (van Zanden et al. 2014 and van der Ploeg 2011). Higher incomes direct activities away from illegal and violent alternatives. In this fixed effects specification, we nevertheless find no evidence for an impact of inequality on violence levels. This might be due to the nature of the fixed effects model, which puts the focus on variation over time but not on variation across countries. Likewise, we find no evidence for a significant impact of education or the execution of the death penalty. The presence of violent interstate conflict or civil war, in contrast, has externalities on interpersonal violence and increases the homicide rate over the entire decade. The dummy for an autocratic institutional setup is negatively associated with the homicide rate. This might be due to the severity of the punishment and prosecution of perpetrators in authoritarian regimes, which might not be fully captured by the death penalty

[16] For a discussion of selectivity of the sample refer to appendix C.8.3.

variable. This is not implausible. Related studies on civil war also find that countries that transitioned from autocracy to democracy were especially vulnerable to this type of violence. Only extremely democratic countries with a history of democratic participation were not violent (Collier and Hoeffler 2004 and Benson and Kugler 1998). Appendix C.8.5 offers various robustness checks, showing that the results remain identical when using country-year observations or different groups of countries with especially high or low silver dependence.

C.4.2. Correlated Random Effects Analysis

In the current literature, it is customary to estimate fixed effects models because the strong assumption of the alternative random effects model (i.e. that the regressors and the unobserved, time-invariant factors are uncorrelated) usually cannot be maintained (LaFree 1999). However, when performing Hausman tests to compare the fixed effects to the random effects results, we discover that the use of a random effects model is actually feasible in our case (the results of the tests are included at the bottom of Table C.4). Hence, we additionally decided to estimate a correlated random effects model as originally proposed by Mundlak (1978) and developed by Allison (2009). This model splits the effect of the cluster-varying covariates into within-cluster (correlation over time) and between-cluster (across cross-sections) effects. This is accomplished by including, as independent variables, both the deviations of the variable from the cluster mean as well as the cluster means of the variable. The assumptions of a pure random effects model are relaxed. The estimated equation is as follows:

$$Y_{it} = \alpha + \theta_1 * (X_{it} - \bar{x}_i) + \theta_2 * \bar{x}_i + \varepsilon_{it} \qquad (2)$$

θ_1 - captures the within-cluster effect

θ_2 - captures the between-cluster effect

The results of the Mundlak-model are presented in Table C.4. Again, we clustered the errors on the country level to allow for heterogeneity and for intra-country correlation of errors.

The results concerning the within effects corroborate the inference obtained from the previous fixed effects regressions (Table C.3). Over time, an increase in silver dependence by one standard deviation leads to around an increase in homicide rates by roughly 10%, which is obviously a substantial effect. However, in the cross-sectional dimension, the silver dependence does not have a robust effect. This finding is in line with Stretesky et al. (2017) who propose that natural resource extraction has an impact over time within countries but not between them.

Again, GDP per capita has a violence-reducing effect, while a higher silver dependence one decade ago increases violence levels significantly. Looking at the between effects, we can now identify the important impact of the inequality measure, the Gini coefficient: Higher inequality is associated with a higher incidence of homicide (Paré 2006). As expected, the impact of inequality on crime and violence can only be observed looking at the cross-sectional level, as we find no impact of inequality on violence over time.

One advantage of the random effects model is that we can also control for time-invariant country characteristics, e.g. being a major drug producer, which might be an important confounding factor. Table C.5 shows that the results are robust to including a dummy variable that indicates if the country is listed as a major drug producer[18].

C.4.3. The Interaction of Institutions and Silver Dependence

In the first two regressions, we have shown that there is significant correlation between silver dependence and crime, even when controlling for different confounding factors. In a second step, we now want to assess the role of the political setup in this relationship.

[18] The dummy variable takes on the value 1 if the country is listed as major illicit drug producing or major drug-transit country in the International Narcotics Control Strategy Report 2015 (US Department of State).

We employ an interaction specification to test our hypothesis that the silver-violence-curse is reinforced in countries with an autocratic political setup that allows kleptocratic behavior if an "easily lootable" resource such as silver is available (van der Ploeg 2011).

We estimate the following model specification:

$$Y_{it} = \beta_0 + \beta_1 L.Autocracy_{it} + \beta_2 L.Silver\ Dependence_{it} + \beta_3 L.(Autocracy\ _{it} x\ Silver\ Dependence_{it}) + X_{it} + \delta_i + \delta_t + \varepsilon_{it} \quad (3)$$

When applying Hausman tests, we again find that the assumptions for the random effects model are met (results are presented at the bottom of Table C.6). Hence, we estimated the correlated random effects model presented in Table C.6.

The results regarding the within effect are consistent with the previous regressions, relating an increase in silver dependence to significantly higher homicide rates. The interaction between institutional setup and silver dependence does not have a significant within effect. When looking at the between effect, the picture is different. The results indeed indicate that an interaction effect exists in the cross-sectional dimension. While the silver dependence and the autocracy dummy alone have no significant impact, the interaction of the two is highly significant and substantial in magnitude: An increase of 1 standard deviation of silver dependence in an autocratic country translates into a 113% increase in homicide rate (model (3)).

The secondary results are consistent with previous findings, e.g. higher GDP per capita is associated with lower violence levels (over time) while inequality is linked to higher violence levels (across cross-sections).

C.4.4. Instrumental Variable Approach

The previous results might be affected by endogeneity problems. Endogeneity could be caused, for example, by reverse causality between homicide rates and silver production or by omitted variables. It might be the case that changes in country-level violence impact on mining activities due to different incentives and conditions. For example, investors might be less likely to invest in mining in countries with high levels of violence, thereby reducing the quantity of silver produced. One additional threat to the validity of the result is the possibility of measurement error in both the silver dependence variable and the homicide rates.

To assess whether the regression results are biased by endogeneity, we adopt an instrumental variable strategy. As a first instrument for silver dependence, we use the number of identified silver deposits in a country relative to their total area (see appendix C.8.2 for additional information). The geographical features that favor the occurrence of silver cannot be affected by the levels of violence in the country, or by other omitted variables that are not geographical in nature. Hence, the number of silver sites per country provides a good source of exogenous variation across cross-sections, which is strictly unrelated to the socioeconomic conditions in a country, since it is predetermined by geographical features. Additionally, we assume that there cannot be any direct effect form the silver deposits in the ground on homicide rates, since the number of discovered silver sites in a country does not have any economic or social impact on society. Only via extraction, once the deposits are being extracted, the impact can show via the mechanisms described above.

Additionally, we add the international silver price as a time-varying instrument. This instrument is not affected by the production quantities of individual countries, since none of the countries included in the sample is a producer with a large enough share of the world market to influence the world market price. The exclusion restriction is also assumed to hold, since it is hard to imagine to have any direct impact of the silver price on a country's homicide rate. Only via the production of silver and hence the silver dependence, the homicide rate might be impacted. Finally, it is likely that an increase in the international silver price raises the incentive to extract silver, and silver production in a country will increase. Hence, the silver prices likewise are a source of exogenous variation.

We regress the silver dependence on the two instruments, the world silver price as well as the predetermined number of (discovered) silver sites per area to obtain exogenous variation in silver dependence. The first stage of our regression is as follows:

$$\text{Silver Dependence}_{it} = \gamma_0 + \gamma_1 \text{Log(Silver Sites per Area)}_i + \gamma_2 Log(Real\ Silver\ Price)_t + \gamma_3 X_{it} + \epsilon_{it} \qquad (4)$$

Table C.7 presents the results of estimating equation (1) using the two stage least squares model (2SLS). The specifications contain different sets of control variables and all contain half-century fixed effects.

As seen from the first stage results, the F-statistics of excluded instruments are at least close to the threshold level of 10. To cope with a potential weak instruments problem, we apply limited information maximum likelihood techniques that were designed for moderately weak instrument estimation and these yield very similar results.

Under the usual assumptions, the Sargan-test signals that overidentification is not a major issue, as p-values are always higher than 0.10. Of course, no empirical economist can ever be sure that the exclusion restriction does indeed hold. However; in the case of silver deposits, it seems likely that the effect on homicide rates runs via silver production, and the same is true for the world market price of silver.

In all specifications, the lagged silver dependence has a positive and significant impact on homicide rates, just as in the previous estimations without instrumental variables. When comparing the results to the fixed and correlated random effects models above, it is striking that the coefficient has increased considerably in magnitude. If the lagged silver dependence increases by one standard deviation, the homicide rate increases by almost two standard deviations (when evaluated at the mean homicide rate). The reason might be the presence of some degree of measurement error in the fixed effects specification, which was considerably reduced using the instrumental variable approach.

Regarding the secondary results, the importance of a conflict in the respective decade is underlined also by the 2SLS results. Inequality tends to increase violence, while the contrary holds for GDP, however these results are not very robust.

C.4.5. Selection on Unobservables

Even though the instrumental variable approach corroborates the findings in Table C.3, the estimates might still be biased by unobservable factors related to the degree of silver dependence in a society. Altonji, Elder and Taber (2005) have suggested a method to gauge the potential bias from unobservables using the selection on observables. This method examines how strong the selection on unobservables has to be in order to annul the estimated effect. Recently, this method has been applied in a variety of empirical frameworks (for example Nunn and Wantchekon 2011).

The method is based on the common phenomenon that in multiple regressions, the size of the coefficient of the main variable of interest declines as more (observable) control variables are included. The Altonji-Elder-Taber-ratio (AET-ratio) compares the size of the coefficient of the full model including the controls to the size of the coefficient of a restricted model with only a constant (and in our case, country fixed effects) included.

The AET-ratio is calculated as follows:

$$AET - ratio = \frac{\beta_{full}}{\beta_{restricted} - \beta_{full}}$$

The bigger the coefficient of the full model, the stronger is the effect of the variable of interest (silver dependence); and the smaller the difference between the coefficients of the two models, the less the size of the coefficient is affected by the selection on observable control variables.

If the control variables do only modestly reduce the magnitude of the silver dependence coefficient, then the unobserved variables would need to have a very strong effect to eliminate this effect completely. This methodology relies on the assumption that the relationship between the treatment and the observed explanatory variables provides information about the relationship between the treatment and the unobserved variables (Altonji, Elder and Taber 2005).

Oster (2017) recently suggested an important improvement to the AET-ratio. She shows that not only the movement of the coefficient matters, but also changes in the explanatory power (as measured by the R^2) need to be taken into account to obtain a consistent estimator for omitted variable bias. Following Oster (2017), the movement of the coefficient is evaluated relative to the changes in R^2 which is the share of variation of the dependent variable explained by the included control variables. A maximum value for R^2 needs to be set, determining the maximum share of variation the unobserved variables could explain. Then we can estimate the explanatory power unobserved variables would need to have in order to turn the estimated treatment effect of silver dependence insignificant (δ).

Table C.9 presents the estimates of the amount of selection on unobservables necessary for the treatment effect to be equal to zero (β=0). [19] Both estimates (including all countries or

[19] We use the Stata command *psacalc* provided by Oster (2017) to calculate the estimates of the sensitivity parameters, and least-squares dummy variable version of model (4) of

including only the countries with significant silver productions) are above 1, hence the results are robust to omitted variable bias according to Oster (2017). When using a less conservative approach and setting the maximum R^2 to 0.9, then the estimates of the sensitivity parameters increase, indicating that the power of the unobservables would need to be at least as big as the explanatory power of the variables already included. We conclude that our findings can be considered robust to omitted variable bias.

C.5. Summary and Conclusions

In the past, it has been shown that the resource curse can have many dimensions. With this paper, we have added to the literature by showing that the presence of valuable mining resources (such as silver) can lead to increased country-level violence. This effect seems to be amplified when being interacted with poor institutional setups. The mechanism might be weak property rights enforcement, because kleptocratic behavior cannot be avoided. Moreover, criminal organization might substitute any public enforcement of property rights. Organizations prone to violence (gangs, guerrillas, paramilitary groups) may benefit from the additional revenue generated by the resources (instead of the government), especially with weak institutional setups. This allows them to become even more violent and powerful, purchasing more weapons and exerting more regional influence. There are several studies that examine the impact of resources on violence and its interaction with institutions in a local context (Angrist & Kugler 2008, Umbeck 1977, Couttenier et al. 2016).

It is important to formalize and regulate the exploitation of valuable resources to avoid conflicts about the distribution of created revenue. Well-defined property rights and the efficient

Table C.3 using the Stata command *areg* with country dummies.

prosecution of delinquency are crucial in this context. In the future, environmental change, economic development and population growth will increase the pressure on natural resources such as water, soil, crude oil, natural gas, coal even more (Bergstrom and Randall 2016, Vörösmarty et al. 2000). This development will create more settings with scarcity of certain resources that might eventually escalate into open violence (Ide 2015). In this context of future developments, the research of the impact of scarce natural resources on human behavior is even more relevant.

Furthermore, our findings add to the previous literature on the determinants of violent crime. First, consistent with most previous investigations, the level of economic development, measured by GDP per capita, is negatively linked to the homicide rate. This link is most pronounced over time. We also studied inequality effects and found that this link is only visible across countries, but not over time.

In this article, we focused on the "silver curse" since this mining resource probably had less of a time variant effect than oil or guano and it has been important for many countries, while gold and diamonds are more concentrated in a few geographical areas. Still, there would be a desideratum for future research to examine a combined resource curse from the sum of all resources. However, conceptually, it is not easy to weigh the different resources according to their appropriability or "lootability" (Boschini et al. 2007). More lootable resources certainly matter more for any potential resource curse and technological changes in the appropriability of resources was considerable, which complicates such an "all-resource" approach. Hence, identifying a "silver curse" is an important first step which needs to be taken when studying the development of welfare in a global perspective.

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C.7. Figures and Tables

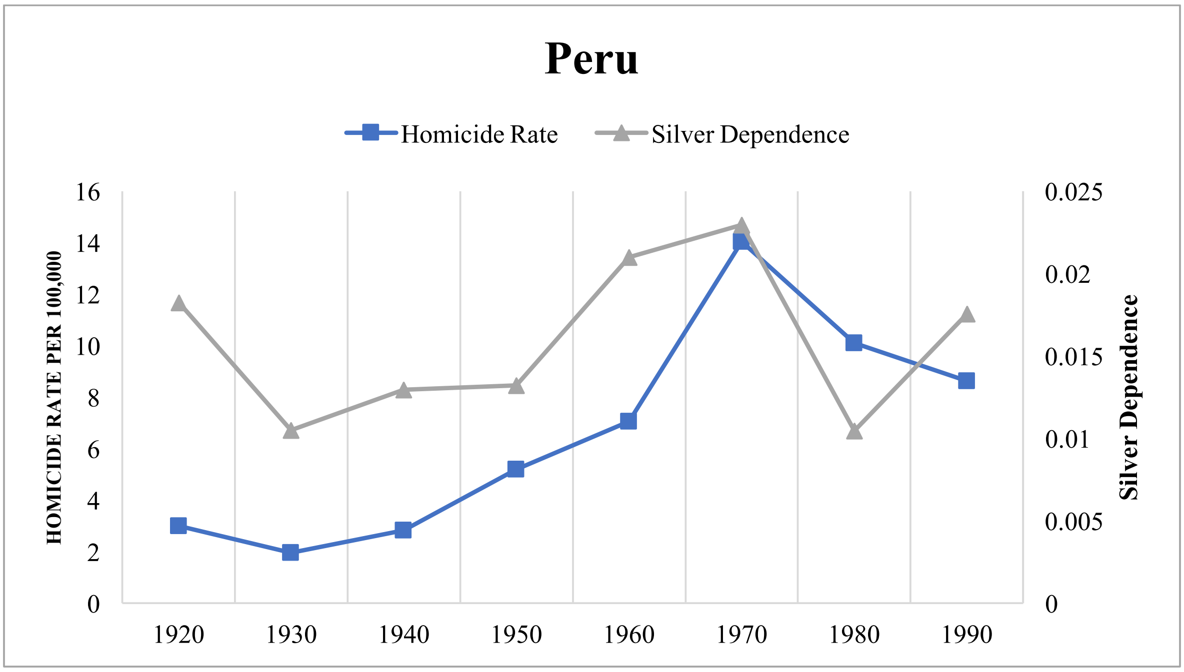
C.7.1. Figures

Figure C.1: Silver Dependence and Homicide Rates for Selected Countries (Panels 1 to 3)[20]

Panel 1

[20] All figures without citation are own elaborations.

Panel 2



Panel 3

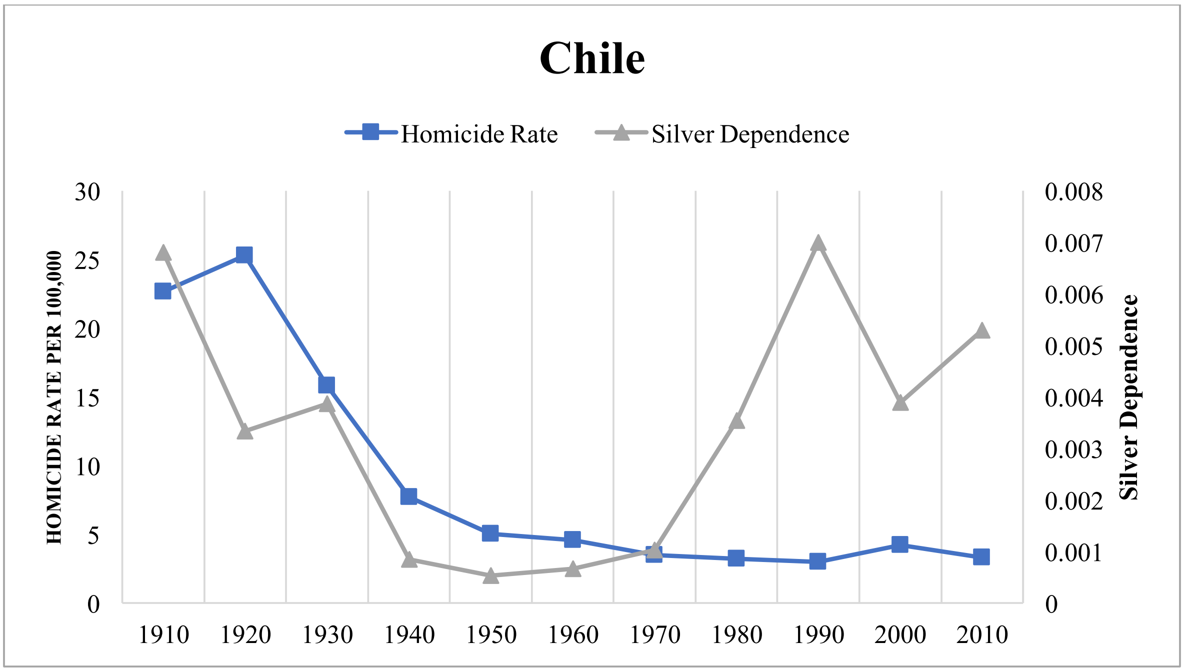
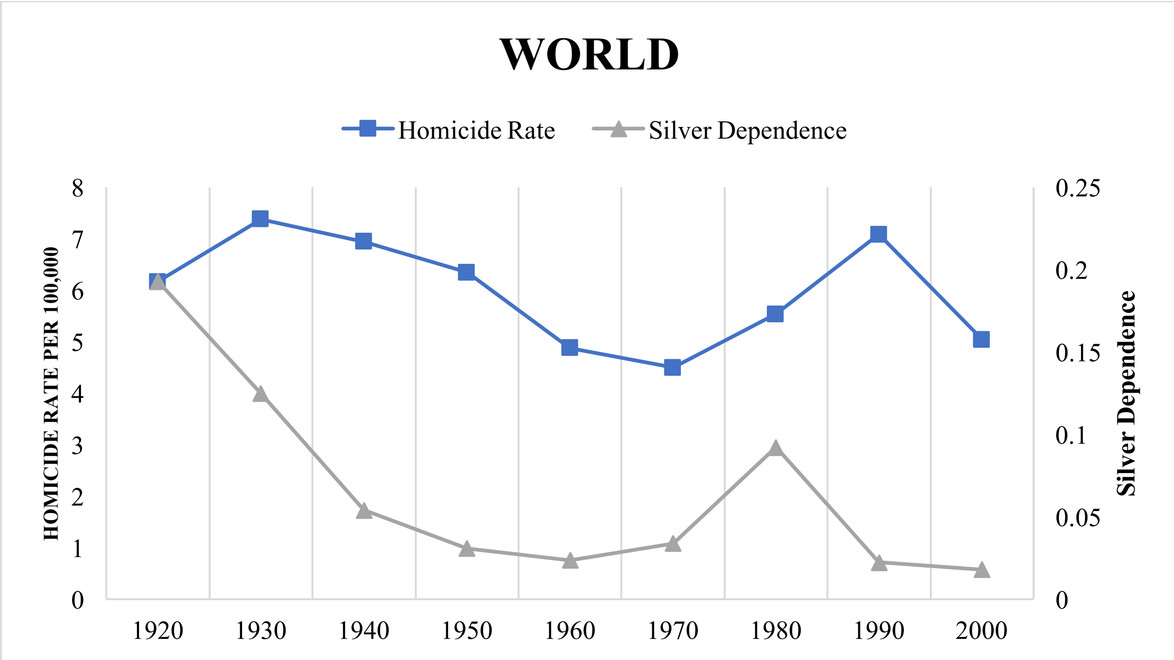
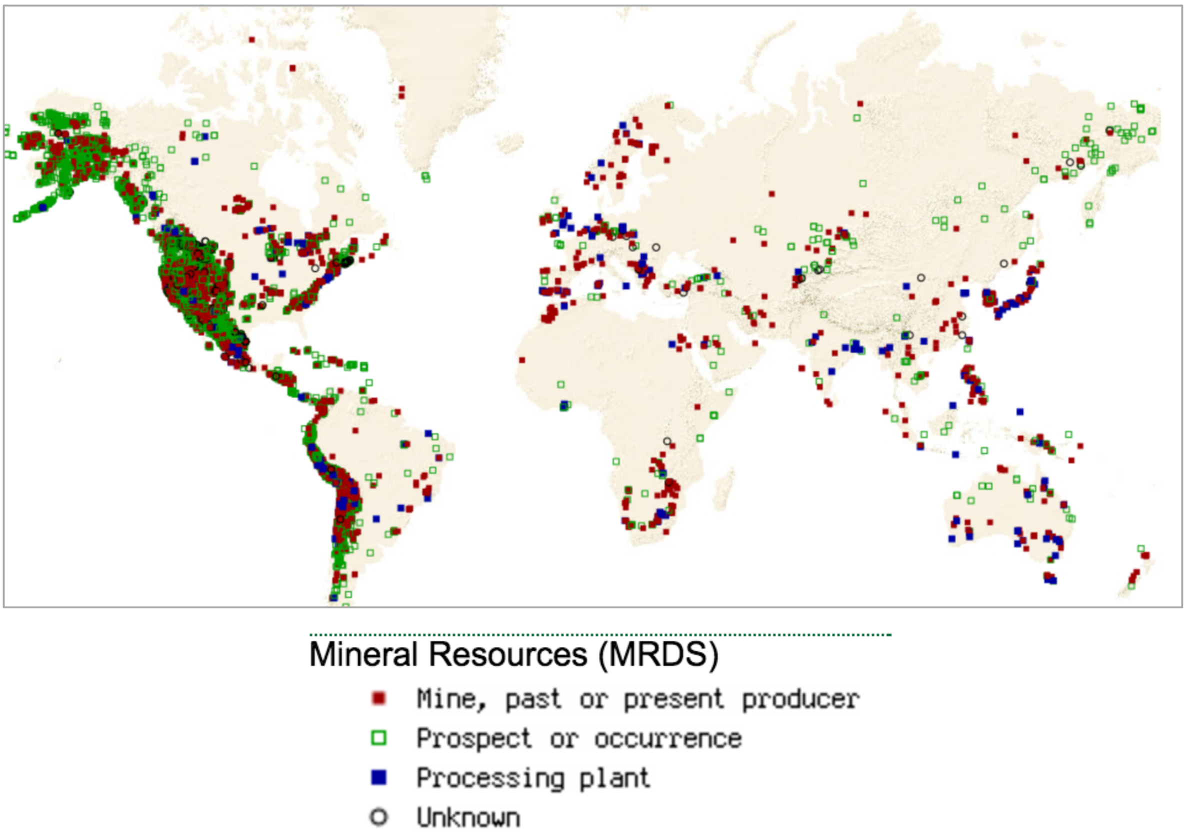


Figure C.2: Silver Dependence and Homicide Rates in Europe, the Americas and the World



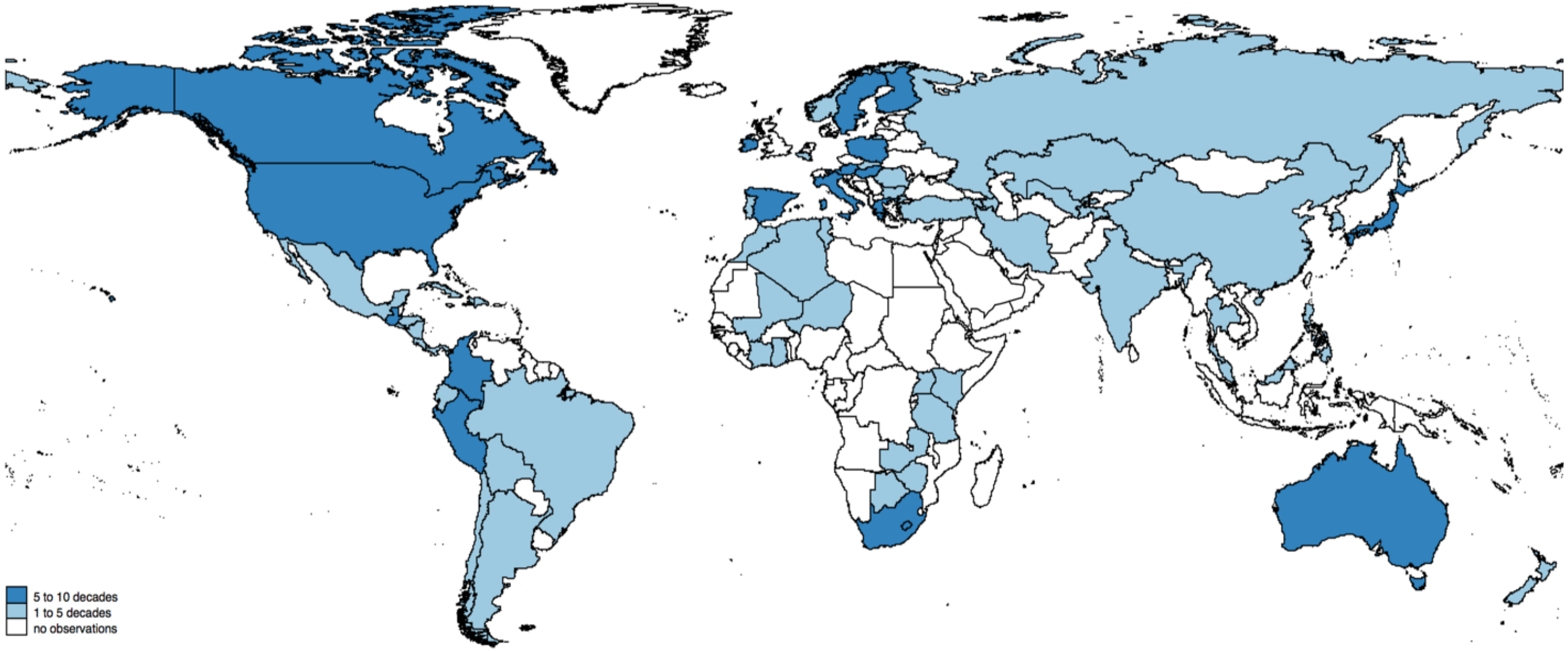
Average homicide rates and silver dependence values for Japan, Australia, New Zealand, Austria, Germany, Spain, Finland, France, Hungary, Italy, Sweden, UK, Canada, Chile, Colombia, Mexico and the US, all countries in the sample for which the full nine decades were available.

Figure C.3: Silver Deposits in the World



Source: http://mrdata.usgs.gov/mrds/map.html#
(USGS – US Geological Survey – Mineral Resources Online Spatial Data)

Figure C.4: Number of Decades per Country Included in the Regression Analysis (Table C.3)



C.7.2. Tables

Table C.1: Mining Contribution to GDP

Country	Decade	Our Calculation of Silver contribution to GDP	Total Mining Contribution to GDP	Source
Mexico	1920[21]	2.3%	8-11.45%	Groningen Growth and Development Center
Peru	1940	0.4%	8.1 – 7 %	Groningen Growth and Development Center
Germany	1870	0.12%	1.9%	Groningen Growth and Development Center
Indonesia	1980	0.01%	0.0% (Gold and Silver)	Van der Eng (2014)
Indonesia	1990	0.05%	0.6% (Gold and Silver)	Van der Eng (2014)

Table C.2: Descriptive Statistics

	Observations[22]	Mean	Standard Deviation	Minimum	Maximum
Log(Homicide rate)	278	1.171	1.196	-1.952	4.751
Silver Dependence	278	0.0607	0.160	0	1.730
Log(GDP per capita)	278	8.254	0.823	6.225	10.11
Gini Coefficient	278	43.40	8.194	21.35	70.10
Education	278	5.992	2.974	0.140	13.05
Conflict Dummy	278	0.439	0.497	0	1
Autocracy Dummy	278	0.335	0.473	0	1
Death Penalty Dummy	278	0.687	0.465	0	1

[21] This observation is not included in the regression analysis; nevertheless, we used it to check the validity of our silver dependence variable.

[22] The number of observations in Table C.3, Table C.4 and Table C.5 is 268, because by lagging the silver dependence variable, we lose 10 observations.

Table C.3: Fixed Effects Regressions of Log(Homicide Rate)

	(0)	(1)	(2)	(3)	(4)
L.Silver Dependence	0.539*	0.540*	**0.446****	0.355*	**0.522*****
	(0.283)	(0.284)	(0.204)	(0.200)	(0.159)
Log(GDP per capita)		-0.138	-0.405*	**-0.467****	-0.397*
		(0.129)	(0.239)	(0.216)	(0.214)
Gini Coefficient			0.012	0.010	0.010
			(0.010)	(0.012)	(0.009)
Education			0.099	0.089	0.095
			(0.07)	(0.072)	(0.071)
Conflict Dummy					**0.448*****
					(0.148)
Autocracy Dummy				-0.325*	**-0.336****
				(0.191)	(0.154)
Death Penalty Dummy					0.005
					(0.158)
Constant	1.791***	2.753***	3.955***	4.121***	3.693***
	(0.268)	(0.873)	(1.364)	(1.284)	(1.202)
Observations	268	268	268	268	268
R-squared	0.052	0.058	0.080	0.090	0.187
Number of Countries	60	60	60	60	60
Half-Century FE	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes

All variables in decade means; standard errors clustered on the country level.

*** p<0.01, ** p<0.05, * p<0.1

Table C.4: Regressions of Log(Homicide Rates): Within- and Between- Country Effects

	(0)	(1)	(2)	(3)
Within Effects				
L.Silver Dependence	**0.628****	0.518*	0.355*	**0.478*****
	(0.273)	(0.285)	(0.198)	(0.152)
Log(GDP per capita)		-0.161	**-0.467****	**-0.383****
		(0.115)	(0.214)	(0.191)
Gini Coefficient			0.0102	0.009
			(0.012)	(0.009)
Education (spliced index)			0.089	0.094
			(0.072)	(0.074)
Conflict Dummy				**0.452*****
				(0.145)
Autocracy Dummy			-0.325*	**-0.332****
			(0.190)	(0.161)
Death Penalty Dummy				-0.012
				(0.154)
Between Effects				
L.Silver Dependence	1.229*	**1.247****	0.755	0.838
	(0.672)	(0.593)	(0.665)	(0.708)
Log(GDP per capita)		**-0.462****	-0.345	-0.317
		(0.188)	(0.273)	(0.334)
Gini Coefficient			**0.062*****	**0.059*****
			(0.023)	(0.023)
Education (spliced index)			0.018	0.023
			(0.086)	(0.089)
Conflict Dummy				0.271
				(0.414)
Autocracy Dummy			-0.167	-0.138
			(0.422)	(0.414)
Death Penalty Dummy				0.125
				(0.530)
Constant	1.231***	4.944***	1.254	0.912
	(0.158)	(1.551)	(2.037)	(2.663)
Observations	268	268	268	268
Number of Countries	60	60	60	60
Hausman Test FE-RE (p-value)	0.24 (0.516)	2.67 (0.263)	8.78 (0.118)	8.91 (0.259)

All variables in decade means; standard errors clustered on the country level.

*** p<0.01, ** p<0.05, * p<0.1

Table C.5: Regressions of Log(Homicide Rates): Including Dummy for Major Drug Producer

	(1)	(2)	(3)
Within Effects			
L.Silver Dependence	0.519*	0.356*	**0.481*****
	(0.284)	(0.198)	(0.152)
Log(GDP per capita)	-0.160	**-0.466****	**-0.380****
	(0.116)	(0.215)	(0.192)
Gini Coefficient		0.01	0.009
		(0.01)	(0.009)
Education (spliced index)		0.088	0.093
		(0.072)	(0.074)
Conflict Dummy			**0.454*****
			(0.145)
Autocracy Dummy		-0.324*	-0.331**
		(0.190)	(0.161)
Death Penalty Dummy			-0.015
			(0.154)
Between Effects			
L.Silver Dependence	-0.189	-0.311	-0.355
	(0.892)	(0.987)	(1.213)
Log(GDP per capita)	**-0.436****	-0.414	-0.359
	(0.183)	(0.265)	(0.306)
Gini Coefficient		**0.056****	**0.052****
		(0.022)	(0.022)
Education (spliced index)		0.037	0.042
		(0.084)	(0.082)
Conflict Dummy			0.165
			(0.441)
Autocracy Dummy		-0.246	-0.203
		(0.415)	(0.416)
Death Penalty Dummy			0.324
			(0.588)
Major Drug Producer	1.149**	0.858	0.995
	(0.582)	(0.627)	(0.907)
Constant	4.729***	2.004	1.377
	(1.509)	(2.003)	(2.507)
Observations	268	268	268
Number of countries	60	60	60

All variables in decade means; standard errors clustered on the country level.

*** p<0.01, ** p<0.05, * p<0.1

Table C.6: Regressions of Log(Homicide Rates): Institutions and Silver Dependence

	(1)	(2)	(3)
Within Effects			
L. Autocracy	-0.124	-0.167	-0.094
	(0.239)	(0.232)	(0.196)
L.Silver Dependence	**0.824****	**0.636****	**0.763****
	(0.322)	(0.322)	(0.322)
L. (Autocracy x Silver Dependence)	-1.006	-0.899	-0.993
	(0.807)	(0.835)	(0.796)
Log(GDP per capita)	-0.147	-0.450*	-0.352
	(0.116)	(0.254)	(0.233)
Gini Coefficient		0.009	0.009
		(0.011)	(0.01)
Education (spliced index)		0.100	0.091
		(0.085)	(0.085)
Conflict Dummy			**0.433*****
			(0.158)
Death Penalty Dummy			-0.09
			(0.168)
Between Effects			
L. Autocracy	-0.656	-0.509	-0.524
	(0.412)	(0.432)	(0.413)
L.Silver Dependence	-1.553	-1.248	-1.254
	(0.988)	(0.940)	(0.946)
L. (Autocracy x Silver Dependence)	**8.053*****	**6.168*****	**6.200*****
	(2.294)	(2.080)	(2.323)
Log(GDP per capita)	-0.502**	-0.343	-0.338
	(0.217)	(0.302)	(0.398)
Gini Coefficient		0.053**	0.052**
		(0.025)	(0.025)
Education (spliced index)		-0.001	-0.004
		(0.097)	(0.103)
Conflict Dummy			-0.036
			(0.486)
Death Penalty Dummy			-0.002
			(0.516)
Constant	5.536***	1.887	1.902
	(1.884)	(2.267)	(3.076)
Observations	255	255	255
Number of Countries	57	57	57
Hausman Test FE-RE (P-value)	8.13 (0.087)	11.4 (0.077)	11.03 (0.200)
All variables in decade means; standard errors clustered on the country level.			

*** p<0.01, ** p<0.05, * p<0.1

Table C.7: 2SLS Regressions of Log(Homicide Rate)

	(1)	(2)	(3)	(4)	(5)
First Stage					
Log(Silver sites per area)	0.037***	0.036***	0.033***	0.022***	0.026***
	(0.01)	(0.01)	(0.01)	(0.008)	(0.008)
Log(L.World Silver Price)	0.072**	0.067**	0.067**	0.064***	0.06***
	(0.029)	(0.028)	(0.028)	(0.021)	(0.022)
F-Stat of excluded instruments	9.34	8.94	8.24	8.05	8.24
P-value	0.000	0.000	0.000	0.000	0.000
Second Stage					
L.Silver Dependence	9.306***	9.320***	10.27***	8.974***	10.63***
	(2.194)	(2.259)	(2.602)	(2.520)	(2.831)
Log(GDP per capita)	0.0239	-0.362	-0.481**		0.466
	(0.391)	(0.223)	(0.238)		(0.431)
Gini Coefficient				0.0347*	0.0116
				(0.0185)	(0.0232)
Education (spliced index)	-0.129				-0.230*
	(0.105)				(0.119)
Conflict Dummy	0.830**	0.904***		0.925***	0.811**
	(0.325)	(0.320)		(0.293)	(0.334)
Autocracy Dummy	-0.0891				
	(0.355)				
	(0.381)	(0.376)	(0.412)	(0.341)	(0.390)
Constant	-0.271	2.046	3.435*	-2.119***	-3.651
	(2.805)	(1.992)	(2.067)	(0.742)	(3.023)
Observations	231	231	231	198	198
Sargan-Test	0.095	0.386	0.699	0.413	0.096
P-value	0.759	0.534	0.403	0.521	0.757
Hausman-Durbin-Wu	65.457	60.149	64.141	37.714	55.322
P-value	0.000	0.000	0.000	0.000	0.000

Standard errors in parentheses. All variables in decade means;
half-century fixed effects included.

*** p<0.01, ** p<0.05, * p<0.1

Table C.8: Regressions of Log(Homicide Rates): LIML

	(1)	(2)
First Stage		
Log(Silver sites per area)	**0.036*****	**0.022*****
	(0.01)	(0.008)
Log(L.World Silver Price)	**0.067****	**0.065*****
	(0.028)	(0.022)
Second Stage		
L.Silver Dependence	**9.507*****	**9.195*****
	(2.323)	(2.599)
Log(GDP per capita)	-0.356	
	(0.227)	
Gini Coefficient		0.034*
		(0.019)
Conflict Dummy	**0.909*****	**0.932*****
	(0.326)	(0.298)
Constant	3.297	-1.327*
	(2.037)	(0.756)
Observations	231	198

Standard errors in parentheses. All variables in decade means; half-century fixed effects included.

*** p<0.01, ** p<0.05, * p<0.1

Table C.9: Oster (2017) Ratios based on Model (4) of Table C.3

Model with Controls	All Countries	With Silver >0
β	0.522	0.491
R^2	0.816	0.819
Model without Controls (only country fe)		
β	0.738	0.841
R^2	0.016	0.027
Sensitivity Parameters δ		
with R^{max}=1, β =0	1.37	1.078
with R^{max}=0.9, β =0	2.96	2.267

C.8. Appendix

C.8.1. Sources of Homicide Rates

The database about homicide rates is the result of a vast amount of research effort realized over the last years. The observational unit of the data set employed in this paper is decade-country averages; hence, the source given in the following table is always the source from which data was retrieved for most of the years in each respective decade. Data has been organized using the current country borders.

Table C.10: Overview Sources of Homicide Data

Source	Number of Observations	Detailed Source Description
WHO Mortality Database	105	The WHO Mortality Database is a collection of cause-of-death data as reported by civil registration systems of the member states. The data is coded according to the ICD-9 and ICD-10. Link: http://www.who.int/healthinfo/mortality_data/en/
Clio Infra	37	Dataset produced by Winny Biermann and Jan Luiten van Zanden in 2014. Most of the data has been collected from statistical yearbooks. Link: https://www.clio-infra.eu/Indicators/HomicideRates.html
UNODC	34	UNODC data, mostly compiled via the UN Survey on Crime Trends and the Operations of Criminal Justice Systems. Link: https://www.unodc.org/unodc/en/data-and-analysis/statistics/historic-data.html
Interpol	26	The International Police Organization (Interpol) is the source of annual published crime statistics for member countries. Link: https://www.interpol.int/News-and-media/Publications2/Annual-reports2

Historical Violence Database	22	Historical Violence Database (see: http://cjrc.osu.edu/research/interdisciplinary/hvd). Randolph Roth, Douglas L. Eckberg, Cornelia Hughes Dayton, Kenneth Wheeler, James Watkinson, Robb Haberman, and James M. Denham. 2008. "The Historical Violence Database: A Collaborative Research Project on the History of Violent Crime and Violent Death." Historical Methods 41, 81-97.
NRILP	16	Lehti, M. (2013), "NRILP Comparative Homicide Time Series (NRILP-CHTS)", National Research Institute of Legal Policy, Research Brief, 32, Helsinki.
Archer & Gartner	14	Comparative Crime Data File by Archer, Dane and Rosemary Gartner (1984) Violence and Crime in Cross-National Perspective. New Haven: Yale University Press., excel available on https://cjrc.osu.edu/research/interdisciplinary/hvd/asia/sri-lanka
SJBDE	6	Statistische Jahrbücher für das Deutsche Reich
Mexico	5	Anuario Estadístico de los Estados Unidos Mexicanos, various years, see inegi.org.mx
India	4	Statistics of the colonies of the British empire.
Brazil	2	Brazil 1832-1890. Center for Research Libraries, Reports of the Brazilian Provinces 1830-1889, http://brazil.crl.edu/bsd/bsd/hartness/crimecomm.html, and Anuario estatistico do Brasil:1908-1912. (available at: http://memoria.org.br/)
Colombia	2	Colombia 1915-1930, Anuario Estadistico de Colombia
Eisner	2	Eisner, M., (2003), 'Long-Term Historical Trends in Violent Crime', *Crime and Justice* 30, 83-142.
Japan	2	Statistical Bureau, Management and Coordination Agency ed., Historical Statistics of Japan, vol.1, 5, Tokyo, 1988
Total	278[23]	

[23] The number of observations in the different regression tables might differ from this total number of observations, since single control variables are not available for all decades.

C.8.2. Sources of the Data on Silver Production, Occurrence and Dependence

C.8.2.1. Silver Production Data

The information about silver production has been retrieved from three main sources:

1) Clio Infra, Silver mining production by decade and country, Kees Klein Goldewijk & Jonathan Fink-Jensen, Utrecht University, 2014, silver mine production, in metric tons, which contains information from:
    a. BGS, British Geological Survey. https://www.bgs.ac.uk/
    b. Mitchell, B.R., International Historical Statistics – Africa, Asia & Oceania 1750-1993 (London, 1998).
    c. Mitchell, B.R., International Historical Statistics – Europe (London, 1998).
    d. Mitchell, B.R., International Historical Statistics – The Americas 1750-1993 (London, 1998).
    e. Schmitz, Christopher J., World Non-Ferrous Metal Production and Prices, 1700-1976 (London, 1979).
    f. http://minerals.usgs.gov/minerals/pubs/commodity/silver/
2) Minerals UK (Centre for sustainable mineral development), World mineral statistics archive from the British Geological Survey (BGS), http://www.bgs.ac.uk/mineralsuk/statistics/worldArchive.html
3) US department of Commerce 1930 (Merrill, Charles White), Summarized Data of silver production, Economic Paper (Bureau of Mines) 8, United States, Washington D.C. : digital.library.unt.edu/ark:/67531/metadc40312/m2/1/high_res_d/bomeconpapers_8_w.pdf

C.8.2.2. Calculation of Gross Value Added of Silver Mining

To construct the gross value added (GVA) of silver mining per capita, we used the silver production quantities reported from our sample in kg per capita. We then multiplied the quantities with the real silver price per capita in 1990 GK USD:

$$GVA\ Silver\ Mining\ per\ capita = silver_{pc}(in\ kg) * world\ silver\ price\ per\ kg$$

The real silver price (in 1990 GK USD) was obtained by dividing the nominal silver prices by a deflator:

$$Real\ Silver\ Price\ (1990\ GK\ USD) = \frac{Nominal\ Silver\ Price\ (current\ USD)}{deflator}$$

We calculated the deflator following the approach by Földvári (2006) with the help of two time series: the current GDP of the US and the GDP expressed in 1990 GK USD. The ratio of the two series is a deflator, which can be used to convert the current USD silver prices to 1990 GK international USD.

$$deflator = \frac{nominal\ GDP\ per\ capita\ (current\ USD)}{real\ GDP\ per\ capita\ (1990\ GK\ USD)}$$

Since no information on the international silver prices could be found, we retrieved the nominal silver price by dividing the New York Market (world) price of gold (per fine ounce) by the gold/silver price ratio. Both variables are reported in Officer and Williamson (2017).

$$Nominal\ Silverprice = \frac{NY\ Market\ Gold\ Price\ per\ fine\ oz}{Gold - Silver - Price\ Ratio}$$

To obtain the real silver price per kg, silver price per oz. was then multiplied with 35.374. The gold/silver price ratio is computed as the ratio of the price of gold to the price of silver. The ratios are “world” market ratios, meaning that the marketplace was always selected to be the best representation of the “world” price ratio by Officer and Williamson as follows: Hamburg 1687-1832, London 1833-1914, New York 1915-1990.

Table C.11: Sources of Nominal and Real GDP and Gold/Silver Prices

Nominal and real GDP of the US	Louis Johnston and Samuel H. Williamson, "What Was the U.S. GDP Then?" MeasuringWorth, 2017
Gold prices and gold/silver price ratio	Lawrence H. Officer and Samuel H. Williamson, "The Price of Gold, 1257 - Present.," MeasuringWorth, 2017 URL: http://www.measuringworth.com/gold/ We used the New York market prices.

C.8.2.3. Silver Occurrence Data

The data on silver occurrences has been retrieved from:

U.S. Geological Survey, 2005, Mineral Resources Data System: U.S. Geological Survey, Reston, Virginia; available under https://mrdata.usgs.gov/mrds/.

For each country, all discovered (identified) geographical sites that contain silver as first, second or third commodity were selected. We included all kinds of silver deposits: simple occurrences (marginally and sub-economic reserves) as well as prospective, current or past producers of silver (economic reserves). In a next step, the number of silver sites was divided by the total surface area of each country to obtain a measure of the intensity of silver occurrences in each country.

C.8.3. Data Selectivity Analysis

The following table gives an overview of the distribution of observations across countries. The most frequent countries in the data set are Germany and France with 11 decadal observations each. The remaining countries are represented with 10 or fewer decades, while for 19 countries we have only one observation in the data set.

Table C.12: Number of Observations per Country

Country	# of obs.	Country	# of obs.	Country	# of obs.
France	11	Costa Rica	4	Botswana	1
Germany	11	Ghana	4	Cuba	1
Australia	10	Morocco	4	Haiti	1
Canada	10	Nicaragua	4	Iran	1
Japan	10	Philippines	4	Kazakhstan	1
United States	10	Tanzania	4	Kenya	1
Colombia	9	Thailand	4	Malaysia	1
Italy	9	Turkey	4	Mali	1
Sweden	9	Zambia	4	Niger	1
Hungary	8	Brazil	3	Romania	1
Ireland	8	Cote d'Ivoire	3	Russia	1
Austria	7	Dominican Republic	3	Slovak Republic	1
Finland	7	Honduras	3	Tajikistan	1
Greece	7	Panama	3	Uganda	1
Poland	7	South Korea	3	Uzbekistan	1
Spain	7	Tunisia	3	Total	278
Guatemala	6	Bolivia	2		
South Africa	6	China	2		
Chile	5	Ecuador	2		
India	5	El Salvador	2		
Mexico	5	Norway	2		
New Zealand	5	Zimbabwe	2		
Peru	5	Algeria	1		
Portugal	5	Armenia	1		
Argentina	4	Azerbaijan	1		
Bulgaria	4	Belgium	1		

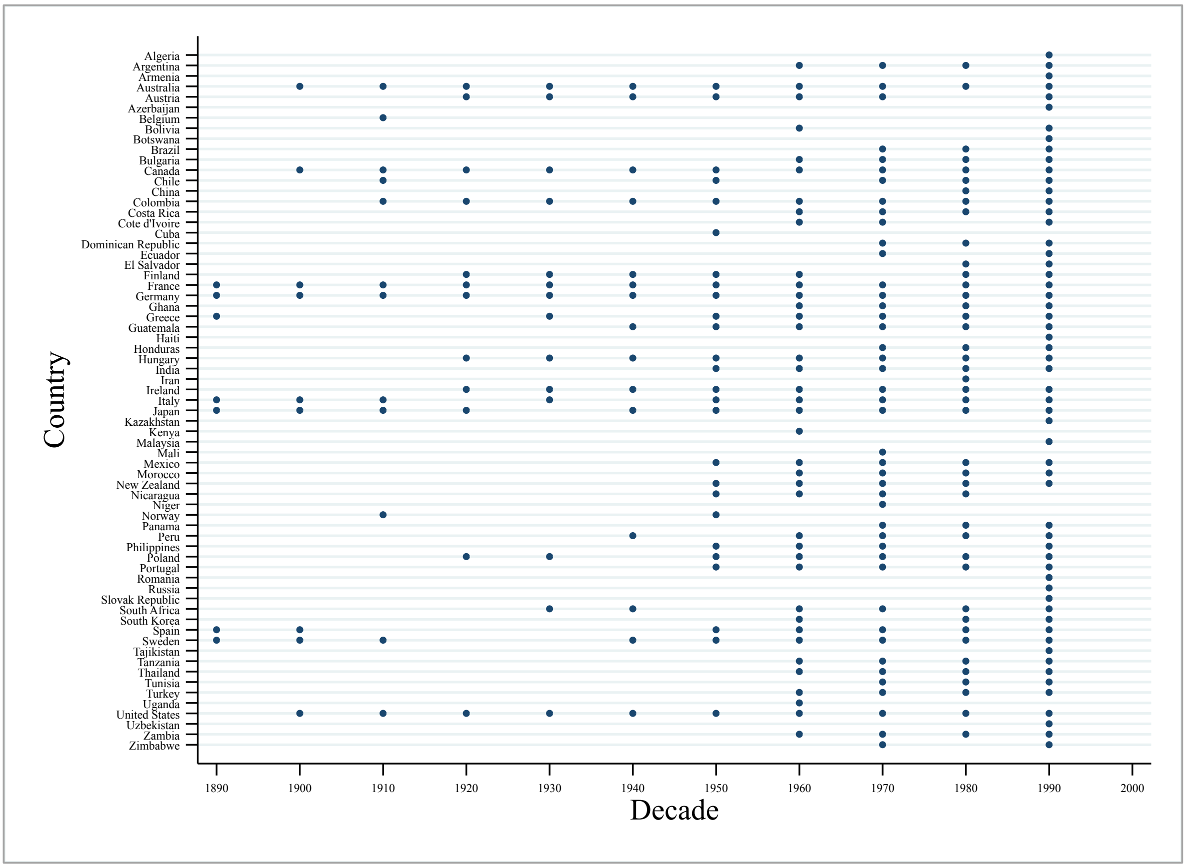
The data is widely distributed geographically. As usual, data availability was slightly better for early industrialized countries such as France, Germany, Australia, Canada, Japan and the US. Nevertheless, there is no underrepresentation of poorer countries, since there is, for example, a very good coverage of Latin American countries like Colombia, Guatemala, Chile, Mexico and Peru. For Asia, India is covered by 5 decades, followed by Thailand and South Korea. For Africa, we have South Africa represented by 6 decades, and Ghana, Morocco and Tanzania by at least 4 decades. This shows that even though there is a slight bias towards richer countries, the data coverage is quite global, representing all world regions.

Table C.13: Number of Observations per Decade

Decade	# of observations
1890	7
1900	9
1910	12
1920	12
1930	14
1940	15
1950	26
1960	39
1970	44
1980	42
1990	58
Total	278

When looking at the distribution of observations over time, it is obvious that the number is continuously increasing when moving from early decades to more recent ones. For the earliest decade, 1890, we nevertheless have 7 observations (Spain, Italy, Germany, Greece, France, Sweden, Japan) and 58 for the most current one.

Figure C.5: Observations by Decades and Countries



C.8.4. Control Variables – Sources and Description

Table C.14: Sources and Description of Control Variables

Variable	Source	Description
Log (GDP per capita)	Bolt, J. and J. L. Van Zanden (2013): "The First Update of the Maddison Project: Re-Estimating Growth before 1820," Clio Infra Project, available at: https://www.clio-infra.eu/datasets/indicators (last accessed: 07.07.2016).	GDP per capita in 1990 international Geary-Khamis dollars
Gini Coefficient of income inequality	Baten, J., J. L. Van Zanden, M. Moatsos, P. Foldvari and B. van Leeuwen (2014): „Gross household income gini 1820-2000", Version 1, Clio Infra Project, available at: https://www.clio- infra.eu/datasets/indicators	
Execution of death penalty (dummy variable)	Own elaboration based on the following sources: Amnesty International 2017, accessed through https://www.amnesty.org/en/what-we-do/death-penalty/ Cornell Center on the Death Penalty Worldwide (2017), accessed through http://www.deathpenaltyworldwide.org/search.cfm	Indicator variable that takes on the value 1 if the death penalty has been executed in the respective decade, and 0 otherwise (independent from legal status of the death penalty)
Education (spliced index of numeracy and enrollment rates)	Average years of schooling: Van Leeuwen, B., J. Van Leeuwen-Li, and P. Foldvari (2013): "Average Years of Education, 1850-2010," Version 2, Clio Infra Project, available at: https://www.clio-infra.eu/datasets/indicators Numeracy: Baten J. (2013): "Numeracy Estimates (ABCC) by Birth Decade and Country," Version 1, Clio Infra Project, available at: https://www.clio-infra.eu/datasets/indicators	

Interstate conflict in that decade (dummy variable)	Constructed based on Brecke, P. and P. Foldvari (2013): "Armed External Conflicts, 1500-2000," Version 1, Clio Infra Project, available at: https://www.clio-infra.eu/datasets/indicators	Indicator variable taking on value 1 if an internal or external violent conflict took place in the respective decade and value 0 otherwise.
Autocracy (dummy variable)	Marshall, M. G., K. Jaggers, and T. R. Gurr (2013): "Autocracy-Democracy Index, 1800-2010," Version 1, Clio Infra Project, available at: https://www.clio-infra.eu/datasets/indicators	

C.8.5. Robustness Checks and Discussion of Magnitudes

To assess the validity of the obtained results, this section presents various robustness checks, first using country-year observations and secondly using different groups of countries.

C.8.5.1. Regressions Based on Country-Year Observations

This regression uses the country-year observations instead of the decadal averages. Due to data availability, only GDP per capita and the Gini coefficient can be added as control variable. Due to the big time dimension of this panel based on yearly observations (between 9 and 30 observations per country) there is a risk of spurious regression. Unit root tests however show, that the series of silver dependence and homicide rate are stationary. Hence, the results are presented here to underline the results obtained using decade averages. The silver dependence has been lagged by 10 years just as in the regressions based on decadal averages.

Table C.15: FE Regressions of Log(Homicide Rates) using Country-Year Observations

	(1)	(2)	(3)
L.Silver Dependence	**0.585*****	**0.590*****	**0.702****
	(0.211)	(0.206)	(0.312)
Log(GDP per capita)		-0.332	-0.358
		(0.320)	(0.328)
Gini coefficient			0.00977
			(0.00809)
Constant	2.445***	4.589**	4.154*
	(0.456)	(2.178)	(2.301)
Observations	527	527	457
R-squared	0.212	0.225	0.266
Number of countries	59	59	52

Decade fixed effects included; country-year observations; standard errors clustered on the country level.

*** p<0.01, ** p<0.05, * p<0.1

Table C.15 shows that the coefficient on the silver dependence is the same in sign, magnitude and significance as in Table C.3, hence corroborating the previously obtained results.

C.8.5.2. Silver Dependent Countries

To check the robustness of the results, we identified the most silver oriented economies with a mean silver dependence higher than 0.5 % and estimated the models for this group separately. The threshold economy is Belgium with a mean silver dependence of 0.06%. We then checked the relationship between silver dependence and homicide rates for this group of countries (24 countries). In all model specifications, the coefficient of the lagged silver dependence is highly significant, indicating that if the silver dependence increases by one percentage point, the homicide rate will increase by around 50%.

Table C.16: Regressions of Log(Homicide Rate): High Silver Dependence

	(1)	(2)	(3)	(4)
L.Silver Dependence	0.335*	**0.639****	**0.552****	**0.605****
	(0.193)	(0.232)	(0.238)	(0.220)
Log(GDP per capita)	0.041	0.153	0.00736	-0.142
	(0.195)	(0.527)	(0.463)	(0.437)
Gini Coefficient		-0.00931	-0.00627	0.000427
		(0.0146)	(0.0141)	(0.0158)
Education		0.00214	0.00690	-0.00911
		(0.131)	(0.118)	(0.121)
Conflict Dummy			-0.385*	-0.333
			(0.206)	(0.205)
Autocracy Dummy				0.120
				(0.176)
Death Penalty Dummy				-0.449
				(0.319)
Constant	2.961	1.966	1.601	2.788
	(1.878)	(3.869)	(3.363)	(3.153)
Observations	126	82	80	80
R-squared	0.128	0.124	0.114	0.139
Number of countries	24	15	15	15

Robust standard errors in parentheses. Half-century fixed effects included.

*** p<0.01, ** p<0.05, * p<0.1

C.8.5.3. Silver Dependent Countries & Political Setup

Since the impact of silver dependence on crime seems to hinge on the quality of institutions, this effect should be more visible in countries with autocratic setup. We therefore estimated the impact of silver dependence on homicide rates separately for countries with good institutional setups and for countries with varying institutional quality.

1) Silver dependent countries with constant democratic setups (6 countries):

These countries are identified by the fact that the dummy variable *autocracy* is constantly zero throughout the observed time period. Hence, these countries are characterized by a constant democratic institutional setup for the observed time period.

2) Silver dependent countries with variable autocratic institutions (18 countries): These countries are identified by the fact that the Autocracy dummy changes its value at least once over the observed time, hence, the governing regime changed. Countries included are among others Mexico, Peru, Honduras, Bolivia, Poland, Uzbekistan and others.

Table C.17: Regressions of Log(Homicide Rate): Democratic Setup

	(1)	(2)	(3)	(4)
L.Silver Dependence	**0.515*** **	0.513*	**0.466** **	**0.502*** **
	(0.051)	(0.182)	(0.128)	(0.049)
Log(GDP per capita)	0.056	0.350	0.401	0.089
	(0.136)	(0.331)	(0.285)	(0.115)
Gini Coefficient		-0.002	-0.004	0.000
		(0.007)	(0.006)	(0.009)
Education	-0.028	-0.034	-0.018	-0.023
	(0.048)	(0.067)	(0.056)	(0.041)
Conflict Dummy			-0.164	-0.052
			(0.084)	(0.039)
Death Penalty Dummy	**-0.465*** **			**-0.444*** **
	(0.03)			(0.058)
Constant	1.03	-1.930	-2.450	0.643
	(1.415)	(2.498)	(2.256)	(1.047)
Observations	33	32	32	32
R-squared	0.762	0.635	0.662	0.764
Number of countries	5	4	4	4

Robust standard errors in parentheses; half-century fixed effects included.
Countries included: Australia, Canada, USA, Belgium, Namibia and Makedonia
*** p<0.01, ** p<0.05, * p<0.1

Table C.18: Regressions of Log(Homicide Rates): Variable Institutions

	(1)	(2)	(3)	(4)
L.Silver Dependence	**0.706****	0.918	1.036*	1.018*
	(0.301)	(0.528)	(0.563)	(0.543)
Log(GDP per capita)	0.284	0.128	0.212	0.192
	(1.014)	(1.127)	(1.179)	(1.178)
Gini coefficient		-0.0112	-0.0112	-0.00714
		(0.0293)	(0.0288)	(0.0321)
Education	-0.0592	-0.0210	-0.0346	-0.0470
	(0.199)	(0.202)	(0.220)	(0.236)
Conflict dummy			0.250	0.299
			(0.380)	(0.394)
Death Penalty dummy	-0.585			-0.353
	(0.404)			(0.636)
Constant	0.506	1.418	0.658	0.873
	(7.356)	(7.719)	(8.154)	(8.085)
Observations	64	50	50	50
R-squared	0.130	0.067	0.084	0.088
Number of countries	14	11	11	11

Robust standard errors in parentheses; half-century fixed effects included.
*** p<0.01, ** p<0.05, * p<0.1

D. Homicide Rates and the Death Penalty

Abstract

This paper challenges the traditional view that the causality runs from the death penalty to the homicide rate via deterrence. Even though a multitude of studies have been conducted on the topic of the deterrent effect of the death penalty during the last almost 50 years, there is no conclusive evidence. One reason for this might be the fact that previous studies looked only at one direction of potential causality, namely they tested if the death penalty had a deterrent effect on homicide rates. It is however likely, that there are at least feedback effects in the reverse direction. In the past, decreases in violence have often been accompanied by a mitigation in the severity of punishments delinquents faced (Eisner 2014), and on the other hand, increasing crime and violence induce fear and insecurity, leading to demands for a tougher treatment of criminals. This paper first conducts Granger-causality tests, an approach traditionally used when the direction of causality is unclear. While there is no evidence for deterrence, the results show that declining homicide rates likely influence the decision to abolish the death penalty. In a second step, this potential link is further scrutinized by conducting event history analysis of the abolition decision revealing the factors that determine the decision to abolish or retain the death penalty, among them the homicide rate.

D.1. Introduction

Homicides are not any crime. UNODC (2013) declares it the “ultimate crime, whose ripple effect goes far beyond the initial loss of human life and can create a climate of fear and uncertainty” (p.9). Intentional homicide causes the death of around half a million people every year across the world. Almost 750 million people, which is around 10% of the world population, live in countries with homicide rates higher than 20 victims per 100,000 inhabitants and hence see their lives affected by the everyday experience of violence and high insecurity (UNODC 2013). Particularly in the Americas, homicide rates are high and not declining since the 1980s in several countries. To combat crimes such as homicides, more severe punishments have been suggested, which is supposed to deter potential delinquents from committing a crime. Increasing the severity of the penalty would finally result in the most severe punishment, the death penalty. But is this mechanism working? Or does it work only to some extent or for certain types of crimes?

The deterrent effect of the death penalty on crime rates is a long debated concept. Different disciplines, such as criminology, sociology and economics have dealt with it using a variety of methods and indicators, yet there is no conclusive evidence (see Shepherd, 2009 and Gerritzen and Kirchgässner, 2013 for a meta-analysis of many empirical studies on the deterrent effect). What complicates the research on this topic is the fact that the causality between crime and punishment might run in either direction. While the punishment in place influences crime via deterrence, one can imagine a causal link in the opposite direction as well: the homicide rate might for example influences the decision of a country to abolish or to retain the death penalty. It is possible that rising violence levels in a country lead politicians to promise a more ruthless treatment of criminals, which might entail the (re-)introduction of the death penalty; or politicians might postpone the abolition of the death penalty to more peaceful times.

In international comparison, the homicide rate in countries with the death penalty in place is on average higher than for countries that are abolitionist (Nagin and Pepper 2012; Lappi-Seppälä and Lehti 2014). This observation is in line with the hypothesis that high-violence countries maintain the death penalty, while low-violence countries are rather prone to abolish it. It is also contradictory to the deterrence hypothesis, since if deterrence works, then the homicide rate would be expected to be lower in a country with the death penalty in place.

Most of the previous empirical studies on this topic look only at one direction of causality and ignore the possibility of reverse causation: they examine either the deterrent effect of punishment, or the impact crime rates have on the abolition decision. This might be one of the reasons why, despite the large number of studies on the topic, there have not been any conclusive results. If deterrence works, which it might very well, then the homicide rate should be lower, ceteris paribus, if the death penalty is in place. The coefficient of the death penalty hence is expected to be negative. However, in the presence of feedback effects from the homicide rate on the death penalty, the coefficient would get less negative or even positive, due to the positive linkage between higher homicide rates and the death penalty.

Additionally, most of the studies use some specification of the number of executions as an explanatory variable, which might be inherently endogenous. Even in the least effective law enforcement regimes an increasing number of homicides would result in an increasing number of executions, if the death penalty is still in place. Alternatively, Nagin and Pepper (2012) suggest that the higher the number of homicides, the lower the conviction rates: "An increase in the homicide rate may decrease the intensity with which the death penalty is applied as death penalty proceedings require more resources than non-death-penalty proceedings" (Nagin and Pepper 2012, p. 66). This would still suggest a positive, but decreasing impact of the number of homicides on the number of executions. The fact that there is usually no data on the intensity of application of the death penalty further obscures the interlinkage between the number of homicides and executions.

By improving the understanding of the underlying patterns and interlinkages between homicides and punishment this study can help to develop strategies to fight homicides. Since the causality could run in either direction, the first part of the study employs causality tests. One of the novelties of the study is the use of a simple, binary indicator variable for the presence of the death penalty as well as the actual practice in a country, i.e. if the death penalty is applied or not. The results show that while there is no evidence for deterrence, the homicide rates might influence the retention or abolition of the death penalty. To further assess this potential effect, event history analysis is applied to the legal abolition as well as to the stops in executions. First, the following sections D.1.1 and D.1.2 introduce the concepts and definition as well as the data set that form the basis for the extensive study of the relationship between the homicide rates and the death penalty.

D.1.1. Definitions and Concepts

The first step towards an analysis of the relationship between the two concepts is a careful definition of the variables used in the study. In the case of the homicide rates, a standard definition has been used, while the death penalty has been measured with a simple dummy indicator variable.

D.1.1.1. Measuring Homicide Rates

The definition of a homicide is based on the UNODC classification of homicide as an "unlawful death purposefully inflicted on a person by another person" (UNODC 2011). This definition stresses that the incident must fulfill the following three points: 1) There must be a killing, 2) the killing was intended by the perpetrator, and 3) the killing was against the law. It also excludes deaths resulting from inter-state wars (external conflicts) and internal conflicts such as civil wars, revolutions, uprisings or genocides (van Zanden et al. 2014, p. 142).

One threat to international comparability of homicide rates is the fact that some countries do not distinguish between manslaughter (unintentional killing) and homicide; others have a different counting method when it comes to the killing of children (infanticide). Additionally, the definition of "unlawful" varies across countries, since in most societies the killing in self-defense is not regarded as homicide. There is also a discrepancy regarding the definition of crimes with numerous victims, such as mass murders and terrorist attacks. According to the UNODC, the victims of terrorist attacks should be counted as homicide victims; however, as an example, the US did not count the victims of the September 11th attack as homicide victims, but created a new category[24].

Despite these discrepancies, the UNODC (2011) reports that most countries' definitions are in line with the official one and, thus, the measurement error due to distinct definitions is quite small. Especially for newer data, the differences in definitions are negligible. A more severe bias should be expected due to underreporting, since the institutions reporting homicide rates (police force, criminal justice system) could have an incentive to artificially lower the number of homicides to mask their own inability to fight crime.

The data on homicide rates used in this study was constructed using two different source types; that is criminal statistics and health statistics, both of which are affected to a certain degree by the two measurement challenges reported above: lack of standardized definition and underreporting (van Zanden et al. 2014).

Criminal statistics are usually compiled by local police forces which simply count the number of reported incidents. This data source can be affected by underreporting, given that in

[24] In comparison to the total number of deaths resulting from homicide, the number of victims of terrorist attacks is minor in the US (for every victim by terrorism, 1000 died from firearms alone) according to the US department of State (www.state.gov).

settings with weak law enforcement, people might consider not reporting the crime at all. Another possible reason for underestimated homicide rates using this source is the manipulation of statistics by political or law enforcement representatives, since they might have an incentive to artificially lower the homicide rate for their own advantage (UNODC 2011, p.84).

The second main source of homicide data are health statistics. This data is collected by health authorities and per UNODC (2011), this source type is less affected by the problems of unequal definitions or underreporting. The deaths certified by health physicians are usually classified using the WHO International Classification of Diseases, version 10 (ICD-10). This classification system has a separate category counting deaths that have been caused by assault, e.g. homicides and "injuries inflicted by another person with intent to injure or kill, by any means" (WHO 2016). Consequently, in this type of cause-of-death data, most countries apply the same definition, regardless of the national legal definition of homicide. The accuracy of health statistics depends mostly on the qualification of the health personnel in the respective countries and if they recognize a homicide as such (UNODC 2011). Due to this nature of public health data source, the health statistics are usually more reliable than criminal statistics and less affected by underreporting (van Zanden et al. 2014). Consequently, while compiling the sample for this study, priority has been given to public health data over criminal statistics, if both were available for a country.

Despite the drawbacks of underreporting and minor differences in the definition, homicide rates are one of the most accurate proxies for violent crime levels, since they have several advantages:

1) In comparison to other crimes such as robbery and rape, a homicide is clearly and universally defined across time and space (van Zanden et al. 2014, p. 149).
2) Homicide rates have high reporting rates, compared to other crimes. Due to the

severity of a homicide, people tend to report a higher share of the total homicides committed, while for example a far lower share of robberies are reported (Fajnzylber et al., 2000).

3) All social groups are affected equally by homicides. Thus, it is an indicator that mirrors the situation of the whole society, not only one special part (van Zanden et al. 2014, p. 140).
4) Homicide trends are correlated with other types of crime such as crimes against the property (Fajnzylber et al. 2000), which makes it a proxy for crime in general.

UNODC (2013) calls the homicide rate "the most readily measurable, clearly defined and most comparable indicator for measuring violent deaths around the world". It is "both a reasonable proxy for violent crime as well as a robust indicator of levels of security within states" (p.9). The data used in this study has been compiled using a variety of publicly available data sets of Clio Infra, Interpol, the WHO Mortality Database, the National Research Institute for Legal Policy (Helsinki, Finland), and the UNODC database. Wherever possible, additional sources such as national statistical yearbooks have been used to amplify the database[25].

[25] Most of the additional data has been compiled by the chair of economic history of Prof. Dr. Jörg Baten at the University of Tübingen over several years. See appendix D.7 for a detailed description of the data sources.

D.1.1.2. Measuring the Death Penalty

Over the course of history, the death penalty has been applied for a variety of crimes. In 18th century Britain, 222 crimes were punishable by death, including cutting down a tree and marrying a Jew (Jones and Johnstone 2011). In most countries, capital crimes have been abolished step-by-step, leaving only murder and in some instances treason in times of war and crimes against humanity punishable by death. In the framework of this paper, the death penalty as a punishment for murder is taken as main indicator, since the list of other capital crimes varies a lot across countries, while murder remains a capital crime in most countries retaining the death penalty. Hence, the death penalty is said to be "abolished" if it is no longer legal or used as punishment for murder, but for example is retained as punishment for crimes against humanity or treason during war times. To measure the presence of the death penalty in a country, two different indicators are employed to capture two different aspects:

1) Legal Status of the death penalty

This dummy variable takes on value 1 if the death penalty is still inscribed as legal within the constitution of the country and value 0 as soon as it is constitutionally abolished. During a moratorium, which is defined as "a suspension of activity or an authorized period of delay" (Lehman and Phelps 2005, "moratorium"), the indicator value will remain 1, until the death penalty is constitutionally declared illegal. This variable captures the "official" aspect of the death penalty, however it cannot gauge the daily practice regarding the death penalty. To better capture the actual experience citizens of a country have with the death penalty, a second indicator is introduced.

2) Execution of the death penalty

This binary value takes on value 1 if the death penalty has been imposed and executed in the respective year. It takes on value 0 if there have not been carried out any executions, regardless of the legal status of the death penalty. Hence, it takes on value 0 if a moratorium is in place or if the country simply has not carried out any executions as a result of a conviction for murder. The reason for the choice of two different dependent variables is the fact that many countries are "abolitionist in practice" for years or even decades before they finally constitutionally abolish the capital punishment. For example, in Argentina, the last civilian execution took place in 1916, but the death penalty was not abolished until 1984 (for civilian crimes). In Mexico, the de facto cessation of the death penalty for ordinary crime preceded the final abolition by 68 years. The Cornell Center on the Death Penalty Worldwide claims that moratoria, whether official or just an unofficial stop in executions, play an important role today (2011). More than half of the countries that retain the death penalty de jure has not carried out executions in the previous years, meaning they are "de facto abolitionist" (Cornell Center on the Death Penalty 2011).

For potential delinquents, it is the de facto punishment they will face after committing a crime that matters. Similarly, for the citizens of a country, the death penalty appears less present if there are no reports about executions. Since the discrepancies between the legal status of the death penalty and the actual practice are substantial, it is important to introduce this second indicator variable, that can better capture the actual practice, and it is assumed to be more informative than the mere legal status variable.

Most of the information on the practice and the legal status of the death penalty has been obtained from Amnesty International (2017) and Death Penalty Worldwide (2017). The only discrepancies found were due to the retention of the death penalty for extraordinary crimes, for example during war times. While some sources counted the death penalty as abolished as soon as it was outlawed for ordinary crimes, others reported the country as retentionist. Whenever possible, the information has been cross-checked with other sources such as national records and publications.

D.1.2. Data Coverage and Historical Background

The data set contains observations on both homicide rates and death penalty status (and additional covariates) for a total of 130 countries from all continents. The nations included in this study were selected on basis of data availability only. For some European countries, such as Belgium, Germany, Spain, Finland, France, Italy and the UK, the data starts as early as 1800. For the second half of the 19th century, the data coverage expands to Chile, Netherlands, Brazil, Austria and the US from 1880 on. For the 20th century, there is yearly data for 18 countries (including now Russia, Japan and India) and the number of countries covered increases steadily for later periods. By 1960, 60 countries are covered, reaching a total of 130 countries by 2008. For a complete overview of the observations contained in the data set see Figure D.1. The complete data set enters the tests in section D.2, however in section D.3, the sample may vary due to the availability of covariates.

To provide a background for the empirical analysis of the relationship between the death penalty and the homicide rate, the following paragraphs will offer a short descriptive overview over the historical developments of the homicide rates in the sample. Homicides have declined from very high levels during the middle ages until today (Eisner 2003). Eisner's work (2003) is the most cited analysis of long-term trends in violent crime. He reports a massive drop in homicide rates from the 15th to the 20th century for European countries such as England, Netherlands, Belgium and Germany, which is clearly a manifestation of a cultural change in most societies (Gurr 1981, Eisner 2003). Growing awareness of violence and increasing controls furthermore contributed to the long-term decline.

After the onset of the 20th century, the trends between the countries diverge. In Europe for example, homicide rates in Europe persisted at a low level, with one small upsurge during World War II (see Figure D.3 and Gurr 1981). Compared to Europe, the US homicide rate persisted on a level almost four times as high all throughout the 20th century. Between 1940 and 1960, the homicide rate dropped to around half, before increasing again after 1960. This increase between 1960 and 1990 is typical for some of the Western countries (Lappi-Seppälä and Lehti 2014), and is also visible if looking at the development of the homicide rate for single European countries (Figure D.4). Some countries, such as Spain and Italy, experienced relatively high levels of homicide rates until the start of the 20th centuries, while other countries such as Belgium or France reached very low levels already by 1800.

In Latin America and the Caribbean, crime rates remained high, mostly due to unstable conditions and the drug industry (Figure D.5). Other factors that seem to have caused short-term upsurges are mainly conflicts, rapid urbanization and industrialization, and changes in the demographic structure (Gurr 1981). Two of the countries with the highest homicide rates in the world are Colombia and South Africa, where rates have even increased towards the end of the 20th century (Figure D.6).

D.2. Causality Tests: Is there Evidence for a Deterrent Effect?

This first part of the study applies causality tests to the link between the two concepts of the death penalty, a proxy for the general severity of punishment, and the death penalty, a proxy for violence and crime. The traditional view at this relationship is the deterrence hypothesis which claims that a higher severity of the punishment leads to decreasing crime rates since potential delinquents are deterred from committing a crime (Ehrlich 1975, Becker 1968).

D.2.1. Literature Review

D.2.1.1. Theoretical Background

The death penalty as a punishment for unwanted behavior has been known and applied since ancient times. One of the most famous examples is the execution of Socrates by hemlock in 399 BC (Linder 2018). The debate about the ability of the death penalty to deter crime is equally old. Socrates' student, Plato, was one of the first scholars to write about the aims of this type of punishment, namely the improvement of society, be it through deterrence or by removal of the offender by exile or death (Saunders 1994). Already roughly 100 years earlier, Diodotus, an Athenian politician, claimed that human nature cannot be influenced by fear of death, but is rather determined by the hope of a successful achievement. Hence crime cannot be reduced by increasing the severity of punishment, but by ensuring that the offender does receive a punishment at all (Thucydides 1968).

Ever since, the debate about the deterrent effect has been ongoing – and unresolved (see for example Hobbes 1651). In 1968, Becker revolutionized the concept of crime by embedding it in an economic framework: he states that potential delinquents respond rationally to incentives, just as every other economic agent, and chose to commit a crime if the potential benefits outweigh the costs. The costs are determined by two factors: the severity and the probability of punishment. In this theoretical framework, it is possible to deter crime by increasing one or both determinants: By increasing the severity of the punishment related to a murder, the expected values of the costs exceed the expected value of the reward, and the potential delinquent choses a different behavioral option. The reward obtained from the crime does not necessarily have to be of monetary nature. The model likewise applies to other form of reward such as for example the psychological satisfaction of needs. Similarly, crime can be deterred by increasing the probability of being punished by improving the detection and conviction rates.

Both the severity of the punishment and the probability of being punished need to be sufficiently high in order to observe a deterrent effect in the model. The pure threat of being punished is not effective, just as the certainty of being punished with an insignificantly high fine is not.

If the probability of being arrested, trialed and punished by death after committing a murder is very variable across countries, then it is difficult to compare the effect of the death penalty across countries, even if the severity of the punishment is the same.

The most important assumption behind this economic theory of crime is however the one of rational choice. If this assumption can be maintained, then potential delinquents should adjust their behavior at least to some extent to the severity and the probability of the punishment. In many cases of hate crimes and crimes against the person it is difficult to maintain this assumption, since they are largely a result of hate, jealousy or other conflicts and decision of committing the crime is probably taken without consideration of prospective gains and losses. In these cases, the crimes could not be deterred by increasing the severity or probability of punishment.

This point has been made by most opponents of the deterrent effect. They have rarely questioned the validity of the mechanisms themselves, but rather the fact that this basic assumption on which the theory of deterrence is based, does not hold in practice (Ehrlich 1975). Some crimes are simply "undeterrable", since they are not based on a rational decision process (Sunstein and Vermeule 2005).

Another theory developed by opponents of the deterrence theory is the "brutalization effect" which indicates that the use of the death penalty by the state diminishes people's respect for life and results in increased violence (King 1978). This theory is the very reverse to the deterrence hypothesis, predicting a homicide-increasing impact of the death penalty and has also been called the “anti-deterrent” effect. When empirically studying the impact of the death penalty on the homicide rates, there could appear both a negative or a positive coefficient. Finding a negative impact of the death penalty indicator on the homicide rate hence supports the deterrence hypothesis, while finding a positive impact would support the brutalization theory.

D.2.1.2. Previous Empirical Evidence

Empirically, it has always been challenging to detect the deterrent effect of punishment, since it is only possible to observe those offenders that have not been deterred, and we may never know how many potential delinquents refrained from committing a crime due to the potential punishment. Numerous empirical studies both in favor of the deterrence argument and against it have been realized. For a good overview of the literature see Shepherd (2009); for a meta-analysis see Gerritzen and Kirchgässner (2013).

The first scholar to use regression analysis to examine the deterrent effect of the death penalty was Isaac Ehrlich in the 1970s. He published two papers, of which the first one (1975) used US time-series data from 1933 to 1969 and the second (1977) US cross-sectional data for the 1950s. Both papers indicate a substantial deterrent effect of the capital punishment on the number of homicides, however he also states that other forms of punishment could be used as substitutes. Pasell and Taylor (1977) examined Ehrlich’s studies and revealed that the results are very sensitive to the specification of the variables and econometric model.

A multitude of econometrics studies followed shortly after – with mixed results: Depending on the cross-section year, the time period and the econometric specification employed, the papers find or do not find evidence for deterrence (for example Ehrlich and Gibbons, 1977; Yunker 1976; Bowers and Pierce 1975; Black and Orsagh 1978). Most of these earlier studies use the same type of data: either national time-series data, which may produce spurious results, or cross-sectional data across American states, which does not allow to include time fixed-effects to control for unobserved heterogeneity across states.

Another wave of papers followed in the late 1980s and the 1990s with improved methods that tried to overcome these flaws by using panel data or the correction of non-stationarity, again with mixed results (Cover and Thistle 1988; Chressanthis 1989).

Dezhbaksh et al. (2003) provide evidence for a strong deterrent effect, relying on US county-level panel data from 1977 to 1996. They use the number of executions as explanatory variable which is negatively associated with the murder rate. Similar studies, using execution rates or the number of executions as explanatory variable and US panel data are Katz et al. (2003) and Lott and Landes (1999), both with limited evidence of a deterrent effect. Katz et al. (2003) find that the quality of life in prison is better suited to deter crime than the execution rate. Donohue and Wolfers (2006 and 2005) look at the most recent studies on the deterrent effect of death penalty, and conclude that there is no plausible evidence on the topic yet. If anything, studies hint towards a murder-increasing effect of the death penalty, but in general the conclusions are very fragile, as do most of the meta-studies (for example Chan and Oxley 2004).

Newer time series studies have been realized for example by Greenberg and Agozino (2012). They used a time series from Trinidad and Tobago for the period between 1955 and 2005. Even though sanction regimes varied substantially, they find that neither imprisonment nor death sentences nor executions had any relationship to murder rates. Cochran and Chamlin (2006) employed weekly time series data 1989 to 1995 from California to analyze the impact of the end of a 25-year moratorium. They find a decline in non-stranger felony-murders and an increase in the level of argument based murders, hence finding both deterrence and brutalization effects.

Maybe it is not surprising that the literature on the deterrent effect is nearly exclusively focused on the United States. Chan and Oxley (2004) analyze 74 studies that have been published on the topic since 1950 and 68 of these examine US data. There are a only a few studies on other countries, for example one longitudinal study on Nigeria by Adeyemi (1987) which shows that there is no support for the deterrence hypothesis in this data; two studies on Canada (Layson 1983, Avio 1979) and one on the UK (Wolpin 1978).

The only two international panel studies are those by Rahav (1983) on 17 countries with inconsistent findings, and Archer et al. (1983), covering 14 countries and concluding that the abolition of the death penalty is followed by a decrease in the homicide rate, which supports the brutalization theory. To my knowledge, there is no recent, international panel study on the topic.

All the traditional studies on the deterrent effect have in common one or both of the following drawbacks: They do not take into account potential feedback effects that might occur from the homicide rate on the fact that the death penalty is in place and/or they use a specification of the death penalty indicator that is flawed or even endogenous. These problems will be discussed in the following two chapters.

D.2.1.3. The Reverse Causality Problem

When analyzing the deterrent effect of the death penalty, most studies ignore the fact that there might be a reverse causality problem. There are many reasons to believe that the level and the development of crime rates in a country importantly influences the decision of a country whether to retain or to abolish the capital punishment. In fact, it could even be that there is no impact of the death penalty on crime rates whatsoever, and that the correlations found are due to the reverse causality present.

There are many potential channels through which the development of the homicide rate could influence the decision about abolition or retention: one possibility is that increasing homicide rates prevents policy makers from abolishing this punishment, while decreasing rates might insinuate the obsolescence of such a harsh punishment. Liu (2004) states that "the abolition or reinstatement decision on the death penalty itself is endogenous, associated mainly with the public sentiment for and against the death penalty". In the case of execution numbers, higher murder rates could cause a public outcry for more executions and hence lead to higher execution numbers (Shepherd 2009). Another way how crime rates could affect the death penalty is that increases in crime may put more stress on the criminal justice system and result in lower conviction rates in the short run (Nagin and Pepper 2012).

A few studies have tried to address this severe problem which highly complicates the estimation of the deterrent effect. Liu (2004) examines the endogeneity of a states' decision to enact death penalty laws. Using switching regression techniques and the same data set as Ehrlich's first study he still finds supporting evidence for the deterrence hypothesis.

Other studies addressed the issue by estimating a system of equations to minimize the bias from endogeneity, such as Dezhbakshsh et al. (2003), finding a negative impact of the death penalty on the homicide rate. A third strategy to deal with the endogeneity is the use of instrumental variables such as police spending, judicial spending, or the proportion of murder committed by non-whites (Zimmerman, 2004; Donohue and Wolfers 2005, 2006). Of the studies using instrumental variables some find evidence for a deterrent effect, some find evidence for a brutalization effect, but all of them have been criticized due to the choice of the instrumental variables used (Nagin and Pepper 2012). The fact that the actual determinants of homicide rates are very heterogeneous makes it very difficult to find a valid instrument.

Stolzenberg and D'Alessio (2004) used monthly Texas time series data, taking into account reciprocal effects by applying ARMA statistical procedures. They found strong evidence for a feedback effect: a negative delayed effect of murder on the execution risk, since more murders reduce the efficiency of the judicial system and hence result in a lower probability of being executed. They found no other significant effects in either direction between the homicide rate and the death penalty. Narayan and Smyth (2006) use a cross-national panel of countries and check for spurious results due to non-stationarity, concluding that there is only limited support for the deterrence hypothesis.

D.2.1.4. Specification of the Dependent Variable

The second drawback of previous studies is the specification of the dependent variable. Most of them use the number of executions as indicator (Dezhbaksh et al. 2003) or the execution rate, i.e. the number of executions per 1,000 homicides (Katz et al. 2003). These measures are flawed in several ways, the main problem being endogeneity. When the homicide rate increases and the judicial and law enforcement systems are at least somewhat effective, then the number of executions will increase, which makes the number of executions an inherently endogenous measure. Furthermore, the short-term fluctuations in the number of executions are probably irrelevant to the decision process of potential murderers, since they base their decision on their perception of the entire criminal sanction regime in place which is constant in the short run and not on the recent occurrence of executions (Nagin and Pepper 2012).

D.2.2. Empirical Strategy

D.2.2.1. Specification of the Variables

The goal of this section is to check if there is a significant impact from the presence of the capital punishment on the homicide rate. When estimating the relationship between the two variables of interest, it is crucial to define the "treatment" and identify which units are "treated" with the death penalty and which are not. As mentioned before, the "treatment" in the case of the deterrence hypothesis is affected by two factors: the probability of being caught and the severity of the punishment.

Previous studies measured the severity of the treatment by using the number of executions, which insinuates varying treatment intensities, even though the severity of the punishment that the murderer would receive is always constant.

The approach of this study is to specify capital punishment not as continuous variable with varying intensity, but as a binary treatment. When the capital punishment is legal and/or applied in a certain year, then the country is considered as “treated”, if not, the country is untreated. In the “untreated” countries, the delinquents face the risk of a lengthy prison sentence.

The second factor, the probability of being caught, is assumed to vary substantially across countries, since political institutions and cultural factors differ substantially. However, within one country, especially in the short run, this probability is assumed to be relatively constant, and hence can be removed by using country fixed effects.

The homicide rate is transformed logarithmically to reduce the severe (positive) skewness and kurtosis present in the distribution (see Figure D.2).

D.2.2.2. Granger-Causality Tests

When estimating the relationship between the death penalty and the homicide rate, it is important to take into account is the potential reverse causality. The econometric methodology needs to allow for feedback effects or should not rely on an ex ante assumption of the direction of causality. The traditional econometric approach when the direction of causality is unclear is to estimate vector panel autoregressions (VAR) and conduct Granger-causality tests (Granger 1969). The basic notion of these tests is to check how much additional predictive power the lags of the variable X add, compared to using the lags of Y alone. If the lagged values of X provide statistically significant information about Y, then the variable X is said to Granger-cause Y. The big advantage of this methodology is that it does not require any previous assumption on the direction of causality; the tests can be conducted in either direction. In the past decades, the Granger-causality approach has been extended to the panel data setting (see Holtz-Eakin, Newey and Rosen 1988 and Hurlin 2004, 2005). Advantages of panel data over the single time-series

Granger-causality test are the ability to control for individual, time-invariant heterogeneity, and increased precision of the estimations due to the higher number of observations, among others. Panel Granger-causality tests are used today in a variety of contexts and disciplines (see for example Hongchang et al. 2018 for a recent application).

One basic assumption of the VAR-model is that it linearly relates current realizations of *Y* to previous realizations of *X* and *Y*, which implies that the dependent variables needs to be continuous-valued. If one of the variables is binary, the assumption of a linear relationship can no longer be maintained. In the context of this study, the death penalty indicator is defined as binary, hence can enter the VAR only on the right-hand side. Using the following equation, it is possible to test the deterrence hypothesis, i.e. the impact of the death penalty on the homicide rate:

$$homicide\ rate_{it} = c_1 + \sum_{k=1}^{p} \alpha_{1k} homicide\ rate_{i,t-k} + \sum_{k=1}^{p} \beta_{1k} death\ penalty_{i.t-k} + \epsilon_{i,1t}$$

In this equation, the finding of at least one of the β_{1k} being significant and negative corresponds to deterrence, while a positive coefficient would support the brutalization theory. Finding no significant effect would suggest that there is no Granger-causality from the death penalty on the homicide rate. Since the death penalty indicator is a binary variable, the Granger-causality tests can only be conducted in this direction, and the impact of the homicide rate on the death penalty cannot be modeled. For a more detailed description of the Granger-causality test methodology please see Appendix D.7.3.

D.2.2.3. Dynamic Logit Model with Feedback Effects

Since in this context, the traditional Granger-causality tests can only be used to test for the impact of the homicide rate on the death penalty, a second model that is able to accommodate reciprocal effects will be estimated: Bartolucci and Pigini (2017) have recently developed[26] a model that can handle a binary dependent variable, a dynamic setup and the violation of the strict exogeneity assumption. This model is well suited to estimate the interdependence between the death penalty and the homicide rate. Additionally, a test for Granger-causality can be derived. The proposed model is a dynamic logit model that allows for a violation of the strict exogeneity assumption by including feedback effects from the dependent on the independent variable.

For i=1, …, n and t=1, …, T we observe the binary response variable y_{it} and the covariate x_{it}. In the framework of this paper, the binary response is the death penalty indicator, while the covariate is the homicide rate.

The binary response has the distribution

$$p\left(y_{it}\middle|a_i, \boldsymbol{X}, \boldsymbol{y}_{i,1:t-1}\right) = p\left(y_{it}\middle|a_i, \boldsymbol{X}_{i,t:t+1}, y_{i,t-1}\right)$$

This implies that the present value of the probability of y_{it} depends on the present and the future value of the covariate. To allow for violation of the strict exogeneity assumption, the lead of the covariate must be included as a correction term. This can be interpreted as a "measure of the effect of the present choice y_{it} on the expected utility (or propensity) at the next occasion (t+1)". In the presence of positive state dependence, the correction term is positive, since making the choice today has a positive impact on the expected utility (Bartolucci and Nigro 2010, Wooldridge 2010).

Chamberlain (1982) shows that the violation of Granger non-causality corresponds to the

[26] Strategies to estimate dynamic models with feedback effects in binary data had not been developed until recently. Mosconi and Seri (2006) present a methodology to test for feedback effects in binary bivariate time series, but Bartolucci and Pigini (2017) is the first model that can accommodate a binary dependent and a continuous-valued independent variable.

presence of feedback effects, hence a test for Granger-causality test can also be derived using the Bartolucci-Pigini-model. The logit model takes into account "feedback effects from the past of the outcome variable on the present value of covariates" (Bartolucci and Pigini, p. 3) and it can be estimated using a pseudo conditional likelihood estimator developed by Bartolucci and Nigro (2012).

The resulting model is specified as follows:

$$p\left(y_{it} \middle| a_i, \boldsymbol{X}_{i,t:t+1}, y_{i,t-1}\right) = g^{-1}\left(a_i + x'_{it} * \beta + x'_{i,t+1} * \nu +, y_{i,t-1} * \gamma\right), \qquad t = 2, \ldots, T-1$$

with $g^{-1}(.)$ being an inverse link function.

This shows that the probability of y_{it} is conditional on the unobserved country fixed effect a_i, the contemporaneous realization of the homicide rate x'_{it}, the future realization of homicide rate $x'_{i,t+1}$ and the past realizations of the death penalty.

The lead of the independent variable is included in order to correct for feedback effects from the dependent variable on the exogenous variable. Using this term, a test for feedback effects can be derived. If the homicide rate is strictly exogenous, then the lead $x'_{i,t+1}$ should be completely unrelated to the death penalty, and hence the coefficient should be insignificant. If it is significant, then there are important feedback effects that cannot be ignored.

D.2.3. Results

This section presents the results of the Granger-causality tests and the dynamic logit models estimated with the goal of identifying if there is a significant impact running from the death penalty on the homicide rate. The panel at hand is a macro panel with large T and limited N. In this type of data set, the possibility of non-stationarity arises. In order to avoid spurious results in the subsequent econometric analysis, the series needs to be pre-tested for the presence of a unit root.

D.2.3.1. Tests for Cross-Sectional Dependence

Most panel unit root tests require cross-sectional independence; hence the homicide time series are first checked for interdependence across countries before conducting unit root tests. Cross-country dependence could emerge if common global shocks impact various countries or if countries within the same region experience similar developments due to spillover effects. The Pesaran-test for cross-sectional dependence is based on the correlation coefficients between the time series for each of the cross-sectional units and can detect cross-section dependence in the form of a single unobserved common factor (Pesaran 2004).

The test can only be applied to balanced panels, which is why the data had to be restricted to common observations between 1950 and 2000. The remaining sample contains 26 countries with 51 observations each. The test then calculates the 26 x 51 coefficients of correlation between country *i* and all other countries. This test is robust to non-stationarity. The null hypothesis is that the data are cross-section independent. The results are reported in Table D.1. For comparability, the test was also conducted for GDP per capita. For the homicide rate, the average coefficient of correlation is 0.261, which is relatively low compared to the average correlation of 0.881 in the case of GDP per capita. Hence, homicide rates are more independent across countries than GDP per capita; and shocks are not as easily transmitted across countries as in the case of GDP[27].

Nevertheless, the cross-sectional correlation is still considerable: The Pesaran-test rejects the null hypothesis of cross-section independence for all variables on all significance levels. Hence, the unit root test to be employed must allow for cross-sectional dependence in the data.

[27] Among the regions, Europe has the highest average correlation of GDP per capita between countries of 0.981, while among the American countries the average correlation is only 0.526. A similar pattern is discernible for homicide rates.

D.2.3.2. Tests for the Presence of Unit Roots

Variables that enter the VAR need to be covariance-stationary, otherwise spurious results can be a problem, especially in panels with a larger time dimension. According to Noriega and Ventosa-Santaularia (2007), a panel data set with more than 25 time periods is prone to display non-stationarity. In the sample at hand, the average number of time periods in the unbalanced panel is 40, which is considerably above the threshold of 25 observations.

In time series studies, unit root testing is standard procedure, however for panel data, tests for unit roots have only been developed in the last two decades (Baltagi and Kao 2000). To test for the presence of unit roots in the presence of cross-sectional dependencies, the cross-sectional augmented Im-Pesaran-Shin test (CIPS) has been developed by Pesaran (2003). It allows for cross-section dependence in the form of a single unobserved common factor with heterogeneous factor loadings in the data. The test consists of country-specific augmented Dickey-Fuller regressions where cross-section averages of both independent and dependent variables are included. In a second step, the single statistics are averaged following the Im, Pesaran and Shin (2003) procedure.

The null hypothesis is that the homicide series are integrated of order 1. The test is conducted for two different balanced panels and the results are presented in Table D.2 (balanced panel from 1950 to 2000) and Table D.3 (balanced panel from 1970 to 1990). The specification without trend is reported, since the trend was not significant. However, when including a trend, the results are identical. The table also reports the Maddala and Wu test (1999) results.

The tests reject the null hypothesis of non-stationarity[28] for all the specifications, except of the specification with two lags included in the shorter balanced panel. Given these results, it

[28] For both the Maddala and Wu (1999) – test and the CIPS test (Pesaran 2003) test the null hypothesis of non-stationarity. Other unit root tests like the Lagrange-multiplier test are based on the null hypothesis of stationarity.

can be concluded that the homicide series are not integrated of some order, and hence can enter the VAR regression untransformed. For the case of the binary death penalty indicator, unit root tests are not necessary, since binary variables are always integrated of order zero and hence stationary.

D.2.3.3. Granger-Causality Tests

Before estimating the VAR, the optimal lag length has to be selected. The difference of the overall coefficient of determination (Abrigo and Love 2015) between different specifications using from 1 to 6 lags is minimal: The coefficient of determination varies between 0.9960 and 0.9962, with the maximum value for 3 lags. Hence the VAR is estimated using 3 lags, using the legal status as well as the execution death penalty indicator; an additional specification with 2 lags is also reported. The results are presented in Table D.4 and Table D.5. The corresponding Granger-causality tests are included at the bottom of each table.

For the homicide rate equations (columns 1 and 3 in each Table), the coefficients of the homicide rate lagged by one, two or three periods is always significant and positive, which stresses the inertia properties of crime. However, none of the coefficients of the death penalty indicators is significant in any of the specifications. Hence neither the legal status nor the application of the death penalty in previous years helps to predict the homicide rate. Likewise, the null hypothesis that all coefficients of the lagged death penalty indicator are simultaneously equal to zero (Granger-non-causality) cannot be rejected. The results are identical using either of the death penalty indicators. There is no evidence for Granger-causality running from the death penalty to the homicide rate. This result contradicts the deterrence hypothesis.

To sum up, the Granger-causality tests based on a vector autoregression with two and three lags respectively did not detect any Granger-causality from the death penalty to the homicide rates, irrespective of the death penalty indicator used.

D.2.3.4. Dynamic Logit model with Feedback Effects

The second approach that can be employed to check for an impact of the death penalty on the homicide rate is the dynamic logit model that can accommodate a binary dependent variable and feedback effects from the dependent on the independent variable (Bartolucci and Pigini 2017). This model is well suited for the two variables and the research question here, since the death penalty indicator is binary and the dependent variable (homicide rate) does not need to be strictly exogenous in order to enter the model. A violation of the strict exogeneity assumption in the form of feedback effects from the death penalty on the homicide rate can be modeled. The dynamic logit model suggested by Bartolucci and Piginin (2017) allows to test the significance of the feedback effect and hence the null hypothesis of Granger-non-causality. If the feedback effect is significant, then there is an impact of death penalty on the homicide rate, and this result would support the deterrence hypothesis.

Since the Bartolucci-Pigini model is only applicable to short panels, the data set had to be restricted to a shorter time frame. According to Eberhardt (2011) a short (micro) panel consist of a “substantial” number of cross-sectional units and covers only a short time period, while a macro panel typically covers considerably more than ten time periods. In order to obtain a short panel but still maximize the number of observations included in the regressions, the panel was restricted to the observations four years before and four years after the last execution or the official legal abolition of the death penalty. This results in a maximum of nine observations per country, less if data is not available for all nine years around the last execution/abolition for the respective country. This way, the time period is strictly shorter than ten and the Bartolucci-Piginin model can be applied.

The first set of regressions[29], (see Table D.6) include the observations in the nine-year time frame around the last execution, resulting in a total of 629 observations for 100 countries. The model has been estimated using both the legal status indicator as well as the execution indicator. The results indicate that only the execution indicator displays significant state dependence, while in the legal status variable, the lagged legal status dummy does not have significant explanatory power. The most important variable of interest is the lead of the log(Homicide rate), since it captures possible feedback effects from the death penalty on the homicide rate. Using any of the death penalty indicator, this variable is insignificant, showing that the current realization of the death penalty is statistically unrelated to future realizations of the homicide rate. Hence, there is no evidence of a deterrent effect from the capital punishment on the homicide rate. Finally, there is no significant contemporaneous impact of the homicide rate on the death penalty in the same year.

The second set of regressions include the observations in the nine-year time frame around the legal abolition of the death penalty, covering 54 countries and a total of 668 observations. The results can be found in Table D.7. Again, the lagged death penalty indicator is only significant in the regression using the execution indicator. As in the first set of regressions, results do not offer any evidence for a feedback effect, because the coefficient of the homicide rate in t+1 is always insignificant. Furthermore, no effect of the homicide rate on the death penalty in the same year is found. To sum up, the results of the Bartolucci-Pigini model applied to the global data set offer no evidence for the deterrence hypothesis or for any effect running from the death penalty on the homicide rate.

[29] The regressions have been conducted using the cquad Stata-package developed by Pigini and Bartolucci (2015).

D.2.4. Summary of the Findings

This section had the goal to add to the vast existing literature on the deterrent effect of the death penalty keeping in mind the possibility of feedback effects or reverse causality. By introducing new econometric methodologies to the topic and using a new data set with global coverage, it was possible to overcome drawbacks of previous studies: The death penalty measure was not defined as a continuous variable as for example the number of executions per year. Instead, a binary indicator of the legal status and the application of the death penalty has been used. First, vector autoregressions and related Granger-causality tests were used to show that there is no Granger causality of the death penalty on the homicide rates. These findings contradict the deterrence theory. Additionally, a dynamic logit model that can accommodate a binary dependent variable and feedback effects from the independent on the dependent variable was estimated (Bartolucci and Pigini 2017). The results confirm the initial findings, namely that there is no significant impact from the death penalty on the homicide rate and hence no evidence for a deterrent or any other effect.

In the framework of Bartolucci and Pigni (2017), the finding of independence of the homicide rate ($x_{i,t}$) can be expressed as follows:

$$p(x_{i,t+1} | a_i, \boldsymbol{x}_{i,1:t}, \boldsymbol{y}_{i,1:t}) = p(x_{i,t+1} | a_i, \boldsymbol{x}_{i,1:t}); \;\; i = 1, \dots, n; \; t = 1, \dots, T-1$$

The binary response $y_{i,t}$ (death penalty) does not cause the covariate $x_{i,t}$ (homicide rate) conditional on the time fixed effect a_i, if $x_{i,t+1}$ is conditionally independent of $y_{i,1:t}$, given a_i and the past realizations of x_i. Bartolucci and Pigini show, that this condition is equivalent to the condition of strict exogeneity with respect to the binary response:

$$p(y_{i,t} | a_i, \boldsymbol{x}_i, \boldsymbol{y}_{i,1:t-1}) = p(y_{i,t} | a_i, \boldsymbol{x}_{i,1:t}, \boldsymbol{y}_{i,1:t-1}); \;\; i = 1, \dots, n; \; t = 1, \dots, T-1$$

Hence the findings of the past analysis open the possibility to add the homicide rate as independent variable when trying to explain the timing of the abolition of the death penalty or the stops in executions, without the risk of endogeneity. The second part of the paper explores this potential impact of homicide rates on the decision of a country to stop executions or to legally abolish the death penalty.

D.3. Event History Analysis

D.3.1. Introduction

The previous chapter D.2 was intended to shed some light on the direction of causality present between the two concepts of the death penalty and the homicide rate. While the advocates of the deterrence hypothesis predict a crime-reducing effect of the death penalty, the performed data analysis could not detect any support for this theory. Interestingly, the analysis has shown potential effects in the opposite direction: the level of the homicide rate might significantly influence the decision of a political system to abolish, introduce or retain the capital punishment.

Several examples, where an increase in violence led to the re-introduction of the death penalty or the increase of the severity of general punishments can be found in history: On December 16th 2014, seven fighters of the Islamic Tehreek-e-Taliban attacked a public army school in Peshawar, Pakistan. The attack resulted in 130 dead school children and as a response to this violent incident, the Pakistani government resumed the execution of the death penalty after a de facto moratorium that had lasted for almost 6 years. This is just one example of how a country saw its decision to abolish the death penalty affected by an upsurge of violence. One potential channel is that even though the research on the deterrent effect is still inconclusive, the public may demand severe punishment in response to high crime rates. This way crime rates might significantly affect the likelihood of abolition. On the other hand, decreasing crime rates might generate a climate more conducive to abolition, since politicians demanding a hard hand against criminals might not get as much support if crime rates are low. Looking at Figure D.3, one can discern that homicide rates started to rise in the US in the 1960s, which is exactly when politicians such as Lyndon B. Johnson and Richard Nixon started to introduce the topics of law enforcement and deterrence into the political discourse. The reasons for the increase in homicides can be found in the "decivilizing process" of the 1960s (Pinker 2011) as well as the riots, strikes and incidents of civil disorder of the African American communities fighting against racism and discrimination (Hinton 2015). As response, Johnson declared a "War on Crime" and effectively replaced anti-poverty programs with "the state apparatus of punishment – including law enforcement, criminal justice and prison systems" (Hinton 2015, p.111). In a presidential campaign speech in 1968 Nixon stated that the "solution to the crime problem is not the quadrupling of funds for any governmental war on poverty, but more convictions" (Crutchfield 2007, p. 52). Finally, the drug war raging in Mexico during the last decade with rampant killings and kidnappings has led to calls to reinstate the death penalty (Olivero 2013).

This illustrates how in times of increasing crime rates and violence, policy makers try to fight this uprising by introducing even harsher punishment and even tougher legislation, instead of addressing the root causes of the problem that might be of social or economic nature.

Looking at the development of homicide rates around abolition for abolitionist countries today, it is possible to discern descending rates in the five years leading up to the abolition. Figure D.7 looks at the trend of the homicide of the 27 countries for which data for all ten years before and after the legal abolition of the death penalty is available. The mean homicide rate decreases by almost 50% in the five years leading up to the legal abolition, suggesting that countries take the decision to abolish after experiencing a decrease in homicide rates. A similar, pattern is discernible for the mean homicide rate development in the three years before the stops in executions (Figure D.8).

While there are several studies that examine the general determinants of the abolition decision of a country, most of them do not consider the role the level of crime and violence in a country might play in this context (for example Miethe et al. 2005, McGann and Sandholtz 2012, Lourtau and Babcock 2016).

This chapter will apply event history analysis to the timing of abolition in order to examine the effect homicide rates have in this context. The previous analysis has shown that the homicide rate is not Granger-caused by the death penalty and can be assumed as fairly exogenous (Bartolucci and Pigini 2017). Therefore, it is possible to include the homicide rate as explanatory variable in the event history study without a high risk of endogeneity issues. The main hypothesis is that increasing homicide rates have a delaying effect on the abolition decision, while decreasing homicide rates lead to a sooner abolition. The analysis follows roughly the methodology of Neumayer (2008) and Kent (2010). Apart from doubling the number of countries included in the analysis, this study introduces a novel indicator of the death penalty: an indicator variable assessing if the death penalty has been applied or not. Since many countries introduce moratoria decades before finally legally abolishing the death penalty, this indicator can better capture the actual practice of the death penalty in a society.

D.3.2. History of the Capital Punishment and Data Coverage

The capital punishment or death penalty, e.g. the practice to put a person to death as a sanction for a forbidden action, has been used in nearly all societies since ancient times (Reggio 2014). The first documented death penalty law goes back as far as the 18th century BC and the first death sentence historically recorded took place in the 16th century BC (Reggio 2014).

The first modern times country that ever abolished the death penalty was Venezuela in 1863, after not having carried out an execution since independence in 1830 (Hood and Hoyle 2008). In general, the Latin American continent was very inclined towards abolition, since several countries in the continent followed Venezuela in the subsequent decades: Costa Rica

(1877), Ecuador (1906), Colombia (1910) and Panama (1922). Many of these abolitions coincided with a universal annulment of colonial laws after the countries won their independence. The second continent with noticeably early abolitions is Europe (for example Iceland, Portugal and Italy all had abolished by 1950). In some European countries, however, the death penalty was reinstated during or after the second World War. In Italy, the reintroduction was induced by the authoritarian regime of Mussolini. In Germany, the death penalty had not been abolished completely before 1933, however the Nazi regime tremendously intensified its use. In Belgium, Denmark, and the Netherlands, the reintroduction was a response to the severity of the crimes against humanity committed during wartime (Hood and Hoyle 2008).

After the second world war, the abolitionist movement gained momentum in the entire world: From 1960 to 1990, 25 countries abolished capital punishment, and in the 1990s, another 35 countries followed (Sinclair and Sinclair 2011). European countries that have been governed by a dictatorship or repressive state such as Spain, Greece and Eastern Germany used the capital punishment longer than democratic countries.

Interestingly, almost all countries display the same pattern: They had the death penalty established since ancient times, abolish it at some point in time and then stay abolitionist thereafter (Neumayer 2008). There are only very few exceptions to this general rule, in which the death penalty was reintroduced after an initial abolition, e.g. the reintroductions during and after World War II, even though most of these reintroductions were limited to the capital punishment for extraordinary crimes (Neumayer 2008). Another example is Iraq, where the capital punishment was repealed after the fall of Saddam Hussein and reintroduced one year later in 2004 (UNAMI/OHCHR 2014). Pakistan that put an end to a 6-year moratorium, introducing the death penalty after the massacre of Peshawar (BBC News 2014).

Another stylized fact about the abolitionist development is that the abolitions seem to happen in waves, which indicates a high degree of cross-country correlation in the decision to abolish the death penalty.

Today, 114 countries have completely abolished the death penalty for ordinary crimes (seven of these retain the death penalty for serious crimes, for example treason during war times). An additional 30 countries are abolitionist in practice: while not having legally abolished the death penalty, they have not imposed the death penalty for at least 10 years. That leaves 57 retentionist countries, of which 23 carried out executions in 2016 (Amnesty International 2017). Most of the retentionist countries are situated in North Africa and the Middle East, some in Asia. China is estimated to be the country with the highest number of yearly executions (Amnesty International 2017).

The described development of a steadily increasing number of abolitionist countries raises the question about the driving forces behind this trend. Why did most of the countries abolish the death penalty while some retain it? What are the most important political and economic factors for the timing of the abolition? And finally, what role do crime rates play in this context? Due to the findings in the first part of this chapter, I expect that high or increasing crime rates decrease the likelihood of abolition, while sinking crime rates might push a country towards abolition, if abolitionist tendencies were already existing.

Of the total 130 countries in the data set, eight enter the data set after have already legally abolished the death penalty[30]. Most of these are countries were some of the first to abolish capital punishment, as for example Venezuela and Panama (1863 and 1903). Since for these countries there is no information available for the time periods leading up to abolition, they cannot be included in the event history analysis when using the legal status death penalty indicator.

An additional 10 countries have never applied the death penalty in the time span covered

[30] Colombia, Costa Rica, Ecuador, Honduras, Iceland, Panama, Portugal, Venezuela

by the observed data[31]; hence these cannot be included when using the second death penalty indicator that captures the application of the death penalty due to missing observations for the years before the last execution.

This leaves a total of 122 countries that have the capital punishment in their constitution when they enter the data set. 62 of these, so roughly half the countries in the data set, legally abrogate the capital punishment in the years included in the data set, the other 60 countries maintain the death penalty in place all throughout the covered time span.

When looking at executions, 112 countries are executing convicted perpetrators at the beginning of the observed time periods. 100 of these countries stop executing at some point, 77 permanently, 23 re-introduce the executions after some time. 12 countries in the data set have at least one execution recorded in every year [32] (of the observed years).

D.3.3. Literature Review

Eisner (2014) draws a graph of the European trend in executions versus trend in homicide rates for the years 1200 until 1900, and is astonished by the similarity of the two curves (p. 41). A direct correlation cannot be the result of a deterrent effect, but could be seen as “evidence that homicide and capital punishment were two sides of the same coin and that their simultaneous decline up to 1800 reflects a more fundamental shift that affected elite attitudes away from approving the spectacle of human beings being debased, tortured [and] killed” (Eisner 2014, p. 42). Pinker (2011) in his seminal work includes in his definition of violence robbery, kidnapping, homicide, assault, rape, war and genocide but also treatment committed by institutions such as corporal and capital punishment. Van Dülmen (1995), looking at early trends of crime and punishment in Germany, claims that the decline in death penalties since the late sixteenth century

[31] Argentina, Gabon, Haiti, Madagascar, Myanmar, Namibia, Nicaragua, Papua New Guinea, Slovenia

[32] Botswana, Chile, China, Eritrea, Fiji, French Guinea, Iraq, Democratic People’s Republic of Korea, Saudi Arabia and Vietnam

is a result of decreasing crime levels. What these authors tentatively suggest is that the causality of this effect is not running from the punishment towards crime but rather in the other direction. Decreasing crime and violence can change the society in a way that it accepts less cruel and less severe forms of punishment. In a similar fashion, where crime and violence are high, the public is more fearful, insecure and social capital is low. In this setting it is more likely that harsher sanction, culminating in the ultimate punishment, will be demanded (Otterbein 1986, Greenberg and West 2008). The reason might be that people simply believe in deterrence or that they demand retribution.

The scientific literature looking at the determinants of the timing of the political decision to do away with the capital punishment is completely disconnected to the literature presented in the first part of this chapter, i.e. the literature on the impact of the death penalty on crime and the deterrence hypothesis. In contrast to the topic of deterrence which has been studied extensively, there is very little research on the determinants of the death penalty itself. Thus, the question why countries choose to abolish, retain or reinstate the death penalty as a legal punishment remains unanswered.

The literature on the factors influencing a country's decision to abolish is mainly characterized by qualitative methods such as case studies. A couple of studies look at one single country, scrutinizing the events, developments and conditions leading up to the abolition in that particular case (Bedau 1997, Lourtau and Babcock 2016). In these case studies, a variety of factors have been identified as being causal to the decision to abolish the death penalty: political factors such as the degree of democratization, a transition from an authoritarian to a democratic government, especially following civil wars or conflicts (Lourtau and Babcock 2016), a left-wing party in power and strong political leaders and a country's experience with war and conflict (long peaceful periods seem to increase the likelihood of abolition). Unstable political systems are more likely to retain the death penalty, not to deter ordinary homicides and crimes, but to secure their status and to be able to govern effectively (Greenberg and West 2008).

Apart from the political conditions, cultural norms and conditions have also been mentioned to be of important influence. While Christianity is usually assumed to be conducive to abolition, Islam is associated with longer retention of the death penalty, as is a high degree of ethnolinguistic or religious fractionalization. The origin of the legal system as well as colonial history also seem important. Finally, there are general social and economic factors that might affect the decision to abolish, such as the level of economic development and the international openness to trade, which goes hand in hand with the pressure exerted by international organizations and treaties (Lourtau and Babcock 2016).

Aside from the qualitative studies looking at single countries, there are a couple of quantitative studies covering more than one country.

Killias (1986) is one of the first scholars to conduct a cross-national comparison and finds that the higher the economic development and the democratization of a country, the more likely that the abolishes the death penalty. The importance of stable, democratic institutions is confirmed by several newer studies (Miethe et al. 2005, Neumayer 2008, McGann and Sandholtz 2012). Neapolitan (2001) finds that political freedom is significant when explaining the use of capital punishment, while also stressing the impact of historic, cultural and geographic conditions.

Rudell and Urbina (2004) emphasize the importance of ethnic heterogeneity when predicting abolition in another cross-national study. Lesser cultural and ethnic diversity within a country is associated with an early abolition of death penalty. Two other studies additionally report significant impact of religion and the legal system (Greenberg and West 2008 and Anckar 2004). Surprisingly, Anckar (2004) finds a significant impact of population size: Bigger countries are more prone to retain the death penalty. One possible explanation is that bigger countries are more difficult to control and hence tend to retain more drastic punishments in their legislation.

Two studies that are worth mentioning due to their choice of methodology are Kent (2010) and Neumayer (2008). Both studies use event history analysis with the dependent variable being the abolition of the death penalty for either all or ordinary crimes. As explained in section D.3.3.2, this estimation method is the most adequate to examine this kind of data with a binary dependent variable, which is why emphasis should be put on the findings of these two studies. Neumayer (2008) confirms that the most important factors are of political nature, such as democracy and international political pressure. He also detects regional contagion dynamics. A legal system based on English common law decreases the likelihood of abolition. Both Kent (2010) and Neumayer (2008) conclude that higher ethnic fractionalization and income inequality are both impeding an abolition of the death penalty.

To sum up, the political system seems to be one of the most important factors influencing the abolition of the death penalty, hence when testing for the impact of the homicide rate, a proxy variable capturing the political system needs to be included as covariate. Other important factors are ethnic heterogeneity and inequality.

Very few of these previous studies consider the potential effect crime rates might have on the severity of the punishment or the presence of the death penalty. Traditionally, studies looked at correlations between crime rates and prison populations (for example Neapolitan 2001) and found positive association, but this is not very informative. If the legal justice system is at least somewhat effective, then higher crime rates should always lead to higher prison population, even if the legal justice system remains completely unchanged. Hence it is not clear, if this correlation is due to an increase in the severity of the application of the law or due to the simple fact that there are more crimes and hence the probability that a delinquent gest caught and convicted is higher. The same holds for studies using the number of executions as indicator of the "severity" of the punishment. An increase in the number of executions might as well be due to the increased number of potential convictions. A change in the status of the death penalty however is always due to a profound change in the legal justice system and hence can better capture the effect homicide rates might have on the severity of punishment.

Of the newer, quantitative studies, four include an indicator of violent crime. Ruddell and Urbina (2004) and Greenberg and West (2008) include homicide rates, but find no significant effect on the likelihood of abolition/retention in a logistic regression. Kent (2010) uses reported crime rates as indicator of crime levels and finds a counterintuitive effect: higher crime rates lead to higher abolition probability. The paper does not offer any explanation of the unexpected result. Finally, the study by Neumayer (2008) shows that higher homicide rates significantly lower the likelihood of abolition, and quite strongly so.

The contradictory previous results could also be a result of the different structure of the data samples employed in each study. Due to the "extremely poor" data availability (Neumayer 2008, p. 22) for the homicide rate, the samples were relatively small and selective. Greenberg and West (2008) could only obtain a total of 116 country-years; Kent (2010) used a multiple imputation procedure to estimate missing information, which might have introduced a substantial amount of measurement error, hence biasing the outcome. Neumayer (2008) was able to increase the number of observations to 768 from 62 countries, and hence the most representative sample so far.

Due to the newly assembled data set at hand, this study is based on the most extensive sample so far. The number of countries covered is almost doubled, reaching a maximum of 121 countries and 4,000 country-years.

D.3.3.1. Specification of the Dependent Variable

In previous studies, the dependent variable has been specified as legal abolition of the death penalty for all crimes or for ordinary crimes (Neumayer 2008, McGann and Sandholtz 2012, Kent 2010). In this study, the legal abolition of the capital punishment for murder will be used as the dependent variable, which is similar to the definition of abolition for ordinary crimes used in the previous studies mentioned. The death penalty is counted as "abolished" as soon as it is removed from the constitution as sanction for murder (even though it might remain legal as sanction for ordinary crimes such as war crimes and crimes against humanity). The reason why this definition is chosen (instead of abolition for *all* crimes) is that the death penalty for murder is first of all the most universal definition, which makes the data more comparable across countries. Furthermore, it is the kind of sanction that matters most for the citizens of the country, whereas death penalty for war crimes and crimes against humanity is only applied in very extreme circumstances, and hence is not perceived by citizens in their everyday lives. Therefore, abolitionist movements and pressures might be higher regarding the death penalty for "ordinary" crimes than regarding the death penalty for extraordinary crimes.

Additionally, a novelty of this study is that apart from the indicator of the legal status of the death penalty for murder in the constitution, an additional measure that gauges the application and actual practice of the death penalty is introduced. Reviewing the history of the capital punishment, it is striking that some countries retain it in their constitution as punishment but do not carry out executions during entire decades. Venezuela had not carried out an execution in the 30 years before abolishing death penalty, and Argentina carried out its last execution in 1916 and did not abolish the death penalty for civilian crimes until 1984. In these cases, the citizens as well as politicians of a country might perceive the death penalty as abolished, since it is not applied anymore, and hence refrain from pushing abolitionist demands, or abolitionist movements might diminish their efforts once executions have stopped. Almost half of the countries retentionist today are not applying the death penalty in practice, even though it remains still legally inscribed in the constitution. These facts illustrate, that a look at the legal status of the death penalty is not sufficient to gauge the experience of the death penalty as a country. The pressure on the government to introduce a moratorium might be even higher, than the pressure to finally abolish it. The fact that the United Nations General Assembly has approved a resolution that calls for a moratorium on the use of the death penalty every year since 2007 illustrates the importance of official moratoria or unofficial stops in executions (UNGA 2016). In many cases, the decision to put a moratorium on executions is the first and at the same time the most important step towards abolition, while the legal abolition is sometimes just a formality. In most cases, moratoria lead to eventual abolition of the death penalty, mainly because it demonstrates that a society can function without the death penalty. The Cornell Center on the Death Penalty Worldwide claims that "moratoria on executions, both official and unofficial, are playing an increasingly important role in eliminating the death penalty throughout the world" (Cornell Center on the Death Penalty 2011).

Hence, the mere legal status indicator is not able to fully capture the daily experience of a country with the death penalty. This study thus uses an additional indicator which captures the fact if an execution was carried out in the respective year or not. Greenberg and West (2008) already introduced a measure of the death penalty with a four-point scale, indicating if the death penalty was in place for ordinary crimes, extraordinary crimes and if the death penalty was actually used. Here, a binary indicator is used that takes on value 1 if any execution took place in the respective year and value 0 if not[33].

Using these two different specifications of the dependent variable allows to test if the

[33] See also section D.1.1.2 for a more detailed description of the *execution* indicator.

independent variables impact the two different forms of abolition differently. Figure D.9 shows the distribution of the number of countries that legally abolish the death penalty each year and Figure D.10 the number of countries that stop executing each year. It is evident, that the numbers of stops in executions are a lot higher, since moratoria or unofficial stops in executions are more frequent than legal abolitions of the capital punishment. Thus, there is more variation in the death penalty indicator using the stops in executions.

D.3.3.2. Cox Proportional Hazards Model

To analyze the factors leading up to an event the scientific literature commonly uses event history models, also called survival analysis or duration models. This class of statistical models has first been developed to analyze the factors determining the probability of survival in medical patients, for example after the onset of a disease. Therefore, the event is commonly referred to as "failure". Logistic models can only analyze if the event occurs or not. They estimate the odds of the presence or absence of a binary characteristic, given a certain exposure to the covariates. In contrast, the event history models can model both the time that goes by before the event and the fact that the event happens. They can estimate the impact of different factors on the time of the occurrence of the event and give an estimate of the risk of the event happening at any given point in time.

Among the event history models, the Cox proportional hazards model (Cox 1972) is best suited to analyze the factors influencing the decision to abolish the death penalty and has been used in the previous studies on the topic by Neumayer (2008) and Kent (2010). The model is a continuous time model, where the event can happen at any point in time, as opposed to discrete time models where the event can only happen at a predetermined point in time (for example election day).

The model assumes that there is a base hazard of abolition at any given point in time.

Individuals are "at risk" of experiencing the event from the moment they enter the sample. Apart from that, observed variables can increase or decrease the probability to a constant proportional extent. The model is called proportional hazards model, since the hazard of the event for any value of x is a constant multiple of the hazard.

The basic proportional hazard model is defined as follows:

$$\rho(t) = \rho_0(t) * \exp\,(\beta_1 x_1 + \cdots + \beta_k x_k)$$

The probability at time t is defined by the baseline hazard $\rho_0(t)$ and the impact of the vector of covariates. The baseline hazard is the probability of failure if all covariates are equal to zero and changes over time, hence is time dependent. The vector of covariates impacts the probability via the vector of parameters that needs to be estimated. The Cox proportional hazards model is semi-parametric: it models the impact of the independent variables; however, it is not necessary to define the time-dependence of the baseline hazard (Box-Steffensmeier and Jones, 2004).

The coefficients are estimated using maximum partial likelihood estimation[34]. The standard errors are clustered on the country level, hence are allowed to be correlated within one country over time. Failure to take into account the likely autocorrelation can lead to underestimated standard errors. The estimated coefficients are hazard ratios, i.e. the ratio of the hazards for two different groups determined by the covariates. A number bigger than one indicates that this variable increases the probability of the event, while a number smaller than one shows that this variable decreases the likelihood of abolition. A coefficient equal to one would indicate no effect, hence the two groups have the same hazard of the event occurring.

In the framework of the abolition of the death penalty, the event is defined as the abolition

[34] The estimations are run using STATA Version 13.0 and the command stcox.

of the death penalty, hence the transition of the death penalty indicator variables described above from 1 to 0. Countries start to be "at risk" of abolition as soon as they enter the sample. Countries that abolished the death penalty before they enter the sample cannot be included in the analysis and hence are removed from the sample. This is called left-censoring, since the event occurs before the start of the observation period, which is a phenomenon unique to event history analysis. It might introduce some bias if important cases are left out of the sample, however in this case only very few countries had to be excluded from the analysis due to left-censoring[35].

The estimated hazard ratios express the difference in likelihood of abolition between two groups, hence the ratio of the hazard rates of the two groups. For example, a hazard ratio of 0.95 expresses that two countries that differ by one unit in the homicide rate face hazard rates that differ by around 5%; e.g. a country with a 1-unit higher homicide rate has a likelihood that is 5% lower.

The assumptions underlying the Cox Model are threefold:

1) The effect β of the covariates is constant over time (proportional hazards assumption). This means that the survival curves of two subgroups (determined by covariates) must be proportional over time, i.e. have a constant relative hazard. Hence, if group A of countries has double the hazard of group B in 1950, then this ratio between hazards needs to be constant over time.
2) The covariates enter the link function as a linear combination.
3) The link function is modeled as exponential.

While assumptions 2) and 3) cannot be tested, the first assumption can be examined using the so called Schoenfeld residuals (Box-Steffensmeier and Jones 2004). They represent the difference

[35] The alternative approach to dealing with left-censored observations is to set the occurrence of the event on the first observed period. This solution might introduce even bigger bias, if the covariates take on significantly different values in the first year of observations than in the year of the actual event happening (Mooney and Lee 2000).

between the observed covariate and the expected value of the covariate, given the risk set at that time. To test the proportionality assumption, the correlation of the residuals with time is examined. If the residuals vary significantly with time, then non-proportionality is present. The correlation should hence not be significantly different from zero.

D.3.3.3. Covariates

The main independent variable of interest is the homicide rate. Since the analyses in the first part of the chapter have shown that the death penalty does not Granger-cause the homicide rate, it is possible to introduce it as independent variable in this framework without a high risk of endogeneity (Wooldridge 2010). The main hypothesis to be tested is that the level of the homicide rate impacts the timing of the abolition of the death penalty.

The literature review in section D.3.3 introduced some of the political, cultural and economic factors that are likely to impact the timing of abolition. To avoid the risk of omitted variable bias, these factors have to be controlled for in order to obtain a correct estimate of the impact of the homicide rate on abolition and stops in executions:

Political and Cultural Factors:

1) Polity IV - Democracy and the degree of democratization have been suggested as most important drivers of the abolition decision (Miethe et al. 2005, Neumayer 2008, McGann and Sandholtz 2012, Killias 1986). democracies are more willing to accept limits to governmental power and to respect the human rights and the human dignity of their citizens (Neumayer 2008) than authoritarian regimes, and hence oppose the death penalty in most cases. As proxy for the democracy level, the indicator from the Polity IV Project (Marshall et al. 2017) is included as explanatory variable. The indicator ranges from -10 to +10, with -10 being a full

autocracy and +10 being a full democracy. The expected direction of the effect is positive, since a higher level of democratization, hence a higher polity score, is expected to increase the hazard of abolition.

2) Ethnic Fractionalization – Kent (2010) states that the "presence of racial or ethnic minorities may affect abolition likelihood" (p. 58), since the presence of minorities often results in political repression and harsher criminal sanctions against ethnic minorities. Ethnic heterogeneity has been shown to explain cross-sectional differences in the presence of the death penalty (Rudell and Urbina 2004, Neumayer 2008, Kent 2010). Fractionalization, measured using the Herfindahl index of ethnic group shares (Alesina et al. 2003), is expected to lower the likelihood of abolition in this study.

3) Education – The role of education has been highlighted in the study by Greenberg and West (2008). Higher levels of education reduce rigor in religious doctrines and increases the number of people questioning long-standing traditions and habits. It also alters the moral sensibilities and increases the importance of human rights. Furthermore, education enables the public to read the body of literature written on the topic of deterrence and question its efficacy. A spliced index of education including both numeracy rates and the number of average schooling years included in the regression analysis is expected to increase the probability of abolition.

4) Conflict Dummy - A country's experience with war and violent conflict has been mentioned repeatedly as a determining factor of abolitionist decisions, especially in single country qualitative studies (Lourtau and Babcock 2016). There are two potential directions: First, war and violent conflict might reduce the probability of

abolition, since during wartime violence against the person is perceived as necessary means and the general acceptance of violence is higher (Greenberg and West 2008). On the other hand, especially after wars and violent conflicts, a county might be more prone to do away with the death penalty after the recent cruel experience with violence. Furthermore, an ending war is often associated with a regime change, which can go hand in hand with new legislation. However, this regime transition might be better captured by the Polity IV variable. The previous empirical evidence is not definite at all, since for example Neumayer (2008) does not find any significant impact of a conflict dummy or the years that have gone by since the last armed conflict.

5) British Legal Origin Dummy –The United Kingdom and other countries that inherited English common law abolished the death penalty late or remain retentionist (Neumayer 2008). Britain has a history of a widespread use of the death penalty. For example, in the 18th century 222 crimes were punishable by death (Jones and Johnstone 2011) and the number of capital offenses reduced slowly compared to other European countries (Greenberg and West 2008). With English common law, the use of the death penalty spread over the British Empire, and the long-term consequences might still be visible today. Hence, this study controls for British legal origin of the law, expecting a negative impact on the likelihood of abolition (as do Neumayer 2008 and Greenberg and West 2008).

Economic and Socioeconomic Factors:

6) GDP per capita - The theory of the civilizing process, first established by Norbert Elias, predicts that as societies develop and evolve, they become more civilized and are less willing to accept cruel and violent treatment of individuals, hence also tend to oppose the death penalty (Neapolitan 2001). Another argumentation is that richer countries can afford alternative to the death penalty such as expensive correctional systems, and hence they might be less likely to retain the death penalty (Ruddell and Urbina 2004). In any case, higher economic income is expected to increase the likelihood of abolition. The empirical results however do not support this link, since none of the previous studies (Neumayer 2008, McGann and Sandholtz 2012, Greenberg and West 2008) could find a significant impact (except for Killias (1986) in a cross-sectional comparison).
7) Economic Inequality (Gini coefficient) - Kent (2010) and Neumayer (2008) both conclude that countries with high inequality have one of the lowest likelihoods of abolition. Some authors theorize that in the presence of high economic inequality, harsh coercion measures are used to enforce order (Kent 2010). Inequality might also reduce social trust and empathy, increasing the willingness to accept harsh punishment (Greenberg and West 2008).
8) Trade share as percentage of GDP - International pressure is exerted via treaties, human rights conventions and UN Protocols demanding abolition of the death penalty (Neumayer 2008). It is voluntary to join international treaties; however, abolitionist countries try to persuade others to do so. For example, Western Europe successfully used political pressure to bring abolition to Easter European countries in the 1990s (Neumayer 2008). In other cases, trade and aid incentives are given to

persuade countries to join international treaties. Neumayer (2008) mentions that Europe might be able to exert abolitionist pressure on Asian and Sub-Saharan Africa via trade incentives, however it is “unlikely” that Europe will pressure US in to abolition (p. 31). In any case, the more international ties a country has, the more likely it is to be influenced by abolitionist movements in other countries. Ruddell and Urbina (2004) likewise suggested that political pressure can be exerted especially when the countries are linked economically through trade. International trade measures the international openness and the degree of integration in the world economy, a factor that had not been examined in previous research. Generally, higher trade share is expected to increase the likelihood of abolition due to greater exposure to abolitionist international pressure. However, there are two countries that might bias the results in the opposite direction: China and US, both retentionist and two of the countries with the highest share in international trade.

For a more detailed description of the data formats and sources, please refer to appendix D.7.4. The information on summary statistics can be found in Table D.8. Because the distributions of the homicide rate, the GDP per capita and the total trade share all show severe skewness, the logarithm of these variables is used (see Figure D.2).

D.3.4. Empirical Results

The objective of this section is to check for a significant impact of the homicide rates on the abolition of the death penalty. The regressions are run using the Cox proportional hazards model following the approach described in Cleves (2008) and in Box-Steffensmeier and Jones (2004). The two previously introduced indicators of the death penalty are used as dependent variables, each reported in separate regressions. First, bivariate analysis is run to offer an initial impression of the link between death penalty abolition and homicide levels. Consequently, different sets of covariates are included to assess the robustness of the results and to explore at the same time which additional variables have an impact on the timing of abolition.

D.3.4.1. Bivariate Analysis

In the bivariate analysis enter 121 countries that had not abolished the death penalty and were carrying out executions when entering the sample. In the case of the execution indicator, there are 110 occasions where a country stops applying the death penalty. For the legal status, a total of 57 abolitions contribute to the analysis.

The proportional hazards assumption is tested using the Schoenfeld residuals. The graphical inspection of the residuals plotted against time shows that the fitted line has a zero slope for both specifications of the model in Table D.9 (see Figure D.11 and Figure D.12). A non-zero slope would indicate a violation of the proportional hazards assumption, e.g. an increase or decrease in the residuals over time. The statistical Schoenfeld-test of the slope of a linear regression of the residuals on the log of time fails to reject the null hypothesis of a non-zero slope, indicating that the proportional hazards assumption can be maintained. The Cox model fits the data well in both specifications. The results of the Schoenfeld-test are reported at the bottom of the regression tables.

Table D.9 presents the results from the bivariate regressions. In both specifications of the dependent variable, the homicide rate significantly decreases the hazard of abolition, and quite substantially so. Per the results in model (1), the likelihood of a stop of executions decreases by 15% if the homicide rate increases by one standard deviation[36]. This result clearly supports the main hypothesis, that an increase in the homicide rate might hinder the stop of the death penalty

[36] The homicide rate in the sample has a standard deviation of 11.24, which translates into a standard deviation of the log(homicide rate) of 2.42.

practice, and that likewise, a decrease in the homicide rates rises the likelihood of a stop. Model (2) offers similar insights for the legal abolition of the death penalty. The percentage change in hazard for a one standard deviation increase in the homicide rate is around 13%. On the other hand, a decrease in homicide rates significantly improves the chances that a legal abolition will occur soon. These estimates are relatively low, compared to the estimates given by Neumayer (2008), who predicts a decrease in the hazard of abolition of up to 80%, following a one standard deviation increase in homicide rates[37]. Given these bivariate baseline estimates, different sets of covariates will now be included in the model to assess the impact of the homicide rate while controlling for other confounding factors.

D.3.4.2. Multivariate Analysis

Prior to estimating the model a correlation analysis of the covariates is standard procedure to avoid multicollinearities (Table D.10). The main explanatory variable, the homicide rate, is significantly correlated with all covariates except for the trade share. Interestingly, high inequality coincides with high homicide rates, while high GDP per capita, good education and democratic systems correlate with low homicide rates. Fortunately, the magnitude of the correlation is not very high, hence multicollinearity is not expected to be an issue here. Positive correlation very high in magnitude is found between the three indicators democratic systems, education and GDP, hence, when these indicators are included at the same time in a model, multicollinearity might occur. Across most previous studies, the level of democracy has proven to be the most important determinant of the decision to abolish the death penalty (Neumayer 2008, Greenberg and West 2008, Killias 1986, McGann and Sandholtz 2012), hence this variable is

[37] In the sample of Neumayer (2008), the homicide rate displays a standard deviation as high as 75, which seems unrealistically high. In the sample at hand for this study, the standard deviation is only 11.25. This difference in standard deviations naturally translates into the interpretation of the coefficients and results in the big difference between the estimated effects. The estimated hazard ratio for a one unit increase in homicide rate is 0.976.

given priority as control variable in this context.

First, the results for the stops in executions are discussed. The model including both the homicide rate and polity index as measure of democratization is reported in column (1) of Table D.11. Due to data availability of the Polity IV indicator, the sample size is slightly reduced to 91 countries and 61 stops in executions. Again, the test of the proportionality assumption indicates that the model fits the data well (p-value reported at the bottom of the table). The hazard ratio associated with a one unit decrease in the log of the homicide rate has a similar magnitude as in the bivariate models and is significant on the 5%-level. The Polity variable is positively associated with the likelihood of abolition, as expected: a one unit increase in the index translates into an increase of 3% in the likelihood.

Having fit a Cox model to the data, it is possible to plot survival functions for a particular group, characterized by the value of the covariates. Figure D.13 plots the survival curve based on model (1) of a representative country evaluated at the mean homicide rate and the mean polity score. At the beginning of the 20th century, the likelihood of a stop in executions is very low, hence the survival curve remains over 0.8 until after 1950. Subsequently, the survival curve drops rapidly, indicating an increase in the likelihood of stops in executions. After 1980, the hazard of abolition reaches 50%. By 2000, the representative country has most certainly experienced a stop in executions. The survival curves can also be drawn at specific values of the independent variables: Figure D.14 compares the survival curves for two countries with the same polity score (mean), but with a homicide rate of two standard deviations over and under the mean value. The country with the higher homicide rate “survives” about one to two decades longer, before stopping the executions than the countries with the lower homicide rate. Finally, Figure D.15 compares the survival curves for two different countries that have the mean polity score and the mean homicide rate of Germany and Russia respectively. While at the beginning of the 20th

century, both have a very high survival rate, it starts to drop shortly after 1950. The difference between the countries varies between 10 and 20 years, so a country that has the characteristics of Germany is expected to stop executing a lot earlier than a country with the characteristics of Russia. Indeed, while executions stopped in Germany after the second World War, Russia executed the last person in 1996.

In the following columns of Table D.11, additional covariates of political and cultural nature are included. Determined by data availability of the covariate, the number of countries and stops in executions covered varies in each column. For the ethnic fractionalization index, no significant impact can be detected. The same holds for the dummies capturing the occurrence of a conflict and the British origin of the legal system. Education has a significant hazard ratio bigger than 1 (column (3)), indicating that higher education increases the odds of a stop in executions happening. However, this effect is not very robust. The homicide rate however is significant across all models in Table D.11 and the magnitude of the hazard ratio remains similar, no matter which covariates are included.

The analysis is extended to the inclusion of economic covariates in Table D.12. Except for the specification in column (1), where only GDP is included as covariate, the effect of the homicide rate is equal to the one in the previous specifications and robust both in significance and magnitude. The GDP per capita is also an important driver of the timing of abolition: An increase in the economic level of development of a country strongly increases the likelihood that the country stops executing. The trade share as percentage of GDP does not display a significant impact. The distribution of the economic income, measured by the Gini coefficient, does not seem to play a role either.

Figure D.16 plots the survival curves of two countries situated one standard deviation over and under the mean GDP per capita. At the beginning of the century, the difference in economic development does not translate in a different likelihood of survival. From 1910 to 1950, there is a small but constant difference, with the richer country being less likely to retain the death penalty longer. After 1950, the difference starts to increase.

Turning to the results using the legal abolition of the death penalty as event, the results are less explicit (Table D.13). The main variable of interest, the homicide rate, is only significant in one of the specifications, and slightly so. This indicates that the impact of the homicide rate on the timing of the legal abolition is not as strong and robust as on the stops of the executions. The Polity IV variable on the other hand is highly significant, hence democracy seems to play an important role when it comes to explaining the legal abolition of the death penalty. In column (3), there is no significant impact of the Polity IV variable. This might be caused by multicollinearity, since the education indicator, that is highly correlated with the Polity variable, is included here. Ethnic fractionalization has an impact significant only at the 10% level, reducing the likelihood of abolition. The legal origin of the legal system also seems to be more important here, than in the case of the stops in executions. The likelihood of abolition is around 64% lower for a country of British legal origin compared to a country of any other legal origin. This is also visible in the survival curves for two representative countries that only differ in the fact that one of them is of British legal origin (Figure D.17). The difference in hazard is increasing over time, resulting in an expected difference of over 50 years. Table D.14 presents the estimation results using the legal abolition as event variable and including economic covariates. The GDP per capita is again highly significant, indicating a higher likelihood of abolition for richer countries. To illustrate this, Figure D.18 plots the survival curves for two countries that differ by two standard deviations in the GDP per capita. First, it is apparent that the hazard of abolition stays close to zero up until 1900, then it starts to increase, and more quickly so for the richer country. For the country with a lower economic development, the hazard of abolition stays very low until the end of the sample period.

An additional result is that, as predicted by previous studies, the Gini coefficient also does significantly decrease the likelihood of abolition. Trade share, as in the results for the execution indicator, is not significantly altering the odds of legal abolition.

To illustrate and compare the magnitude of the impacts, Table D.15 reports the percentage changes in the hazard rate corresponding to a one standard deviation increase in the covariates for selected models. Only the variables significant in the respective models are reported. The impact with by far the biggest magnitude on both the hazard of a stop in executions and the hazard of legal abolition has the GDP per capita. An increase of one standard deviation causes the hazard rate to double (in the case of the execution variable) or to even triple (in the legal status variable). This shows, that the level of economic development, or the conditions and circumstances it entails play a major role determining the abolition decision of a country. The legal origin variable only impacts the decision of a country to legally abolish the death penalty. Countries that are of British legal origin have a 60%-lower likelihood of abolition than countries of other legal origin. The impact of democratization is the less steady in magnitude, since it entails an increase in the likelihood of stops in executions of 30% and an increase of 86% in the likelihood of legal abolition. Finally, the homicide rate has a relatively robust, negative impact: A one standard deviation change in the homicide rate makes a country between 20 and 30 % less likely to stop executions, and about 40 less likely to legally abolish the death penalty. The latter effect however is not very robust to alterations in the model specification.

The obtained results for the legal abolition indicator can be compared to the previous studies using a similar indicator. Of the four studies that considered the potential impact of crime rates on the abolition of the death penalty, two had found no effect using cross-sectional analysis (Ruddell and Urbina 2004; Greenberg and West 2008). The two studies using event history analysis had opposite results: while Kent (2010) found that increasing reported crime rates make a country more likely to abolish the death penalty, Neumayer (2008) was able to show that higher homicide rates have the opposite effect. The results in this paper with an increased number of countries covered in the sample corroborate the results by Neumayer (2008). The contradictory results obtained by Kent (2010) might be biased by the measurement error introduced by the imputation procedure used to increase the number of observations.

Regarding democratization, most previous studies agreed that it importantly impacts the decision to abolish the death penalty (Miethe et al. 2005, Neumayer 2008, McGann and Sandholtz 2012). This is confirmed by the results of this study. The higher the level of democratization of a country, the higher the likelihood that it will soon abolish the death penalty. At the same time, the results about the role of ethnic fractionalization can be confirmed. As previous studies suggest (Rudell and Urbina 2004, Neumayer 2008, Kent 2010), countries with higher ethnic heterogeneity are less likely to abolish the death penalty. Likewise, the previous findings on the British Legal origin could be confirmed (Neumayer 2008, Greenberg and West 2008). Education, that had been found to play a significant role by Greenberg and West (2008) did not show any significant effect in this analysis. Regarding the general income level measured by GDP per capita, the findings show that changes of the average income level do indeed have a significant impact on the abolition decision. This contrasts with most previous studies, where the income level did not show significance (Neumayer 2008, McGann and Sandholtz 2012, Greenberg and West 2008). Finally, earlier findings that higher income inequality hinders the abolition of the death penalty could be corroborated (Kent 2010 and Neumayer 2008). Since there are no previous studies looking at the stops in executions, those results obtained here cannot be compared.

D.3.4.3. Robustness Checks

The trade share was expected to increase the likelihood of abolition due to greater exposure to international political abolitionist pressure, however, no significant impact could be found. One possibility is that the outliers, China and the US, who both have a high trade volume but are retentionist, bias the result. To check this possibility, the model is estimated excluding China and the US from the sample (column (1) of Table D.16 and of Table D.17). However, regarding both the stops in executions as well as the legal abolitions, the results do not change and hence the insignificance is not a result of outlier bias.

Another phenomenon that will be assessed here is the fact that most of the Latin American countries abolished the death penalty very early and yet maintain a high level of violence until today. This is contradictory to the theory that countries with high homicide rates retain the death penalty longer. However, when estimating the model for the stops in executions for the Americas only, the coefficient of the homicide variable even increases in magnitude (column (2) of Table D.16). This illustrates, that even though the Latin American countries all abolished the death penalty early and have high homicide rates, the variation within the American continent still supports the theory, because even within the continent, countries with higher homicide rates retained the death penalty longer. GDP per capita, the Gini coefficient and the Polity variable all show no significant impact in this regression. This could likely be a result of the small number of observations and the fact that now only seven stops in executions are contained in the data set. For the legal abolition indicator, it is not possible to estimate the model for the Americas only, since the number of observations is insufficient. Estimating the model excluding the American countries (columns (3) of Table D.16 and of Table D.17), the results obtained for the entire sample are corroborated.

D.3.5. Summary of the Findings

Section D.3 examined the hypothesis that homicide rates have an impact on the death penalty, measured as both the inscription in a country's legislation as well as the actual use of the death penalty. Using event history analysis, the impact of homicide rates on the hazard of abolition as well as on the hazard of a stop in executions, for example via the introduction of a moratorium, was analyzed. Higher homicide rates were expected to delay the abolition/stop, while lower homicide rates were expected to lead to higher hazard rates of abolition/ a stop.

The main hypothesis could be confirmed in the case of the tangible application of the death penalty: Homicide rates have an important impact on the timing of stops in executions. Higher homicide rates importantly lower the hazard that a stop of the executions occurs, while lower homicide rates make it more likely, that a country stops applying the death penalty. The results indicate that the homicide rates influence the legal abolition of the death penalty in the same way, however this effect is not as robust as in the case of the executions.

This discrepancy in the results using the different indicators of the death penalty confirms the initial assumption that the two indicators capture two very different aspects of the death penalty that are also perceived differently by the public. The introduction of a moratorium or an unofficial stop in executions is often the first, and many times the most important step towards an abolition. This first step is much more susceptible to the impact by increasing violence rates. Once the moratorium is in place and the public might realize that a stop in executions is not accompanied by an increase in violence and that the death penalty is not crucial for the functioning of the society. Afterwards, an increase in violence does no longer provoke the call for harsher punishments or a tougher treatment of criminals.

To control for the impact of covariates, a number of other factors that have been shown to impact the timing of abolition in previous research have been included in the study, and this way the impact of these factors on abolition and stops in executions could be examined as well. The factor that has been unanimously claimed as most important for the decision of a county to abolish the death penalty by previous studies is democratization. Indeed, the results have shown that a higher level of democracy, measured by the Polity IV variable, increases the likelihood of legal abolition. The impact on the stops in executions however is not as strong and robust. The level of economic development, measured as GDP per capita, matters for both the timing of legal abolition as well as stops in executions. There are several channels through which GDP impacts a country's decision to do away with the death penalty, since GDP might be a proxy not only for increasing living standards but also for higher education or a more efficient system of institutions.

Ethnic fractionalization, the origin of the legal system as well as inequality only have a significant impact on the legal abolition, not on the initial stop in executions. These variables measure characteristics that are mainly determined by a country's history such as colonization, migration and by how the society is structured. Finally, the fact that a county experiences a violent internal or international conflict in the respective decade as well as the level of education have no significant impact on any of the two dependent variables in this study.

The takeaway message of this analysis is that the initial step a country takes towards abolition in the form of a moratoria is highly influenced by the experience with violence in the recent years; however, for the following legal abolition, other factors such as the degree of democratization, the economic development and the inequality are more important determinants.

D.4. Conclusions

This paper scrutinized the interlinkages between homicide rates and capital punishment. The traditional view of deterrence assumes that the presence of a severe punishment, such as the death penalty, has a crime reducing effect, since it makes a criminal behavioral option less attractive for potential delinquents taking into account the costs and benefits of the crime. However, there are many examples throughout history where politicians, the media and the public demand tougher legislation and harsher punishment of criminals as an answer to an increase in crime rates. Hence, it can be hypothesized that the causality runs in opposite direction: the development in homicide rates might dictate the introduction, retention or abolition of harsher punishments such as the death penalty. Some empirical studies as well as evidence from recent or historic events back up this hypothesis. Reading through historical reports and tales on trends in crime one often comes across the fact that an increase in crime and violence was countered by an aggravation of the punishments by the governing institutions (Eisner 2014). The more violent the times, the more cruel and severe the punishments. The recent demand of US president Donald Trump to change the law to be able to execute drug dealers (Drash 2018) is just the most recent example of politicians promoting "getting tough" policies when confronted with increasing (or persistently high) crime rates.

The first part of this study was looking at the deterrent effect of the death penalty. The relationship between homicide rates and the death penalty was modeled empirically using methodologies that allow for feedback effects from the death penalty on the crime rates. The Granger-causality tests and the estimation of a dynamic logit model recently developed by Bartolucci and Pigini (2017) could not offer any support for the deterrence hypothesis. Given these results, it was possible to introduce the homicide rate as explanatory variable when explaining the timing of the abolition of the death penalty or the stop in executions in the second part of the paper. The event history analysis revealed that the homicide rate does indeed significantly impact the timing: increasing homicide trends lead to a lower probability of abolition or a stop in executions. One novelty of this study was the proxy used to measure the death penalty. Two dummy variables were employed, one indicating the legal status of the death penalty and the other the actual practice, that is if the death penalty was applied and executions were carried out. Using the two indicators, two different dimension of the capital punishment could be measured. A stop in executions, either via the introduction of an official moratorium or just an unofficial stop, is an important initial step towards the abolition of the capital punishment. This initial step has been shown to be highly influenced by the development of crime rates in the recent years. Countries experiencing an increase in violence are less prone to put a preliminary stop on the execution practice. The second and definite step in the abolition of the death penalty is rather influenced by other factors such as the degree of democratization, the economic development, inequality and the origin of the legal system.

In the last couple of years, even countries with a traditionally low violent crime incidence have experienced a recurrence in violent crime (BKA 2016) accompanied by the usual demands for tougher legislation. Hence it is more important than ever to understand the relationship between crime and punishment to not commit the mistake of increasing the severity of the punishment as a counter-measure of rising crime rates instead of looking for the real reasons behind the increase. The evidence of a deterrent effect of the death penalty is far too weak as to refer to it as a valid and universal anti-crime measure. Alternative strategies such as addressing the socioeconomic conditions that are conducive to criminal behavior are probably more meaningful.

D.5. References

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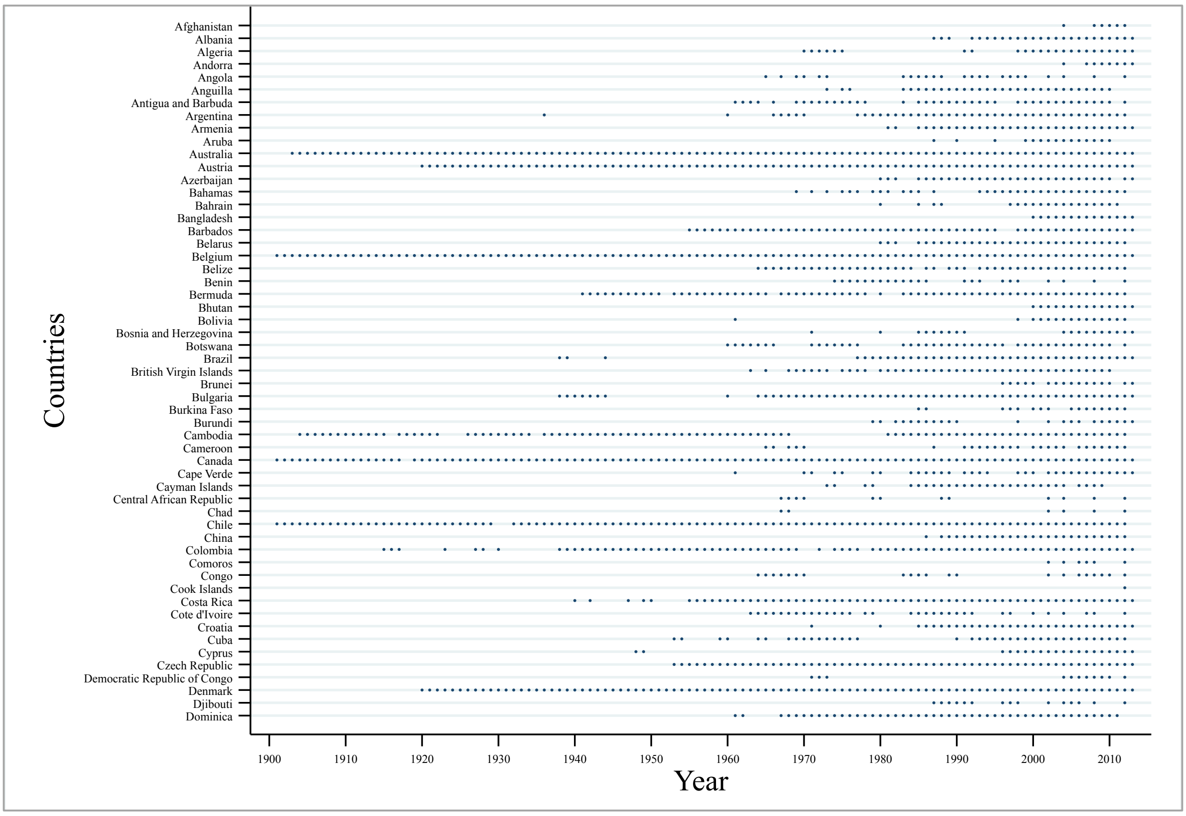
D.6. Figures and Tables

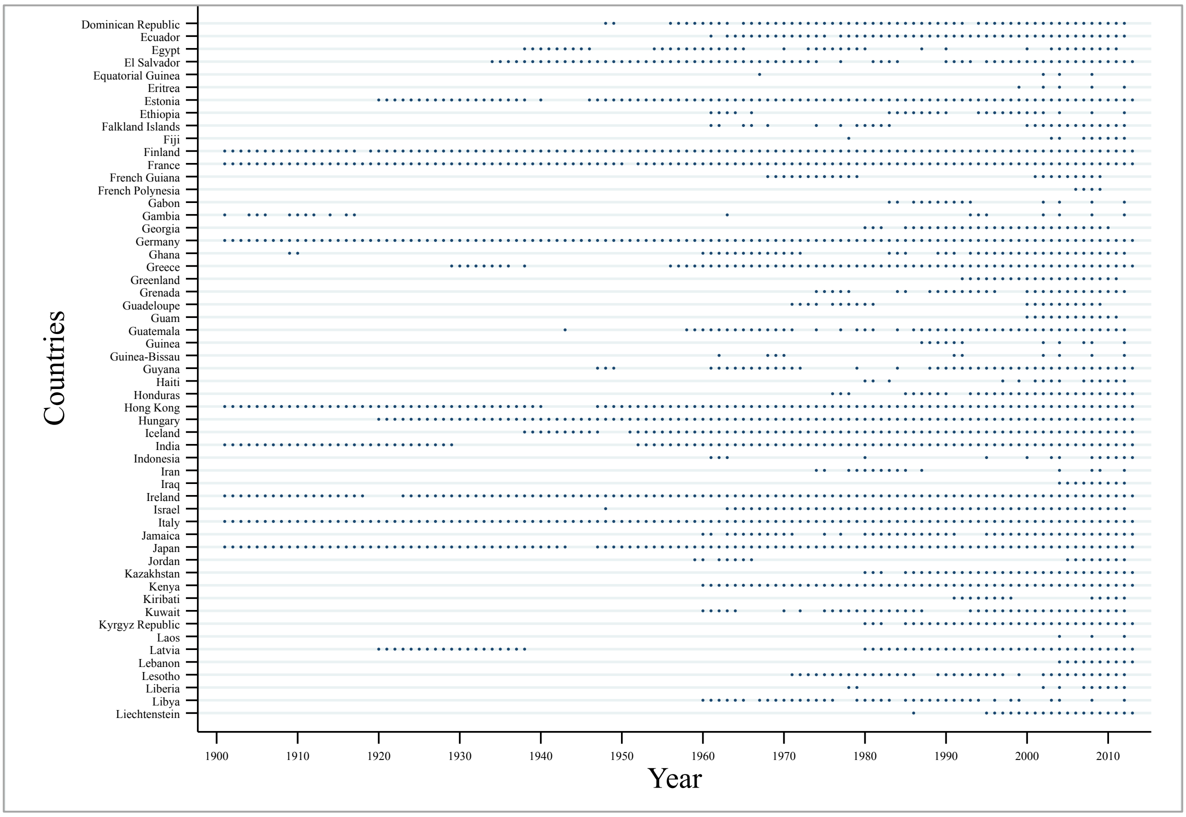
D.6.1. Figures

Figure D.1: Observations by Country and Year (Panels 1 to 4)

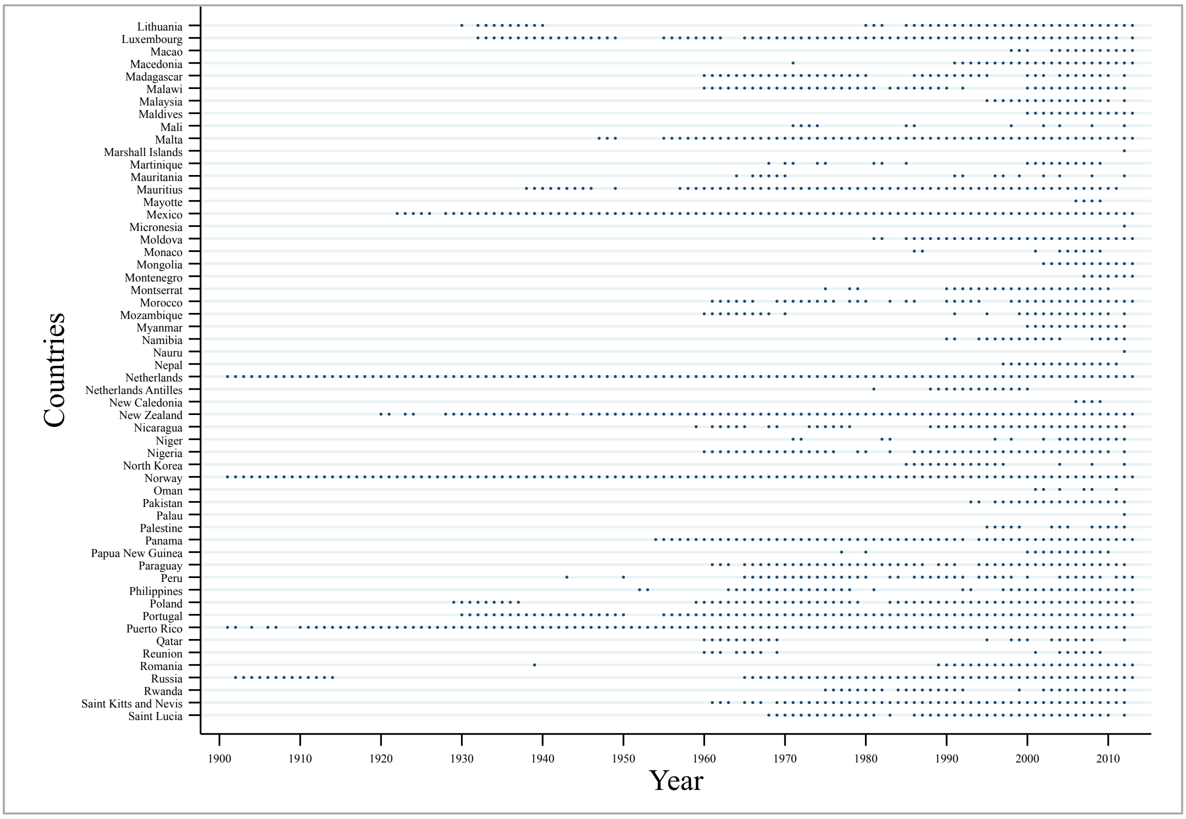
Panel 1



Panel 2



Panel 3



Panel 4

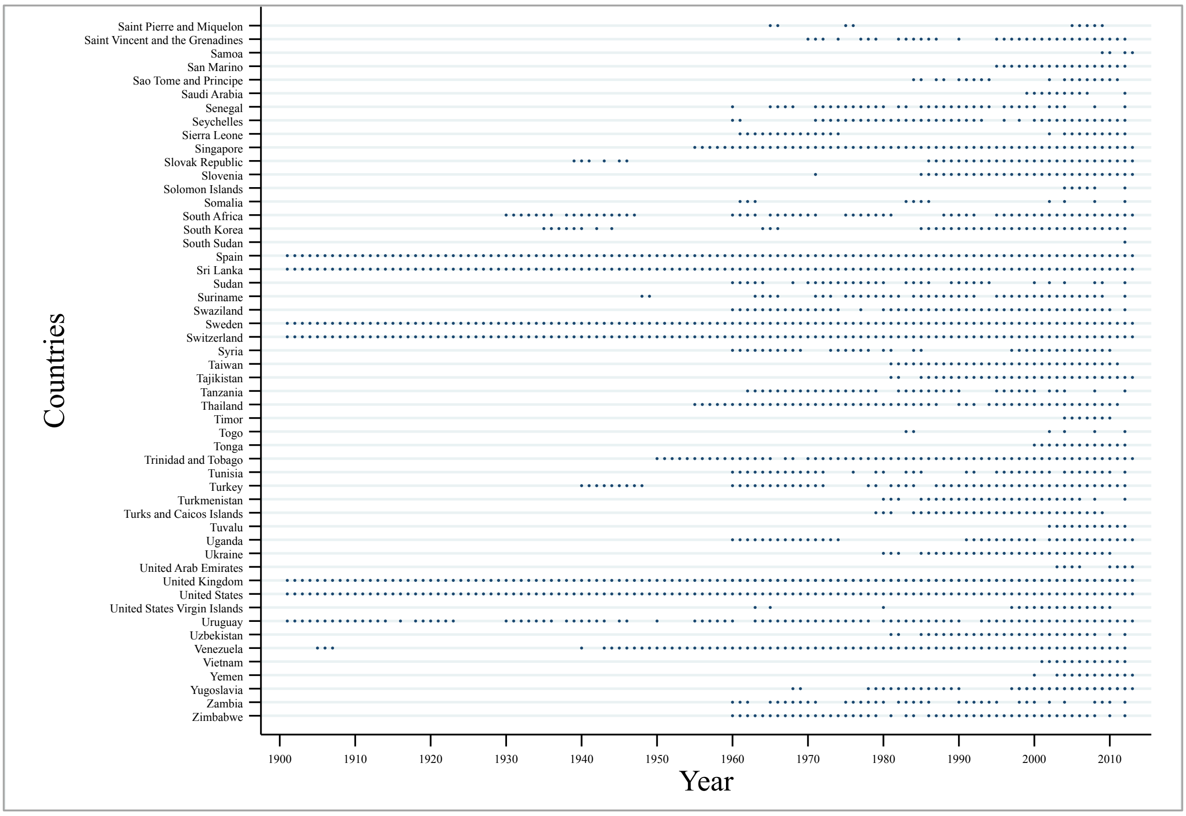
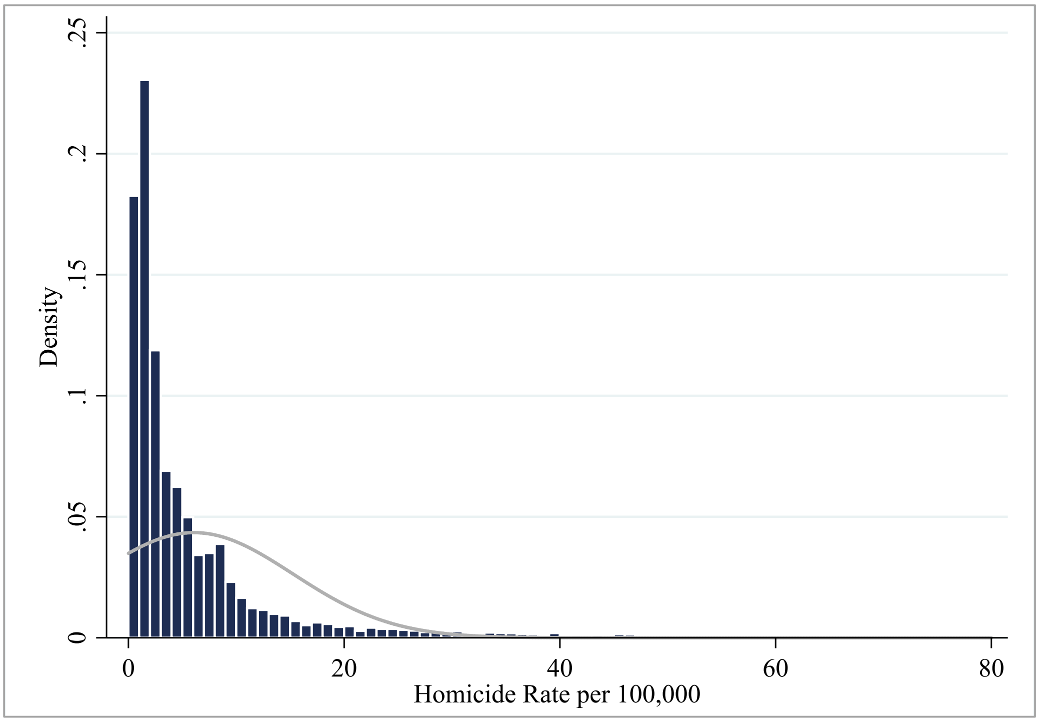

Saint Pierre and Miquelon
Saint Vincent and the Grenadines
Samoa
San Marino
Sao Tome and Principe
Saudi Arabia
Senegal
Seychelles
Sierra Leone
Singapore
Slovak Republic
Slovenia
Solomon Islands
Somalia
South Africa
South Korea
South Sudan
Spain
Sri Lanka
Sudan
Suriname
Swaziland
Sweden
Switzerland
Syria
Taiwan
Tajikistan
Tanzania
Thailand
Timor
Togo
Tonga
Trinidad and Tobago
Tunisia
Turkey
Turkmenistan
Turks and Caicos Islands
Tuvalu
Uganda
Ukraine
United Arab Emirates
United Kingdom
United States
United States Virgin Islands
Uruguay
Uzbekistan
Venezuela
Vietnam
Yemen
Yugoslavia
Zambia
Zimbabwe
Countries
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
Year

Figure D.2: Distributions of Homicide Rate (Panel 1) and Log(Homicide Rate) (Panel 2)

Panel 1



Panel 2

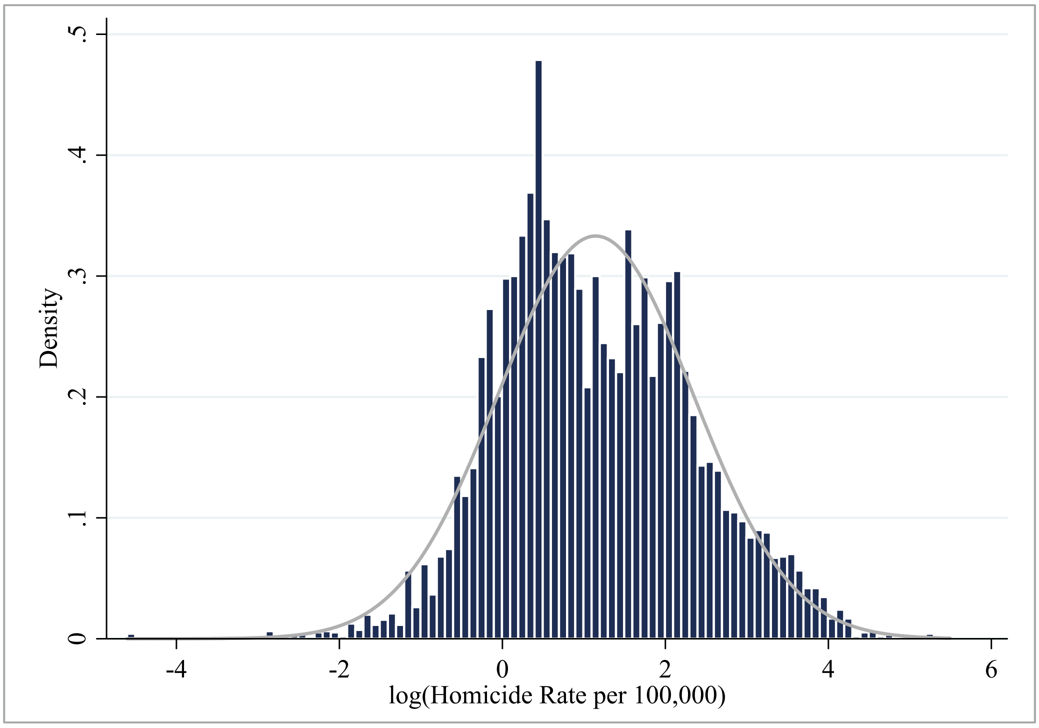


Figure D.3: Homicide Rate Trends in the 20th Century - Europe vs. the US[38]

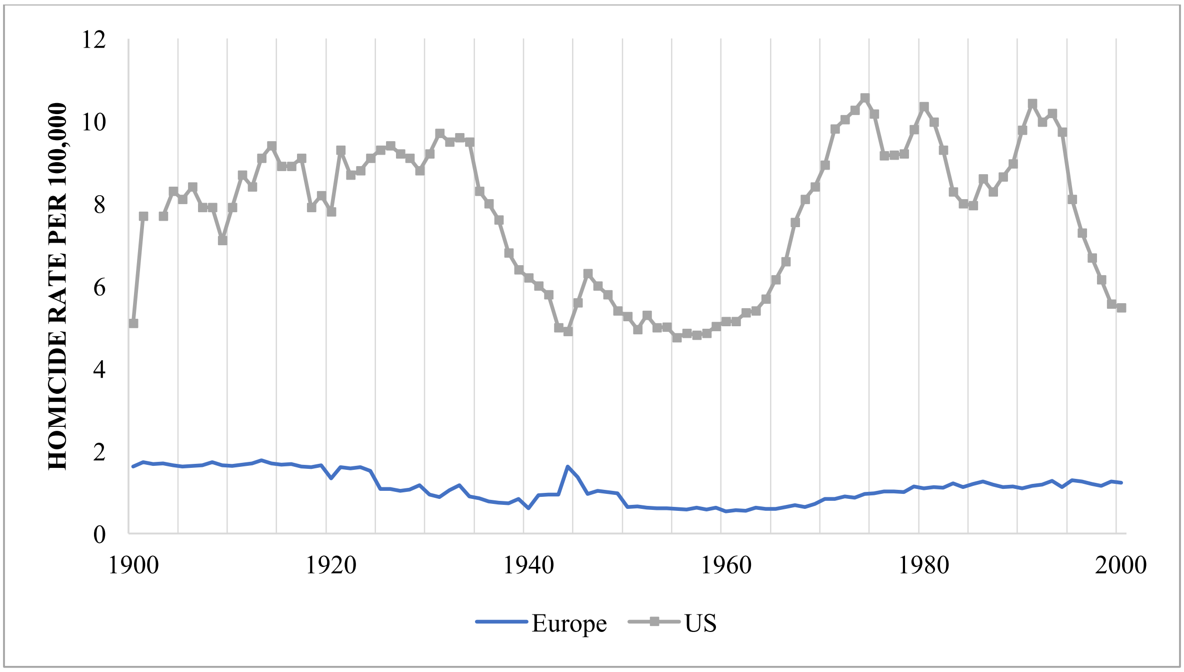
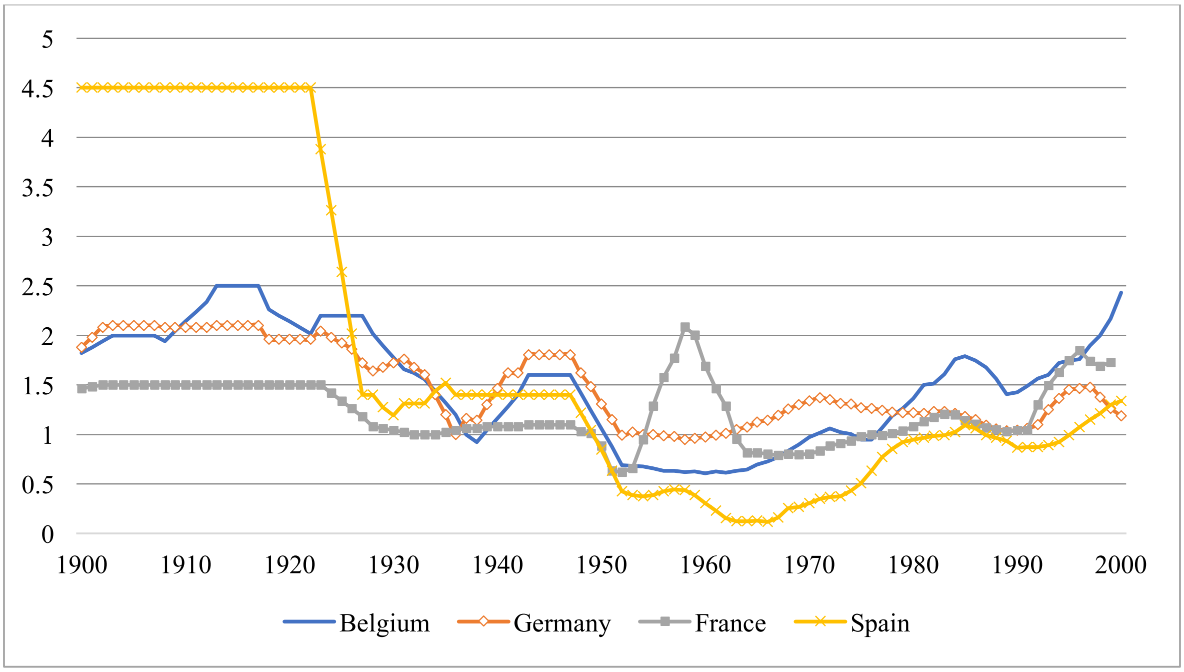


Figure D.4: Homicide Rate Trends in Europe



[38] In Figure D.3, Europe consists of Belgium, Germany, Spain, Netherlands, Norway, Sweden, UK and Switzerland. For these countries homicide data is available for all years.

Figure D.5: Homicide Rate Trends in Latin America

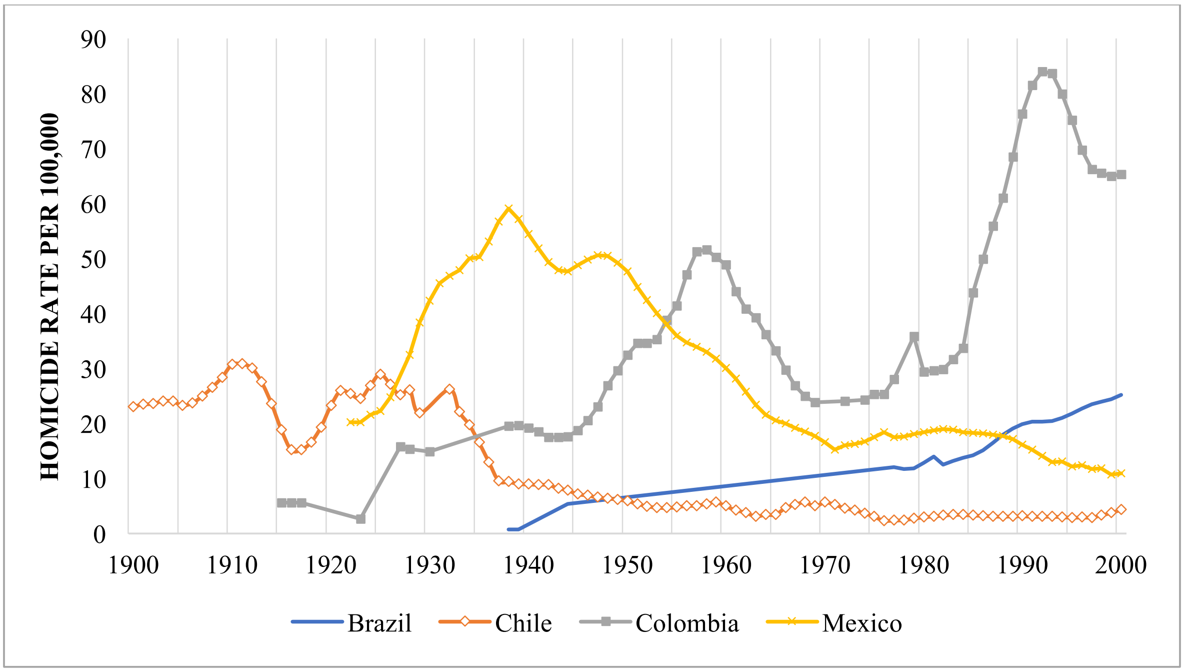


Figure D.6: Homicide Rate Trends in Asia and Africa

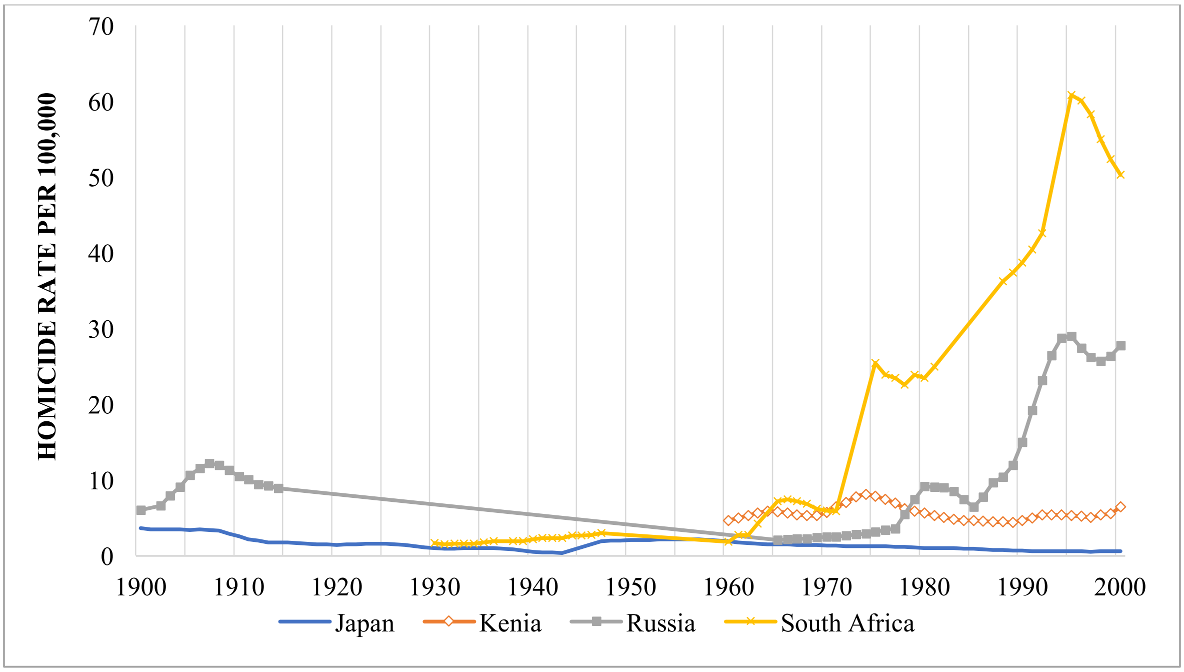


Figure D.7: Mean Homicide Rate before/after Abolition of the Death Penalty

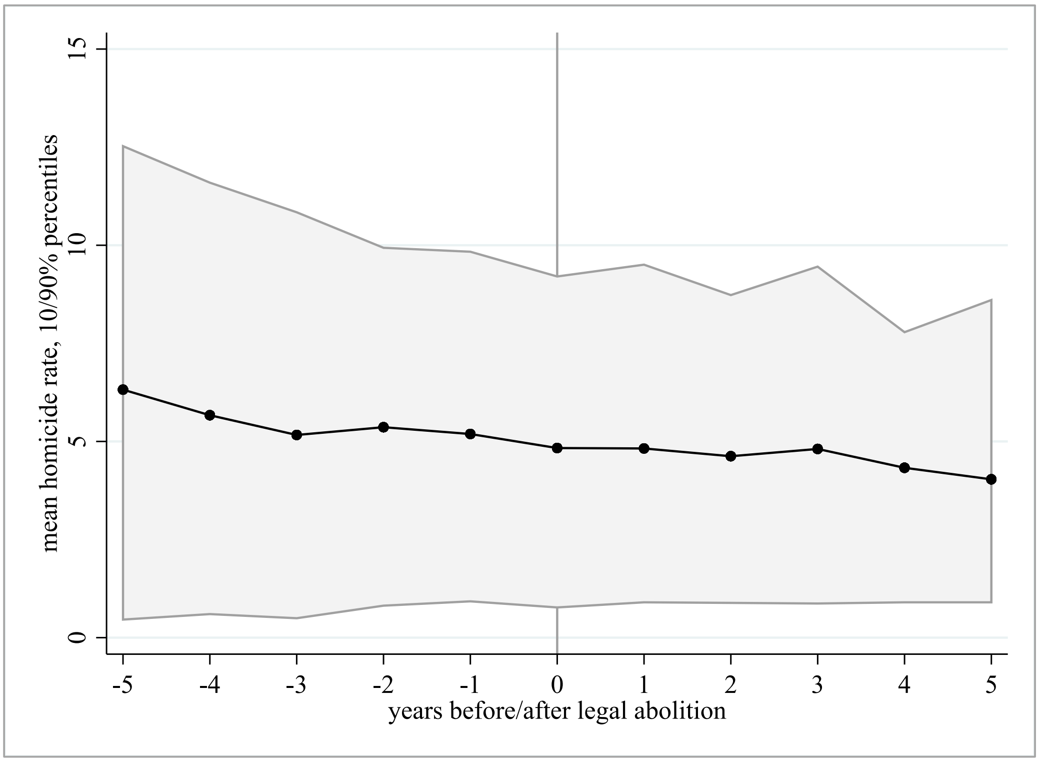


Figure D.8: Mean Homicide Rate before/after Stops in Executions

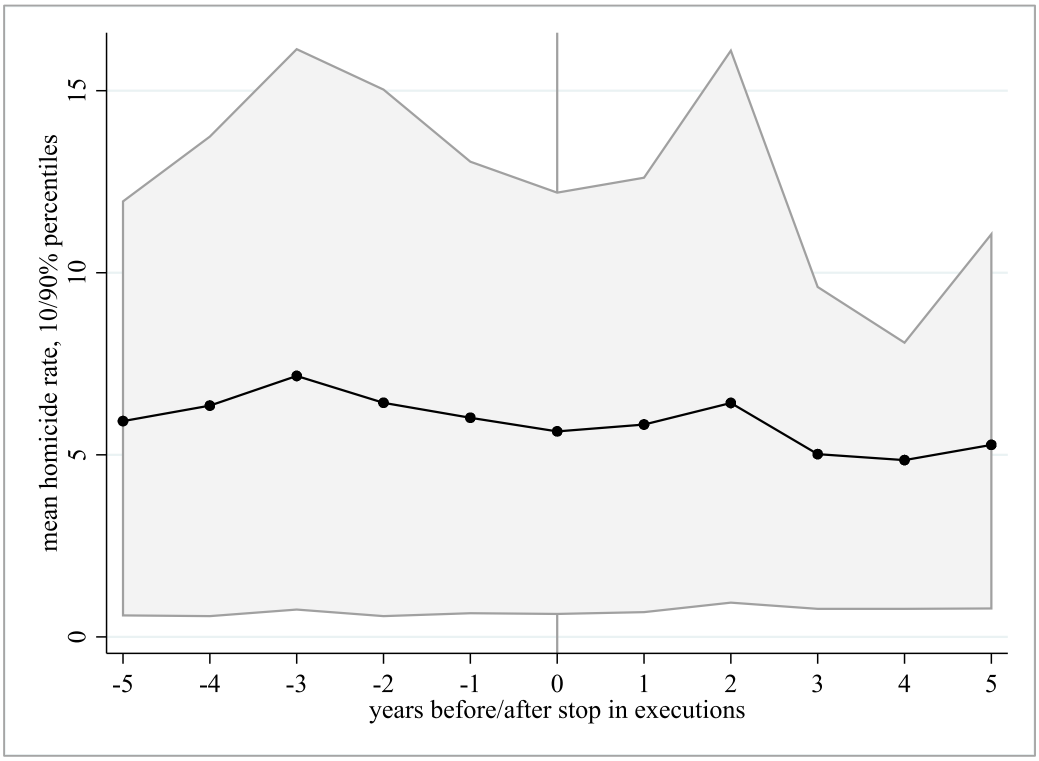


Figure D.9: Number of Legal Abolitions per Year

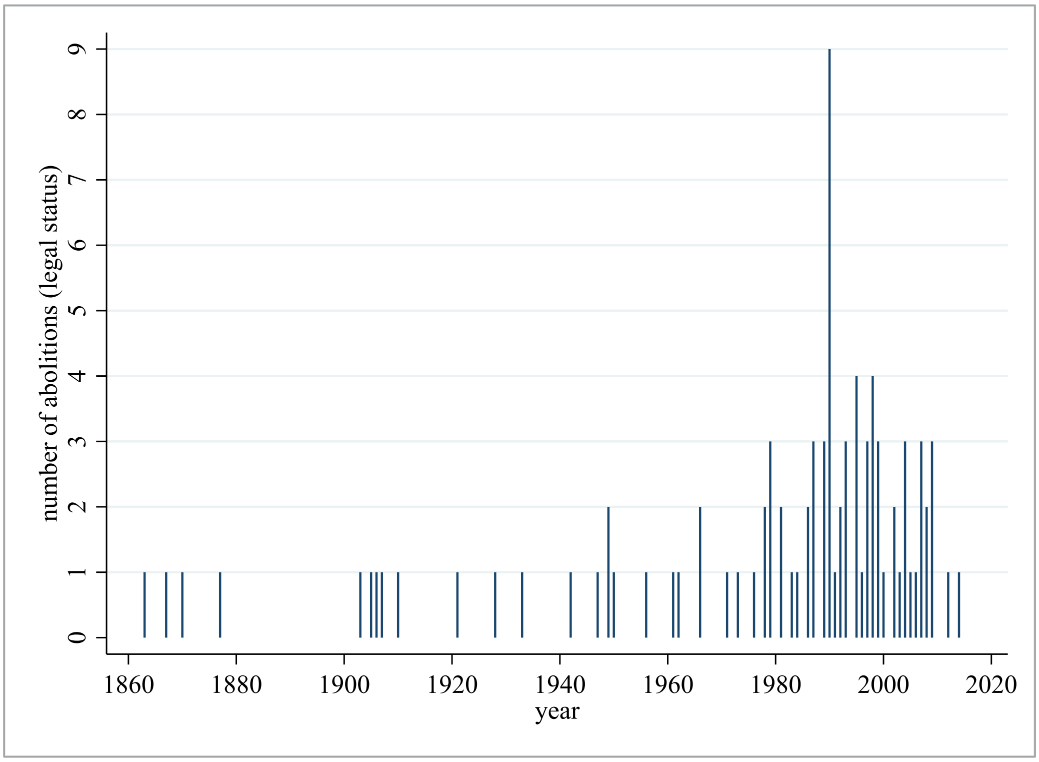


Figure D.10: Number of Stops in Executions per Year

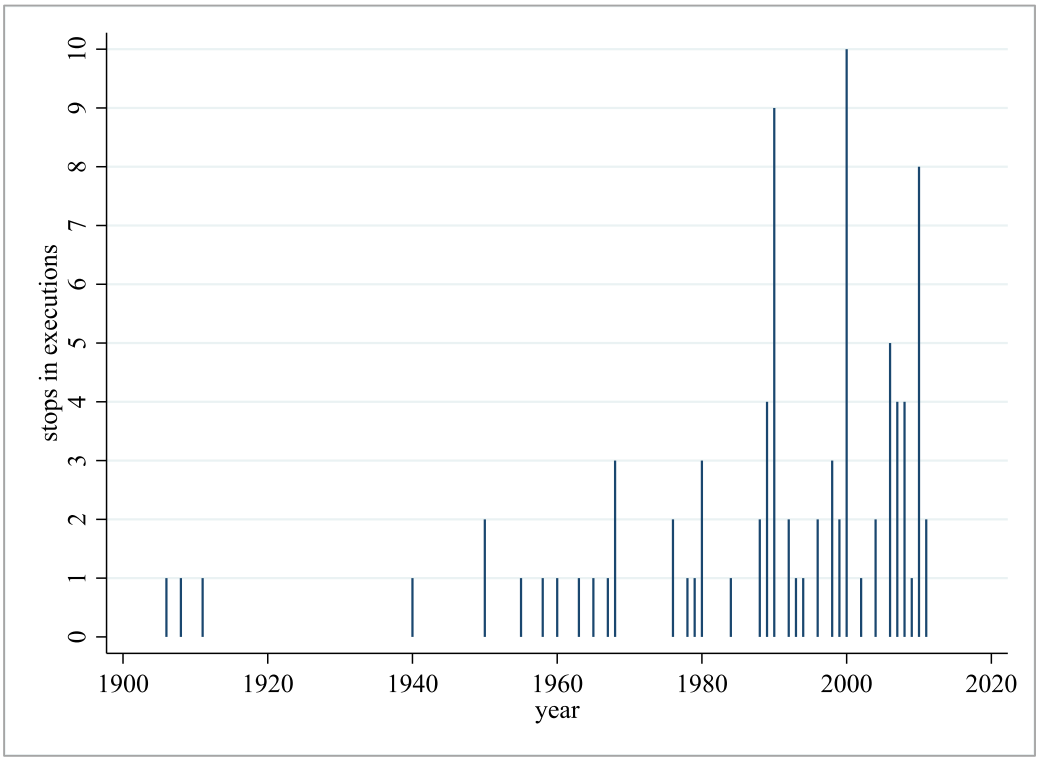


Figure D.11: Graphical Test of the PH-Assumption (Execution Indicator)

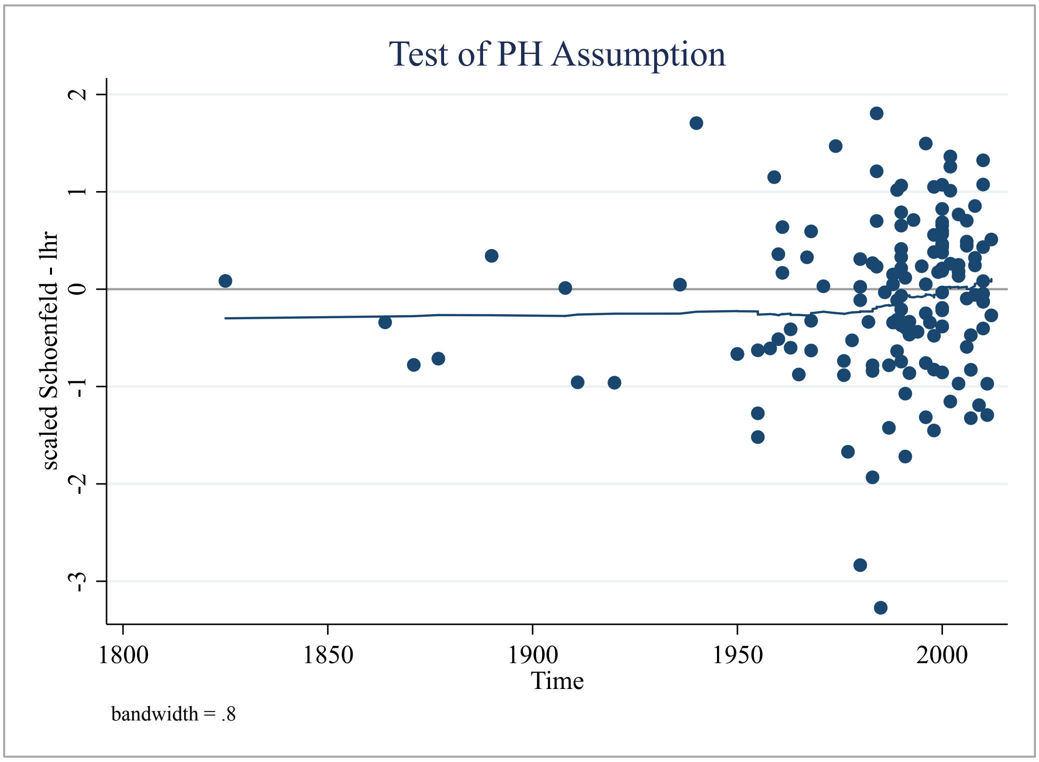


Figure D.12: Graphical Test of the PH-Assumption (Legal Status Indicator)

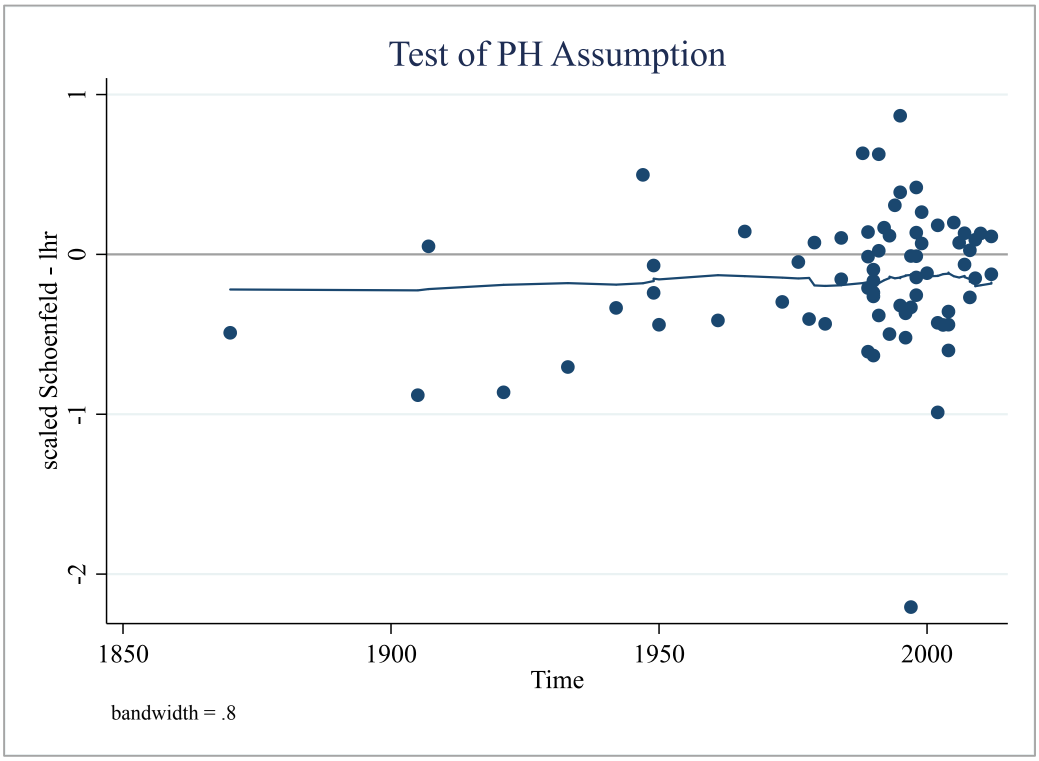


Figure D.13: Survival Curve: Mean Homicide Rate and Polity IV (Model (1) of Table D.11)

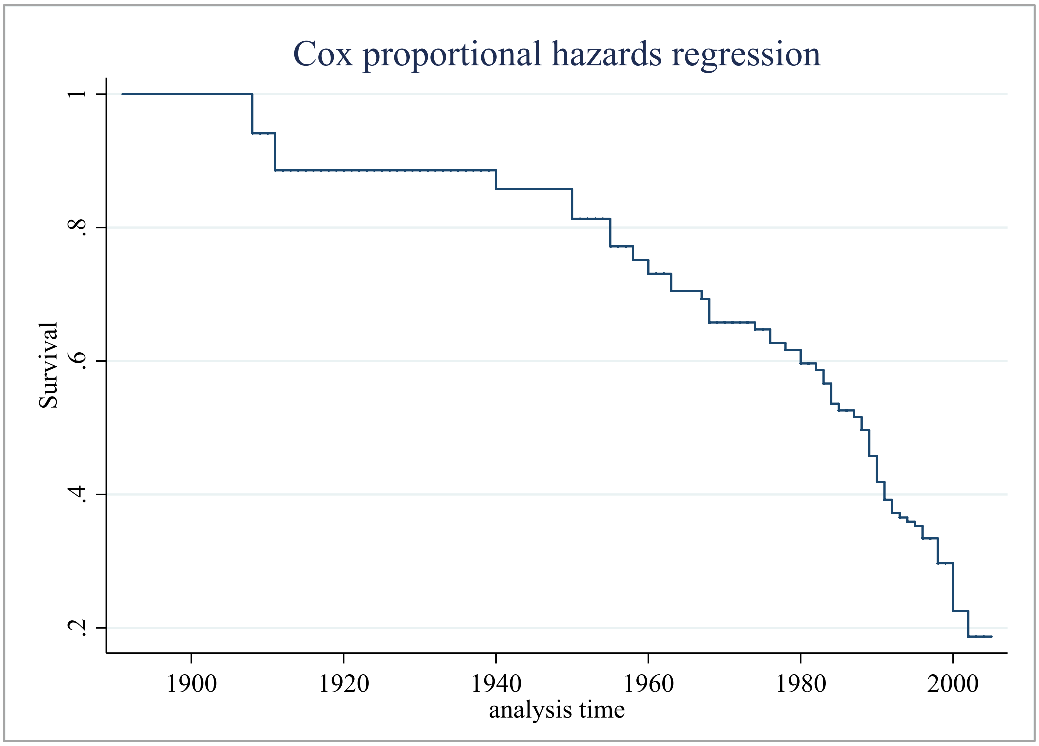
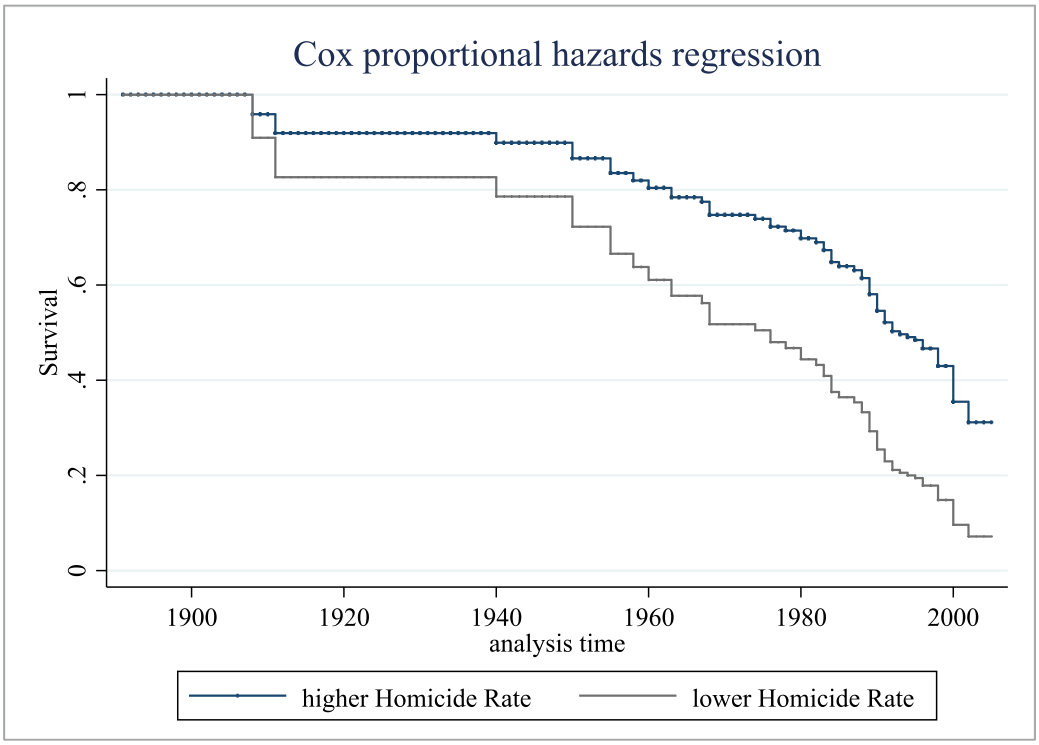


Figure D.14: Survival Curves: High and Low Homicide Rate (Model (1) of Table D.11)



Survival curves for two representative countries one standard deviation over and under the mean homicide rate.

Figure D.15: Survival Curves: Germany vs. Russia (Model (1) of Table D.11)

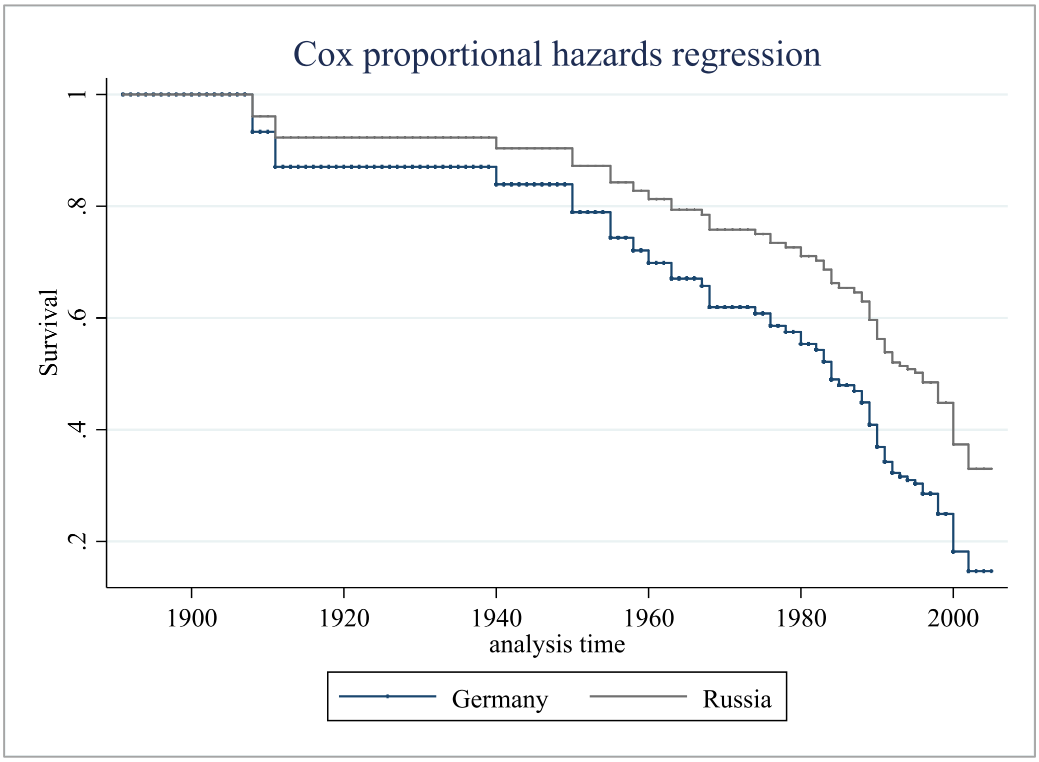
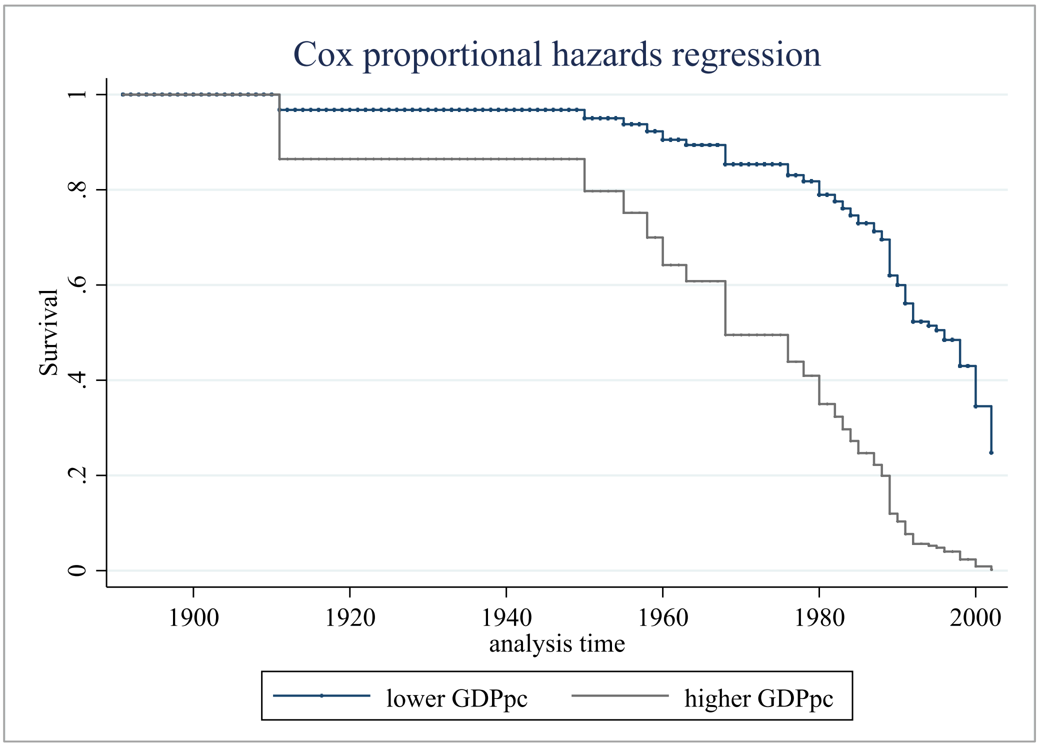


Figure D.16: Survival Curves: High and Low GDP per capita (Model (5) of Table D.12)



Survival curves for two representative countries one standard deviation over and under the mean GDP per capita.

Figure D.17: Survival Curves by Legal Origin (Model (5) of Table D.13)

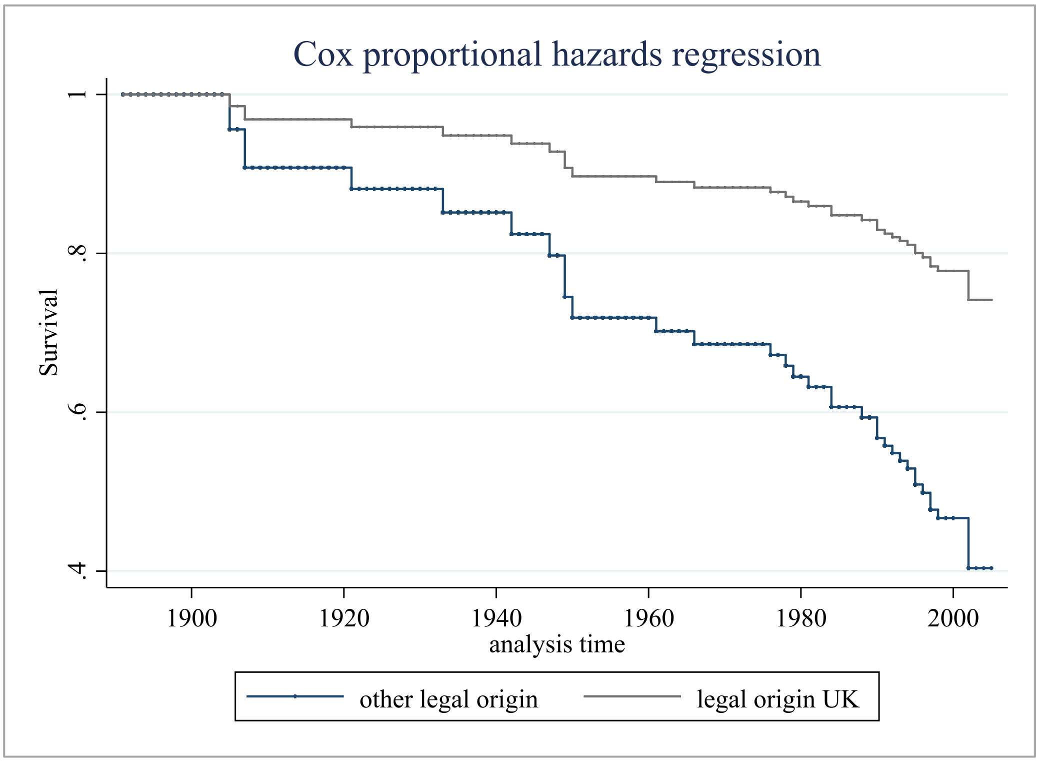
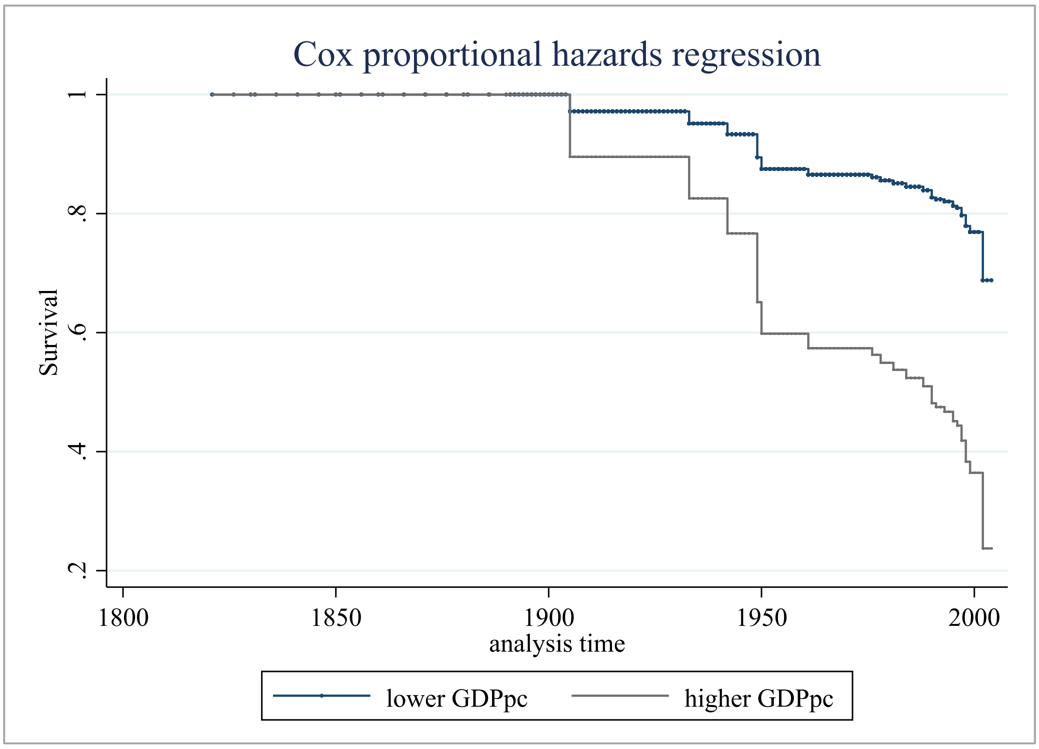


Figure D.18: Survival Curves: High and Low GDP per capita (Model (5) of Table D.14)



Survival curves for two representative countries one standard deviation over and under the mean GDP per capita.

D.6.2. Tables

Table D.1: Pesaran (2004) Tests of Cross-Sectional Dependence (Balanced Panel 1950-2000)

Variable	CD-Test	p-value	Average Correlation
Log(Homicide Rate)	28.851	0.000	0.261
Log(GDP per capita)	96.634	0.000	0.881
# of Countries	26		
Average # of Observations	51		

Table D.2: Unit Root Tests of Log(Homicide Rate) (Balanced Panel 1950-2000)

Pesaran Test	Number of Lags	Zt-bar	p-value
	0	-9.075	0.000
	1	-5.095	0.000
	2	-3.728	0.000
Maddala-Wu Test	0	213.137	0.000
	1	78.489	0.010
	2	63.475	0.132
# of Countries		26	
Average # of Observations		51	

Table D.3: Unit Root Tests of Log(Homicide Rate) (Balanced Panel 1970-1990)

Pesaran Test	Number of Lags	Zt-bar	p-value
	0	-9.107	0.000
	1	-5.006	0.000
	2	-1.142	0.127
Maddala-Wu Test	0	241.587	0.000
	1	153.563	0.000
	2	139.157	0.003
# of Countries		48	
Average # of Observations		21	

Table D.4: Granger-Causality Tests based on VAR with 2 Lags

	DP[39] Legal Status Indicator		DP Execution Indicator	
	(1)	(2)	(3)	(4)
Dependent Variable	**Log (Homicide Rate)**	**DP**	**Log (Homicide Rate)**	**DP**
L. Log(Homicide Rate)	**0.281*****	0.001	**0.282*****	-0.001
	(0.054)	(0.001)	(0.054)	(0.001)
L2. Log(Homicide Rate)	**0.365*****	0.000	**0.366*****	-0.001
	(0.038)	(0.000)	(0.038)	(0.001)
L.DP	-0.062	**1.007*****	0.108	0**.889*****
	(0.141)	(0.004)	(0.127)	(0.048)
L2.DP	0.088	-0.000194	-0.099	0.101**
	(0.081)	(0.001)	(0.107)	(0.048)
Granger-causality tests (p-value)				
excluding DP	0.512		0.636	
excluding Log(Homicide Rate)		0.565		0.309
Observations	8,274	8,274	8,274	8,274
# of Countries	207	207	207	207
Average # of Observations	40	40	40	40

*** p<0.01, ** p<0.05, * p<0.1

Standard errors in parenthesis

[39] In all the tables, "death penalty" is abbreviated as "DP".

Table D.5: Granger-Causality Tests based on VAR with 3 Lags

	DP Legal Status Indicator		DP Execution Indicator	
	(1)	(2)	(3)	(4)
Dependent Variable	**Log (Homicide Rate)**	**DP**	**Log (Homicide Rate)**	**DP**
L. Log(Homicide Rate)	**0.228*** **	0.001	**0.228*** **	-0.001
	-0.056	(0.001)	(0.056)	(0.001)
L2. Log(Homicide Rate)	**0.360*** **	0.000	**0.360*** **	-0.001*
	(0.039)	(0.000)	(0.039)	(0.001)
L3. Log(Homicide Rate)	**0.125*** **	0.000	**0.125*** **	-0.001
	(0.046)	(0.000)	(0.046)	(0.001)
L.DP	-0.017	**1.006*** **	0.130	**0.889*** **
	(0.125)	(0.003)	(0.122)	(0.044)
L2.DP	0.023	-0.000	-0.129	**0.156** **
	(0.083)	(0.000)	(0.133)	(0.070)
L3.DP	0.069	0.000	0.048	-0.060
	(0.050)	(0.000)	(0.045)	(0.036)
Granger-causality Tests (p-values)				
Excluding DP	0.309		0.607	
Excluding Log(Homicide Rate)		0.405		0.310
Observations	7,837	7,837	7,837	7,837
# of Countries	200	200	200	200
Average # of Observations	39	39	39	39

Standard errors in parenthesis

*** p<0.01, ** p<0.05, * p<0.1

Table D.6: Dynamic Logit Model (4 years before and after last execution)

# of Countries	100					
# of Observations	629					
Dependent Variable	**DP Legal Status Indicator**			**DP Execution Indicator**		
	Coefficients	Standard errors	p-values	Coefficients	Standard errors	p-values
Log(Homicide Rate)	-0.555*	0.317	0.080	-30.718	283.812	0.914
Log(Homicide Rate) in t+1	0.175	0.193	0.365	33.806	81.962	0.680
L.DP	**7.255*****	2.231	0.001	282.441	4698.252	0.952

*** p<0.01, ** p<0.05, * p<0.1

Table D.7: Dynamic Logit Model (4 years before and after legal abolition)

# of Countries	54					
# of Observations	668					
Dependent Variable	**DP Legal Status Indicator**			**DP Execution Indicator**		
	Coefficients	Standard errors	p-values	Coefficients	Standard errors	p-values
Log(Homicide Rate)	2.175	2.742	0.428	0.472	33.592	0.989
Log(Homicide Rate) in t+1	0.717	2.022	0.723	-3.884	30.464	0.899
L.DP	**13.227*****	2.761	0.000	61.323	104.846	0.559

*** p<0.01, ** p<0.05, * p<0.1

Table D.8: Summary Statistics

	# of Observations	Mean	Min	Max	Standard Deviation
Homicide Rate	9876	6.284	0	240	12.031
Log(Homicide Rate)	9876	0.837	-9.210	5.481	2.116
Death Penalty Indicators					
DP Execution Indicator	9876	0.534	0	1	0.498
DP Legal Status Indicator	9876	0.708	0	1	0.454
Year of Last Execution	6076	1965.655	1830	2016	35.779
Year of Legal Abolition	5046	1960.188	1863	2014	39.179
Covariates					
Population	6271	34485.02	45.183	1264093	102484.6
GDP per capita	4442	5386.796	1.1365	33326	4991.255
Gini Coefficient	4914	42.8105	21.352	70.099	7.830
Spliced Education Index	4323	5.783	0.07	13.05	3.107
Polity IV	4162	3.230	-10	10	6.780
Conflict Dummy	4572	0.388	0	1	0.487
Legal Origin UK	4572	0.238	0	1	0.426
Ethnic Fractionalization	4045	0.366	0.01	0.959	0.274
Trade (% of GDP)	4852	7.308	0.143	222.037	15.519

Table D.9: Bivariate Analysis

	(1)	(2)
	DP Execution Indicator	**DP Legal Status Indicator**
Log(Homicide Rate)	0.886*	0.868**
	(0.056)	(0.062)
Observations	3,723	5,034
# of Countries	121	121
# of Abolitions	110	57
p-value Global Schoenfeld -Test	0.541	0.393

Standard errors (clustered on the country level) in parenthesis.

*** p<0.01, ** p<0.05, * p<0.1

Table D.10: Correlation Analysis

	Log(HR)			
Polity IV	-0.245***	Polity IV		
Conflict Dummy	0.167***	-0.181***	Conflict	
Eth. Fractionalization	0.339***	-0.213***	0.109*	Fractionalization
Education Index	-0.308***	0.677***	-0.275***	-0.282***
Population	0.102*	0.0342	0.164***	0.229***
Log(GDP per capita)	-0.293***	0.651***	-0.252***	-0.365***
Gini Coefficient	0.393***	-0.436***	0.207***	0.348***
Trade (% of GDP)	-0.032**	0.086***	-0.25***	-0.024

*** p<0.01, ** p<0.05, * p<0.1

	Education			
Population	-0.0481	Population		
Log(GDP per capita)	0.898***	-0.0889*	Log(GDP per capita)	
Gini Coefficient	-0.499***	-0.0428	-0.426***	Gini
Trade (% of GDP)	0.0833***	-0.578	0.128***	-0.219***

*** p<0.01, ** p<0.05, * p<0.1

Table D.11: Determinants of Stops in Executions: Political and Cultural Factors

	(1)	(2)	(3)	(4)	(5)
Log(Homicide Rate)	**0.815****	**0.824****	**0.814****	**0.798****	**0.826****
	(0.069)	(0.071)	(0.079)	(0.076)	(0.08)
Polity IV	1.038*	1.019	0.978	1.010	1.026
	(0.023)	(0.024)	(0.027)	(0.024)	(0.029)
Ethnic Fractionalization		1.137	1.762		
		(0.524)	(0.805)		
Education Index			**1.136****	1.071	1.043
			(0.067)	(0.051)	(0.052)
Conflict Dummy				1.08	
				(0.264)	
Legal Origin UK					0.660
					(0.212)
Observations	2,054	1,829	1,787	1,986	1,986
# of Countries	91	71	66	81	81
# of Stops	61	51	48	57	57
PH-Test (p-value)	0.517	0.746	0.864	0.654	0.6

Standard errors (clustered on the country level) in parenthesis.

*** p<0.01, ** p<0.05, * p<0.1

Table D.12: Determinants of Stops in Executions: Economic Factors

	(1)	(2)	(3)	(4)	(5)
Log(Homicide Rate	0.889	**0.777*****	**0.825*****	**0.745*****	**0.729*****
	(0.089)	(0.073)	(0.055)	(0.075)	(0.069)
Log(GDP per capita)	1.437**			**3.165*****	**2.813*****
	(0.243)			(0.937)	(0.846)
Gini Coefficient		1.004		0.994	0.999
		(0.017)		(0.017)	(0.018)
Log(Trade (% of GDP))			1.016	0.850	0.869
			(0.139)	(0.236)	(0.248)
Polity IV					1.031
					(0.026)
Observations	2,238	2,693	2,453	1,518	1,420
# of Countries	94	82	99	70	67
# of Stops	59	53	88	41	41
PH-Test (p-value)	0.084	0.269	0.73	0.061	0.169

Standard errors (clustered on the country level) in parenthesis.

*** p<0.01, ** p<0.05, * p<0.1

Table D.13: Determinants of Abolition: Political and Cultural Factors

	(1)	(2)	(3)	(4)	(5)
Log(Homicide Rate)	0.825	0.816*	0.813	0.836	0.823
	(0.099)	(0.098)	(0.110)	(0.096)	(0.110)
Polity IV	**1.092*** **	**1.069** **	1.015	**1.066** **	**1.095*** **
	(0.027)	(0.029)	(0.033)	(0.028)	(0.031)
Ethnic Fractionalization		0.285*	0.384	0.310*	0.447
		(0.191)	(0.269)	(0.207)	(0.314)
Education Index			1.156*		
			(0.092)		
Conflict Dummy				0.635	
				(0.235)	
Legal Origin UK					**0.364*** **
					(0.141)
Observations	2,846	2,611	2,530	2,611	2,611
# of Countries	103	82	76	82	82
# of Abolitions	37	28	26	28	28
PH-Test (p-value)	0.637	0.658	0.686	0.63	0.634

Standard errors (clustered on the country level) in parenthesis.

*** p<0.01, ** p<0.05, * p<0.1

Table D.14: Determinants of Abolition: Economic Factors

	(1)	(2)	(3)	(4)	(5)
Log(Homicide Rate	0.887	**0.777****	0.867*	**0.684****	**0.662****
	(0.104)	(0.099)	(0.075)	(0.127)	(0.129)
Log(GDP per capita)	**1.871*****			**6.967*****	**6.016*****
	(0.350)			(3.351)	(3.358)
Gini Coefficient		**0.927*****		**0.923****	**0.925****
		(0.024)		(0.029)	(0.031)
Log(Trade (% of GDP))			1.272	1.111	1.229
			(0.278)	(0.342)	(0.407)
Polity IV					1.027
					(0.041)
Observations	3,056	3,531	3,611	2,115	2,000
# of Countries	105	93	108	81	79
# of Abolitions	39	34	44	22	22
PH-Test (p-value)	0.345	0.136	0.617	0.718	0.877

Standard errors (clustered on the country level) in parenthesis.

*** p<0.01, ** p<0.05, * p<0.1

Table D.15: Percentage Changes of Hazard Rates following a One-Standard Deviation Increase of the Covariates

	Execution Indicator			Legal Status	
	Table D.11 Column (1)	Table D.11 Column (5)	Table D.12 Column (5)	Table D.13 Column (5)	Table D.14 Column (5)
Log(Homicide Rate)	-21.5	-20.3	-30.8	ns	-42.7
Polity IV	29.2	ns	ns	85.8	ns
Log (GDP per capita)	--	--	102.8	--	270.5
UK Legal Origin	--	--	--	-63.7	--

This table reports percentage changes in the hazard of abolition following a one standard deviation increase in the independent variable.

Table D.16: Determinants of Stops in Executions: Robustness Checks

	(1)	(2)	(3)
	Excluding US and China	Americas	Excluding Americas
Log(Homicide Rate	**0.815****	**0.326****	**0.756*****
	(0.0800)	(0.181)	(0.0631)
Log(GDP per capita)	**1.169****	1.713	**1.006*****
	(0.293)	(2.308)	(0.276)
Gini Coefficient	0.971	0.879	0.961*
	(0.0192)	(0.104)	(0.0234)
Log(Trade (% of GDP))	0.926	0.0677*	1.135
	(0.266)	(0.106)	(0.352)
Polity IV	1.017	0.861	**1.042****
	(0.0297)	(0.116)	(0.0374)
Observations	825	136	710
# of Countries	65	9	58
# of Stops	37	7	31
PH-Test (p-value)	0.218	0.699	0.453

Standard errors (clustered on the country level) in parenthesis.

*** p<0.01, ** p<0.05, * p<0.1

Table D.17: Determinants of Abolition: Robustness Checks

	(1)	(2)
	Excluding US and China	Excluding Americas
Log(Homicide Rate	0.747	**0.679****
	(0.153)	(0.147)
Log(GDP per capita)	**1.918****	**1.512*****
	(0.610)	(0.461)
Gini Coefficient	**0.888*****	**0.879****
	(0.0322)	(0.0390)
Log(Trade (% of GDP))	1.099	1.136
	(0.365)	(0.416)
Polity IV	1.088	1.102
	(0.0665)	(0.0708)
Observations	1,227	968
# of Countries	76	66
# of Abolitions	18	17
PH-Test (p-value)	0.838	0.953

Standard errors (clustered on the country level) in parenthesis.

*** p<0.01, ** p<0.05, * p<0.1

D.7. Appendix

D.7.1. Data Sources Homicide Rates

The homicide rate database has been constructed over years, using a variety of sources. The most important ones are described in the following list:

Source	Detailed Source Description
WHO Mortality Database	The WHO Mortality Database offers data on the causes of death for numerous countries from 1972 until 2011, mainly retrieved from civil registration systems of the member states. The classification of the causes of death follows the WHO International Classification of Diseases (ICD). During the period of observation, various revisions of the ICD classification took place, however, the definition of violent death has been unaffected. The major revision has been the inclusion of deaths due to legal intervention (police killings or the execution of the death penalty). Link: www.who.int/healthinfo/mortality_data/en/
Clio Infra	This dataset was constructed by Winny Bierman and Jan Luiten van Zanden in April 2014 and was revised by Jonathan Fink Jensen in 2015. The sources were mainly statistical yearbooks. A detailed description of the sources can be found in the working paper "World Countries Homicide Rate, 1500-2000" by Fink-Jensen (2015). Link: www.clio-infra.eu/Indicators/HomicideRates.html
UNODC	UNODC data, mostly compiled via the UN Survey on Crime Trends and the Operations of Criminal Justice Systems. Link: www.unodc.org/unodc/en/data-and-analysis/statistics/historic-data.html
Interpol	The International Criminal Police Organization (Interpol) has conducted yearly crime surveys from 1950 onwards, sending questionnaires to the member countries to obtain data on several crime indicators, as for example the intentional homicide rate. The data stems from criminal justice data sources. The Interpol definition of homicide also includes infanticide, and excludes manslaughter. Furthermore, it includes attempted murder in contrast to the other sources. Link: www.interpol.int/News-and-media/Publications2/Annual-reports2

Source	Detailed Source Description
Historical Violence Database	Historical Violence Database (see: cjrc.osu.edu/research/interdisciplinary/hvd). Randolph Roth, Douglas L. Eckberg, Cornelia Hughes Dayton, Kenneth Wheeler, James Watkinson, Robb Haberman, and James M. Denham. 2008. "The Historical Violence Database: A Collaborative Research Project on the History of Violent Crime and Violent Death." Historical Methods 41, 81-97.
NRILP	The National Research Institute of Legal Policy in Helsinki produced a Comparative Homicide Time Series (version 10-4-2014). The data can be found in the following publication: Lehti, M. (2013), "NRILP Comparative Homicide Time Series (NRILP-CHTS)", National Research Institute of Legal Policy, Research Brief, 32, Helsinki.
Archer and Gartner	Comparative Crime Data File by Archer, Dane and Rosemary Gartner (1984) Violence and Crime in Cross-National Perspective. New Haven: Yale University Press., excel available on cjrc.osu.edu/research/interdisciplinary/hvd/asia/sri-lanka
Eisner	Eisner, M., (2003), 'Long-Term Historical Trends in Violent Crime', *Crime and Justice* 30, 83-142.

Single country sources and statistical yearbooks:

SJBDE	Statistische Jahrbücher für das Deutsche Reich
Mexico	Anuario Estadístico de los Estados Unidos Mexicanos, various years, see inegi.org.mx
India	Statistics of the colonies of the British empire.
Brazil	Brazil 1832-1890. Center for Research Libraries, Reports of the Brazilian Provinces 1830-1889, brazil.crl.edu/bsd/bsd/hartness/crimecomm.html, and Anuario estatistico do Brasil:1908-1912. (available at: memoria.org.br/)
Colombia	Colombia 1915-1930, Anuario Estadistico de Colombia
Japan	Statistical Bureau, Management and Coordination Agency ed., Historical Statistics of Japan, vol.1, 5, Tokyo, 1988

D.7.2. Data Sources Death Penalty

The data on both the execution of the death penalty as well as the legal status have been retrieved from two main sources:

1) Amnesty International – This NGO has been campaigning again the use of the death penalty since 1961, and over the course of its activities has published numerous reports and country briefs containing information about the use and the legal status of the death penalty. All of the resources can be accessed on their website www.amnesty.org/en/what-we-do/death-penalty/
2) Death Penalty Worldwide, a project founded in 2011, has created a worldwide database containing information about the status and the use of the death penalty. The database can be accessed under: www.deathpenaltyworldwide.org/

When possible, the data from these two sources have been cross-checked and supplemented with information from national reports, official statements and newspaper articles.

D.7.3. Granger-Causality Tests - Methodology

The concept of Granger-causality (Granger 1969) is defined as follows: One variable x is said to Granger-cause another variable y if y can be better predicted using the joint history of y and x as opposed to using the history of y only.

In the following, y_t and x_t are two stationary time series (with $t = 1, 2, 3, \dots, T$). A simple Granger-causality test consists of regressing the following vector autoregressive model (VAR):

$$y_t = c_1 + \sum_{k=1}^{p} \alpha_{1k} y_{t-k} + \sum_{k=1}^{p} \beta_{1k} x_{t-k} + \epsilon_{1t}$$

$$x_t = c_2 + \sum_{k=1}^{p} \alpha_{2k} y_{t-k} + \sum_{k=1}^{p} \beta_{2k} x_{t-k} + \epsilon_{2t}$$

and then testing the coefficients β_{1k} and α_{2k} for significance. There are four potential outcomes of the test:

1) Unidirectional Granger-causality from x to y. In this case, at least one of the β_{1k}-coefficients is different from zero and all the α_{2k} are equal to zero.
2) Unidirectional Granger-causality from y to x with at least one of the α_{2k}-coefficients nonzero and $\beta_{1k} = 0$ for all k.
3) Bidirectional causality (feedback). If at least one of the β_{1k} and at least one of the α_{2k}-coefficients has a nonzero value.
4) Independence. If the realizations of x and y only depend on their own lagged values, then there is no Granger-causality in any direction.

In the context of the deterrence effect, the death penalty series Granger-causes the homicide rate, if the lagged death penalty indicator helps to forecast the development of the homicide rate. A recent change of the death penalty indicator from 1 to 0 (an abolition) should help predict the development of the homicide rate, if deterrence is present. On the other hand, past values of the homicide rate could help predict the abolition or retention of the homicide rate if feedback effects exist.

D.7.4. Data Sources Covariates

Variable	Data Sources
Polity IV	The annual polity score capturing political regime characteristics is available for 168 countries from 1800 to 2016 from the Polity IV Project (Marshall et al. 2017). The Polity2 index, the revised combined polity score is used. For this standardized authority scores have been converted to conventional polity scores by the authors. Link: www.systemicpeace.org/inscrdata.html
Ethnic Fractionalization	This fractionalization measure has been developed by Alesina et al. (2003). It is defined as one minus the Herfindahl index of the ethnic group shares: $$Frac_j = 1 - \sum_{i=1}^{N} s_{ij}^2$$ for country *j* and its ethnic groups *i (i=1 .... N).* The ethnic fractionalization variable is chose here, since ethnicity combines both racial and linguistic characteristics, and hence is a more universal measure than using mere racial or mere linguistic fractionalization. The data on the fractionalization index is obtained from Alesina et al. (2003), Data source: Romain Wacziarg, available at: www.anderson.ucla.edu/faculty_pages/romain.wacziarg/papersum.html
Education	Numeracy rates have been proven to be highly correlated with traditional education measures such as years of schooling (Crayen and Baten 2010) and both indicators have been used as measures of educational attainment in a country. To obtain a proxy of the educational level that covers the entire period of the data set, both indicators have been combined into one spliced indicator: The logarithm of average years of schooling has been linearly regressed on numeracy, and then the average years of schooling are predicted using the numeracy value, when the average years of schooling are not available. Otherwise, the original value of the years of schooling is left in place. Sources: Van Leeuwen, B., J. Van Leeuwen-Li, and P. Foldvari (2013): “Average Years of Education, 1850-2010,” Version 2, Clio Infra Project, available at: www.clio-infra.eu/Indicators/AverageYearsofEducation.html

	Baten J. (2013): "Numeracy Estimates (ABCC) by Birth Decade and Country," Version 1, Clio Infra Project, available at: www.clio-infra.eu/Indicators/NumeracyTotal.html
Conflict Dummy	Dummy variable, taking on value 1 if an internal or international armed conflict took place in the decade and 0 otherwise. It was constructed using the two indicators provided in the following datasets: Armed internal conflicts, 1500-2000, Peter Brecke and Peter Foldvari, 2013, Version 1, Clio Infra Project, link: www.clio-infra.eu/Indicators/ArmedconflictsInternal.html Armed external conflicts, 1500-2000, Peter Brecke and Peter Foldvari, 2013, Version 1, Clio Infra Project, link www.clio-infra.eu/Indicators/ArmedConflictsInternational.html
Legal Origin UK	Following the classification of LaPorta et al. (2008), the following countries are considered of British/English legal origin: Australia, Canada, India, South Africa, United Kingdom, United States
GDP per capita	GDP per capita in 1990 international Geary-Khamis dollars (conversed by the author). Source: Bolt, J. and J. L. Van Zanden (2013): "The First Update of the Maddison Project: Re-Estimating Growth before 1820," Clio Infra Project, Link: www.clio-infra.eu/Indicators/GDPperCapita.html
Gini Coefficient	Baten, J., J. L. Van Zanden, M. Moatsos, P. Foldvari and B. van Leeuwen (2014): „Gross household income Gini 1820-2000", Version 1, Clio Infra Project, available at www.clio-infra.eu/Indicators/IncomeInequality.html
Total Trade Volume	Sum of imports and exports, extracted from Correlates of War Project Trade Data Set, Version 4.0 1870 – 2014, Katherine Barbieri and Omar Keshk Both imports and exports are measured in current US millions of dollar.

E. Summary and Outlook

Together, the chapters of this thesis contribute to the ongoing effort of shedding light on the dynamics of violence and violent crime in human societies. The first contribution to the literature is the extension of the available data both for Mexico and the world, reconstructing the development of violent crime rates back until the beginning of the 20^{th} century. Secondly, this thesis has assessed the determinants of the long run development of violent crime in Mexico and the world with a special focus on the role of deterrence and natural resources. A number of conclusions can be drawn from the results that are common across all chapters:

The importance of economic development and the general income level for reducing the incentives to commit crime has been corroborated. As the rational choice theory of crime developed by Gary Becker (1968) predicts, higher income levels imply higher opportunity costs, and therefore, criminal options become unattractive for a large part of society. This implies that rising income levels in the poorer countries of the world today would not only reduce poverty, but has a number of positive side effects such as reducing crime rates. However, if inequality increases alongside with income, then the positive side effects might not be as pronounced, since higher inequality has been shown to be a crime increasing factor. This result supports several of the sociological theories that predict a higher crime level if society is divided and heterogeneous (see for example Merton 1968).

The second consolidated result of the chapters is the fact that there is no evidence for deterrence in any of the setups, using the death penalty as indicator of the severity of the punishment. In the case of Mexico, it could be shown that the quality of the law enforcement system is much more effective in deterring crime by increasing the likelihood of apprehension and receiving the punishment. While even the most severe punishment cannot have a deterrent effect if it is not consequently imposed, a mild punishment can deter crime if it is imposed with certainty. These results imply that an effective anti-crime measure is an increase in the probability of being detained so that it appears in the cost-benefit analysis of offenders and significantly reduces the expected utility of the crime. To achieve this, it is necessary to improve the policing, law enforcement and judicial systems instead of reverting to the traditional demand of tougher punishment in the face of increasing crime rates.

In Mexico, in the recent years, the strategy of fighting crime has been heavy militarization and the passing of a law that grants the military unprecedented policing abilities (Chávez Courtright 2018). This naturally comes along with the killing of innocent bystanders, subsequent impunity of the military forces and even more violence in the aftermath. In places that were targeted by military operations, the homicide rates have increased even more (ProDH Center 2017). Hence, instead of improving the economic and educational conditions, strengthening civilian institutions, and establishing a strong rule of law, the government turned to more violence to combat the symptoms of the problem. The root causes however remain overlooked.

At the same time, the passing of the new law could worsen the situation around Mexico's natural resource extraction (Chávez Courtright 2018). Environmental defenders have always faced oppression and violence in the past (Estévez 2017), but the use of the military in internal affairs could exacerbate the problem. This is another example of how the presence of natural resource extraction leads to heightened violence levels, just as shown in the second part of this thesis. Since violence is a mean to prevail over others in the conflicts over natural resources, the extraction of natural resources has to be administered using a democratic and public approach in order to prevent violent outbursts. Other contexts where violence emerging around natural resource extraction is highly topical are the illegal and legal logging of mahogany in Honduras (Environmental Investigation Agency 2005), mineral mining in Nicaragua and Guatemala, chrome mining in Zimbabwe, titanium extraction in South Africa and oil palm plantations in the Philippines. In all of these cases, natural resource extraction is accompanied by protests, assassinations and violent confrontation.

My hope is, that some of the insights developed in this thesis will be used in the future as a basis to rethink anti-crime measures, and to implement more effective strategies that can improve living conditions in the countries suffering from the detrimental burden of violent crime.

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