The role of social networks for combating money laundering

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The role of social networks for combating money laundering

De rol van sociale netwerken voor de bestrijding van het witwassen van geld

(met een samenvatting in het Nederlands)

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Chapter 1

Introduction

Money laundering is part of white collar crime (Erp et al, 2015). It is an activity aimed at concealing the unlawful origin of money. Predicate crimes, of which the returns are related to money laundering, are drug trafficking, terrorist activity, corruption, fraud, tax evasion and other serious crimes such as human trafficking or counterfeiting[1] (Savona, 2005). Although money laundering is an old phenomenon, it became an issue of international concern only in the mid-1980s. The modern debate on money laundering started in the US, which decided to change its anti-drug policy and to follow the money rather than to follow drug dealers unsuccessfully. The US pushed strongly for the international combatting of money laundering. This is understandable, seen that, according to experts, half of the globally laundered funds are transferred through American banks (Walker, 1999; Unger 2007). With the consequence that today, money laundering is seriously criminalized in almost all countries of the world.

Money laundering is a complex process which requires many actors. By connecting with bank employees, lawyers, and public notaries, criminals seek to transfer their illicit proceeds into the legal financial system with the ultimate aim of covering up the origins and tracks of their proceeds. Despite its importance, research on money laundering is relatively scarce. As a symptom of that, much of the focus in the economics literature is still on the measurement of aggregate money laundering flows.[2] The central questions of this literature are: how sizable are the global money laundering flows? Which countries are threatened by money laundering activities and which might benefit? What are the implications of money laundering for "clean" investments? A second strand of the literature deals with regulation issues: Should one combat money laundering at all? Can one find incentives for the private sector to truly report suspicious transactions to the authorities? And what are the policy options and optimal fines for non-compliance (Masciandaro 2007, Takats 2007)? A third strand of the literature focuses on the economic, social and political effects of money laundering and the estimation of its

[1] The term 'money laundering' goes back to the activities of the Chicago gangster Al Capone who funneled his ill-gotten gains from alcohol sales during times of the prohibition through launderettes to make them appear legal (Van Duyne et al, 2003).
[2] Several noticeable examples are Walker (1999), Unger (2007), Unger et al. (2006) and Unger & Van der Linde (2013), Schneider (2008), Truman and Reuter (2004), Bagella, Busato and Argentiero (2009) and Baker (2005). One of the reasons for the shortage of research is that there have been up until now only few hard facts on this topic, i.e., hardly any reliable data. Most existing research on this topic in economics has been therefore either trying to find empirical evidence and proxy variables (Truman and Reuter, 2004; Ferwerda, 2009, 2012; Unger, 2007; Unger, 2011) or to deal with its regulation theoretically (see e.g. Azevedo Araujo, 2010, Masciandaro, 1999, 2004, 2007; Takats, 2007; and Eide, 2000). Next to the problem that money laundering is difficult to measure, is the fact that money laundering is what John Stuart Mill called a 'victimless crime' (Mill, 1859). The person laundering the money as well as the person accepting it, do so voluntarily. So there is no direct victim. This makes it difficult to regulate money laundering.

macroeconomic implications (Unger et al 2006, Ferwerda 2009, Unger and van der Linde, 2013). Money laundering can affect investment and growth (Ferwerda 2009), can lead to unfair competition with criminals infiltrating business, can lead to corruption, and can undermine democracy with criminals infiltrating the economic, social and politic sphere. Many of these effects are anecdotal and have neither been proven theoretically nor solidly empirically tested (Unger et al 2006). It is this infiltration of the legal economy by criminals which this thesis wants to further explore.

What this thesis wants to add to the existing literature is a microeconomic analysis of the individual actor's incentives for money laundering and a bottom-up analysis of its adverse effects. For this, I study money laundering from a network perspective. Criminals have to connect to all kinds of facilitators of the legal economy in order to launder. Real-estate agents must keep their eyes closed when the buyer of a house is obviously not the economic owner but a strawman. Notaries must look away when a house is being bought by exchanging a suitcase of cash money underneath the table. Accountants of a company must look away when payments are made for fake bills from an offshore company of which the ultimate beneficial owner is the company itself. Tax advisors must look away when offshore companies are set up for the sole purpose of not paying taxes. However, a large part of money laundering still takes place through banks. A recent study on offshore companies (van Koningsveld 2015) showed that in 80 percent of criminal cases using offshore constructions for laundering, banks were involved. The focus of my thesis is, therefore, on networks between criminals and banks.

The infiltration of the legal sector by criminals with the help of bank employees can be manifold, because criminals place money in the legal financial system in different ways. To give some examples of money laundering techniques using banks: through asset purchase onshore or offshore, through opening a bank account by a straw man, through blending (i.e. hiding illegal funds in big financial vehicles), or to stay below the radar of modern financial regulations by splitting large amounts of money into such small parts that the depositing of these amounts into the financial system would not raise any suspicion. This latter technique is called "smurfing" and gets particular attention in my thesis. Using smurfing techniques and other techniques of money laundering so that criminal money can enter the banking system, criminals will have to hold many money laundering ties at the same time in order to avoid the risk of detection.[3] They will have to establish a sophisticated money laundering network with several actors (bank employees) involved. Based on this network approach, I then develop policy recommendations to optimally limit the incentives for domestic and international money laundering operations.

In Chapter 2, I develop a model in which criminals infiltrate banks. I answer the question as to why a criminal organization seeks the help of "corrupt" workers (bank employees) to launder its

[3] See Bramoullé and Kranton (2007) and Fafchamps and Gubert (2007) for other network studies with a risk sharing motive.

criminal proceeds and how these money laundering ties feed back into the growth of the organization. Chapters 3 and 4 then gradually expand this model and build upon this framework. Chapter 3 abstracts from the internal hierarchical structure of the criminal organization, and instead extends the model to non-hierarchical criminal networks. The new implication of this model is that one can derive policy recommendations for the optimal budget for combating domestic crime and for combating money laundering. Chapter 3 advises policy makers on how much effort and money they should devote to fighting the predicate crime underlying money laundering and how much they should devote to the infiltration of the legal economy by launderers. To illustrate the predictions of the model, the optimal budget sharing rule is calculated for the Netherlands based on the so called sufficient statistics approach pioneered by Chetty (2009).

Chapter 4 then develops a model with international money laundering networks. This model explicitly takes into account that when criminals try to place their money in the legal financial world, they do not solely focus on their own country. Instead, they target other countries, when the chances of getting caught there are lower (Unger & Rawlings, 2008). The model in this chapter can be regarded as a micro-foundation for the famous Walker gravity model (Walker, 1995 and 1999). In a nutshell, the Walker model wants to find out how much global criminal money is attracted by each country for laundering purposes. It uses attractiveness indicators, which relate international money laundering flows to the GDPs of the exporting and the importing nation and some aggregate societal measures of the institutional and geographical distance between the two countries. Instead, my model focuses on cross-country differences in factors that have an immediate impact on the payoffs from pursuing a legal or illegal career, such as cross-country differences in wages, potential criminal earnings, the chances of detection etc., as these are what criminals consider in their decisions. Moreover, I do not consider aggregate measures of social distance (e.g. different languages), cultural distance (e.g. colonial background) or geographical distance between countries as the impediment to money laundering flows. New technologies, like electronic wire transfers together with liberalization of financial markets enable criminals to send their crime proceeds to almost any place in this world within minutes. Also, language barriers have been eroded with English as the unofficial world language. Instead, the impediments in my model stem from the risk of detecting an illegal money transfer.

What is the micro foundation in my thesis useful for? Past research in economics (Unger & Van der Linde, 2013) has focused on the estimation of money laundering flows between countries. As this research correctly points out, these estimates have meaning, if they help to find out by how much anti-money laundering policies could potentially reduce money laundering flows. The value of the models presented in this thesis is that they provide guidelines for the policy maker of how to influence individual behavior in order to reach this policy goal. Policies to fight money laundering are ultimately targeted at factors that influence the incentives to commit crime, such as detection rates, threshold values for money transfers, or international collaboration in the exchange of information etc. In my thesis, these policy instruments enter as parameters that immediately affect incentives of individual criminals and ultimately shape the money laundering flows at the network level. In particular, the model of Chapter 3 predicts that the individual incentives of criminals to commit crime or money laundering can be inferred from some fairly trustable aggregate macroeconomic statistics. Applying some of the fundamental assumptions of the microeconomics of crime (see next section) to money laundering, my empirical implementation of this model shows that one needs no more than estimates of the current size of the criminal market in a country, an estimate of the rate of being detected as a money launderer, and the knowledge of the level of fines on money laundering activities in order to derive meaningful policy recommendations. In particular, in that chapter, I derive the optimal split of an anti-crime budget into how much to spend on fighting money laundering and how much to spend on fighting the underlying criminal activity. Going beyond some optimal national policies, Chapter 4 assesses the value of several of the money laundering regimes combating money laundering globally. It aims at finding the optimal way of international cooperation.[4] Overall, in this dissertation I try to understand the role of social networks in the money laundering process and to develop policies to fight and destroy money laundering networks.

The microeconomics of crime

In this dissertation, I analyze money laundering as the interactive decisions of rational actors (criminals, workers in the legal economy, and authorities). Becker (1968) was the first to realize that criminal activity can be understood as the consequence of a rational decision, i.e., criminals commit crime, if the expected utility exceeds the utility from legal activities. This micro perspective is still very little developed in the money laundering literature. In Becker's (1968) seminal crime model, each individual makes a choice between becoming a criminal and participating in the labor market by means of a cost-benefit analysis. The behavior of criminals (not launderers) has also been studied later by Levitt and Dubner (2010). They discuss the Venkatash's PhD field work who lived six years with a drug gang to complete his research. Sudhir Venkatash, a PhD student in sociology at the University of Chicago went to visit Chicago's poorest black neighborhoods with a clipboard and a multiple-choice survey. He ended up in a crack dealer's gang and lived there with them for six years under the gang leader's protection. He observed that drug organizations have a clear hierarchical framework, in which a few drug dealers (criminal bosses) earn the majority of drug proceeds while a large number of them (foot soldiers) make hardly sufficient profits to survive, and even need additional sources of income. The authors suggest this to be the reason why these foot soldiers have no choice but 'to live with their mothers' (Levitt & Dubner, 2010).

Calvo-Armengol and Zenou (2004) were the first to develop a microeconomic model on the interaction of criminals on the same hierarchical level in a social network representing individual actors

[4] As a response to the increasing threat money laundering imposes to the global economy, the Financial Action Task Force, an intergovernmental group first consisting of the G-7 countries, and now of almost all countries in the world, has been set up in 1989 to combat the spread of money laundering all over the globe.

in terms of nodes and relations or interactions in terms of the ties or edges that connect them.[5] Calvo-Armengol and Zenou (2004) studied the structure of a criminal network and the amplification of criminal activity through it. In their model, criminals benefit from being connected to other criminals in their network by learning from them how to commit crime in a more efficient way and by sharing knowledge on the crime business. In this way, criminals' chances of being caught decrease as they have more connections to other criminals since they can learn to become better criminals through these knowledge sharing links. Their model is not only of theoretical value for two reasons: First, the assumptions of the model have also been confirmed empirically. Sarnecki (2001), for example, using data from the Stockholm police force and from interviews with victims of criminal offences, finds that adolescents more easily become delinquents, when there is at least one delinquent friend in their network of friendships. Also, as assumed in the model, delinquents learn through the direct interaction with other delinquents. Second, the predictions of the Calvo-Armengol and Zenou (2004) network model are also of policy relevance: Since the shape of the real delinquency network is unknown to authorities, they might instead use the model to gain at least some intuition on how the few observed delinquency ties fit into the bigger picture of the entire criminal network. By having an idea of the shape of the criminal network, authorities might then develop some better understanding of how to effectively fight crime, where again the model is of help in the development of some clever policing strategies.

With respect to effective policy against crime, the inspection game, introduced by Dresher (1962) and Maschler (1966), is a first attempt to model the strategic interaction between criminals and an authority aiming at reducing crime levels. In this game, both parties aim to find the optimal strategy to increase their payoffs. Criminals try to pursue their criminal activities without the fear that their attempt will be detected by the authority and simultaneously the authority aims to detect the criminal operation at the minimum cost. The game between criminals and authorities has a probabilistic equilibrium, which means that there is no optimal pure strategy and that only a mixed strategy is optimal in equilibrium. This inspection game can straightforwardly be used to study the strategic interaction between an authority and all kinds of criminals, including tax evaders and money launders.

Next to the literature on the individual incentives for criminal activities, another strand in the microeconomic literature focuses on the development of optimal policies to fight crime, whereby most of the existing literature is again concerned with commercial crimes other than money laundering. Slemrod (2007) reviews the theoretical literature on tax enforcement policies. The standard framework for considering an individual's choice of whether and how much to evade taxes is the deterrence model by Allingham and Sandmo (1972), who adapted Becker's (1968) model of the

[5] The analysis started in sociology, but expanded to many other disciplines including economics. Jackson and Wolinsky (1996), Bala and Goyal (2000), and Goyal and Joshi (2003) have studied network formation under various assumptions on the underlying incentives and show how agents strategically link to other agents in the network and which structure of the network is stable and/or efficient.

economics of crime. In this model, taxpayers decide whether and how much to evade in the same way they would approach any risky decision or gamble—by maximizing expected utility—and are influenced by possible legal penalties in just the same way they are influenced by any other contingent cost. Tax evasion depends on the chance of getting caught and penalized, the size of the penalty for evasion, and the individual's degree of risk aversion. Based on this framework, later research has then focused on optimal tax enforcement policies. A basic insight since Becker (1968) is that a government will want to set the penalty for detected crimes as high as possible, so that even with a low resource cost of enforcement, the overall expected deterrent effect will be large. However, harsh penalties are not generally desired, as the level of punishment should fit the crime.[6] Slemrod and Yitzhaki (1985) thus went on trying to theoretically answer the question of how much tax evasion should be tolerated. They show that the simple rule of increasing the probability of detection until the marginal increase of tax revenues thus generated equals the marginal resource cost of so doing is incorrect. The correct rule equates the marginal social benefit of reduced evasion to the marginal resource cost. The distinction suggests that unregulated privatization of tax enforcement, in which profit-maximizing firms would maximize revenue collection net of costs, would lead to socially inefficient overspending on enforcement (Slemrod, 2007).

Moore, Clayton, and Anderson (2009) look at "best practices" in fighting online crime. They point out that banks often hide fraud losses and hesitate to share information with other banks and even police agencies. The refusal of banks to share information and thus the lack of accurate information on online crime, makes fighting this sort of crime difficult. However, they predict that the online fraud rate will drop by sharing information and banks will benefit by sharing their fraud experience with other banks just like the antivirus companies began to share data on virus samples 15 years ago. This data sharing improved the quality of protection available to consumers and businesses. Moore and Clayton (2008, October) point out that not only information sharing on a national level is sufficient, but since online crime is a transnational crime, also the coordination of law enforcement is needed to combat this sort of crime. The authors suggest that a mechanism to develop a global strategy on cybercrime is needed, and that countries should cooperate with each other to fight international online crime following the precedent of SHAEF, the Supreme Headquarters Allied Expeditionary Force, in World War II and NATO today.

The only two studies on anti-money laundering policies with a microeconomic background are Masciandaro (1999) and Takáts (2007). The former is the first to build an economic model of money laundering. Masciandaro (1999) develops a model of money laundering and of anti-money laundering regulation and shows that the optimal policy to fight money laundering will be the one that minimizes crime, while keeping the social costs of regulation at a tolerable level. He also establishes the role of

[6] Slemrod (2007) suggests that in cases of tax evasion harsh penalties are not generally desired, as there is the risk that an authority might punish an honest person who just made a mistake. However, honest people who might make mistakes hardly exist in cases of money laundering and for this sort of crime a maximum penalty should apply.

the multiplier effect of money laundering in criminal financial activities in which more money laundering opportunities increase criminal investments. Takáts (2007), on the other hand, analyzes theoretically the agency problem between banks and the government to fight money laundering. He focuses on the ruled-based report on the United States anti-money laundering regimes. In his model, banks aim to avoid fines of not reporting money laundering at all costs. Since the reporting involves relatively little costs, banks will make sure to report any suspicious transaction. Prosecutors, in contrast, have to investigate these transactions in detail, which is very costly for them. This entails the problem for the prosecutor who is seeking to maximize social welfare by finding the optimal fine imposed on the banks for not reporting money laundering. While weak fines give no incentive for banks to monitor and report, strong fines, however, lead to a "crying wolf problem" of over-reporting. The author shows that very high fines lead to a lower social welfare than no fines at all. Moreover, the crying wolf problem can be solved by reducing fines and introducing reporting fees, i.e. by charging banks for informing law enforcement agencies.

In my thesis, I advance on this microeconomics literature by studying money laundering as an activity pursued by rational actors. In this regard, my thesis is one of the first to study money laundering from this perspective. For simplicity, I assume that criminals mainly use smurfing techniques in that they break down their crime proceeds and form money laundering ties with other criminals and workers to minimize the risk of being detected. I start from Becker's (1968) rational choice model of crime, in which individuals choose between a legal and a criminal career. Then, expanding on the criminal network model by Calvo-Armengol and Zenou (2004), criminals build up a money laundering network, where in contrast to the original study their primary motive is the hedging of detection risks. Finally, adopting the policy frameworks of Slemrod (2007) and Moore, Clayton and Anderson (2009), I develop policy recommendations to optimally reduce the social costs of crime and money laundering.

In particular, I aim to answer the following research questions:

1. What does the structure of a money laundering network look like which is formed by rational criminals who need the assistance of corrupt workers (bank employees) to launder their criminal proceeds?

2. Based on the theoretical predictions on Question 1, how can an anti-crime agency optimally reduce the economic costs of crime and money laundering, when the agency operates under a budget constraint?

3. Regarding the theoretical predictions of the structure of a money laundering network, what is the economic value of coordinating anti-money laundering policies at the international level? And,

what is the optimal means of coordination when countries have different size crime and money laundering markets?

Outline

In the three chapters of my dissertation, I analyze criminal activity as a strategic game between self-interested agents who interact with each other and with other non-criminals to launder their criminal proceeds. In particular, I investigate the emerging network when criminals make use of the "smurfing" technique, i.e., they separate their proceeds into such small parts, that their placement in the financial system does not raise any suspicion.

In Chapter 2, I analyze the role of money laundering networks infiltrating the legal economy, where I particularly take into consideration the insights from Levitt and Dubner (2010) that criminal organizations are typically hierarchical. For modelling this 'Italian mafia' type of organization, I distinguish between criminal bosses and their foot soldiers. I start with a model with three different agents: criminal bosses, foot soldiers, and workers. The latter can be interpreted as bank employees in cases where criminal organizations infiltrate banks. In the model, criminal bosses and foot soldiers, first, choose between a legal and criminal career. Then, criminals will become either the boss of an organization or a foot soldier. This is determined by pure chance in my model, as it is ex-ante not clear at all what it takes for a successful criminal career. Afterwards, the bosses of the criminal organizations form money laundering ties with workers (and other bosses) and, finally, criminal bosses hire foot soldiers to run their business. In particular, in the tie formation stage, criminal bosses try to conceal the source of their expected crime proceeds by forming links to other criminals and workers who (possibly against a transfer or bribe) accept their dirty money. The expected value of a tie for a boss decreases with the linking cost, which is composed of the probability of being caught when laundering money and the expected fine. In the final stage of my model, criminal bosses send out their own foot soldiers to compete for sales in a competitive crime market.

The main purpose of this chapter is to answer Research Question 1 regarding the predicted structure of a money laundering network. I find that in the equilibrium of my model, criminal bosses form money laundering links with all workers in order to decrease their chances of being caught. That is, they extend their network as much as possible to keep the amount of money laundered through each tie below the reporting threshold of a bank.[7] I also characterize the size of the money laundering network and derive the number of bosses in this network. I then investigate the comparative statics properties of the derived equilibrium values with respect to some critical variables. Among others, I predict that the number of criminal bosses decreases when the salary they have to pay to their foot soldiers increases and when the wage of the legal economy increases. I also find the "multiplier effect"

[7] More specifically, the criminal should make sure that these smaller amounts are below the reporting thresholds that is relevant in the applicable jurisdiction. E.g. in the US such a reporting threshold for banks is 10,000 USD, while in the Netherlands it is 15,000 Euro.

of money laundering on crime that Masciandaro (1999) first formulated, as in my model more money laundering ties mean more crime incentives. However, I find an additional "feedback effect", as the expectation of higher criminal proceeds implies that bosses prefer to form as many money laundering ties as possible.

It is worthwhile to mention that I derive all these results under some fairly stylized assumptions. Most notably, the workers in my model do not communicate. In particular, they do not give away their dubious second identity. Moreover, the bosses in my model do not engage in some form of strategic behavior where they either kill or discredit each other. However, under these assumptions, I succeed in modelling the infiltration of crime into the legal economy and derive interesting relationships between the structure of money laundering networks and the number of criminal actors.

The purpose of Chapter 3 is to develop micro-founded policy recommendations. I therefore simplify the previous model to the extent that I abstract from the internal criminal organization and just consider the organization as a whole. There are indeed criminal networks which are not hierarchical, such as reported by Kleemans (2007) describing the crime networks in The Netherlands, which are often ethically determined, are rather flexible depending on the type of crime the network aims to commit, can form themselves and dissolve themselves very quickly in order to be more difficult to be traced and are non-hierarchical. This chapter models these types of flexible criminal networks. In particular, I assume that hiring foot soldiers is now considered the criminal effort level of the head of the organization. Moreover, I introduce a new actor into the game: a law enforcement agency with the role to find and arrest criminals and to minimize the volume of money laundering. In other words, this agency aims at minimizing the total economic costs of crime and money laundering, while it tries to maintain the detection costs at a tolerable level. Since the most direct effect of fighting money laundering is that of providing law enforcement agencies with a second chance to catch a criminal (Ferwerda, 2012), anti-money laundering policies are an important tool. I indeed predict in this chapter that authorities can fight crime by either targeting criminals directly or by combating money laundering, i.e. by scanning financial transactions in the hope of detecting money laundering links between criminal organizations and workers, respectively other organizations. I furthermore develop recommendations for an optimal budget sharing rule between crime and money laundering policies. I predict that the optimal crime budget share depends on the effort of criminals, the reporting threshold, the crime probability of detection and the number of criminals. And the optimal money laundering budget share depends on the effort of criminals, the reporting threshold, the crime expected punishment, the money laundering expected punishment and the number of criminals. By so doing, I develop an answer concerning the main Research Question 2 of this thesis which is, how can an anti-crime agency optimally reduce the economic costs of crime and money laundering, when the agency operates under a budget constraint? I finally use empirical data from the Netherlands to put numbers on the model. In fact, I show that one needs no more than estimates of the current size of the criminal market in a country, an estimate of the rate of being detected as a money launderer, and the knowledge of the level of fines on money laundering activities to derive quantitative predictions. My calculations for the Netherlands suggest that the optimal budget share for fighting money laundering is 30%.

Chapter 4 takes into account that money laundering is an international cross border problem. Criminals can infiltrate not only the domestic legal economy but can also infiltrate foreign legal economies by being internationally active or by placing their criminal money abroad. The fact that money laundering is an international issue, poses a particular challenge for policy makers. The role of small offshore centers giving shelter to launderers at the cost of big countries has been at the very beginning of the modern money laundering debate (see FATF 1989, OECD 2000). These tax havens (see OECD 2000) are also mostly poor compared to the countries where the money for laundering comes from. Many offshore companies do not do any business on the offshore island (van Koningsveld 2015). So, the laundered money will be reinvested in big and rich countries. In Chapter 4, I extend the model of Chapter 3 to predict how criminal organizations allocate their laundered money across different countries and study policy options for an international approach to fight money laundering. Specifically, I look at the case of two countries in this model, which differ in terms of their population size and their average wage levels in order to model the dilemma of poor and small countries as opposed to rich and big laundering countries.

In Chapter 4 I first provide some comparative statics analysis with regard to this new international dimension of the model. I theoretically investigate and find that a criminal organization in one country transfers dirty money to the other country in order to avoid national controls, i.e., the dirty money flows to the country with the less precise controls. This reflects the stylized fact that criminal organizations try to target small countries with a lax anti-money laundering policy to launder their dirty money. Therefore they prefer countries with a high level of bank secrecy and a lax anti-money laundering policy (countries which do not follow the international anti-money laundering regulations). I also predict that money laundering has a negative effect on poor countries, as it can increase the quantity of crime in these countries. Criminals however prefer to launder their crime proceeds in the rich countries. Crime problems therefore stay in poor countries, yet the money goes to the rich countries.

The most important results of this chapter are, however, on the policy analysis. Europe recognizes the international character of money laundering and the important role of international cooperation in order to avoid loopholes in the anti-money laundering combat chain. At the moment it tries hard to improve law enforcement cooperation among its Member States. In Chapter 4 I theoretically analyze four different anti-money laundering regimes, which capture the main features of the currently debated regimes regarding the role of an European Public Prosecution Office (EPPO). The first regime is no information exchange between two countries; the second regime is an information exchange between national public prosecutors; the third regime is a regime with a central money laundering authority (a European Public Prosecutor) and a centralized identical budget (paid as a lump sum by each of the Member States) split between resources that flow into fighting crime, and respectively money laundering; the fourth regime is a regime with a central money laundering authority (a European Public Prosecutor) and tailor-made budgets for each country. This tailor made budget consists of a central prosecutors' office which provides the instructions for countries to fight money laundering, but countries use these harmonized rules to the benefit of their own country. Based on a comparison of these regimes, I determine respectively the regime which minimizes the economic costs of crime and money laundering in both countries jointly, and in each country separately. This is my contribution to answer Research Question 3 of this thesis about the economic value of an international coordination of anti-money laundering policies. I predict that information sharing is strictly better than no information exchange for both countries. However, a centralized authority that determines the same budget split for both countries can be to the disadvantage of the richer country. Since there are less criminals in a rich country, but it is committed to invest the same level to combat money laundering, the rich country will subsidize the poor country by using this system. Finally, I predict that the best regime to combat money laundering and minimize the total economic costs is to use a central authority with a tailor-made budget system. If the countries use a tailor-made budget system, the sum of social losses is less than the sum of social losses in countries with other regimes. With this chapter I tried to provide a simple model to identify criteria according to which policy choices for international cooperation can be made. For this I assume that countries act independently and form no strategic coalitions. I do not treat differences in the Criminal Law Systems of Member States like differences between Common Law and Civil Law systems which give the Public Prosecutor very different power. I also assume that the European Public Prosecutor represents the Member States equally and does not give preference to some of them. However, I could show that in such an idealistic scenario international cooperation pays and should be tailored to country needs.

In summary, this dissertation tries to study money laundering from a microeconomic angle. It highlights important parts of this complex phenomena that are relevant in today's discussion, and shows how a microeconomic analysis can help to explain the growth of criminal networks and what policy can do in order to combat them. First, I develop a theoretical model that makes predictions about the infiltration of criminal hierarchical organizations into the banking sector and the overall structure of a money laundering networks. Then, I investigate the optimal balance between anti-crime and anti-money laundering policies in this theoretical framework. Finally, I study the optimal division of anti-money laundering policies in a two-country version of my model. I am aware of the heroic assumptions I had to make in order to reduce the complex money laundering debate, which mainly takes place among non-academics or within disciplines which focus on qualitative inductive methods and do not use deductive methods, in order to be able to model it. However, this thesis is the first of its kind to show that the microeconomics of crime and network analysis can offer a fruitful base for further research. I hope this is a useful first step and that it invites other researchers to either develop some more rigorous empirical testing of my models or to expand them into more elaborate models that lend themselves more easily to some more realistic counterfactual policy analysis than the singled out-examples which I present in this thesis.

Bibliography

Allingham, M. G., & Sandmo, A. (1972). Income tax evasion: A theoretical analysis. Journal of public economics, 1(3-4), 323-338.

Azevedo Araujo, R. (2010). An evolutionary game theory approach to combat money laundering. Journal of Money Laundering Control, 13(1), 70-78.

Baker, R. W. (2005). Capitalism's Achilles heel: Dirty money and how to renew the free-market system. John Wiley & Sons.

Bagella, M., Busato, F., & Argentiero, A. (2009). Money laundering in a microfounded dynamic model: simulations for the US and the EU-15 economies. Review of Law and Economics, 5(2), 879-902.

Bala, V., & Goyal, S. (2000). A noncooperative model of network formation. Econometrica, 68(5), 1181-1229.

Becker, G. S. (1968). Crime and punishment: An economic approach. In The Economic Dimensions of Crime (pp. 13-68). Palgrave Macmillan UK.

Bramoullé, Y., & Kranton, R. (2007). Risk-sharing networks. Journal of Economic Behavior & Organization, 64(3), 275-294.

Calvó-Armengol, A., & Zenou, Y. (2004). Social networks and crime decisions: The role of social structure in facilitating delinquent behavior. International Economic Review, 45(3), 939-958.

Chetty, R. (2009). Sufficient statistics for welfare analysis: A bridge between structural and reduced-form methods. Annu. Rev. Econ., 1(1), 451-488.

Dresher, M. (1962). A sampling inspection problem in arms control agreements: A game-theoretic analysis (No. RM-2972-ARPA). RAND CORP SANTA MONICA CA.

Eide, E. (2000). Economics of criminal behavior. Encyclopedia of law and economics, 5, 345-389.

Fafchamps, M., & Gubert, F. (2007). The formation of risk sharing networks. Journal of development Economics, 83(2), 326-350.

Ferwerda, J. (2009). The economics of crime and money laundering: does anti-money laundering policy reduce crime?. Review of Law and Economics, 5(2).

Ferwerda, J. (2012). The multidisciplinary economics of money laundering (Doctoral dissertation, Utrecht University).

Goyal, S., & Joshi, S. (2003). Networks of collaboration in oligopoly. Games and Economic behavior, 43(1), 57-85.

Jackson, M. O., & Wolinsky, A. (1996). A strategic model of social and economic networks. Journal of economic theory, 71(1), 44-74.

Kleemans, E. R. (2007). Organized crime, transit crime, and racketeering. Crime and Justice, 35(1), 163-215.

Levitt, S. D., & Dubner, S. J. (2010). Freakonomics (Vol. 61). Sperling & Kupfer editori.

Maschler, M. (1966). A price leadership method for solving the inspector's non-constant-sum game. Naval Research Logistics (NRL), 13(1), 11-33.

Masciandaro, D. (1999). Money laundering: the economics of regulation. European Journal of Law and Economics, 7(3), 225-240.

Masciandaro, D. (Ed.). (2004). Global financial crime: Terrorism, money laundering, and off shore centres. Ashgate Publishing, Ltd.

Masciandaro, D. (2007). Divide et impera: Financial supervision unification and central bank fragmentation effect. European Journal of Political Economy, 23(2), 285-315.

Mill, J.S. (1859). On Liberty, republished as J.S. Mill (1982) On liberty, penguin classics.

Moore, T., & Clayton, R. (2008, October). The consequence of non-cooperation in the fight against phishing. In eCrime Researchers Summit, 2008 (pp. 1-14). IEEE.

Moore, T., Clayton, R., & Anderson, R. (2009). The economics of online crime. The Journal of Economic Perspectives, 23(3), 3-20.

Sarnecki, J. (2001). Delinquent networks: Youth co-offending in Stockholm. Cambridge University Press.

Savona, E. (2005) (ed). Responding to Money Laundering. Routledge.

Schneider, F. (2008). Money laundering and financial means of organised crime: some preliminary empirical findings. Global Business and Economics Review, 10(3), 309-330.

Slemrod, J., & Yitzhaki, S. (1985). The optimal size of a tax collection agency.

Slemrod, J. (2007). Cheating ourselves: The economics of tax evasion. The journal of economic perspectives, 21(1), 25-48.

Takáts, E. (2007). A theory of "crying wolf": The economics of money laundering enforcement (No. 7-81). International Monetary Fund.

Truman, E. M., & Reuter, P. (2004). Chasing dirty money: Progress on anti-money laundering. Institute for International Economics, United States: Washington.

Unger, B., Siegel, M., Ferwerda, J., de Kruijf, W., Busuioic, M., Wokke, K., & Rawlings, G. (2006). The amounts and effects of money laundering. Report for the Ministry of Finance.

Unger, B. (2007). The scale and impacts of money laundering. Edward Elgar Publishing.

Unger, B., & Rawlings, G. (2008). Competing for criminal money. Global Business and Economics Review, 10(3), 331-352.

Unger, B. (2011). Regulating money laundering: From Al Capone to Al Qaeda. In David Levi-Faur. Handbook on the Politics of Regulation, Chapter 45, Edward Elgar Publishing.

Unger, B., & Van der Linde, D. (Eds.). (2013). Research handbook on money laundering. Edward Elgar Publishing.

Van Duyne, P., von Lampe, K., & Newell, J. L. (2003). Criminal finances and organising crime in Europe. Wolf Legal Publishers.

van Erp, J., Huisman, W., & Walle, G. V. (Eds.). (2015). The Routledge handbook of white-collar and corporate crime in Europe. Routledge.

Van Koningsveld, I. (2015). De Offshore Wereld geontmaskeerd, Dissertation of Tilburg University, Presentation to the European Parliament, Panama Committee, 26th of January 2017.

Walker, J. (1995). Estimates of the extent of money laundering in and through Australia, paper prepared for Australian transaction reports and analysis centre. Queanbeyan: John Walker Consulting Services.

Walker, J. (1999). How big is global money laundering?. Journal of Money Laundering Control, 3(1), 25-37.

Chapter 2

A Model of Crime and Money Laundering*

2.1 Introduction

Nobody is born as a criminal, nor is there a school that teaches people how to become criminal. However, the economic argument relating to this is that a person will become criminal, if the expected criminal earnings exceed the earning from attending the labor market (Engelhard, Rocheteau and Rupert, 2008). The next step in the criminal career is to become the boss of a criminal organization. As it goes with all hierarchies, the chance of becoming a boss is very low and most criminals end up as foot soldiers. The bosses, on the other hand, build up and expand their organizations by hiring foot soldiers. In the example of a drug cartel, the foot soldiers are selling their drug on the street and are bringing back the revenues to their bosses. This is where the money laundering network comes into play, because the bosses launder their criminal proceeds to hide the origin of the money. According to the UNODC (see the Guardian dec 13th 2009), the financial crisis has created additional opportunities for organized crime to infiltrate the banking sector. Banks have had to search for fresh money as the financial crisis has paralyzed inter-bank lending. Criminals could make use of this to increase their influence by for example depositing banknotes, acquiring shares and sitting on boards. Since any transaction above 10000 Euro raises suspicions of money laundering, bank employees have to report such transactions to the Financial Intelligence Unit FIU. To keep the money below this reporting threshold, criminals send their money to their foot soldiers and other launderette owners' bank accounts (who help criminals to launder their money), using the banks' electronic money transfer systems. This allows them to launder their money and hide the origin of their crime proceeds.

How do criminal actors form money laundering networks to minimize the risk of being detected and detained? In this chapter, we formalize this simple story in a game theoretic model and show how the behavior of individual criminals, criminal organizations, and corrupt workers culminate in a money laundering network at the societal level. We focus on a specific phase of the money laundering process in particular. Money laundering traditionally consists of three phases: placement, layering and integration.[8] This chapter focuses on the first phase of money laundering: the funneling of criminal funds into the financial sector. This placement phase is the most risky step for the criminal who

* The study presented in this chapter is a joint work with Bastian Westbrock.

[8] *Placement* is the depositing of funds in financial institutions or the conversion of cash into negotiable instruments. *Layering* involves the transfer of money through a series of accounts in an attempt to hide the money's true origins. This often means transferring funds to countries that have strict bank-secrecy laws (where banks do not provide any personal and account information about their customers to authorities). *Integration* involves the movement of layered funds which are no longer traceable to their criminal origin into the real world such as business investments or consumption.

launders money. Placement can be done through different ways, for example through asset purchase, opening a bank account by a straw man, or blending (i.e. hiding illegal funds in big financial vehicles). In particular, we focus on one specific technique of the placement phase, which is called smurfing. The idea of smurfing is to separate the criminal proceeds into smaller parts, parts which are so small that the depositing of these amounts into the financial system would not raise any suspicion.

We adopt Becker's (1968) model of the economics of crime in which agents decide to be either criminals or become workers, for example bank employees. Then by formalizing Levitt and Dubner (2010)'s insights into the functioning of a typical drug cartel, we model the hierarchical structure of a criminal organization. We assume that criminals divide into two groups, foot soldiers and bosses, and that the allocation into those two groups is randomly determined. The chance that a criminal becomes a criminal boss is low while the chance to become a foot soldier is high.[9] As Pietschmann (2013) mentioned, there is a 'power law' distribution in cocaine seizures in which a few traffickers make large profits –and have thus huge sums available that need to be laundered– while a large number of small-scale traffickers make hardly sufficient profits to survive, and thus need additional sources of income. In line with Pietschmann (2013) and the evidence reported in Levitt and Venkatesh (2000), Levitt & Dubner (2010), and Kilmer and Reuter (2009), we assume that bosses employ foot soldiers against the lowest feasible compensation to sell their drugs. All the surplus flows back to the bosses, which is also in line with Kilmer and Reuter (2009) who show for drug sales, certainly for heroin, cocaine, and to a lesser extend for marihuana, that most of the revenues go to sellers at the top of the system. This is the reason why foot soldiers have no choice but 'to live with their mothers' (Levitt & Dubner, 2010). In the next stage of my game, bosses then decide with whom they want to launder their ill-gotten gains by adding collaboration links to other agents. These links are pairwise, that is they are agreed upon by two involved agents, and they come at a cost to each of them. They are costly, because they involve the risk of being caught in the transaction by keeping the money below the reporting threshold of the bank. But, they help to lower the marginal costs of selling drugs, because they replace the crime proceeds with clean ones. As the money laundering process bears some risk also for the person who accepts the money, it is costly for a corrupt worker to link with a criminal boss. Thus, the boss must offer some transfer in order for a worker to agree to the link.

By studying the (subgame-perfect) equilibrium of this game, we make three main discoveries: we first characterize the pairwise stable network architectures, i.e. the networks in which no single agent has an incentive to delete a money laundering link, and no two agents have an incentives to add a link (Jackson & Wolinsky, 1996). We show that the money laundering network is an extended inter-linked star comprising all agents willing to get involved in money laundering. We also show that competition in the criminal market can maintain only few, very large organizations (see Figure 2.4 for

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[9] While the allocation may to some degree be determined by the individual characteristics of the criminals (e.g. charisma, ruthlessness, skill), we abstract from this causal relation by assuming homogeneity among criminals, as it may not be clear to a criminal ex ante which characteristics are relevant.

an illustration). This insight reflects research done by the US Institute for Defense Analysis suggesting that the cocaine market is characterized by a 'power law' distribution (Antony and Fries, 2004).

Second, my model reproduces the "multiplier effect" of money laundering on crime (Masciandaro, 1999 and Mackrell, 1996). Mackrell (1996) argued that money laundering could increase crime by making criminal activities worthwhile and providing criminal organizations with capital they can use to further expand their criminal activities. As a reflection of this, in my model every additional money laundering connection helps criminals to decrease the chance of being caught for drug trafficking. Therefore, it increases the incremental payoff of additional drug sales. However, we find an additional "feedback effect" of criminal activity on money laundering, with the consequence that in my model all bosses prefer to have as many ties as possible. Having established the structure of the equilibrium network, we also investigate the comparative static effects of several variables on the size of the network. In particular, we analyze the effect of the size of the potential criminal and labor force, the reporting threshold of banks, and the size of the drug market. Our findings on this matter support the intuition that all of these variables have a positive effect on the number of criminal bosses. A larger population of criminals and of workers will produce more criminal bosses. So will larger drug markets and higher reporting thresholds for money laundering of banks. Also, with respect to increasing the foot soldiers' salary, the wage of workers, the monetary fine on drug trafficking, the fine on money laundering, or the demand elasticity of drugs, we find the expected negative effect on the number of criminal bosses. Higher wages to drug dealers and collaborating workers and higher fines on drug trafficking will drive drug prices and money laundering costs up. A greater sensitivity of drug consumers to increased prices will reduce drug demand. All this will produce less criminal bosses.

The remainder of this chapter is organized as follows. In Section 2.2, we present some definition of networks and the money laundering model. Sections 2.3-2.6 solve the model. Section 2.7 presents the comparative static effects of some model parameters, and Section 2.8 concludes.

2.2 The Model

We consider a setting in which a society of agents first chooses to be either criminals or workers. Then, by chance some of these criminals become big bosses and choose their foot soldiers for crime purposes. Finally, the big bosses not only have collaborative links with these foot soldiers and workers for performing money laundering, but also choose their collaborative links with other criminal bosses. These collaborative links are pair-wise and costly and help criminal bosses to launder their illegal proceeds. Figure 2.1, presents the sequence of decisions in this game.

Figure 2.1. The sequence of decisions in the smurfing game.

2.2.1 Notation

Let $N=\{1,2,...,n\}$ denote a set of ex-ante identical agents. In the first stage of the game, these agents decide to become either criminals or workers. Agents who become criminals are members of the subset $R \subseteq N$ and divide into two groups in the second stage of the game by chance. Criminals who become big bosses are the member of $S \subseteq R$ and criminals who become foot soldiers are the member of $R \setminus S$. Likewise, agents who decide to participate in the labor market are members of $N \setminus R$. We shall assume that the number of agents is $n > 2$. For any distinct $i, j \in N$, a pairwise relationship between the agent is depicted by a bilateral link $g_{ij} \in \{0,1\}$. We say that agent i has a money laundering link with agent j if $g_{ij} = 1$ and $g_{ij} = 0$ otherwise.

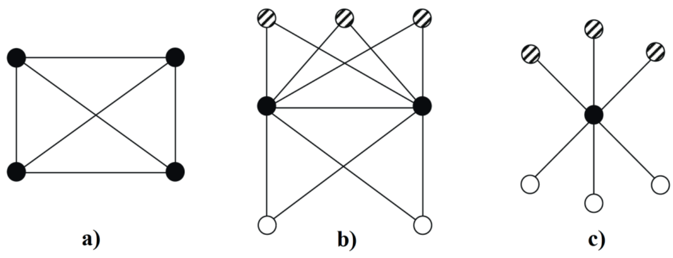
A *network* $g = \{(g_{ij})_{i,j\in N}\}$ is a formal description of the pair-wise collaboration that exists between the agents. Let $g + g_{ij}$ denote the network obtained from g by adding link g_{ij} and $g - g_{ij}$ denote the network obtained by subtracting link g_{ij} from g. Links are undirected, so that $g_{ij} = g_{ji}$ and by convection $g_{ii} = 0$.

Define $N_i(g) = \{j : g_{ij} = 1 \,\&\, j \in N\}$ as the set of agents which agent i has formed a link, $N_i^S(g) = \{j : g_{ij} = 1 \,\&\, j \in S\}$ as a set of bosses which agent i has formed a link and $N_i^{N\setminus S}(g) = \{j : g_{ij} = 1 \,\&\, j \in N \setminus S\}$ as the set of agents except bosses which agent i has formed a link. Let $\eta_i(g) = |N_i(g)|$, $\eta_i^S(g) = |N_i^S(g)|$ and $\eta_i^{N\setminus S}(g) = |N_i^{N\setminus S}(g)|$.

Suppose that s is the number of bosses. We now define two networks that play a prominent role in our analysis. The *complete* network, g^c, is a network in which $g_{ij} = 1 \;\; \forall i, j \in N$. An extended inter-linked star is a partition of agents $\{h_1(g), h_2(g), h_3(g)\}$ with following features:

(i) For all $i \in h_1(g),\; \eta_i(g) = n-1$

Figure 2.2. Pair-wise stable money laundering networks.



Note: In this figure criminal bosses are depicted by filled circle, foot soldiers are depicted by dashed circles, and workers are depicted by empty circles. Figure (a) shows the complete network (n=4). Figures (b) and (c) show the extended inter-linked star networks which are pair-wise stable against transfers ($n=7$).

(ii) For all $j \in h_2(g),\ \eta_j(g) = s$

(iii) For all $k \in h_3(g),\ \eta_k(g) = s$.

2.2.2 The Money Laundering Game

Agents in the labor force earn a wage ω, whereas those involved in criminal activities receive an expected payoff equal to:

$$E[\Pi_i] - \sum_{j\in N\setminus R} t_i^j = \begin{cases} p_i\left(y_i - f\right) + \left(1-p_i\right)y_i - \sum_{j\in N\setminus R} t_i^j & \text{if} \quad i \in S \\ p_i'\left(F - f'\right) + \left(1 - p_i'\right)F - \sum_{j\in N\setminus R} t_i^j & \text{if} \quad i \in R\setminus S \end{cases} \tag{2.1}$$

Criminals will become either a boss or a foot soldier by chance. Based on Becker (1968), we defined y_i as criminal bosses' booty, p_i as his probability of being detected and f the corresponding fine. Also we define F as foot soldier's fixed amount of salary[10], p_i' his probability of being detected and f' the corresponding fine. Criminal bosses try to launder their crime proceeds by adding a link to others to conceal the crime source of this money.

Big bosses launder their dirty money in order to decrease the risk of detection. In addition, money laundering prevents the funds from being confiscated by the police. Criminal bosses want their illegal funds laundered so they can move their crime proceeds through society freely, without the fear

[10] Criminal bosses will give the fixed amount of salary to their foot soldiers. This salary is not high and foot soldiers do not need to launder it.

that the funds can be traced back to them. Therefore, money laundering allows criminal bosses to transform illegally obtained proceeds into seemingly legitimate funds (for a formalization of this reasoning, see Ferwerda, 2009, Appendix 1).

The primary goal in the money laundering process is to funnel the criminal proceeds into the banking system.[11] As already mentioned, in our cases this is done by criminals with a technique called smurfing. The idea is that a criminal boss splits his proceeds in many small amounts and then asks other people to put these small parts into the financial system. The advantage is that many small amounts deposited by different people will raise less suspicion than the deposit of a large amount by one person. More specifically, the criminal should make sure that these smaller amounts are below the reporting thresholds that is relevant in the applicable jurisdiction. E.g. in the US such a reporting threshold for banks is 10,000 USD, while in the Netherlands it is 15,000 Euro. We assume that the more connections a criminal boss has, the lower his individual probability of being caught.

This suggests that the criminal boss may have an incentive to offer transfers to others to induce them to form links. This compensation may take the form of social favors or direct transfers, and should at least cover the cost of linking which are implicitly contained in the detection probability, p_i. Let $t_i = \left\{t_i^1, ..., t_i^n\right\}$ be the transfers offered by agent i to other agents. If $t_i^j > 0$ then this means i pays to j whereas $t_i^j < 0$ means i receives transfers from j. For a balanced set of transfers, it naturally follows $t_i^j = -t_j^i$ for all $i, j \in N$.

We consider the following five-stage money laundering game (see Figure 2.1):

- In the first stage, each agent in N decides to enter the labor market or to become a criminal.
- In the second stage, agents who become criminals divide into two groups, namely big bosses and foot soldiers by chance.
- In the third stage, agents who become big bosses decide about whether they want to link to others for money laundering purposes.
- In the fourth stage, agents who become big bosses choose non-cooperatively the crime effort level they provide, this crime effort level is the number of foot soldiers hired by a boss.
- In the fifth stage, money is earned and laundered. Workers earn ω, foot soldiers earn a fixed amount of F and big boss earn y_i. In addition, policies become effective then and criminals are possibly detected and fined. So, all decisions upfront are in terms of expected payoffs.

In the first stage of the game, all agents receive a crime opportunity. The willingness to become a criminal is represented by a reservation value in equation (2.2) upon which individuals decide to become criminal (Engelhard, Rocheteau and Rupert, 2008). This reservation value depends on current

[11] In this chapter we focus on the placement stage of money laundering. In practice, the detection of money laundering by designated reporting institutions and law enforcement agencies also seems to focus on this stage.

income and prospects for future incomes represented by ω and, in the spirit of Becker (1968), we would expect that a rise in the income available in legal activities reduces the incentive to illegal activities and thus the number of offences.[12]

Criminals decide to commit a crime if the expected utility of being a criminal exceeds the wage they get from being workers. There is also the chance that they will become big bosses and increase their payoff by hiring the foot soldiers. In addition, criminal bosses can add links to other agents to exchange their dirty proceeds with clean ones to conceal the source of their crime money and decrease the chance of being detected by the police. After deciding to add links to others for money laundering purposes, criminals can choose how many foot soldiers they need to perform the crime activity.

In the following, we describe the game in more detail. It should be emphasized that we assume complete information between agents in the network of money laundering. Each agent knows the payoffs of others and strategies available to other agents. Furthermore, workers are aware of performing money laundering operations for criminals.

2.2.3 Criminals' Payoff

The game is solved by backward induction. Suppose that e_i is the criminal boss's effort, which is assumed to correspond to the number of foot solders hired by him. Further we use α to denote the intercept of the crime market, β as the criminal boss' demand elasticity, γ as the adjusted reporting threshold, $\eta_i^S(g)$ as the number of criminal bosses who formed a link with agent i, $\eta_i^{N\setminus S}$ as the number of workers and foot soldiers who formed a link with agent i, $\eta_i(g)$ as the number of agent's i connections, ω as the wage of workers, and ϕ_c' as the foot soldier's crime punishment, F as the foot soldier's fixed amount of salary, and finally ϕ_c and ϕ_m as the expected crime and money laundering punishment respectively. We define individual expected payoffs (2.1) as follows:

$$E\left[\Pi_i\right]=\begin{cases} \underbrace{e_i\left(\alpha-\beta\sum_{j\in S}e_j\right)}_{y_i}-\underset{p_c f_c}{\phi_c}\, e_i\left(1-\gamma\eta_i(g)\right)-e_iF-2\phi_m\eta_i^S(g)-\phi_m\eta_i^{N\setminus S}(g) & \text{if} \quad i\in S \\ F-\phi_c'-\phi_m\eta_i^S(g) & \text{if} \quad i\in R\setminus S \\ \omega-\phi_m\eta_i^S(g) & \text{if} \quad i\in N\setminus R \end{cases} \tag{2.2}$$

[12] Here we also lean on Baumol's (1996) idea that individuals channel their effort in different directions depending on the quality of prevailing economic, political, and legal institutions. In our setting, the institutional structure determines the relative reward (wage) from investing energies into productive market activities versus unproductive criminal activities.

Denote by $e=(e_1,...,e_n)$ a population crime effort profile. The decision to enter the labor market (respectively to become a criminal) at the first stage is implicitly captured by setting $e_i=0$ (respectively $e_i>0$) at the fourth stage.

We define $e_i\left(\alpha-\beta\sum_{j\in S}e_j\right)$ as the criminal boss's booty for which the criminal boss has to compete with all the other criminal bosses in which α is the intercept of the crime market (e.g. the drug market), i.e. it measures how much money a single foot soldier would bring to his boss, if he is the only one in the market. And β measures by how much the earnings per foot soldier go down, when there are more of them in the market (β can therefore be interpreted as – but is not identical to – the elasticity of e.g. the price for a gram of drugs with respect to an additional foot soldier in the market). We shall assume that $\alpha>F$.

In formula (2.2), we decompose $p_i(e,g)f$ from formula (2.1) into two components. Let $\phi_c=p_cf_c$ represent a criminal boss's expected marginal cost of investing one unit of criminal effort, when he has no ties. The expected marginal cost of crime activities decreases by forming money laundering ties. Likewise, let $\phi_c'=p_c'f_c'$ represent a foot soldier's expected punishment when he is engaging in the crime pool. We define $\gamma={r}/{y_i}$, in which r is the reporting threshold of the bank and y_i is the proceeds per criminal boss and $0<\gamma\le 1/(n-1)$, where n is the number of agents who construct the money laundering network (criminals and dishonest workers). Therefore γ is the effectiveness of money laundering which is determined by the adjusted reporting threshold. This effectiveness is an institutional parameter which determines how hard it is to use the money laundering technique smurfing. For example, a low γ means that big bosses have to find more money launderers to separate the dirty money into smaller parts. They need to divide it over more people to stay below the reporting threshold of the bank and to make sure the bank will not report the transaction(s) to the police.[13] Therefore, a lower γ means that a money laundering tie is less effective and that big bosses require more ties to launder a given proceed.

We assume that when a criminal boss i adds a link to another criminal boss in network g , his cost of linking is twice the cost of linking when he adds a link to a worker or a foot soldier. This assumption is based on the following reasoning: criminal bosses can launder their dirty proceeds by adding links directly to a worker or a foot soldier. However, they might also give the money to other criminal bosses who, through their own links to workers and foot soldiers, launder their money for them. As the money is indirectly channeled in this case, the chance of detection are twice as high and therefore the criminal boss's cost of linking to another criminal boss is twice the cost of linking directly

[13] This reporting to the police is normally done indirectly. The bank reports suspicious transactions to a central institution, the FIU, which filters out the relevant reports and forwards them to a relevant law enforcement agency.

to a worker or a foot soldier. Since criminal bosses either do not necessarily know all dishonest workers or finding a worker to launder the money may be difficult and risky, they have to add links to other criminal bosses for money laundering purposes.

However, the decision to launder dirty money is not risk-free for criminal bosses, because money laundering is a crime. If the illegal tie is detected, the criminal boss will not only lose the expenses paid for the money laundering operations, but he will also suffer legal sanctions. We define the costs of linking as the expected sanction $\phi_m = p_m f_m$, given by the probability of being caught when criminals or workers engage in money laundering operations, p_m, times the fine related to the conviction for money laundering, f_m.

Consider $s > 0$ criminal bosses in the society, where a criminal boss $i \in S$ has no money laundering ties and the network between all other bosses has the shape of an extended inter-linked star network of money laundering. The cost of linking, $\phi_m = p_m f_m$, is such that:

$$E\left[\Pi_i \middle| g + g_{ij}\right] - E\left[\Pi_i \middle| g\right] > 0 \tag{2.3}$$

for j being either a worker (foot soldier) or another criminal. This requires:[14]

$$0 < 2\phi_m < \frac{\phi_c \gamma (s-1)}{\beta^2 (s+1)^2}\left[2(\alpha - \phi_c - F) + \phi_c \gamma (s-1)(5-2n)\right] \tag{2.4}$$

This assumption requires several justifications: first, the binding condition (2.3) concerns the incremental payoff from criminal boss i's link to another agent j and is derived from the optimal crime level efforts in stage four (see below). Second, this assumption is equivalent to the Goyal & Joshi (2003) analysis of R&D networks with small linking costs. The assumption will have strong implications for the shape of the equilibrium networks of money laundering ties, because it suggests that regardless of the initial network g all criminal bosses would want to link to every other player with which they are not yet connected. For example, Proposition 2.1 is an immediate result of this assumption. However, We should also stress that the level of linking costs will still determine the number of criminal bosses in our society, because a higher risk of being caught will deter entry into the criminal occupation. We discuss the assumption further in the conclusion of this chapter.

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[14] When criminal boss i adds a link to either a worker or a foot soldier in network g, his incremental payoff is as follows:

$$E\left[\Pi_i \middle| g + g_{ij}, e^*(g + g_{ij})\right] - E\left[\Pi_i \middle| g, e^*(g)\right] = \frac{\phi_c \gamma s}{\beta^2 (s+1)^2}\left[2(\alpha - \phi_c - F) + \phi_c \gamma ((s-1)(5-2n)+1)\right] - 2\phi_m > 0$$

Therefore, when this criminal boss adds a link to another criminal boss in the complete component of network g, his expected payoff is smaller than when he adds a link to a worker or foot soldier.

2.3 The Forth-Stage: Criminal Network between Bosses and Foot Soldiers

In this stage we consider the crime network between bosses and their foot soldiers. Each boss chooses his own foot soldiers for crime activity. Bosses form links to foot soldiers as long as the marginal earning from adding one additional foot soldier is more or equal to the fixed amount of salary which they have to pay to the foot soldiers. In other words, bosses expand their crime network by forming links to the foot soldiers as long as $\partial y_i / \partial e_i \geq F$. Because competition in the crime market increases with every additional foot soldier, the equality must be strict in equilibrium.

Suppose S is the subset of criminal bosses in any network g and the net profit of each boss $i \in S$ is given by (2.2). Suppose that s is the number of big bosses and r is the number of criminals in the society. If a typical boss hires e_i^* foot soldiers, then in a market-clearing equilibrium the relationship $r = s\left(e_i + 1\right)$ must hold, which is what we exploit in stage one of the game.

Here, we are going to determine the equilibrium level e_i^* of foot soldiers hired by a typical boss under the assumption that there are sufficient foot soldiers to satisfy his demand. Taking the first derivative of equation (2.2) with respect to e_i and solving the order condition, leads to the following best response function of the number of foot soldiers:

$$\begin{aligned}
&\frac{\partial E\left[\Pi_i\right]}{\partial e_i} = \alpha - \beta \sum\nolimits_{j \in S} e_j - \beta e_i - \phi_c \left(1 - \gamma \eta_i(g)\right) - F = 0 \Rightarrow \\
&\quad \beta e_i = \alpha - \beta \sum\nolimits_{j \in S} e_j - \phi_c \left(1 - \gamma \eta_i(g)\right) - F \Rightarrow \\
&\quad \beta \sum\nolimits_{i \in S} e_i = \sum\nolimits_{i \in S} \alpha - \beta \sum\nolimits_{i \in S} \sum\nolimits_{j \in S} e_j - \sum\nolimits_{i \in S} \phi_c + \sum\nolimits_{i \in S} \phi_c \eta_i(g) \gamma - \sum\nolimits_{i \in S} F \Rightarrow \\
&\quad \sum\nolimits_{i \in S} e_i = \frac{s\alpha - s\phi_c + \phi_c \sum\nolimits_{i \in S} \eta_i(g)\gamma - sF}{\beta\left(s+1\right)}
\end{aligned} \tag{2.5}$$

Note that $\sum\nolimits_{i \in S} e_i = \sum\nolimits_{j \in S} e_j$. Therefore, by substituting $\sum\nolimits_{i \in S} e_i$ equation into $\sum\nolimits_{j \in S} e_j$ in equation (2.5) we reach the following crime effort level:

$$e_i = \frac{\alpha - \phi_c - F + s\phi_c \eta_i(g)\gamma - \phi_c \sum\nolimits_{j \in S \setminus \{i\}} \eta_j(g)\gamma}{\beta\left(s+1\right)} \tag{2.6}$$

By substituting equation (2.6) into equation (2.2) for all $i \in S$ the net profit is given by:

$$E\left[\Pi_i \left| g\right.\right] = e_i^2\left(g\right) - 2\phi_m \eta_i^S(g) - \phi_m \eta_i^{N\setminus S}(g) \tag{2.7}$$

We now move on to show what the shape of the money laundering network is when criminal bosses correctly anticipate the effort levels presented in (2.6).

2.4 The Third-Stage: Money Laundering Network between Bosses and Others

We now study the architecture of the money laundering network under the assumption that criminal bosses, foot soldiers, and workers perfectly foresee the expected benefits and costs of the fifth stage-game. The payoffs of criminal bosses, foot soldiers, and workers are determined by (2.2) and (2.6). These payoffs depend on the geometry of the network connecting them. Some agents may thus have incentives to manipulate the network to their advantage. Criminal bosses benefit from their money laundering ties with other agents, because this allows them to exchange their criminal proceeds with clean ones and to conceal the source of their crime money. Nevertheless, their money laundering activity also inflicts costs on criminals as well as on the cooperating workers. It is costly for workers, because if authorities detect their money laundering operations, these workers will be arrested and punished as well. Therefore, criminal bosses need to bribe workers by means of some side payment. These considerations motivate an analysis of the nature of stable networks when transfers are allowed across agents.

Following the stability concept of Goyal and Joshi (2003) which is inspired by the notion of stability presented in Jackson and Wolinsky (1996), a network g of money laundering is defined to be pairwise stable if any agent who is linked to another agent in the network has an incentive to maintain the link and any two agents who are not linked have no incentive to form a link with each other. Mathematically, the concept of stability we use is defined as follows:[15]

Definition 2.1. *A network g is stable against transfers if:*

(1) For all $g_{ij} = 1$,

$$\left(E\left[\Pi_i \left| g\right.\right] - E\left[\Pi_i \left| g - g_{ij}\right.\right]\right) + \left(E\left[\Pi_j \left| g\right.\right] - E\left[\Pi_j \left| g - g_{ij}\right.\right]\right) > 0 \;\;,\;\; \forall i, j \in N.$$

(2) For all $g_{ij} = 0$,

[15] Goyal and Joshi (2003) have a third condition to guarantee that no agent would remove all his ties simultaneously. However, they show later in their paper that, given the shape of their (and our) payoff function, condition (3) is automatically satisfied if condition (2) is satisfied.

$$\left(E\left[\Pi_i \middle| g+g_{ij}\right]-E\left[\Pi_i \middle| g\right]\right)+\left(E\left[\Pi_j \middle| g+g_{ij}\right]-E\left[\Pi_j \middle| g\right]\right)<0 \ , \ \forall i,j\in N.$$

The next lemma shows that the net profits of a criminal boss exhibit increasing returns with respect to the number of links which the boss has with others.

Lemma 2.1. *Suppose g is a network with n agents where r is the number of criminals, the number of bosses is $0<s<r$, payoff satisfies (2.2), and crime effort level satisfies (2.6).*
Consider any network g and distinct agents $i\in S$ and $j,k\in N\setminus R$, $g_{ij}=g_{ik}=0$. Then:

$$E\left[\Pi_i \middle| g+g_{ij}+g_{ik}\right]-E\left[\Pi_i \middle| g+g_{ij}\right]>E\left[\Pi_i \middle| g+g_{ij}\right]-E\left[\Pi_i \middle| g\right].$$

Proof. The proof is given in Appendix A.

As can be seen from Lemma 2.1, a criminal boss's incremental payoff from forming a link with another agent increases with every link he already possesses in the money laundering network. We refer to this property as "economies of scale in linking" and it provides a theoretical foundation for the famous "multiplier effect" which means that more money laundering opportunities increase criminal investments (Masciandaro, 1999). Because every money laundering connection helps a criminal boss to reduce the expected costs to an additional unit of crime effort, having more ties spurs the incentives for additional criminal operations.

We now develop a complete characterization of the architecture of stable money laundering networks. A first observation is that by the virtue of low linking cost assumption, the empty network of criminal bosses is certainly not a stable network. The reason is that even in the worst circumstances a criminal boss would be willing to form a link with another agent, because linking cost are so small. Since the empty network is not the worst case a criminal boss might be in, he is definitely willing to form a link there too. In order to find the money laundering networks, the behavior of at least three agents must be taken into account: the criminal boss, on the other the foot soldiers and finally workers.

Part (i) of the following lemma provides a partial characterization of a stable network, and it is a result of assuming low linking cost. Part (ii) and (iii) of the following lemma state that in a stable money laundering network workers as well as foot soldiers do not form links among each other.

Lemma 2.2. *In any stable money laundering network we have the following results:*

(i) Criminal bosses form the complete component among each other.
(ii) Workers do not have an incentive to form money laundering collaboration links with each other.
(iii) Foot soldiers do not have an incentive to form any money laundering links among each other.

Proof. The proof is given in Appendix A.

The above result follows simply from the fact that workers and foot soldiers would only risk detection without having the benefit of cleaner money. Criminal bosses, on the other hand, might be willing to pay transfers to workers to form a link with them. If these transfers are higher than the worker's expected cost of linking, a worker may indeed want to form a link.

In the next proposition we will show that the resulting money laundering network is an extended inter-linked star and that this network is the unique stable network against transfers for low ϕ_m.

Proposition 2.1. *Suppose that payoff satisfies (2.2), and crime effort level satisfies (2.6). Network* g *is stable against transfers if and only if it is an extended inter-linked star.*
Proof. The proof is given in Appendix A.

Extended inter-linked stars are illustrated in Figure 2.2, where Figure 2.2 (b) presents a money laundering network with two criminal bosses, three foot soldiers, and two workers, whereas Figure 2.2 (c) presents a money laundering network with one criminal boss, three foot soldiers, and three workers.

2.5 The Second-Stage: The Criminal Hierarchy

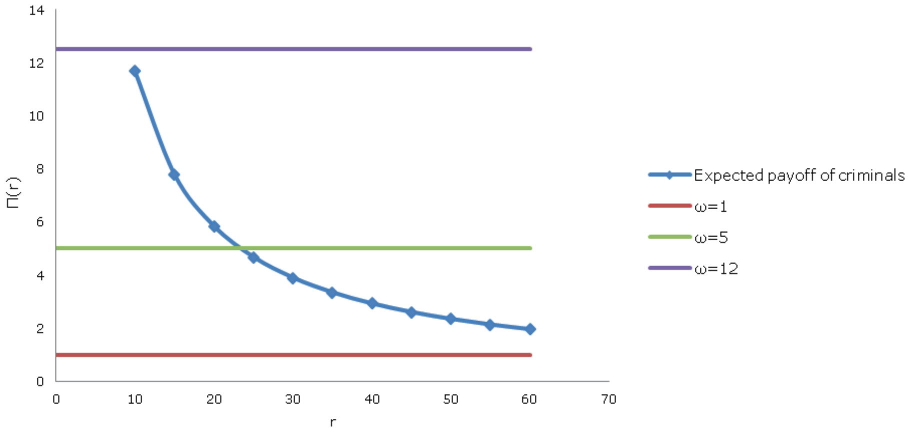
In the second stage of the game, we assume that criminals will become either a criminal boss or a foot soldier by chance. Suppose the number of criminals is r and that all these criminals aim to become a boss. However, it is clear that not everyone will eventually become a boss since a lot of people are competing for very few prizes and hoping for an opportunity. At the beginning of a criminal career, it is difficult to predict whether someone has the potential to become a criminal boss or whether he ends up as a foot soldier, after all, this career is not what he has been prepared for at school or at home. So, for someone who chooses this type of occupation, we assume that his career looks like a lottery (Levitt & Dubner, 2010).

Suppose that criminal $i \in R$ aims to become a criminal boss. The chance that agent $i \in R$ becomes a criminal boss with $(s-1)$ other bosses from the remaining $(r-1)$ criminals is as follows:

The chance that agent $i \in R$ becomes a criminal boos: $\dfrac{\binom{r-1}{s-1}}{\binom{r}{s}} = \dfrac{s}{r}$

The number of bosses is fixed by the fact that in a market-clearing equilibrium it must hold that there are just enough foot soldiers to satisfy the demand of criminal bosses, i.e., the value for $s(r)$ is given by the relationship $r = s(e_i + 1)$.

Figure 2.3. First stage of the game.



Note: Occupational decision for different wage (ω) levels with, $n = 100$, $\phi_m = 0.00001$, $\phi_c = 0.05$, $\phi_c{}' = 0.001$ and $\gamma = 0.009$.

The remaining $(r - s)$ criminals which didn't have a chance to become a boss will end up becoming foot soldiers and will be hired by a boss. We assume that at this stage of a criminal career, it is too late for a foot soldier to return to a normal live, and that he would therefore accept any F as long as what he earns is better than having nothing. Therefore foot soldiers earn less than the minimum average wage (Levitt & Dubner, 2010). Thus, we assume that the value of this fixed amount of salary is equal to $\phi_c{}'$, hence, $F = \phi_c{}'$.

2.6 The First-Stage: The Market for Criminals

At the first stage of the money laundering game, we model agents' decisions for one of the two occupations: becoming a worker or a criminal.

We assume that all agents correctly anticipate the equilibrium money laundering network of stage two. Hence, an agent will decide to become criminal if the anticipated crime proceeds are above the reservation value. However, the payoffs of the one or the other occupation also depend on the expectation of side payments to be received or made. Note that workers accept contacts to criminals, provided that they are at least compensated for their linking costs. We assume in the following that the value of this transfer is equal to ϕ_m, hence, transfers just compensate for the worker's costs, meaning that $t_i^j = \phi_m$ in which $i \in S, j \in N \setminus R$.

Moreover, for simplicity we will assume that the entry of a single additional worker into the criminal pool will not have an effect on the number of bosses in stage two of our game[16]. Formally, $ds(r)/dr = 0$.

Under these assumptions, the payoff of each agent i is given by (2.8).[17]

$$E\left[\Pi_i\right] = \begin{cases} \frac{s}{r}\left(e_i^2(g) - 2\phi_m(n-1)\right) & \text{if} \quad i \in R \\ \omega & \text{if} \quad i \in N \setminus R \end{cases} \tag{2.8}$$

The decision problem (2.8) is illustrated in Figure 2.3. The vertical axis shows the payoff of the marginal agent who is pondering about becoming a criminal as a function of the number of criminals already in the pool. As can be seen in this figure, an agent's willingness to become a criminal is endogenously determined. In particular, it declining as the number of other active criminals increases, because of the increased intensity of competition in the criminal market. As a result, when wages are high, it does not pay off to become a criminal regardless of the number of other criminals. Also, when wages are very low, the expected crime proceeds are higher regardless of the number of incumbent criminals. In between, when the wage line intersects with the criminal payoff curve, the marginal agent becomes criminal as long as the number of incumbent criminals is sufficiently low.
Hence, the equilibrium of the first stage game is characterized by following proposition:

Proposition 2.2. *Suppose payoff satisfies (2.8) and crime effort level satisfies (2.6). Then the following properties hold:*

(i) When $\omega \geq E\left[\Pi \middle| r = 1\right]$ *then there exists a unique equilibrium in which every agent enters the labor market.*

(ii) When $\omega \leq E\left[\Pi \middle| r = n\right]$ *then there exists a unique equilibrium in which every agent becomes a criminal.*

(iii) When $E\left[\Pi \middle| r = 1\right] < \omega < E\left[\Pi \middle| r = n\right]$ *then there exists a unique equilibrium number of criminals* r^* *such that* $E\left[\Pi \middle| r^*\right] \geq \omega$ *and* $E\left[\Pi \middle| r^* + 1\right] < \omega$*. The equilibrium number of criminals is:*

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[16] Since there is so many criminals, but the chance of becoming a boss is too low.

[17] Criminals might end up either as a criminal boss or a foot soldier. The expected payoff of all criminals is as follows:

$$E\left[\Pi_i\right] = \frac{s}{r}\left[e_i^2(g) - 2\phi_m(n-1)\right] + \left(1 - \frac{s}{r}\right)\left(F - \phi_c'\right) \quad \text{if} \quad i \in R$$

In the second stage of the game we assume that $F = \phi_c'$. Therefore the zero profit of a foot soldier stems from this result.

$$r^* = \frac{s\left(e_i^2(g) - 2\phi_m(n-1)\right)}{\omega}$$

Proof. The proof is given in Appendix A.

Furthermore, when applying the market-clearing relationship, $r = s\left(e_i + 1\right)$, allows to calculate the equilibrium number of criminal bosses as follows:

Proposition 2.3. *Suppose payoff satisfies (2.8) and crime effort level satisfies (2.6). Then the equilibrium number of criminal bosses is:*

$$s^* = \frac{\left(\alpha - \phi_c - F + \phi_c\gamma(n-1)\right)\left(\sqrt{\omega^2 + 4\left(\omega + 2\phi_m(n-1)\right)} - \omega\right)}{2\beta\left(\omega + 2\phi_m(n-1)\right)} - 1$$

Proof: The proof is given in Appendix A.

2.7 Comparative Static Analyses

In the previous sections, we have shown that the model has a unique equilibrium. This invites some comparative statics analyses with regard to the key parameters, adjusted reporting threshold, foot soldier's fixed amount of salary, the size of the crime market, wage of workers, and crime and money laundering punishment. Since only the criminal boss has enough money to launder, we consider the number of bosses as the dependent variable.

Denote $a = \omega + 2\phi_m\left(n-1\right)$ and $b = \alpha - \phi_c - F + \phi_c\gamma\left(n-1\right)$. Then, the following comparative static results can be derived.

The number of bosses is larger, the higher the adjusted reporting threshold:

$$\frac{\partial s}{\partial \gamma} = \frac{\phi_c\left(n-1\right)\left(\sqrt{\omega^2 + 4a} - \omega\right)}{2\beta a} > 0$$

Therefore, when the reporting threshold of the bank increases, a criminal boss can launder his money easier and cheaper by forming less money laundering ties. The result is intuitive because, as was already mentioned in the introduction, criminal boss send their money to their foot soldiers and other launderette owners to keep the money below this reporting threshold. When the reporting threshold of the bank increase, a criminal boss can launder his money easier as he does not need to form many links for laundering purposes.

The number of bosses is lower, the higher the foot soldier's fixed amount of salary:

$$\frac{\partial s}{\partial F} = \frac{\omega - \sqrt{\omega^2 + 4a}}{2\beta a} < 0$$

The above result shows that when the foot soldier's fixed amount of salary increases, the number of bosses decreases. According to Levitt & Dubner (2010), criminal bosses can easily afford to pay their foot soldiers more, but it will not be prudent since big bosses have to show their foot soldiers that they are the boss. If a criminal boss starts taking losses, foot soldiers see him weak and aim to take over his position. This is reflected in our model since by increasing the fixed amount of salary, the number of bosses decreases.

The number of bosses is larger, the higher the size of the crime market:

$$\frac{\partial s}{\partial \alpha} = \frac{\sqrt{\omega^2 + 4a} - \omega}{2\beta a} > 0$$

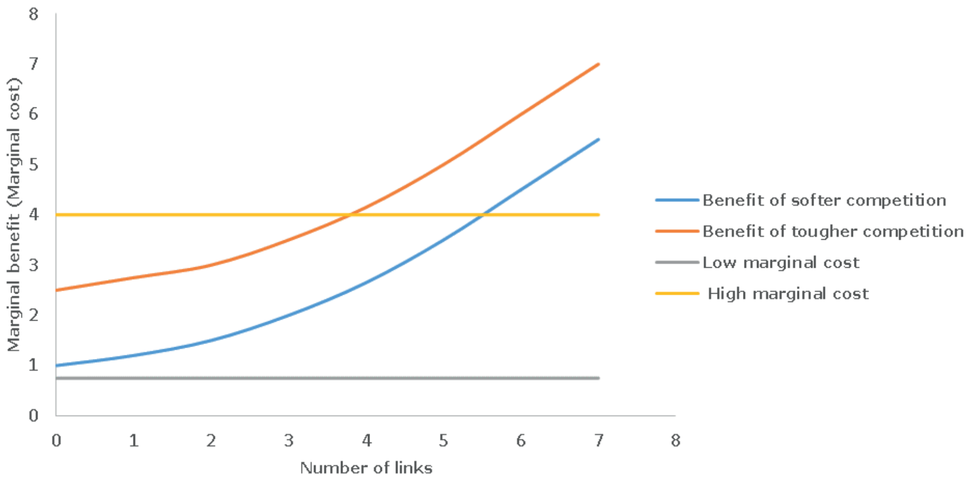
From the above result we conclude that when the size of the crime market increases, the number of bosses increases as well. The result is intuitive because by increasing the size of the crime market, agents has more incentives to become a criminal boss and earn more money.

The number of bosses is lower, the higher the wage of the workers:

$$\frac{\partial s}{\partial \omega} = \frac{-b}{2\beta a^2 \sqrt{\omega^2 + 4a}} \left[(a - \omega)\left(\sqrt{\omega^2 + 4a} - \omega + 2 \right) + 2\omega \right] < 0$$

By virtue of the above results we conclude that by increasing the wage of workers, the number of bosses decreases since the number of criminals decreases. Criminal activities would be seen as a 'buffer' that economic agents use in 'bad times'. Therefore a relatively larger GDP could mean greater opportunities, better living conditions and hence form a deterrent to being a member of the criminal sector (Bagella, Busato and Argentiero, 2013). According to on Levitt & Dubner (2010) people do not grow up dreaming of becoming criminals, so the supply of potential criminals is relatively small. Moreover, the chance of becoming a foot soldier is much higher than becoming a criminal boss. Furthermore, foot soldiers who are known as the street-level salesmen, along with their bad payment,

Figure 2.4: Size of the money laundering network and the magnitude of linking cost.



Note: The figure plots the marginal benefit and marginal cost of an added money laundering tie against the current number of money laundering links of a criminal boss (with a limit of $n-1$ links). Irrespective of the size of the linking cost and the intensity of competition in the criminal market, the net benefit of an extra link is a convex function of the current links. Thus, in equilibrium, a criminal boss either has 0 or $n-1$ links.

face terrible job conditions. They have to stand on a street corner all day and sell drugs. They also risk being arrested, inflicted with violence, and even run the chance of being killed. This reasoning is in line with our finding that when the wage of workers increases the number of criminals decreases. When there are not enough foot soldiers around to work as a drug dealer for a boss, the number of criminal bosses decreases as well.

The number of bosses is lower, the higher the crime punishment:

$$\frac{\partial s}{\partial \phi_c} = \frac{\left(1-\gamma(n-1)\right)\left(\omega-\sqrt{\omega^2+4a}\right)}{2\beta a} < 0$$

As punishment is a deterrence variable, when the crime punishment increases the number of bosses decreases.

The number of bosses is lower, the higher the money laundering punishment:

$$\frac{\partial s}{\partial \phi_m} = \frac{b(n-1)\left(\omega\sqrt{\omega^2+4a}-\omega^2-2a\right)}{\beta a^2\sqrt{\omega^2+4a}} < 0$$

Masciandaro (2013) shows that the costs of money laundering procedures depend on the anti-money laundering regulation, given that the legal regulations and their enforcement increase the transaction costs. Every improvement in the effectiveness of the anti-money laundering regulation will produce a decrease in the money laundering activity. The above equation confirms Masciandaro (2013) and shows that when the money laundering punishment increases, the number of bosses decreases, i,e, punishment is a deterrence variable.

2.8 Conclusion and Discussion

In this chapter, we develop a model of network formation to explore the incentives of criminal organizations to form money laundering links. In particular, we determine and characterize the unique subgame perfect equilibrium of a five-stage game where people in a society decide for or against a criminal career, find a place in a criminal organization, and decide about the level of criminal activity as well as seek the help of money launderers in case they advance to the head of an organization. All in all, the findings of this chapter address the first research question of this thesis concerning the shape of a money laundering network. The answer that we develop is that if the costs of forming and maintaining money laundering ties are reasonably small, then an extended inter-linked star structure is the uniquely stable network. Thus, despite its complicated structure, the model allows for a unique subgame-perfect equilibrium. This in turn invites an analysis of policies to fight money laundering and drug trafficking which is the subject of the following chapter.

This naturally raises the question what happens to the model's predictions when high linking costs are assumed instead? Figure 2.4 helps us to understand this. The figure plots the gross marginal benefit and marginal cost of adding money laundering ties against the current number of money laundering ties of a criminal boss. As illustrated in the figure, the marginal benefit of a link is an increasing function of a boss's own ties, which is a consequence of the "feedback effect" highlighted in this chapter. Additionally, however, the marginal benefit depends on the number of money laundering ties of other criminal organizations and, thus, by the logic of the "multiplier effect", on the intensity of competition in the criminal market. Throughout this chapter, we have looked at the case of low linking cost, i.e., the grey line in Figure 2.4, so that even for a single boss who is left out of an inter-linked star of all other bosses, it pays off to form money laundering links (for the formal condition, see Footnote 14). If linking costs were instead high (the yellow line in the figure), a boss would not want to form a link, while all other bosses keep their links.[18] If one would exclude two bosses from the inter-linked star, instead, and if the marginal benefit function of each of the two bosses were represented by the red line in Figure 2.4, neither of them would want to form any link. In other words, high linking costs give rise to multiple stable networks: a criminal boss might either maintain a link with all available money launderers or might not establish any link at all. Yet, the architecture of all these stable networks is still the same inter-linked star structure that is highlighted in this chapter.

[18] This strictly speaking requires that the integral of the net marginal benefit function (the blue line minus the yellow line in the figure) over the range between 0 and $n-1$ is positive.

Bibliography

Anthony, R., & Fries, A. (2004). Empirical modelling of narcotics trafficking from farm gate to street. Bull Narc, 1-48.

Bagella, M., Busato, F., & Argentiero, A. (2013). Using dynamic macroeconomics for estimating money laundering: a simulation for the EU, Italy and the United States. Research Handbook on Money Laundering, 207.

Baumol, W. J. (1996). Entrepreneurship: Productive, unproductive, and destructive. Journal of Business Venturing, 11(1), 3-22.

Becker, G. S. (1968). Crime and punishment: An economic approach. In The Economic Dimensions of Crime (pp. 13-68). Palgrave Macmillan UK.

Engelhardt, B., Rocheteau, G., & Rupert, P. (2008). Crime and the labor market: A search model with optimal contracts. Journal of Public Economics, 92(10), 1876-1891.

Ferwerda, J. (2009). The economics of crime and money laundering: does anti-money laundering policy reduce crime?. Review of Law and Economics, 5(2).

Goyal, S., & Joshi, S. (2003). Networks of collaboration in oligopoly. Games and Economic behavior, 43(1), 57-85.

Jackson, M. O., & Wolinsky, A. (1996). A strategic model of social and economic networks. Journal of economic theory, 71(1), 44-74.

Kilmer, B., & Reuter, P. H. (2009). Prime Numbers Doped. Foreign Policy, 175, 2-6.

Levitt, S. D., & Venkatesh, S. A. (2000). An economic analysis of a drug-selling gang's finances. The Quarterly Journal of Economics, 115(3), 755-789.

Levitt, S. D., & Dubner, S. J. (2010). Freakonomics (Vol. 61). Sperling & Kupfer editori.

Mackrell, N. (1996). Economic consequences of money laundering. Research and Public Policy Series, (2), 29.

Masciandaro, D. (1999). Money laundering: the economics of regulation. European Journal of Law and Economics, 7(3), 225-240.

Masciandaro, D. (2013). Money laundering and its effects on crime: a macroeconomic approach. Research Handbook on Money Laundering, 47.

Pietschmann, T. (2013). 16. Efforts of the UN to find out about major routes of drugs and drug money. Research Handbook on Money Laundering, 194.

Chapter 3

A Microeconomic Foundation for Optimal Money Laundering Policies*

3.1 Introduction

The previous chapter developed a microeconomic model of a criminal society where a few large criminal organizations hire a number of foot soldiers and maintain money laundering ties with bank employees to launder their crime proceeds. On the macro level, these money laundering ties result in a network that spans all agents with criminal intent. In this chapter, we expand on the model of Chapter 2 by focusing on the development of policy recommendations to fight money laundering. To do this, we simplify the model by abstracting from the internal structure of a criminal organization: whoever starts a criminal career becomes the boss of an organization and the number of foot soldiers a boss hires is simply represented by his criminal effort. Thus, the network looked at in this chapter only consists of ties between criminal bosses and money launderers. An alternative motivation for my model is a society of criminal entrepreneurs who form a non-hierarchical network, which is according to Kleemans (2007) the predominant form of the criminal organization, for example, in the Netherlands. On the other hand, we introduce a new actor to the game: a law enforcement agency that aims to find, arrest, and punish criminals.

We assume that the agency has a limited budget available to divide over two policy goals: to fight crime and to fight money laundering. The agency spends money on personnel and equipment to monitor people and financial transactions and to investigate their criminal activity. We make the simplifying assumption that the more money the agency spends on a policy goal, the greater the chance of either catching a criminal subject or detecting an illicit transaction in the large number of mostly legal financial transactions. The aim of the agency is to minimize the total criminal efforts, while keeping its budget at a tolerable level. This raises the question of why the agency does not invest all its money in the anti-crime policy? There is widespread consensus among money laundering researchers and policy makers that the fundamental rationale for money laundering controls is not to reduce the amount of money laundered, but to dry out and fight criminal organizations (e.g. Reuter and Truman, 2004 and Ferwerda, 2012). This rationale is also part of the present model: both types of

* The study presented in this chapter is joint work with Stephanie Rosenkranz, Bastian Westbrock, Brigitte Unger and Joras Ferwerda.

policies ultimately deter criminal activity in the society. The budget spend on anti-crime policies does so directly by increasing the risk of being detected in flagrante. The money spend on the fight against money laundering, in contrast, has only an indirect deterrence effect, because it reduces, in a first instance, a criminal's prospects of hiding his proceeds. This indirect effect might, however, be stronger than the direct effect which depends on the legal, technological, and economic conditions of the society in question.

We develop recommendations for an optimal budget sharing rule between crime and money laundering policies. The optimal budget share is dependent on the parameters of the model, the reporting threshold for financial transactions, and the economy's labor market conditions. First, We show that when the reporting threshold for financial transactions increases the optimal crime budget share declines. A higher threshold means that criminals can transfer larger chunks of money without the fear of a rule-based suspicious activity report by their financial institution. Hence, crime activity increases, because criminals can more easily hide their proceeds. This in turn implies that the agency should focus on a more in-depth, risk-based investigation of financial transactions, even those below the threshold. Second, we find that next to the well-known direct effect that a higher legal wage leads to lower crime rates (Becker, 1968; Engelhard, Rocheteau and Rupert, 2008), an economy's wage level also plays a decisive role in the determination of the optimal budget split. By increasing the wage level the optimal money laundering budget share decreases, because both the number of criminals as well as the number of ties decreases, but the number of money laundering ties decreases significantly more as each criminal has many money laundering ties. In this respect anti-crime policies become relatively more effective than anti-money laundering policies. Third, we show that the optimal anti-crime budget share increases in line with the penalty for the crime (drug trafficking in the model), and the same complementary relationship holds for anti-money laundering policies and the penalties on money laundering. This seems at odds with the widely held view that a high penalty on a criminal act allows an agency to slack on the prosecution of this crime, because the overall deterrence effect will still be high (Becker, 1968). However, by prosecuting precisely those types of crimes that are penalized most severely, the deterrence effect of the overall budget will be maximized. Thus, the result of the present model is that an agency should focus its attention precisely on those types of criminal acts.

Finally, to illustrate the predictions of the model we calculate the optimal budget sharing rule for the Netherlands. Towards this end, we make use of the sufficient statistics approach pioneered by Chetty (2009). In line with this approach, a nice feature of the model is that the formula for the optimal budget share depends on no more than just a few constructs of parameters and variables that have some immediate real-world correspondences. In particular, to predict the optimal budget share, one needs no more than an estimate of the average wage in the legal economy, an estimate of the size of the criminal market in a country, an estimate of the probability of detecting illicit money laundering transactions, and the level of fines on money laundering. For the wage of workers, we use data from the Dutch Central Planning Bureau and the Central Bureau of Statistics. To quantify the total proceeds of drug crimes, we use data collected by Savona and Riccardi (2015, p.122), Killmer and Pacula (2009), and Caulkins et al. (2013). For the fines on money laundering, we use an estimate from the ECOLEF[19] study. Finally, for the crime and money laundering probabilities of detection, we use 10% for the purpose of illustration, since these values are by definition unknown. My calculations for the Netherlands show that the optimal budget share for fighting money laundering is 30%.

The model presented in this chapter is related to several strands in the existing literatures. It is related to the theoretical network literature on crime, in particular Ballester, Calvó-Armengol and Zenou (2006) who derive a network statistic to target the key player in a network. In their definition, the key player is the person who once removed, leads to the maximal change in aggregate criminal activity. Thus, by targeting the key criminal in a network, an agency can make substantial changes in the overall criminal activity. However, to find the key player in a network, the whole structure of the network has to be known. However, for a crime network it is not possible to know the shape of the network. In the equilibrium of the present model, all criminals have the same number of links and there is, thus, no single key player. Therefore, in the model, the agency randomly targets all people and financial transactions in the network. The present study is also related to Gaigné and Zenou (2015). The authors theoretically show that an increase in the number of policemen (by increasing workers' income taxes) has an ambiguous effect on crime rates. On the one hand, it directly deters crime, because criminals are more likely to be arrested but, on the other, it induces more people to become criminals, since the net income of workers decreases. Just like in the model of the authors, we consider a policy that randomly targets people and financial transactions and more police men lead to a higher probability of detection. The difference of the present model to both these papers is that there the entire anti-crime budget is spent on fighting one particular criminal activity. In the present model, in contrast, we focus on the optimal budget split to fight crime and money laundering.

The remainder of this chapter is structured as follows. In Section 3.2, we define the network structures relevant for the analysis and present my money laundering model. Section 3.3-3.5 solve the model. In Section 3.6, we derive the optimal budget sharing rule for a law enforcement agency. Section 3.7 shows my empirical results for the Netherlands and Section 3.8 concludes. For the proof of all lemmas and propositions please see Appendix B.

3.2 The Model

We consider a setting in which a society of agents first chooses to be either criminals or workers. Then, the criminals choose their collaboration links with other criminals and workers. These collaboration links are pair-wise and costly and help criminals to launder their illegal proceeds.

[19] ECOLEF is an EU financed project on the Economic and Legal Effectiveness of Anti-Money Laundering and Counter Terrorism Financing in the 27 EU Member States.

3.2.1 Notation

Let $N = \{1,2,...,n\}$ denote a set of ex-ante identical agents. In the first stage of the game, these agents decide to be either criminals or workers. Agents who become criminals are members of

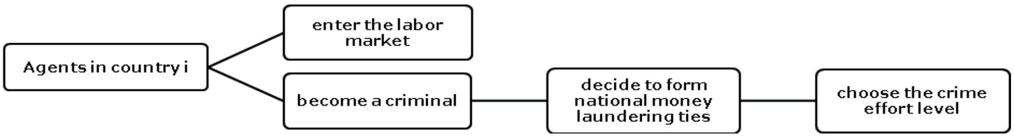


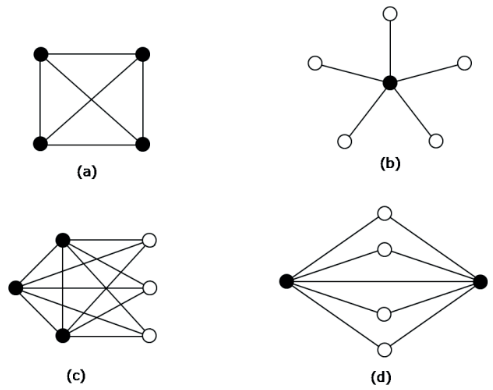
Figure 3.1. The sequence of decisions in the smurfing game.

$N \setminus S$. We shall assume that the number of agents is $n \geq 3$. Let i and j be typical members of this set and for any $i, j \in N$, the pair-wise relationship between the two agents is captured by a binary variable $g_{ij} \in \{0,1\}$. Agent i has a money laundering link with agent j if $g_{ij} = 1$ and $g_{ij} = 0$ otherwise. A network $g = \{(g_{ij})_{i,j \in N}\}$ is a formal description of the pair-wise collaboration that exists between the agents. Let $g + g_{ij}$ denote the network obtained by replacing $g_{ij} = 0$ in network g by $g_{ij} = 1$ and $g - g_{ij}$ denote the network obtained by replacing $g_{ij} = 1$ in network g by $g_{ij} = 0$. Links are taken to be reciprocal (undirected), so that $g_{ij} = g_{ji}$. By convention, $g_{ii} = 0$. Let $N_i(g) = \{j \in N \setminus \{i\} : g_{ij} = 1\}$ denote the set of players in $N \setminus \{i\}$ directly connected to i, and let $\eta_i(g) = |N_i(g)|$ be the size of this set, which denotes agent i's degree. Define $N_i^{N \setminus S}(g) = \{j : g_{ij} = 1 \,\&\, j \in N \setminus S\}$ as the set of workers with whom i has formed a link and $N_i^S(g) = \{j : g_{ij} = 1 \,\&\, j \in S\}$ denote the set of criminals that formed a link with i, and let $\eta_i^{N \setminus S}(g) = |N_i^{N \setminus S}(g)|$ and $\eta_i^S(g) = |N_i^S(g)|$.

We now define two networks that play a prominent role in our analysis. The *complete* network, g^c, is a network in which $g_{ij} = 1 \quad \forall i, j \in N$. An *inter-link star* is a partition of agents $\{h_1(g), h_2(g)\}$ with two features:

(i) $N_i(g) = N \setminus \{i\}$ s.t. $\eta_i(g) = n - 1$, for all $i \in h_2(g)$, and

Figure 3.2. Pair-wise stable money laundering networks.



Note: These figures show the stable money laundering networks in which criminals are depicted by filled circles and workers are depicted by empty circles. Figure (a) shows the complete network (n=4). Remaining figures show the inter-linked star networks which they are pair-wise stable against transfers ($n=6$). (b) Star network with black node as the center. (c) Three inter-linked stars with black nodes as the centers. (d) Two inter-linked stars with black nodes as the centers.

(ii) $N_j(g)=h_2(g)$ s.t. $\eta_j(g)=|h_2(g)|$, for all $j \in h_1(g)$.

Inter-linked stars are illustrated in Figure 3.2. Figure 1b presents a star network with a criminal as the center and workers as peripherals, whereas Figures 1c and 1d present money laundering networks with multiple criminals being in the center and workers in the periphery.

An agent in the former group is referred to as a *central* agent, while an agent in the latter group is referred to as a *peripheral* agent. The *star* is a special case of this architecture, in which for the two groups $|h_1(g)|=1$ and $|h_2(g)|=n-1$ holds.

3.2.2 The Money Laundering Game

Agents may either be criminals or participate in the labor force as workers. Agents in the labor force earn a wage ω, whereas those involved in criminal activities receive an expected payoff equal to

$$E[\Pi_i]-\sum_{j\in N\setminus\{i\}} t_i^j = p_i(y_i-f)+(1-p_i)y_i-\sum_{j\in N\setminus\{i\}} t_i^j \tag{3.1}$$

where the gross income of criminal $i \in S$ from illegal activity is equal to a fixed booty y_i. All agents who become criminals compete to earn this fixed booty. This income can be spent immediately, but only at the risk of detection, which occurs with probability p_i, and being fined with f (based on

Becker 1968). Criminals benefit if they can add links to others in order to launder their criminal proceeds.

Beside of being competitors in the crime market, criminals may link to other criminals and workers for money laundering purposes. Criminals want to launder their dirty money in order to prevent the money from being confiscated by the police. We again assume that criminals use the smurfing technique to launder their criminal fund. We defined $t_i^j > 0$ as the transfer offered by agent i to agent j.

Consider the following four-stage money laundering game (see Figure 3.1):

- In the first stage, each agent in N decides to enter the labor market or to become a criminal.
- In the second stage, agents who become criminals decide whether they want to link to workers or other criminals for money laundering purposes.
- In the third stage, all agents who have decided to become criminals choose non-cooperatively the crime effort level they provide.
- In the fourth stage, money is earned and laundered. Workers earn ω and criminals earn y_i. In addition, policies become effective then and criminals are possibly detected and fined. So, all decisions upfront are in terms of expected payoffs.

Criminals choose to commit crimes because they expect to eventually make more money than when following legitimate activity. Hence, an agent decides to be a criminal if the expected utility of being a criminal exceeds the wage he gets from being a worker. In addition, criminals can add links to other agents to exchange their dirty proceeds with clean ones to conceal the source of their crime money and decrease the chance of being detected by the police. After deciding to add links to others for money laundering purposes, criminals can choose how much effort they want to spend on crime activity.

We shall assume that there are two types of workers in a money laundering network, namely: honest workers and dishonest workers. Honest workers are risk-averse workers who want to stay honest and don’t perform any money laundering operations. However, dishonest workers are risk takers and accept linking to criminals for money laundering purposes if they receive a transfer.

It should be emphasized that as in the previous chapters we assume complete information between agents in the network of money laundering. Each agent knows the payoffs of others and strategies available to other agents. Furthermore, workers are aware of performing money laundering operations for criminals.

3.2.3 Criminals' Payoff

Before we solve the game by backward induction, we must first specify some additional assumptions with respect to all variables that affect an agents' payoffs.

Suppose that e_i is the criminal's effort, α is the intercept of the crime market, β is the criminal demand elasticity, γ is the adjusted reporting threshold, $\eta_i^S(g)$ is the number of criminals which formed a link with agent i, $\eta_i^{N\backslash S}$ is the number of workers which formed a link with agent i, $\eta_i(g)$ is the agent's i connections, ω is the wage of workers and finally ϕ_c and ϕ_m are the expected crime and money laundering punishment respectively. We define individual expected payoffs (3.1) as follows:

$$E\left[\Pi_i \middle| e, g\right] = \begin{cases} e_i\left(\alpha - \beta\sum_{j\in S} e_j\right) - \phi_c e_i\left(1-\gamma\eta_i(g)\right) - 2\phi_m\eta_i^S(g) - \phi_m\eta_i^{N\backslash S}(g), \text{ if } & e_i > 0 \\ \omega - \phi_m\eta_i(g) & , \text{ if } \; e_i = 0 \end{cases} \tag{3.2}$$

Denote by $e = (e_1, ..., e_n)$ a population crime effort profile. The decision to enter the labor market (respectively to become a criminal) at the first stage is implicitly captured by setting $e_i = 0$ (respectively $e_i > 0$) at the third stage.

We define $y_i(e) = e_i\left(\alpha - \beta\sum_{j\in S} e_j\right)$ as the individual criminal proceeds for which the criminal has to compete with all the other criminals.[20] Consider, for example, the booty earned by drug dealing. In this case the effort of the dealers is the hours they spend in a park or street to sell their drugs. Suppose that two drug dealers try to sell their drugs in the same park. If one of them spends longer hours in the park he attracts more people to buy his drugs. As a consequence, the other dealer's booty will decrease. To launder his drug dealing proceeds, the dealer can take advantage of connections with workers and/or other criminals. Based on the above reason, criminals communicate with workers and/or other criminals to form a network.

However, the decision to launder dirty money is not risk-free for criminals because money laundering is a crime. If the illegal tie is detected, the criminal will not only lose the expenses paid for the money laundering operations, but will also suffer legal sanctions.

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[20] The predicate crimes that generate most of the crime money that is in need of laundering, are drug dealing and fraud (see Walker 1995 and 1999). However, a significant part of the money derived from fraud offences is not in cash (one can think of investment fraud, where the money is normally transferred to the fraudulent investor electronically). Therefore, we see drug dealing as the main crime that needs the smurfing technique that this paper deals with. We consider a drugs market with relatively stable demand and sufficient competition among sellers, such that the price is basically given for them. This would mean that the total amount of crime proceeds that can be made here is relatively fixed at price times quantity demanded. We therefore consider the booty a fixed amount of money, which is shared between the criminals.

To formalize these benefits and costs of money laundering ties, in formula (3.1), we divide the overall probability of being detected and the anticipated fine into two components: the costs of engaging in crime and the costs of pursuing money laundering. The first relates to investing effort into crime and the other to the risk of engaging into money laundering activities.

Let $\phi_c = p_c f_c$ represent an agent's expected marginal cost of investing one unit of criminal effort, when he has no money laundering ties, and assume $\phi_c > 0$. The expected marginal cost of crime activities decreases by forming links with other agents. This is formally captured by assuming $0 < \gamma \leq 1/(n-1)$ which is a measure of the degree to which the individual probability of being caught decreases with contact to others for laundering the money.

We assume that when criminal i adds a link to another criminal in network g, his costs of linking are twice the costs of linking when he adds a link to a worker. The rationale for this assumption is as follows. Criminals can launder their dirty proceeds by adding links directly to a worker. However, they might also give the money to other criminals who, through their own links to workers, launder their money for them. As the money is indirectly channeled in this case, the chance of detection is twice as high and therefore the criminal's cost of linking to another criminal is twice the cost of linking directly to a worker. Since criminals don't know all dishonest workers or finding a worker to launder the money is difficult and risky, they have to add links to other criminals for money laundering purposes.

Concerning the expected cost of money laundering, we define $\phi_m = p_m f_m$ where p_m is the probability of being caught when criminals or workers engage in money laundering operations and f_m is a fine related to the conviction for money laundering. Suppose that forming a money laundering link is costly and each link imposes a cost $\phi_m > 0$ on each of the two agents forming the link. Moreover we will assume that the cost of linking is not too "large" in comparison to the gains. In particular, the incremental payoff from forming a link with either another criminal or a worker is positive for a criminal, even in the worst possible network configuration.

Consider a network g with a full component apart from one isolated criminal i. The cost of linking, $\phi_m = p_m f_m$, is such that:

$$E\left[\Pi_i \left| g + g_{ij}, e^*\left(g + g_{ij}\right)\right.\right] - E\left[\Pi_i \left| g, e^*\left(g\right)\right.\right] > 0 \tag{3.3}$$

for j being either a worker or another criminal. This requires:[21]

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[21] We will show in Appendix B that a network g with a full component apart from one isolated criminal i is a crucial network.
When criminal i adds a link to a worker in network g, his incremental payoff is as follows:

$$0 < 2\phi_m < \frac{\phi_c \gamma (s-1)}{\beta^2 (s+1)^2} \left[2(\alpha - \phi_c) + \phi_c \gamma (s-1)(5-2n) \right] \tag{3.4}$$

This assumption requires several justifications: 1) the binding condition (3.3) concerns the incremental payoff from criminal i's link to another criminal j and is derived from the optimal crime level efforts in stage three (see below). 2) This assumption is equivalent to the analysis of R&D networks with small linking costs presented by Goyal & Joshi (2003). 3) The assumption will have strong implications for the shape of the equilibrium networks of money laundering ties, because it suggests that, regardless of the initial network g, all criminals would want to link to every other player with whom they are not yet connected. Hence, Proposition 3.1 is an immediate result of this assumption. However, we should also stress that the level of linking costs will still determine the number of criminals in our society, because a higher risk of being caught will deter entry into the criminal occupation.

It becomes obvious from equation (3.2) that in order to prevent crime or money laundering, authorities can focus on three parameters, namely ϕ_c, ϕ_m and γ. We defined ϕ_c and ϕ_m as the expected cost of crime and money laundering respectively. We can define γ as the effectiveness of money laundering that is determined by the adjusted reporting threshold. This institutional parameter determines how hard it is to use the money laundering technique smurfing. Therefore, Authorities can increase p_m or p_c by hiring more staff or decrease the reporting threshold to detect money laundering more effectively.

3.3 The Third-Stage: Crime Effort Levels

The game described in Section 3.2 is solved by using backward induction. We begin by characterizing the third stage game. Suppose s is the number of criminals in any network g and the net profit of each criminal $i \in S$ is given by (3.2). In order to determine the equilibrium level e_i^* of crime effort, maximizing (3.2) with respect to e_i, for any e_i positive, leads to the following first-order condition:

$$\frac{\partial E\left[\Pi_i \middle| g, e\right]}{\partial e_i} = \alpha - \beta \sum_{j \in S} e_j - \beta e_i - \phi_c + \phi_c \gamma \eta_i(g) = 0 \iff$$

$$\beta e_i = \alpha - \beta \sum_{j \in S} e_j - \phi_c + \phi_c \gamma \eta_i(g)$$

$$E\left[\Pi_i \middle| g + g_{ij}, e^*\left(g + g_{ij}\right)\right] - E\left[\Pi_i \middle| g, e^*(g)\right] = \frac{\phi_c \gamma s}{\beta^2 (s+1)^2}\left[2(\alpha - \phi_c) + \phi_c \gamma \left((s-1)(5-2n)+1\right)\right] - 2\phi_m > 0$$

Therefore, when this criminal adds a link to another criminal in the complete component of network g, his expected payoff is smaller than when he adds a link to a worker.

Summing up the optimal e_i over $i \in S$ yields the following expression:

$$\sum\nolimits_{i \in S} e_i = \left[s\alpha - s\phi_c + \sum\nolimits_{i \in S} \phi_c \gamma \eta_i (g) \right] \Big/ \beta(s+1)$$

Note that $\sum\nolimits_{i \in S} e_i = \sum\nolimits_{j \in S} e_j$. Therefore, by substituting above equation into $\sum\nolimits_{j \in S} e_j$ in FOC, the equilibrium crime effort level can be written as:

$$e_i^* = \frac{\alpha - \phi_c + s\phi_c \gamma \eta_i(g) - \phi_c \gamma \sum\nolimits_{j \in S \setminus \{i\}} \eta_j(g)}{\beta(s+1)}, \qquad \forall i \in S \tag{3.5}$$

By substituting equation (3.5) in equation (3.2) for all $i \in S$ the net profit is given by

$$E\left[\Pi_i \middle| e, g\right] = e_i^2(g) - 2\phi_m \eta_i^S(g) - \phi_m \eta_i^{N \setminus S}(g) \tag{3.6}$$

We now move on to determine the shape of the money laundering network when criminals correctly anticipate the equilibrium effort levels presented in (3.5).

3.4 The Second-Stage: Endogenous Network Formation

In our analysis of the national money laundering network, we use Goyal and Joshi's (2003) formal definition of stable network. The concept of stability is defined as follows:

Definition 3.1. *A network g is stable against transfers if:*

(1) For all $g_{ij} = 1$,

$$\left(E\left[\Pi_i \middle| g\right] - E\left[\Pi_i \middle| g - g_{ij}\right]\right) + \left(E\left[\Pi_j \middle| g\right] - E\left[\Pi_j \middle| g - g_{ij}\right]\right) > 0 \;\;, \;\; \forall i, j \in N.$$

(2) For all $g_{ij} = 0$,

$$\left(E\left[\Pi_i \middle| g + g_{ij}\right] - E\left[\Pi_i \middle| g\right]\right) + \left(E\left[\Pi_j \middle| g + g_{ij}\right] - E\left[\Pi_j \middle| g\right]\right) < 0 \;\;, \;\; \forall i, j \in N.$$

It means that in a stable network against transfer, any two agents who are linked with each other have no incentive to sever the link and any two agents who are not linked should have no incentive to establish a collaboration link.

Our next result establishes that the net profits of a criminal exhibit increasing returns with respect to the number of links that the criminal has with other agents.

Lemma 3.1. *Suppose* g *is a network with* n *agents, the number of criminals is* $0 < s < n$, *payoff satisfies (3.2), and crime effort level satisfies (3.5). Suppose that criminals add links directly to workers for money laundering purposes or first add links to criminals and then to a worker. Consider any network* g *and distinct agents* $i, j, k \in S$ *or* $i \in S$ *and* $j, k \in N \setminus S$ *or* $i, j \in S$ *and* $k \in N \setminus S$ *such that* $g_{ij} = g_{ik} = 0$. *Then:*

$$E\left[\Pi_i \middle| g + g_{ij} + g_{ik}\right] - E\left[\Pi_i \middle| g + g_{ij}\right] > E\left[\Pi_i \middle| g + g_{ij}\right] - E\left[\Pi_i \middle| g\right].$$

Proof. The proof is given in Appendix B.

As can be seen from Lemma 3.1, a criminal's incremental payoff from forming a link with another agent increases with every link he already possesses in the money laundering network. This lemma, which reflects the multiplier effect, allows us to conclude that a criminal's expected payoff increase by adding more money laundering ties.

The following lemma provides a partial characterization of a stable network, and it is a result of our low linking cost assumption.

Lemma 3.2. *When multiple criminals are in a network that is stable, they are fully connected.*
Proof. The proof is given in Appendix B.

The following lemma states that in a stable money laundering network, workers do not have links with each other.

Lemma 3.3. *In any stable money laundering network, workers don't have an incentive to form money laundering collaboration links with each other.*

The next proposition shows that the resulting money laundering network is an inter-linked star and that this network is the unique stable network against transfers for low ϕ_m. Also, criminals have $n-1$ links and workers have s links in this network.

Proposition 3.1. *Suppose that the payoff satisfies (3.2), and the crime effort level satisfies (3.5). Network* g *is stable against transfers if and only if it is an inter- linked star. In addition,* $h_1(g)$ *is the group of cooperating workers and* $h_2(g)$ *is the group of criminals, also* $|h_1(g)| = s$ *and* $|h_2(g)| = n-1$.

Proof. The proof is given in Appendix B.

Equilibrium networks, i.e. inter-linked stars, are illustrated in Figure 3.2. Criminals are depicted by filled circles and workers are depicted by empty circles. Figure 1b presents a star network with a criminal as the center and workers as peripherals, whereas Figures 1c and 1d present money laundering networks with multiple criminals being in the center and workers in the periphery.

3.5 The First-Stage: Occupational Decision

In the first stage of the money laundering game, we model agents' decisions for one of the two occupations: becoming a worker or a criminal. Denote agent i 's strategy if he enters the labor market as $e_i = 0$, and as $e_i > 0$, if he becomes a criminal.

We know that workers accept money laundering contacts to criminals, if they are at least compensated for their linking costs. We assume in the following that the value of this transfer is equal to ϕ_m, hence, transfers just compensate for the worker's costs. Moreover, criminals do not pay any transfers to each other. Therefore in the first stage of the money laundering game, the payoff of each agent i is given by (3.7).

$$E\left[\Pi_i \middle| g\right] = \begin{cases} \omega & \text{if} \quad e_i = 0 \\ e_i^2(g) - 2\phi_m(n-1) & \text{if} \quad e_i > 0 \end{cases} \tag{3.7}$$

The equilibrium of the first stage game is characterized by the following proposition:

Proposition 3.2. *Suppose the payoff satisfies (3.7) and the crime effort level satisfies (3.5). Then the following properties hold:*

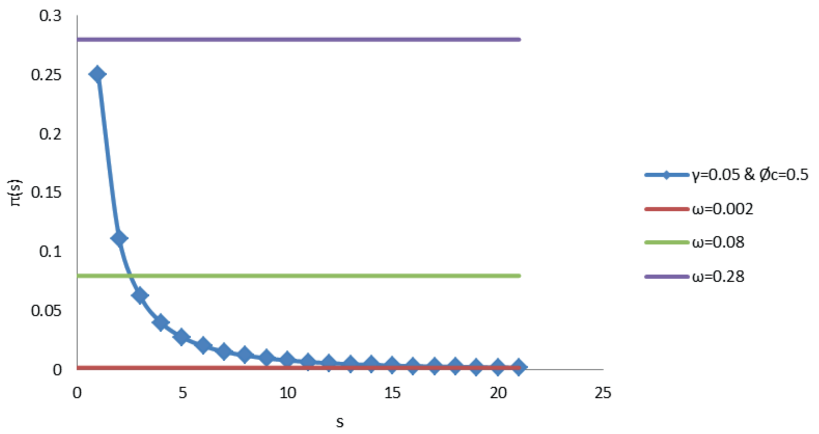
(i) When $\omega \geq E\left[\Pi \middle| s = 1\right]$ then there exists a unique equilibrium in which every agent enters the labor market.

(ii) When $\omega \leq E\left[\Pi \middle| s = n\right]$ then there exists a unique equilibrium in which every agent becomes a criminal.

(iii) When $E\left[\Pi \middle| s = 1\right] < \omega < E\left[\Pi \middle| s = n\right]$ then there exists a unique equilibrium number of criminals s^* such that $E\left[\Pi \middle| s^*\right] \geq \omega$ and $E\left[\Pi \middle| s^* + 1\right] < \omega$. The equilibrium number of criminals is:

$$s^* = \frac{\alpha - \phi_c + \phi_c \gamma(n-1)}{\beta\sqrt{\omega + 2\phi_m(n-1)}} - 1$$

Figure 3.3. First stage of the game.



Note: Occupational decision for different wage levels (ω) with, $n=21$, $\phi_m=0.00001$, $\phi_c=0.5$ and $\gamma=0.05$.

Proof. The proof is given in Appendix B.

We conclude that the level of legally obtained income has substantive effects on the extent of criminal activity in a society. An increase in workers' wages leads to lower crime rates and less money laundering operations. In other words, we confirm the conclusions of Engelhard, Rocheteau and Rupert (2008), as our results also show that labor market policies can play a crucial role in reducing crime and money laundering.

3.6 Anti-Money Laundering Policy

In the previous sections, we have characterized a society of criminals and workers, where criminals form money laundering ties with other criminals and workers. Here, we identify an effective mix of policy instruments to fight or even deter crime and money laundering in this society. By so doing, we assume that the authorities have, unlike the agents of the previous sections, only imperfect information about who is doing what. They know how many people live and work in their society. Also, they do know the society's wage level ω, but not who is a criminal and who is involved in money laundering activities.

In order to accommodate such imperfect information in our model, we assume that n number of agents construct the money laundering networks. In these networks s is the number of criminals, and $n-s$ is the number of conspiring workers. Regarding the imperfect information, authorities seek optimal levels of ϕ_c and ϕ_m.

The optimal level for each policy instrument will be the one that minimizes the search costs while keeping crime and money laundering at a tolerable level. Hence, we assume that authorities seek to minimize a social loss function given by:[22]

$$V = \sum_{i \in S} e_i^* + \theta_c p_c^2 + \theta_m p_m \tag{3.8}$$

where p_c is the crime policy variable ($\phi_c = p_c f_c$) and p_m is the money laundering policy variable ($\phi_m = p_m f_m$). Moreover, θ_c and θ_m are the costs of hiring agents or buying equipment for combating crime and money laundering, respectively.

Based on Proposition 3.2, the equilibrium effort of each active criminal is:

$$e^* = \frac{\alpha - \phi_c + \phi_c \gamma (n-1)}{\beta (s+1)}$$

whereby s^* is given in Proposition 3.2. Therefore we can write the social loss function as follows:

$$V\left(e(s), s, p_c, p_m\right) = s^* e^* + \theta_c p_c^2 + \theta_m p_m \tag{3.9}$$

Authorities aim to minimize this function by finding the optimum levels of p_c and p_m, which are determined in the following. Moreover, we analyze the moderating effects of increases in the parameters γ, ω, and $(n+m)$.

Proposition 3.3. *The optimal policies to combat crime and money laundering satisfy the following properties:*

(i) The optimal level of crime policy variable is given as follows:

$$p_c^* = \frac{f_c \left(1 - \gamma (n-1)\right)}{2 \beta \theta_c}.$$

(ii) The optimal level of money laundering policy variable operations is given by:

$$p_m^* = \frac{f_m (n-1)}{2 \theta_m^2} - \frac{\omega}{2 f_m (n-1)}.$$

[22] Note that we assume quadratic costs for crime detection policies, but a linear cost function for anti-money laundering operations. The reason is simply to achieve some convenient, interior expressions for the optimal policy levels.

(iii) When the money laundering reporting threshold γ increases, money laundering policies becomes relatively more important than crime policies. Formally, $\frac{\partial(p_c^* - p_m^*)}{\partial\gamma} < 0$ *.*

(iv) When wages ω increase, crime detection policies become relatively more important. Formally, $\frac{\partial(p_c^* - p_m^*)}{\partial\omega} > 0$ *.*

(v) θ_c and p_c, as well as θ_m and p_m are substitutes.

(vi) f_c and p_c, as well as f_m and p_m are complements.

Proof. The proof is given in Appendix B.

Part (i) of the result suggests that when γ increases the optimal level of crime policy variable decreases. A high level of γ means that the reporting threshold at the local banks is higher than the crime proceeds, making it easier for criminals to launder their money. Therefore, when γ is high, it is difficult and costly for authorities to identify and catch criminals, because they do not have any evidence to hold against them. Therefore, Part (iii) shows that when γ increases anti-money laundering policy becomes more important.

When the societal wage level increases, then according to Part (ii), the optimal level of money laundering policies (represented by the optimal level of money laundering policy variable) decreases. Based on the first stage of the money laundering game (Section 3.5), a wage increase decreases the number of criminals, and therefore also the number of crimes and money laundering operations in the society. We know that each criminal has many money laundering ties. In this case when the number of criminals decreases the number of ties among them goes down significantly. Hence, it becomes more costly to randomly investigate all financial transactions (legal and illegal links). Furthermore, in the proof of Part (i), we have shown that when the wage of workers increases they will be more active in crime and will invest more crime effort. As can be seen in Part (iv), anti-crime policies become more important in a high wage society. In this case it is better for authorities to focus on anti-crime policies instead of trying to find money laundering links.

Part (v) of the proposition shows that when the cost of combating crime θ_c increases, optimal crime policy declines, and when cost of money laundering policy θ_m is increased, the optimal money laundering policy goes down. Therefore we conclude that when the cost of combating crime increases then money laundering policy becomes more effective, and when the cost of combating money laundering increases, then crime policy becomes more important. Thus, when the cost of combating crime is increased, it is better and more efficient for authorities to combat money laundering. The equivalent result holds for the case of increasing cost of combating money laundering.

Regarding to Part (vi) of the result, when the fine of crime is increased then crime policy becomes more effective. The result is based on the fact that when authorities increase the fine for crime (e.g. increase the sentence time or change the life-time sentence to a death penalty) instead of the fine for money laundering, it will be more effective to combat the crime. The reason is based on the fact that when the fine of crime is increased authorities can focus on catching the criminals and it will be more risky for criminals to commit crimes. The same result holds for money laundering operations.

We also can explain this complementary relationship through the equation (3.9):

We know that $s^*e^* = \dfrac{\alpha - \phi_c\left(1-\gamma(n-1)\right)}{\beta} - \sqrt{\omega + 2\phi_m\left(n-1\right)}$. Since ϕ_c and ϕ_m are the deterrence variables for criminals, we have the following relationships:

$$\frac{\partial s^* e^*}{\partial \phi_c} = \frac{-\left(1-\gamma(n-1)\right)}{\beta} < 0 \quad \text{and} \quad \frac{\partial s^* e^*}{\partial \phi_m} = \frac{-\left(n-1\right)}{\sqrt{\omega + 2\phi_m\left(n-1\right)}} < 0$$

Further, note that $\phi_c = f_c p_c$ and $\phi_m = f_m p_m$. Therefore we conclude that to minimize s^*e^* (total effort of criminals) and therefore minimize the social loss, authorities must focus on either ϕ_c or ϕ_m. Therefore, when f_c increases, p_c must increase, and the same result hold for the case of money laundering.

3.7 Empirical Application of the Model

Now that we have derived the optimal policy response and all the underlying relations, we fit the model to real world data and estimates, in order to calculate an optimal policy response numerically. The focus of our analysis is on the share of the total crime-fighting budget that should be spent on anti-money laundering programs. We will calculate this share using a "sufficient statistics approach" (Chetty, 2009), where we make use of some macro constructs of parameters and variables that are more easily observable in the currently available data.

3.7.1 Sufficient-Statistics Approach to Determine the Optimal Policy

Due to data-availability, we apply the model to the Netherlands. For ω (wage in the formal sector), we use the average gross income in the Netherlands in 2013, which is about 33,000 euro per year (see CBS[23], 2013, and CPB[24], 2013). For ys (total proceeds of drug crimes), we add up the averages of the latest estimates of the sizes of the different drug-related crime markets in the Netherlands (which are collected by Savona and Riccardi, 2015, p.122): 66.5 million euro for the

[23] This statistic is online available at the Dutch Central Bureau of Statistics (average income per household, all households combined, retrieved on March 6, 2015): http://www.cbs.nl/nl-NL/menu/themas/inkomen-bestedingen/cijfers/extra/inkomensverdeling.htm
[24] See (retrieved on March 6, 2015): http://www.gemiddeld-inkomen.nl/modaal-inkomen/

heroin market (see Savona and Riccardi, 2015 and Killmer and Pacula, 2009), 93.5 million for cocaine market (see Savona and Riccardi, 2015 and Killmer and Pacula, 2009), 346 million for the cannabis market (see Caulkins and Kilmer 2013 and Killmer and Pacula 2009), 73 million for the Ecstasy market (see Killmer and Pacula 2009), 19 million for the Amphetamines market (see Killmer and Pacula 2009). In total, these proceeds of drug-related crimes in the Netherlands add up to 598 million euro. For f_c (fine for drug-related crimes) we use an estimate based on the average imprisonment for dealing drugs on the street multiplied by the value of a year of imprisonment, which would be around 31,250 euro.[25] For f_m (fine for money laundering), we use an estimate of the ECOLEF study (see Unger et al. 2014) of 150,000 euro.[26] To calculate money laundering and crime expected punishment (MLEP and CEP respectively) we need to know the policy variable ($MLEP = f_m p_m$ and $CEP = f_c p_c$). Since money laundering and crime probabilities are by definition unknown, we use 10% for the purpose of illustration. As there is also no estimate on the number of top criminals, we use for the purpose of illustration $s = 100000$.

Our policy objective function is to minimize the following social loss function:

$$V\left(e(s), s, p_c, p_m\right) = s^* e^* + \theta_c p_c^2 + \theta_m p_m \tag{3.10}$$

From Proposition 3.3 the crime and money laundering optimal policy variables are respectively given as:

$$p_c^* = \frac{f_c\left(1-\gamma(n-1)\right)}{2\beta\theta_c} \tag{3.11}$$

$$p_m^* = \frac{f_m\left(n-1\right)}{2\theta_m^2} - \frac{\omega}{2f_m\left(n-1\right)} \tag{3.12}$$

We can calculate the following share of the crime-fighting budget that should be spent on fighting money laundering:

[25] The common punishment for dealing drugs on the street in the Netherlands is between 3 months and a year (see http://www.judex.nl/rechtsgebied/strafrecht/veel-voorkomende-misdrijven/artikelen/379/verdovende-middelen-en-straffen-.htm), retrieved March 6, 2015). The Innocence project (see http://www.innocenceproject.org, retrieved March 6, 2015) proposes the transformation that one year in prison is worth 50.000 euro. Punishments would then range between 12.500 euro and 50.000, with a modus of 31.250 euro.

[26] This estimate is based on the average imprisonment in the Netherlands for money laundering of 1,83 years and an average fine of 58.500 euro.

Table 3.1. Empirical application of the model for the Netherlands.

Variable	Value	Short description
f_c	31,250	Fine for crime (drugs)
f_m	150,000	Fine for money laundering
ω	33,000	Wage in formal sector
ys	598,000,000	Size of the drug market
CEP	3,125	Expected fine for crime $\left(p_c * f_c\right)$
$MLEP$	15,000	Expected fine for ML $\left(p_m * f_m\right)$
s	100,000	Number of top criminals
p_c	0.1	Estimate crime policy variable
p_m	0.1	Estimate money laundering policy variable
e	251	Effort level
α	1,137,483	Maximum willingness to pay for drugs
V	25,100,000	Social Loss Function for the government
$\theta_m p_m / \left(\theta_c p_c + \theta_m p_m\right)$	30%	Optimal share of police budget spent on fighting money laundering

Notes: The first seven values are based on estimations mentioned in the text, the next four are values for the purpose of illustration, while the remaining values are the (intermediate) results of the model.

$$\frac{\theta_m p_m}{\theta_c p_c^2 + \theta_m p_m} = \frac{2\beta^2\theta_c\left(f_m^2(n-1)^2 - \omega\theta_m{}^2\right)}{2\beta^2\theta_c\left(f_m^2(n-1)^2 - \omega\theta_m{}^2\right) + \theta_m f_m f_c^2\left(n-1\right)\left(1-\gamma(n-1)\right)^2} \tag{3.13}$$

Optimal Effort Spend on Fighting Crime

Before calculating the optimal crime policy, we need additional estimates for α (the drug market size), e (the criminal effort/number of stooges hired) and s (the number of top criminals).

We calculated the number of criminals in Proposition 3.2, as follows:

$$s^* = \frac{\alpha - \phi_c + \phi_c\gamma(n-1)}{\beta\sqrt{\omega + 2\phi_m\left(n-1\right)}} - 1 \tag{3.14}$$

However, s will remain a floating parameter in our model and thus needs to be assumed.

The effort of each criminal in inter-linked star network is as follows:

$$e^* = \frac{\alpha - \phi_c + \phi_c \gamma(n-1)}{\beta\left(s+1\right)} \tag{3.15}$$

Therefore by substituting equation (3.14) in equation (3.15) we can calculate the effort of each criminal as follows:

$$e^* = \sqrt{\omega + 2\phi_m\left(n-1\right)} \tag{3.16}$$

If we denote the expected punishment for money laundering as $MLEP = \phi_m\left(n-1\right)$, e can be obtained from equation (3.16) as follows:

$$e = \sqrt{\omega + 2MLEP} \tag{3.17}$$

Regarding to equations (3.14) and (3.16), we can calculate β through the following equation:

$$s^* e^* = \frac{\alpha - \phi_c + \phi_c \gamma(n-1)}{\beta} - e \quad \Rightarrow \quad \beta = \frac{\alpha - \phi_c + \phi_c \gamma(n-1)}{e\left(s+1\right)} \tag{3.18}$$

Therefore we can calculate α from the following relationship, where $CEP = \phi_c e\left(1 - \gamma(n-1)\right)$ denotes the expected punishment for crime (drug dealing) in monetary terms:

$$ys = e\left(\alpha - \beta s e\right)s = es\left(\frac{\alpha + s\phi_c\left(1-\gamma(n-1)\right)}{s+1}\right) \quad \Rightarrow \quad \alpha = \frac{y\left(s+1\right)}{e} - s\phi_c\left(1-\gamma(n-1)\right)$$

$$\Rightarrow \quad \alpha = \frac{ys\left(s+1\right)}{es} - \frac{s\phi_c e\left(1-\gamma(n-1)\right)}{e} \quad \Rightarrow \quad \alpha = \frac{ys\left(s+1\right)}{es} - \frac{s.CEP}{e} \tag{3.19}$$

In equation (3.19) we can calculate α in which ys can be estimated by the total income generated from drug dealing and e can be obtained from the equation (3.17). At this point we need an estimate for s, the number of top criminals.

Therefore optimal effort spends on fighting crime is as follows:

$$p_c = \frac{f_c\left(1-\gamma(n-1)\right)}{2\beta\theta_c} \quad \Rightarrow \quad p_c^2 = \frac{\phi_c\left(1-\gamma(n-1)\right)}{2\beta\theta_c} \quad \Rightarrow$$

$$\theta_c p_c^2 = \frac{e\phi_c\left(1-\gamma(n-1)\right)}{2\beta e} = \frac{\text{CEP}}{2\left(\dfrac{\alpha e - CEP}{e\left(s+1\right)}\right)} \quad \Rightarrow \quad \theta_c p_c^2 = \frac{e\left(s+1\right).\text{CEP}}{2\left(\alpha e - \text{CEP}\right)}$$

Optimal Effort Spend on Fighting Money Laundering

To minimize social loss function of equation (3.10), we can calculate the optimal effort which must be spend on fighting money laundering from equation (3.12) as follows:

$$p_m^* = \frac{f_m\left(n-1\right)}{2\theta_m^2} - \frac{\omega}{2f_m\left(n-1\right)} \quad \Rightarrow \quad \theta_m p_m = \frac{f_m\left(n-1\right)}{2\theta_m} - \frac{\omega\theta_m}{2f_m\left(n-1\right)} \quad \Rightarrow$$

$$\left(\theta_m p_m\right)^2 = \frac{\phi_m\left(n-1\right)}{2} - \frac{\omega\theta_m{}^2 p_m}{2f_m\left(n-1\right)} \quad \Rightarrow \quad \left(\theta_m p_m\right)^2 = \frac{\phi_m\left(n-1\right)}{2} - \frac{\omega\left(\theta_m p_m\right)^2}{2\phi_m\left(n-1\right)} \quad \Rightarrow$$

$$\left(\theta_m p_m\right)^2\left(1 + \frac{\omega}{2\ MLEP}\right) = \frac{MLEP}{2} \quad \Rightarrow$$

$$\left(\theta_m p_m\right)^2 = \frac{\left(MLEP\right)^2}{2MLEP + \omega} \quad \Rightarrow \quad \theta_m p_m = \frac{MLEP}{e}$$

From the last equality it becomes clear that all that is needed is an estimate for the expected punishment for money laundering (in monetary terms) which is $MLEP = \phi_m\left(n-1\right)$ and the outside option wage rate (for a serious criminal).

Now we can calculate the following optimal policy ratio:

$$\frac{\theta_m p_m}{\theta_c p_c^2 + \theta_m p_m} = \frac{2\left(\alpha e - \text{CEP}\right).MLEP}{e^2\left(s+1\right).\text{CEP} + 2\left(\alpha e - \text{CEP}\right).MLEP} \tag{3.20}$$

Using the above-mentioned values for all variables and substituting those in equation (3.20), allows us to estimate the share of the budget that should be spent on fighting money laundering to optimize the crime-fighting results (and therefore minimizing the social loss function) to be 30%. Table 3.1 shows the used values for all variables, the intermediate results for the different variables, and the final result.

3.8 Conclusion

In this chapter, we study the effect of anti-crime and anti-money laundering policies on a group of criminals that maintain money laundering ties between each other as well as with a group of dishonest bankers. We develop a simple model of network formation to inquire the incentives of agents to form money laundering links with other agents. In this model, we study a three-stage money laundering game. We first adopt Becker's (1968) seminal model of the economics of crime, according to which agents decide to start a criminal career purely based on the financial incentives. In the second stage of the game, criminals form stable collaboration links with other agents in order to launder their criminal proceeds. These links are costly, but help to lower the marginal costs of crime by replacing the crime proceeds with clean ones. In the third stage of the game, criminals decide on the crime effort level they provide.

The first result of this chapter is the characterization of the shape of the money laundering network. If the cost of a money laundering tie is small, then an inter-linked star is the uniquely stable network. The second and crucial focus of this chapter is the analysis of the optimal mixture of anti-crime and anti-money laundering policies. Which policies should a law enforcement agency focus on to combat either crime or money laundering in order to minimize total criminal activity in a society? In the present model, this is expressed in terms of an optimal budget sharing rule. We show that when the reporting threshold for financial transaction increases, anti-money laundering policies become more important, while when the average wage rate in the economy goes up, a crime detection policy becomes more effective. Finally, we conclude that fines on crime and crime detection policies as well as the fines on money laundering and anti-money laundering policies are complementary.

We provide an empirical application of the model and calculate the optimal budget sharing rule for the Netherlands. Towards this end, we implement a sufficient statistics approach for the model and use available data for the constructs of parameters and variables that are sufficient to predict the optimal budget share. We find that the optimal share of the enforcement budget that should be spent on fighting money laundering is 30% for the Netherlands.

A limitation of the model is that it does not help to identify any key players, as defined by Ballester, Calvó-Armengol and Zenou (2006), in the criminal network. There are no key player in the present model, because all criminals maintain the same number of links in equilibrium. In this respect, the model does not help law enforcement agencies to save a lot of resources by focusing their activities on just a few players who occupy central positions in the network. Further work should, thus, expand the model along the lines of this key player literature.

Bibliography

Ballester, C., Calvó-Armengol, A., & Zenou, Y. (2006). Who's who in networks. Wanted: The key player. Econometrica, 74(5), 1403-1417.

Becker, G. S. (1968). Crime and punishment: An economic approach. In The Economic Dimensions of Crime (pp. 13-68). Palgrave Macmillan UK.

Caulkins, J. P., & Kilmer, B. (2013). 4. Estimating the size of the EU cannabis market. Further insights into aspects of the EU illicit drugs market, 27.

Chetty, R. (2009). Sufficient statistics for welfare analysis: A bridge between structural and reduced-form methods. Annu. Rev. Econ., 1(1), 451-488.

Engelhardt, B., Rocheteau, G., & Rupert, P. (2008). Crime and the labor market: A search model with optimal contracts. Journal of Public Economics, 92(10), 1876-1891.

Ferwerda, J. (2012). The multidisciplinary economics of money laundering (Doctoral dissertation, Utrecht University).

Gaigné, C., & Zenou, Y. (2015). Agglomeration, city size and crime. European Economic Review, 80, 62-82.

Goyal, S., & Joshi, S. (2003). Networks of collaboration in oligopoly. Games and Economic behavior, 43(1), 57-85.

Kleemans, E. R. (2007). Organized crime, transit crime, and racketeering. Crime and Justice, 35(1), 163-215.

Kilmer, B., & Pacula, R. L. (2009). Estimating the size of the global drug market: A demand-side approach. A Report on Global Illicit Drug Markets 1998-2007, 25.

Reuter, P., & Truman, E. M. (2004). Chasing dirty money. Institute for International Economics.

Savona, E. U., & Riccardi, M. (2015). From illegal markets to legitimate businesses: the portfolio of organised crime in Europe. Trento: Transcrime–Università degli Studi di Trento.

Unger, B., Ferwerda, J., van den Broek, M., & Deleanu, I. (2014). The Economic and Legal Effectiveness of the European Union s Anti-Money Laundering Policy. Edward Elgar Publishing.

Walker, J. (1995). Estimates of the extent of money laundering in and through Australia, paper prepared for Australian transaction reports and analysis centre. Queanbeyan: John Walker Consulting Services.

Walker, J. (1999). How big is global money laundering?. Journal of Money Laundering Control, 3(1), 25-37.

Chapter 4

International Regulation of Money Laundering*

4.1 Introduction

The globalization of crime and money laundering creates new challenges for law enforcement agencies. Criminal organizations have become skilled and experienced at moving property from one country to another. This raises new challenges for policymakers, as it is more difficult to enforce criminal laws when criminals commit crimes or launder money outside their home country. Hence, it is no longer enough for policymakers to just be aware of what is occurring inside their own borders. Rather, important decisions have to be addressed: should law enforcement agencies join forces and fight money laundering at a central or even global level? Should they exchange information? Should they determine anti-crime budgets of their own or, at the other extreme, leave the budget allocation to a central authority? The ambition of the European Union to establish a European Public Prosecutor's Office (EPPO[27]) is a good example in this regard. The main purpose of the EPPO is to provide a coherent supranational response to the Protection of the Financial Interest of the European Communities (referred to as PIF offences). The EPPO could foster effective cooperation and information exchange at the transnational level. It could also ensure a more effective, consistent and homogenous approach to the investigation and prosecution of PIF offences that is less affected by national interests and priorities as compared to the current situation. However, the debate on the need of an EPPO and the feasibility and its' potential modalities is on-going. The extent and nature of the value added will depend on the design of the EPPO - i.e. its material scope of competence, powers and its link to the national criminal justice systems-, the number and nature of member states that take part in the EPPO, and the effectiveness of its implementation, including the degree to which it will be able to effectively cooperate with the MSs, other EU bodies and third countries[28].

The current chapter contributes to this discussion. While earlier chapters in this thesis analyzed money laundering networks and optimal policy responses for a closed economy, this chapter takes into account that money laundering is an international crime. We present an extension of the model

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* The study presented in this chapter is joint work with Bastian Westbrock, Stephanie Rosenkranz and Brigitte Unger.

27 See the work of Hamran and Szabova (2013), Ligeti and Simonato (2013), Ligeti and Weyembergh (2015), Weyembergh and Briere (2016): http://www.europarl.europa.eu/RegData/etudes/STUD/2016/571399/IPOL_STU(2016)571399_EN.pdf for more details.

28 See http://www.consilium.europa.eu/en/press/press-releases/2017/03/pdf/eppo-factsheet_pdf/ for more detailes.

from the previous chapter where, in order to keep things simple, we focus on a two-country setting. In this model, all criminals from the same country compete with each other to earn a booty in their domestic market. At the same time, they form domestic and international money laundering ties to reduce the probability of being detected as criminals. Criminals form links to criminals and willing collaborators in another country, since by adding more links their chance of being detected and caught will go down. The risk of detection when forming an international tie is dependent on the regime which countries apply to fight money laundering. If countries do not share information about detected illegal transactions, there is no risk involved for criminal money launderers. If, in contrast, countries share information, the probability of being detected will increase by adding an international link.

As in the previous chapters, we study the equilibrium of this game. We derive the shape of the international money laundering network and show that, also on the international stage, it is an inter-linked star that comprises all agents willing to engage in money laundering. However, there are several new findings emerging from the two-country setting: First, we show that criminals tend to launder their criminal proceeds in the richer country, as measured by the average wage. Hence, the predictions of the model are consistent with the stylized empirical fact that the crime problem stays in poorer countries, but that criminals try to get their money into the richer countries. The findings hence explain why offshore islands and countries like Switzerland, Austria and Luxemburg are highly attractive for international money launderers because of their greater internal stability (von und zu Liechtenstein, P. M. 2013). Moreover, the model's predictions confirm those of earlier models on the topic. McCarthy (2013), for example, shows that only small, open, or developing countries benefit from the market for money laundering. These countries have an incentive to fight domestic crimes, while profiting from the criminal revenues created in other countries. Moreover, the famous 'Walker gravity model' (Walker, 1995) estimates that richer countries attract more money laundering funds from poorer countries.

We then move on to the central question of this chapter, namely the evaluation of policy options to fight money laundering in the international domain. In this respect, the current chapter addresses the last research question of the thesis which is: what is the economic value of an international coordination of anti-money laundering policies? And, what is the optimal means of coordination when countries have different sized crime and money laundering markets? We consider four possible regimes to combat money laundering, which can be interpreted in the light of the policy options for the EPPO design (see Figure 4.1 below): A first choice is whether countries opt for a centralized authority (like the EPPO) or not (Non-EPPO). If they decide against the centralized authority then they can either exchange information (exchange) or not (baseline scenario). The baseline scenario corresponds exactly to the setting of Chapter 3: In each country an independent authority decides about a national anti-crime and anti-money laundering budget without any positive spillovers on the other country. If countries decide to exchange information then they will benefit from each other's efforts at combating money laundering. In particular, if an agency detected an international money

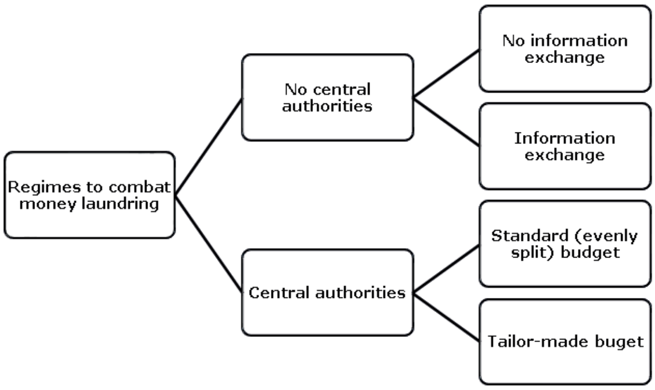

Figure 4.1. Regimes to combat money laundering.

laundering tie, it will inform the other country about its existence so that international money launderers face the risk of being sanctioned by their home country. If countries use a centralized authority (like the EPPO) the authority on top takes over the job of the national authorities and decides whether to distribute the anti-money laundering budget either in a flat way or in a tailor-made way. If the authority chooses the flat way, it will distribute the budget equally between the two countries. The tailor-made rule, in contrast, specifies for each country an amount that aims to minimize money laundering according to each country's need. All these options have been under discussion at the European level since 2012[29]. The regime of information sharing in my model has much in common with the discussed policy option to proactively *strengthen existing arrangements (enhanced Eurojust, Art. 85)*. Typical platforms for such an information exchange are the Egmont Group and FIU.net which Financial Intelligence Units worldwide, or Europe-wide, use for international information exchange. The regime of distributing the budget in a flat way can be regarded as similar to the installation of a *centralized EPPO,* which is not dependent on national prosecution services and acts on the basis of a supranational substantive and procedural law. The tailor-made approach in the present model corresponds to the *Integrated EPPO* policy option. This option is based on cooperation and information exchange between the EPPO and EU's member states[30].

The comparison of the regimes reveals that the information exchange regime is Pareto-superior to the baseline scenario, as the social loss, which is the aggregate of criminals' effort plus the cost of fighting crime and of fighting money laundering, in each country decreases. Both countries further benefit from installing a centralized authority, as compared to a pure information sharing regime. We also compare the cases of an evenly-split budget versus a tailor-made budget. The findings show that

[29] For more details see Section 4.2.
[30] For more details see Section 4.2.4.

the first-best regime is to implement a central authority which allocates tailor-made budgets, since the sum of the social losses by using this regime is less than the sum of the social losses under any other regime. Installing a centralized authority that uses the same budget split for both countries, in contrast, produces some mixed results. It is disadvantageous for the richer country, because there is less criminal activity in the richer country while that country receives the same treatment as the poorer country. Conversely, this however implies that a tailor-made budget is disadvantageous for the poorer country. Hence, a main conclusion from the present model is that global and European anti-money laundering policies should be centrally organized, but that the choice of a tailor-made versus a one-size-fits-all approach is a matter of preference given to the interests of poorer countries.

The findings of this chapter contribute to a growing literature on international regulation of anti-crime and anti-money laundering activities. They confirm the assessment methods of Brettl and Usov (2010) and Walker (2011), which rank rich western EU countries as the most vulnerable/attractive to dirty money, while poorer countries and the new accession countries are ranked as the least threatened countries. My theoretical findings on the optimal policy regime also support the empirical findings of Unger et al (2014) who studied anti-money laundering policy in 27 EU Member States and criticized the one-size-fits-all approach of the European Union. The conclusion from the present analysis is that the preference for a tailored budget might however come from the rich countries at the cost of the poorer countries Since crime is higher in poor countries, tailor made budgets would save rich countries money to subsidize poorer countries.

The remainder of this chapter is structured as follows. Section 4.3 presents the network structures relevant for the analysis and presents the model. Section 4.4-4.6 solve the model. Section 4.7 examines the country differences in wages and country sizes in international money laundering network. Section 4.8 derives the optimal anti-money laundering policies at the international level and Section 4.9 concludes. For the proof of my Propositions, please see Appendix C.

4.2 The European Public Prosecution Office (EPPO) Proposal

To motivate the policy options considered in this chapter, we briefly summarize in the following a study commissioned by the European Union in 2012 concerning the comparison of different policy options to protect the financial interests of the member states by means of criminal law, including the possibility of establishing a European Public Prosecutor's Office (EPPO).[31] We focus on the legal and institutional implication of the debated policy options and the potential effectiveness in

[31] In 2012 the European Commission commissioned a report assessing the protection of the EU financial interest by means of criminal law, and specifically, the need to ensure consistent and effective investigation and prosecution of crimes against the EU financial interests by establishing a European Public Prosecutor's office (EPPO). The report is written by economists from Ecorys Nederland and lawyers that are connected to the ECLAN network. Researchers from ECorys were Dr. Brigitte Slot (project leader), Lydeke Schakel, Anja Willemsen and Lorijn de Boer. The ECLAN team was led by Prof. Dr. Katalin Ligeti (University of Luxembourg), with assistance of Michele Simonato (University of Luxembourg).

terms of achievement of the policy objectives. The five policy options discussed were: no changes, strengthening of current arrangements, a college-type EPPO, an integrated EPPO, and the establishment of a supranational EPPO. While the first two options do not include the establishment of an EPPO, the latter three do explicitly include this option.

4.2.1 Baseline Scenario (No Policy Change)

This policy option is the status quo. Therefore, it does not address any of the weaknesses in the protection of EU's financial interests, which are all problems resulting from so-called PIF ("Protection of the Financial Interest of the European Communities", collectively referred to as the "PIF Convention") offences, such as fraud, misappropriation, corruption, obstruction to public procurement or grant procedures, and money laundering. It has been agreed that the status quo can only be chosen, if there is the conclusion that the weaknesses of the status quo and the magnitude of the problems are not significant enough to justify any action.

4.2.2 Strengthening Existing Arrangements (Enhanced Eurojust, Art. 85)

This option has three main objectives: to address present weaknesses in the institutional and legal structures at the national level by tackling specific deficiencies in each country; to address inefficiencies of cooperation mechanism; and to strengthen the prosecution of crimes affecting the EU financial interests through the reinforcements of the role of Eurojust. Eurojust, which was established in 2002, is an agency of the European Union (EU) dealing with judicial co-operation in criminal matters. It was created to improve handling of serious cross-border and organized crime by stimulating investigative and prosecutorial co-ordination among agencies of the EU Member States. This option mainly aims at granting new powers to Eurojust to trigger investigations on PIF offences, an area that already forms part of Eurojust's mandate. Eurojust national members, after a decision of the College in this regard, should communicate such a decision to national prosecutors. The main advantage of this option is the fact that it allows for targeted solutions of which some would differ greatly per member state.

4.2.3 Eurojust College EPPO

The objective of this option is a fully-fledged EPPO, which will be in charge of the investigation and prosecution of suspects of PIF offences. A collegial body, composed of prosecutors appointed in every member states participating in the establishment of the EPPO, will take the majority decisions on investigations and prosecutions concerning PIF offences throughout the EU. Consequently, national members would be granted more incisive powers, as they would need to be able to provide national prosecutions with binding instructions.

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4.2.4. Integrated EPPO

The integrated EPPO consists of a central EU prosecutors' office assisted by deputy prosecutors integrated in national systems. The chief prosecutor (central office) would give instructions to the deputy prosecutors, which therefore would act with a "double hat", i.e. both as national prosecutors and as EU authorities. Two main sub-options could be outlined:

a. *Integrated EPPO: based on national laws*

The first sub-option entails the creation of an EPPO on two levels: an EU central office and deputies in each member state acting on the basis of their national laws. This option aims at the creation of a hierarchical structure, keeping at the same time a strong connection with national systems in order to have a softer impact on the member states' legal systems.

b. *Integrated EPPO based on harmonized EU procedural rules*

This sub-option is very similar to the previous one regarding its structure, which aims at maintaining a strong connection with the national systems. Nevertheless, in this scenario, the central EPPO would provide instructions to the delegated EPPs, which, although integrated in national systems, would act on the basis of harmonized EU rules.

4.2.5. Centralized EPPO

This option entails the creation of a central EPPO, mostly acting on the basis of a supranational substantive and procedural law, possessing the full legal and practical capacity required to lead investigations and prosecutions on PIF offences, and not depending on the national prosecution services. This authority would be composed of a chief prosecutor and several specialized deputy prosecutors at the central level, acting throughout the whole EU. The supranational EPPO would act directly, bringing suspects to judgment before national Courts (not through delegated prosecutors embedded in the member states).

The members of the study group concluded the following:

1. Baseline scenario: all interviewees have rejected this option.
2. Strengthening existing arrangements (enhanced Eurojust, Art. 85): all interviewees agree that this option will positively affect the protection of the EU's financial interest. However, most of the interviewees think that this will not be sufficient to effectively protect the EU's financial interests.
3. Eurojust College EPPO: while this option has certain advantages, overall it was not identified as an optimal option because it suffers from serious drawbacks. This is also confirmed by the field missions, as most of the interviewees expressed to be not in favor of this option. A major drawback of this option is the collegial manner of decision-making. This type of decision-making is not appropriate for an EPPO. Fears exist that: a) it may be too political, as College members may act based on their own national, political, interests instead of on the common interests of the EU; b) it may

relatively take much time to process fraud concerns; c) a system of majority voting may dilute the responsibility felt for the decision; d) and actions to be undertaken in MSs that disagreed with the binding decision may not receive the necessary follow-up.

4. Integrated EPPO: The overwhelming majority of the interviewees are in favor of this model. Its main benefits are that it entails a system whereby protecting the EU's financial interests are point of departure, incentive and capacity problems at the prosecution level are addressed and cooperation and information exchange problems between EPPO and member states' authorities are improved in an efficient and effective way, while being firmly embedded in national systems. Opinions differ regarding which sub-option is preferred. Various interviewees consider sub-option b) EPPO based on EU rules to be better in theory than sub-option a) EPPO based on national laws. This is because supranational procedural rules are deemed necessary since EPPO's effectiveness will then not be dependent on mutual recognition. Nevertheless, almost all of the interviewees favor option a) in practice, as it is considered to be more feasible in the near future.
5. Centralized EPPO: this option allows for a more comprehensive protection of the EU's financial interest across the member states. It would be able to address the national incentive and capacity problems at the investigation and prosecution phase effectively; it would address the problems related to the judicial cooperation between the member states, and it would solve the problems that some member states face related to the fact that their national substantive and procedural legal framework is inadequate to fight PIF offences effectively. Nevertheless, it also suffers from significant disadvantages. First of all, there are concerns about the potential effectiveness of a "foreign body" when it comes to investigating offences in the member states. Secondly, it involves the establishment of a parallel system of detection and prosecution, which presents some disadvantages. More fundamentally, however, it is not politically feasible at present, nor was it seen as being appropriate given the current level of EU integration.

In the next sections, we compare several of the policy options from the viewpoint of a microeconomic model. The purpose of this analysis to provide a comparison based on the economic effect of each regime. We focus on four different regimes from the EPPO proposal, namely the baseline scenario, the option to strengthen existing arrangements, an integrated EPPO, a centralized EPPO. We do not model the Eurojust College EPPO option, because as mentioned in the EPPO proposal, this option has serious drawbacks.

4.3 The Model

As in the previous chapters, we first consider a setting in which agents in the society first choose to either be a worker or to be directly involved in criminal activity. Then, criminals choose their collaboration links with other criminals and also with workers. The new feature of this chapter is that criminals and workers between whom links can be formed can be domestic or international. These collaboration links are pair-wise (bilateral, undirected) and costly and help criminals to launder their crime money by adding links to others in their own country and other countries. Since the costs of linking are again assumed to be low, criminals form money laundering ties to all money launderers in their home country. In order to decrease the chance of being caught by forming more money laundering links, criminals try to form links with other money launderers in another country.

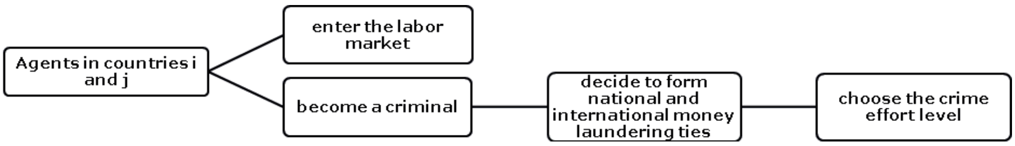


Figure 4.2. The sequence of decisions in the smurfing game.

4.3.1 Notation

Let $R=\{1,2\}$ denote two countries and let $N_r=\{1,2,...,n_r\}$ denote a finite set of initially identical agents in country $r\in R$. Define S_r as a subset of criminals and $N_r\setminus S_r$ as a subset of workers where s_r is the number of criminals and (n_r-s_r) is the number of dishonest workers in country $r\in R$. Suppose $N=N_1\bigcup N_2$ with $n\geq 3$. This network is composed of $S\subseteq N$, the subset of criminals, and $N\setminus S$ the subset of workers. For any distinct $i,j\in N$, a pairwise domestic and international relationship between the agents is depicted by a bilateral link $g^{ij}\in\{0,1\}$, where $g^{ij}=0$ means that no link is formed between agents i and j while $g^{ij}=1$ means that a link is established. A *network* $g=\{g^{ij}:i,j\in N,i\neq j\}$ is formed describing the links that exist among agents. Let $g+g^{ij}$ denote the network obtained from g by adding link g^{ij}. Similarly, let $g-g^{ij}$ denote the network obtained by subtracting link g^{ij} from g. Links are undirected, so that $g^{ij}=g^{ji}$ and by convection $g^{ii}=0$. Furthermore, for every $r\in R$ denote by $N^i_{rr}(g)$ the set of agents, with which agent $i \in r$ has a domestic link in g and $N_{rl}^{i}(g)$ the set of agents with which agent $i \in r$ has an international link in g . let $\eta_{rr}^{i}(g) = \left|N_{rr}^{i}(g)\right|$ and $\eta_{rl}^{i}(g) = \left|N_{rl}^{i}(g)\right|$.

Define $N_{rr}^{i\ N\backslash S}(g) = \left\{ j : g^{ij} = 1 \,\&\, j \in N_r \setminus S_r \right\}$ as the set of workers with whom i has formed a domestic link and $N_{rr}^{i\ S}(g) = \left\{ j : g^{ij} = 1 \,\&\, j \in S_r \right\}$ denote the set of criminals that formed a domestic link with i, and let $\eta_{rr}^{i\ N\backslash S}(g) = \left|N_{rr}^{i\ N\backslash S}(g)\right|$ and $\eta_{rr}^{i\ S}(g) = \left|N_{rr}^{i\ S}(g)\right|$. We also define $N_{rl}^{i\ N\backslash S}(g) = \left\{ j : g^{ij} = 1 \,\&\, j \in N_l \setminus S_l \right\}$ as the set of workers that formed an international link with i, and $N_{rl}^{i\ S}(g) = \left\{ j : g^{ij} = 1 \,\&\, j \in S_l \right\}$ as the set of criminals which has an international link with i, and let $\eta_{rl}^{i\ N\backslash S}(g) = \left|N_{rl}^{i\ N\backslash S}(g)\right|$ and $\eta_{rl}^{i\ S}(g) = \left|N_{rl}^{i\ S}(g)\right|$.

Let g^c denote the *complete network* in which $g^{ij} = 1$, $\forall i, j \in N$. An *inter-linked star* is a network with two groups of agents namely $\left\{ h_1(g), h_2(g) \right\}$. The group of agents in which $\eta^i(g) = n-1$ for all $i \in h_2(g)$ denote the center group and $\eta^j(g) = \left|h_2(g)\right|$ for all $i \in h_1(g)$ belongs to the periphery.

4.3.2 The International Money Laundering Game

In our model agents have two choices: being workers or participating in the crime pool. Workers earn a wage $\omega_r > 0$ in country $r \in R$, whereas criminals receive an expected payoff equal to

$$E\left[\Pi_r^i\right] - \sum_{j \in N\setminus\{i\}} t^{ij} = p_r^i \left(y_r^i - f_r\right) - \left(1 - p_r^i\right) y_r^i - \sum_{j \in N\setminus\{i\}} t^{ij} \tag{4.1}$$

where y_r^i is i's booty, p_r^i his probability of detection and f_r the corresponding fine (based on Becker 1968) . Criminals know that clean money is more worth than dirty money. Therefore, they prefer to launder their crime proceeds to decrease the chance of being detected by the police. They want to launder these proceeds in their own country as well as in the other country. Note that criminals would benefit by adding links to others in order to launder their crime proceeds and earn clean liquidity. At the same time, money laundering is a crime, and therefore it is costly for others to form links with criminals. Therefore criminals may have an incentive to offer transfers to others to form links with them. We define $t^{ij} = \left\{ t^{i1}, \ldots, t^{in} \right\}$ as the transfers which are offered by agent i to any j . If $t^{ij} > 0$

then this means i pays to j whereas $t^{ij} < 0$ means i receives transfers from j. For a balanced set of transfers the following must hold: $\forall g_{ij}: \; t^{ij} + t^{ji} = 0$.

We consider the following four-stage international money laundering game (see Figure 4.2):

- In the first stage, agents in N decide to enter the crime pool or to become a worker.
- In the second stage, agents who became criminals decide to form links to workers and other criminals in their own country as well as in other countries for money laundering purposes.
- In the third stage, all agents in the crime pool choose non-cooperatively the crime effort level they provide.
- In the fourth stage, money is earned and laundered. Workers earn ω and criminals earn y_i. Furthermore, policies become effective then and criminals are possibly detected and punished. So, all decisions ex ante are in terms of expected payoffs.

4.3.3 Criminals' Payoff

We assume that when criminal i adds a link to another criminal in network g, his cost of linking is twice the cost of linking to a worker. We know that workers can launder the money for criminals and other criminals play the role of mediator for laundering the money. It means that criminals form links with other criminals, these other criminals have to form links to workers for laundering the money. In this case criminals accept two times the risk of being arrested by forming links with criminals rather than workers.

Define individual expected payoffs (4.1) as follows:

$$E\left[\Pi_r^i \middle| e_r, g\right] = \begin{cases} \pi_r^i - \phi_r^m - \sum_{j \in N^i(g)} g^{ij} t^{ij} & \text{if} \quad e_r^i > 0 \\ \omega_r - \left(\phi_{rr}^m \eta_{rr}^i(g) + \phi_{rl}^m \eta_{rl}^i(g) + \sum_{j \in N^i(g)} g^{ij} t^{ij}\right) & \text{if} \quad e_r^i = 0 \end{cases} \tag{4.2}$$

Further, define $\pi_r^i = e_r^i \left(\alpha_r - \beta_r \sum_{j \in S_r} e_r^j\right) - \phi_r^c e_r^i \left(1 - \sum_{j \in N_{rr}^i(g)} g^{ij} \gamma_r - \sum_{j \in N_{rl}^i(g)} g^{ij} \gamma_l\right)$ as a gross profit of agent i in country $r \in R$ and $\phi_r^m = \phi_{rr}^m \left(2\eta_{rr}^{i\,S}(g) + \eta_{rr}^{i\,N \setminus S}(g)\right) + \phi_{rl}^m \left(2\eta_{rl}^{i\,S}(g) + \eta_{rl}^{i\,N \setminus S}(g)\right)$ as an overall money laundering punishment. In π_r^i define $e_r^i \left(\alpha_r - \beta_r \sum_{j \in S_r} e_r^j\right)$ as the criminal's proceed for which the criminal has to compete with other criminals, and $\alpha_r, \beta_r > 0$. Let $p_r^i(e,g) f_r$ represent the overall probability of being detected times the corresponding fine in country r. The latter can be decomposed into two components: the risk of engaging in crime activities, and the risk of attending in money laundering operations. Define $\phi_r^c = f_r^c p_r^c$ as an agent's marginal cost of investing crime effort in country $r \in R$ when he has no money laundering ties and let $\phi_r^c > 0$. Define $\gamma_r \leq 1/\left(2(n_r - 1)\right)$ and $\gamma_l \leq 1/\left(2n_l\right)$ as a measure of the degree to which the individual probability of being caught decreases with contacts to agents in their own country, and in another country respectively, for laundering the crime proceeds, where n_r is the number of agents in their own country and n_l is the number of agents in another country. It follows that $\sum_{j \in N_{rr}^i(g)} g^{ij} \gamma_r + \sum_{j \in N_{rl}^i(g)} g^{ij} \gamma_l \leq 1$.

Criminals try to launder their money by adding links to others - note that money laundering is a crime and thus communicating is costly for both groups, criminals and workers. In the case of ϕ_r^m we define $\phi_{rr}^m = f_r^m p_r^m$ as the cost of domestic linking, where p_r^m is the probability of being caught when criminals or dishonest workers form money laundering ties among each other in their own country, and f_r^m is a fine related to this crime. Moreover ϕ_{rl}^m is the cost of international linking when criminals in country $r \in R$ form links with criminals and dishonest workers in another country which we will define in Section 4.7.

We will assume that the costs of domestic and international linking are "small" in comparison to the gains. In particular, criminals' payoff from forming a link with others is positive, even in the worst possible network configuration[32].

Consider a network g with a full component apart from one isolated criminal i. The cost of domestic linking, ϕ_{rr}^m, is such that:

$$E\left[\Pi_r^i \middle| g + g^{ij}, e^*\left(g + g^{ij}\right)\right] - E\left[\Pi_r^i \middle| g, e^*\left(g\right)\right] > 0$$

for j being either a worker or another criminal in country $r \in R$.[33]

[32] The worst possible money laundering network configuration is one with the full components apart from one isolated criminal.

[33] When criminal i adds a link to another criminal or a worker in network g, we have the following condition (4.3) for his incremental payoff:

$$E\left[\Pi_r^i \middle| g + g^{ij}, e^*\left(g + g^{ij}\right)\right] - E\left[\Pi_r^i \middle| g, e^*\left(g\right)\right] =$$

$$0 < 2\phi_{rr}^m < \frac{\phi_r^c \gamma_r \left(s_r - 1\right)}{\beta_r^2 \left(s_r + 1\right)^2}\left[2\left(\alpha_r - \phi_r^c\right) + \phi_r^c\left(s_r - 1\right)\left((5 - 2n_r)\gamma_r - 2n_l\gamma_l\right)\right] \qquad i \in S_r$$

This assumption is again equivalent to the Goyal & Joshi (2003) analysis of R&D networks with small linking costs. The binding conditions (4.3) and (4.4) concern the incremental payoff from criminal i's link to another criminal j in their own country, and also in another country respectively, and are derived from the optimal crime level efforts in Stage 3 (see Page 71).

4.4 The Third-Stage: Crime Effort Levels

We now characterize the third-stage game. Maximizing expected payoff in equation (4.2) with respect to e_r^i lead to the following first order condition:

$$\frac{\partial E\left[\Pi_r^i \middle| g, e_r\right]}{\partial e_r^i} = \alpha_r - \beta_r \sum_{j \in S_r} e_r^j - \beta_r e_r^i - \phi_r^c + \phi_r^c \left(\eta_{rr}^i(g)\gamma_r + \eta_{rl}^i(g)\gamma_l\right) = 0 \Leftrightarrow$$

$$\beta_r e_r^i = \alpha_r - \beta_r \sum_{j \in S_r} e_r^j - \phi_r^c + \phi_r^c \left(\eta_{rr}^i(g)\gamma_r + \eta_{rl}^i(g)\gamma_l\right)$$

Summing up the optimal e_r^i over $i \in S_r$ leads to the following expression:

$$\sum_{i \in S_r} e_r^i = \left[s_r \alpha_r - s_r \phi_r^c + \phi_r^c \sum_{i \in S_r} \left(\eta_{rr}^i(g)\gamma_r + \eta_{rl}^i(g)\gamma_l\right)\right] \Big/ \beta_r \left(s_r + 1\right)$$

Note that $\sum_{i \in S_r} e_r^i = \sum_{j \in S_r} e_r^j$. Therefore, by substituting above equation into $\sum_{j \in S_r} e_r^j$ in FOC, the equilibrium crime effort level can be written as:

$$0 < 2\phi_{rr}^m < \frac{\phi_r^c \gamma_r s_r}{\beta_r^2 \left(s_r + 1\right)^2} \left[2\left(\alpha_r - \phi_r^c\right) + \phi_r^c \left(s_r \gamma_r - 2\left(s_r - 1\right)\left((n_r - 2)\gamma_r + n_l \gamma_l\right)\right)\right] \quad i \in N_r \setminus S_r \qquad (4.3)$$

Moreover, when this criminal adds a domestic link to another criminal in the complete component of network g, his expected payoff is smaller than when he adds a domestic link to a worker.

And also the cost of international linking, ϕ_{rl}^m, is such that:

$$E\left[\Pi_r^i \middle| g + g^{ij}, e^*\left(g + g^{ij}\right)\right] - E\left[\Pi_r^i \middle| g, e^*\left(g\right)\right] > 0$$

for j being either a worker or another criminal in country $l \in R$. This requires:

$$0 < 2\phi_{rl}^m < \frac{\phi_r^c \gamma_l s_r}{\beta_r^2 \left(s_r + 1\right)^2} \left[2\left(\alpha_r - \phi_r^c\right) + \phi_r^c \left(s_r \gamma_l - 2\left(s_r - 1\right)\left((n_r - 2)\gamma_r + n_l \gamma_l\right)\right)\right] \qquad (4.4)$$

$$e_r^i = \frac{\alpha_r - \phi_r^c + s_r \phi_r^c \left(\eta_{rr}^i (g) \gamma_r + \eta_{rl}^i (g) \gamma_l \right) - \phi_r^c \sum_{j \in s_r \setminus \{i\}} \left(\eta_{rr}^j (g) \gamma_r + \eta_{rl}^j (g) \gamma_l \right)}{\beta_r \left(s_r + 1 \right)} \tag{4.5}$$

where $i, j \in S_r$ and s_r is the number of criminals in country $r \in R$. The criminals' payoff is given by (4.2), which can be shown to be given by:

$$E\left[\Pi_r^i \middle| g, e^*(g) \right] = E\left[\Pi_r^i \middle| g \right] = \left(e_r^i \right)^2 - \phi_r^m - \sum_{j \in N^i(g)} g^{ij} t^{ij} \ . \tag{4.6}$$

4.5 The Second-Stage: Endogenous Network Formation

In our analysis of the international money laundering network, we again use Goyal and Joshi's (2003) formal definition of stable network. The concept of stability we use is defined as follows:

Definition 4.1. *A network g is stable against transfers if:*

(1) For all $g^{ij} = 1$, $\left(E\left[\Pi_r^i \middle| g \right] - E\left[\Pi_r^i \middle| g - g^{ij} \right] \right) + \left(E\left[\Pi_r^j \middle| g \right] - E\left[\Pi_r^j \middle| g - g^{ij} \right] \right) > 0$,

$\forall i \in N_r$, $j \in N$ *and* $r \in R = \{1, 2\}$.

(2) For all $g^{ij} = 0$, $\left(E\left[\Pi_r^i \middle| g + g^{ij} \right] - E\left[\Pi_r^i \middle| g \right] \right) + \left(E\left[\Pi_r^j \middle| g + g^{ij} \right] - E\left[\Pi_r^j \middle| g \right] \right) < 0$,

$\forall i \in N_r$, $j \in N$ *and* $r \in R = \{1, 2\}$.

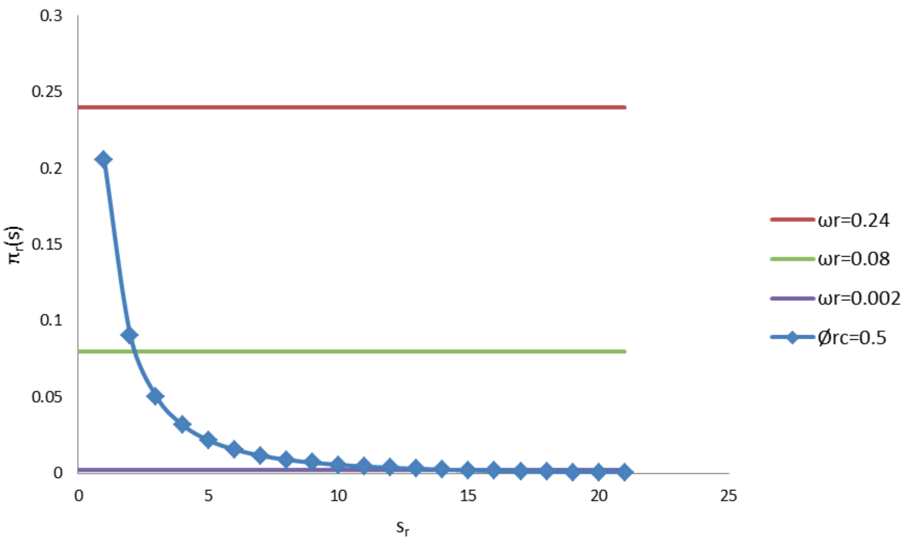
It means that in a stable network against transfer, any two agents who are linked with each other have no incentive to sever the link and any two agents who are not linked should have no incentive to establish a collaboration link.

The next proposition shows that the resulting international money laundering network is an inter-linked star and that this network is the unique stable network against transfers for low cost of money laundering linking.

Proposition 4.1. *Suppose that payoff satisfies (4.2), and crime effort level satisfies (4.5). Let g be an international money laundering network. Network g is stable against transfers if and only if it is an inter-linked star.*

Proof. The proof is given in Appendix C.

Figure 4.3. First stage of the game.



Note: Occupational decision for different wage levels (ω) in country r, with $n_r = 21$, $n_l = 42$, $\phi_r^m = \phi_l^m = 0.00001$, $\phi_r^c = 0.5$ and $\gamma_r = 0.02 \,\&\, \gamma_l = 0.01$.

4.6 The First-Stage: Occupational Decision

At the first stage of the international money laundering game, an agent in country $r \in R$ chooses to participate in the labor market or being a criminal. We say that when $e_r^i = 0$, agent $i \in r$ enters the labor market, and when $e_r^i > 0$, he becomes a criminal.

Since money laundering is a crime, some workers accept contacts to criminals if they receive a transfer, where these transfers are higher than the cost of linking. In this stage we assume that transfers just compensate for the worker's costs, which establishes the minimum value of this transfer. Moreover, criminals do not pay any transfers to each other.

In the first stage of the money laundering game the minimum payoff of each agent has the form of (4.7).

$$E\left[\Pi_r^i \middle| g^{\text{interlinked star}}, s_r\right] = E\left[\Pi_r^i \middle| s_r\right] = \begin{cases} \omega & \text{if} \quad e_i = 0 \\ \left(e_r^i\right)^2 - 2\left(\left(n_r - 1\right)\phi_{rr}^m + n_l \phi_{rl}^m\right) & \text{if} \quad e_i > 0 \end{cases} \tag{4.7}$$

The equilibrium of the first stage of the international money laundering game is characterized by following proposition:

Proposition 4.2. *Suppose a criminal's payoff satisfies (4.7) and the crime effort level satisfies (4.5) for an inter-linked star network. Then the following properties hold:*

(i) When $\omega_r \geq E\left[\Pi_r^i \middle| s_r = 1\right]$ *then there exists a unique equilibrium in which every agent enters the labor market.*

(ii) When $\omega_r \leq E\left[\Pi_r^i \middle| s_r = n_r\right]$ *then there exists a unique equilibrium in which every agent becomes a criminal.*

(iii) When $E\left[\Pi_r^i \middle| s_r = 1\right] < \omega_r < E\left[\Pi_r^i \middle| s_r = n_r\right]$ *then there exist an unique equilibrium number of criminals* s_r^* *such that* $E\left[\Pi_r^i \middle| s_r^*\right] \geq \omega_r$ *and* $E\left[\Pi_r^i \middle| s_r^* + 1\right] < \omega_r$ *. The equilibrium number of criminals is given by:*

$$s_r^* = \frac{\alpha_r - \phi_r^c + \phi_r^c\left((n_r - 1)\gamma_r + n_l\gamma_l\right)}{\beta_r\sqrt{\omega_r + 2\left(\phi_{rr}^m(n_r - 1) + \phi_{rl}^m n_l\right)}} - 1$$

Proof. The proof is given in Appendix C.

4.7 International Money Laundering Network and Country Differences in Wages and Country sizes

Throughout this section, we assume that the two policy variables are exogenously fixed, i.e. the optimal policies do not change with wage, country size etc. As shown in Figure 4.1, when ω_r increases then the number of criminals in country $r \in R$ decreases. Therefore we conclude that, ceteris paribus, in comparison to the rich, high wage, countries, in the poor, low wage countries the number of criminals and hence crime is higher.

In following, we will show that not only criminals launder their crime money in their own country, but also they prefer to launder their dirty proceeds in the rich countries.

Proposition 4.3. (*Comparative Statics) Suppose that the wage rates in countries* r and l differ.

(i) If ω_r *increases, then the number of domestic money laundering collaboration links in country* r *decreases.*

(ii) Suppose $n_r = n_l$, $\gamma_r = \gamma_l$, ... *If* $\omega_r > \omega_l$ *, then the number of international money laundering collaboration links satisfies:*

$$\sum\nolimits_{i\in Nl} \eta^{i}_{lr} > \sum\nolimits_{i\in N_r} \eta^{i}_{rl}$$

Proof. The proof is given in Appendix C.

Regarding to above Proposition we conclude that in high wage countries, the number of money laundering links which go to another country decreases, but in low wage counties, criminals prefer to launder their money in the high wage countries. It means that the crime problem stays in the poor country while the money from it goes to the rich country where it is laundered and may turn into financial assets or is reinvested in real estate or real business. In this case crime increases in the poor country and money laundering goes up in the rich country. Although money laundering may have a negative effect on the rich country (e.g. through an increase of inflation), this country will also gain from the positive effects of more money (Unger, 2007, Chapter 7.8).

Positive effects can be expected from the pure fact that more money circulates in the country, making it easier and more cheaply available, providing easier loans for businesses and consumers, more transaction money, all these resulting in a positive stimulus for investment and higher growth rates (Unger & Rawlings, 2008). Overall, national politicians can expect positive macroeconomic effects such as low unemployment and high growth without having to implement unpopular policies such as raising taxes or cutting public expenditure.

Proposition 4.4. *Suppose* n *is the number of agents who construct the money laundering network and that if* n *is large, also the country size is large. In the case of different country size in* $r \in R = \{\mathrm{r,l}\}$ *the following holds:*

(i) If n_r *increases then the number of domestic money laundering collaboration links in country* r *increases.*

(ii) Suppose $\omega_r = \omega_l$, $\gamma_r = \gamma_l$, ... *If* $n_r > n_l$*, then the number of international money laundering collaboration links is:*

$$\sum\nolimits_{i\in N_r} \eta^{i}_{rl} > \sum\nolimits_{i\in N_l} \eta^{i}_{lr} \quad \textit{where } r,l \in R .$$

Proof. The proof is given in Appendix C.

Based on Part (i) of this proposition the number of domestic money laundering collaboration links in large countries is higher than in small countries. It seems that in large countries the number of criminals and dirty money created by these crimes increase compared to small countries. Based on Proposition 4.4. we can conclude that a country with more criminal potential (larger n , at the same

ω) is expected to have more active criminals, more domestic money laundering problems, and more outgoing money laundering ties (all in absolute terms).

4.8 Anti-Money Laundering Policy

In the case of an international money laundering network, $n_r + n_l$ agents construct this network where n_r is composed of s_r number of criminals and $n_r - s_r$ number of dishonest workers (who help criminals to launder their money) in country $r \in R$ and n_l is composed of s_l number of criminals and $n_l - s_l$ number of dishonest workers in country $l \in R$.

In the case of international money laundering, authorities must randomly investigate and find criminals, and domestic and international money laundering ties by seeking optimal levels of ϕ^c and ϕ^m. The optimal level for each policy instrument will be the one that minimizes crime and money laundering activities while keeping the search costs at a tolerable level. Suppose that authorities seek to minimize a social loss function given by:

$$V_r = \sum_{i \in s_r} e_r^i + \theta_r^c \left(p_r^c\right)^2 + \theta_r^m p_r^m \tag{4.8}$$

where p^c is the crime policy variable ($\phi^c = p^c f^c$) and p^m is the money laundering policy variable ($\phi^m = p^m f^m$). Moreover, θ^c and θ^m are the costs of hiring agents or buying equipment for combating crime and money laundering, respectively.

Note that the number of criminals is given in Proposition 4.2 and equilibrium effort of each criminal in the inter-linked star network is given by:

$$e_r^i = \frac{\alpha_r - \phi_r^c + \phi_r^c \left((n_r - 1)\gamma_r + n_l \gamma_l\right)}{\beta_r \left(s_r + 1\right)}$$

Therefore we can rewrite the social loss as follows:

$$V_r = s_r^* e_r^* + \theta_r^c \left(p_r^c\right)^2 + \theta_r^m p_r^m \tag{4.9}$$

In the following we compare the four different policy regimes from the EPPO proposal, two of which refer to decentral authority (Non-EPPO) and two to centralized authority (EPPO). We model the first decentralized regime of this chapter (no information exchange) based on the baseline scenario in EPPO proposal and the second decentralized regime (the information exchange) based on the strengthening of existing arrangements option. The first centralized regime in my model (evenly split budget) is based on the integrated EPPO and the second centralized regime (tailor-made budget) is based on centralized EPPO. We do not model the Eurojust College EPPO option because, as is mentioned in the EPPO proposal, this option has serious drawbacks.

Under all regimes considered in this chapter, we assume that each country implements its crime policy independently of the other country. As a consequence, we arrive at the following optimal level for the crime policy variable, which is independent of the regime:

Lemma 4.1. *The optimal level of the crime policy variable is given by:*

$$p_r^c = \frac{f_r^c\left[1-\left((n_r-1)\gamma_r+n_l\gamma_l\right)\right]}{2\beta_r\theta_r^c}$$

Proof. The proof is presented in Appendix C.

4.8.1 Decentral Regimes without International Information Exchange

This regime is based on the *Baseline Scenario* of non-EPPO policy option. Therefore in this regime we suppose that $\phi_{rr}^m = f_r^m p_r^m$ is the cost of domestic linking and $\phi_{rl}^m = f_r^m p_r^m$ is the cost of international linking since in the Baseline Scenario no policy changes are defined. Authorities aim to minimize social loss as much as possible by finding the optimal levels of p_r^m while money laundering reaches the tolerable level in their own country. The following proposition characterizes the optimal level of money laundering policy variable in this regime.

Proposition 4.5. *In the absence of an international information exchange regime, the* optimal level of the money laundering policy variable *is given by:*

$$p_r^m = \frac{f_r^m\left(n_r+n_l-1\right)}{2\left(\theta_r^m\right)^2} - \frac{\omega_r}{2f_r^m\left(n_r+n_l-1\right)} \tag{4.10}$$

Proof. The proof is given in Appendix C.

Comparing the optimal money laundering policy variable given by equation (4.10) to the policy in an isolated (closed) country (see Chapter 3, Proposition 3.3), and taking into account that

$\frac{\partial p_r^m}{\partial n_l} = \frac{f_r^m}{2\left(\theta_r^m\right)^2} + \frac{\omega_r}{2 f_r^m \left(n_r + n_l - 1\right)^2} > 0$, allows to conclude that countries invest more in the fight against money laundering when criminals have additional money laundering opportunities abroad.

4.8.2 Decentral Regimes with International Information Exchange

With the idea that fighting money laundering needs international cooperation, the Egmont Group of FIUs was formed in 1995. The aim of this group is to cooperate, especially in the areas of information exchange, training and the sharing of expertise to combat money laundering. Therefore, we refer to this group as the decentral regime with international information exchange. Also, this regime reflects *the enhanced Eurojust, Art. 85 which formulated cooperation* as *strengthening existing arrangements, described above in Subsection 4.2.2.* In this regime, suppose that $\phi_{rr}^m = f_r^m p_r^m$ is the cost of domestic linking and $\phi_{rl}^m = f_r^m \left(p_r^m + p_l^m\right)$ is the cost of international linking. In the following Lemma, we first derive the best response function of the money laundering policy variable:

Lemma 4.2. *In the presence of an international information exchange regime, the best response function of the money laundering policy variable is given by:*

$$p_r^m = \frac{f_r^m \left(n_r + n_l - 1\right)}{2\left(\theta_r^m\right)^2} - \frac{\omega_r + 2 n_l f_r^m p_l^m}{2 f_r^m \left(n_r + n_l - 1\right)} \tag{4.11}$$

Proof. The proof is given in Appendix C.

Equation (4.11) allows us to conclude that in countries that use an international information exchange regime to combat money laundering, money laundering policies are strategic substitutes. When one country increases its expenditure to fight money laundering, another country will reduce its expenditure. In part (i) of the following Proposition, we show the equilibrium level of the money laundering policy variable when countries using the information exchange regime to fight money laundering:

Proposition 4.6. *Comparing the optimal policy levels with and without an international information exchange regime leads to the following result:*

(i) *The equilibrium value of the money laundering policy variable in country* $r \in R$ with an international information exchange regime is as follows:

$$\left(p_r^m\right)^* = \frac{\left(n_r + n_l - 1\right)^2}{\left(n_r + n_l - 1\right)^2 - n_r n_l} \cdot \left[\frac{\omega_l n_l}{2 f_l^m \left(n_r + n_l - 1\right)^2} + \frac{f_r^m \left(n_r + n_l - 1\right)}{2\left(\theta_r^m\right)^2} - \frac{\omega_r}{2 f_r^m \left(n_r + n_l - 1\right)} - \frac{f_l^m n_l}{2\left(\theta_l^m\right)^2} \right]$$

(ii) Each country invests less when using an international information exchange regime.

(iii) Social loss decreases in each country when using an international information exchange regime.

Proof. The proof is given in Appendix C.

We can thus conclude that since the social loss is lower in countries with an international information exchange regime it would be beneficial for countries to use such a regime to combat money laundering.

Next, we consider two countries that establish a central money laundering authority. This authority implements a common budget to fight money laundering in both countries. Further, suppose that this central authority can either use an evenly split budget or a tailor-made budget to fight money laundering. We refer to the FATF (established in 1989) as the central authority to fight money laundering worldwide.

4.8.3 Central Regimes with an Evenly Split Budget

This policy option is based on the *Centralized EPPO,* which is not dependent on the national prosecution services and acts on the basis of a supranational substantive and procedural law. Consider two countries with central authorities and a standardized budget. In this case, the total social loss of the two countries together is as follows:

$$A : V_r + V_l = s_r^* e_r^* + s_l^* e_l^* + \theta_r^c \left(p_r^c\right)^2 + \theta_l^c \left(p_l^c\right)^2 + \left(\theta_r^m + \theta_l^m\right) p^m$$

By taking the first derivative with respect to p^m the following optimal level of a money laundering policy variable can be derived:

$$\frac{\partial A}{\partial s_r} \cdot \frac{\partial s_r}{\partial p^m} + \frac{\partial A}{\partial e_r} \cdot \frac{\partial e_r}{\partial p^m} + \frac{\partial A}{\partial e_r} \cdot \frac{\partial e_r}{\partial s_r} \cdot \frac{\partial s_r}{\partial p^m} + \frac{\partial A}{\partial s_l} \cdot \frac{\partial s_l}{\partial p^m} + \frac{\partial A}{\partial e_l} \cdot \frac{\partial e_l}{\partial p^m} + \frac{\partial A}{\partial e_l} \cdot \frac{\partial e_l}{\partial s_l} \cdot \frac{\partial s_l}{\partial p^m} + \frac{\partial A}{\partial p^m} =$$

$$-\frac{f_r^m \left(n_r + 2n_l - 1\right)}{\sqrt{\omega_r + 2 f_r^m \left(n_r + 2n_l - 1\right) p^m}} - \frac{f_l^m \left(2n_r + n_l - 1\right)}{\sqrt{\omega_l + 2 f_r^m \left(2n_r + n_l - 1\right) p^m}} + \theta_r^m + \theta_l^m$$

In an interior optimum, it thus needs to hold:

$$\frac{f_r^m\left(n_r+2n_l-1\right)}{\sqrt{\omega_r+2f_r^m\left(n_r+2n_l-1\right)p^m}}+\frac{f_l^m\left(2n_r+n_l-1\right)}{\sqrt{\omega_l+2f_r^m\left(2n_r+n_l-1\right)p^m}}=\theta_r^m+\theta_l^m \tag{4.12}$$

In the following proposition, we first look at countries which are identical in all respects, then we consider the case of countries with wage heterogeneity:

Proposition 4.7. *Consider two countries which are identical in all respects but have heterogeneous wages. Each country invests more to combat money laundering and the social loss will be lower in each country under an evenly split budget regime than under an international information exchange regime.*

Proof. The proof is given in Appendix C.

We consider the case that countries are identical in all respects but have non-identical wages. If these two countries have identical wages, p_m can be calculated. However, in the case of non-identical wages, it is impossible to calculate p_m explicitly from identity (4.12). Therefore we use numerical simulations to solve the problem (see also Figure 4.6) The simulations allow us to conclude that when the wage of workers goes down in one country the optimal level of the money laundering policy variable will be increased. The result is based on the fact that lower wage will lead to an increase in the number of criminals in that country, and thus an increase in crime. As a consequence, the central authority invests more to make crime unattractive, i.e., it increases the level of the money laundering policy variable.

When countries use the evenly split budget to combat money laundering, the optimal level of money laundering policy variable increases since authorities have to spend more to fight money laundering. However, social loss in each country decreases compare to a regime with international information exchange.

4.8.4 Central Regimes with a Tailor-Made Budget

This regime is based on the *Integrated EPPO* which in the majority of the EU's member states is the best policy to protect the financial interests of the Union by means of criminal law. In countries with a central authorities and a tailor-made budget, the social loss is as follows:

$$B: V_r+V_l=s_r^*e_r^*+s_l^*e_l^*+\theta_r^c\left(p_r^c\right)^2+\theta_l^c\left(p_l^c\right)^2+\theta_r^m p_r^m+\theta_l^m p_l^m$$

As authorities aim to minimize the social loss, we can consider the first derivative with respect to p_r^m :

$$\frac{\partial B}{\partial s_r}.\frac{\partial s_r}{\partial p_r^m}+\frac{\partial B}{\partial e_r}.\frac{\partial e_r}{\partial p_r^m}+\frac{\partial B}{\partial e_r}.\frac{\partial e_r}{\partial s_r}.\frac{\partial s_r}{\partial p_r^m}+\frac{\partial B}{\partial p_r^m}+\frac{\partial A}{\partial s_l}.\frac{\partial s_l}{\partial p_r^m}+\frac{\partial B}{\partial e_l}.\frac{\partial e_l}{\partial p_r^m}+\frac{\partial B}{\partial e_l}.\frac{\partial e_l}{\partial s_l}.\frac{\partial s_l}{\partial p_r^m}=$$

$$-\frac{f_r^m\left(n_r+n_l-1\right)}{\sqrt{\omega_r+2f_r^m\left((n_r+n_l-1)p_r^m+n_lp_l^m\right)}}-\frac{f_l^m n_r}{\sqrt{\omega_l+2f_l^m\left((n_r+n_l-1)p_l^m+n_rp_r^m\right)}}+\theta_r^m$$

Therefore, the optimal level of the money laundering policy variable laundering from the authorities' perspective is as follows:

$$\frac{f_r^m\left(n_r+n_l-1\right)}{\sqrt{\omega_r+2f_r^m\left((n_r+n_l-1)p_r^m+n_lp_l^m\right)}}+\frac{f_l^m n_r}{\sqrt{\omega_l+2f_l^m\left((n_r+n_l-1)p_l^m+n_rp_r^m\right)}}=\theta_r^m \tag{4.13}$$

We conclude that when the wage of workers goes down in one country, the optimal level of the money laundering policy variable will increase in this country and will decrease in the other country. The intuition is that by decreasing the wage of workers, the number of criminals will increase. Therefore, authorities have to spend more to fight crime and money laundering related to it. Since countries use the tailor-made budget system, when one country spends more to fight money laundering, the other country will benefit from it and reduce its expenditures.

The following two results compare the tailor-made budget regime with its alternatives:

Proposition 4.8. *Consider two countries which are identical in all respects but have heterogeneous wages. In countries with homogenous wages as well as with heterogeneous wages for workers, each country invests more to combat money laundering and social loss will lower in each country with a tailor-made budget regime than under an international information exchange regime.*

Proof. The proof is given in Appendix C.

Since countries are better off by using either of the central authorities regimes to combat money laundering in comparison with an international information exchange regime, we will next compare these two central regimes with each other to identify the best policy to fight money laundering.

Proposition 4.9. *Consider two countries with wage levels* ω_r *and* ω_l *and a centralized authority.*

(i) In countries with homogenous wage levels, each country invests the same to fight money laundering in both central authority regimes i.e. with an evenly split budget or a tailor-made budget. Likewise, social loss will be the same under both regimes.

(ii) In countries with heterogeneous wages levels, the low wage country spends more to fight money laundering and also social loss is higher under a tailor-made budget than under an evenly split budget regime. However, the high wage country will spend less and also social loss will be less under a tailor-made budget than under an evenly split budget regime.

(iii) If countries use the tailor-made budget regime, the total social loss in these countries is less that when they use an evenly split budget system.

Proof. The proof is given in Appendix C.

Since we could not calculate p_m explicitly through the equation (4.12), we used the numerical simulation to prove part (ii) and (iii) of the above proposition.

4.8.5 Comparison of regimes: which country is better off?

Next, we analyze which country will benefit **relatively more** from changing to an international information exchange regime as compared to without international information exchange regime. In Figures 4.4 – 4.7, we first consider the case of countries which are identical in all respects but have **heterogeneous wages**. The horizontal axis shows the ratio of labor while the vertical axis shows the social loss ratio. Countries with point one on the horizontal axis are homogenous, while for all other points they are heterogonous in the wages of workers. Suppose that the wage of workers in country r stays the same while it increases in country l. Based on the first stage of the international money laundering game, when the wage of workers in one country is higher, the number of criminals in this country is less, which leads to a lower social loss compare to a low wage country.

First we compare the two decentralized regimes with each other (Figure 4.4). Consider two homogeneous countries. The optimal level of money laundering policy variable is given as follows:

1. Countries without an international information exchange regime:

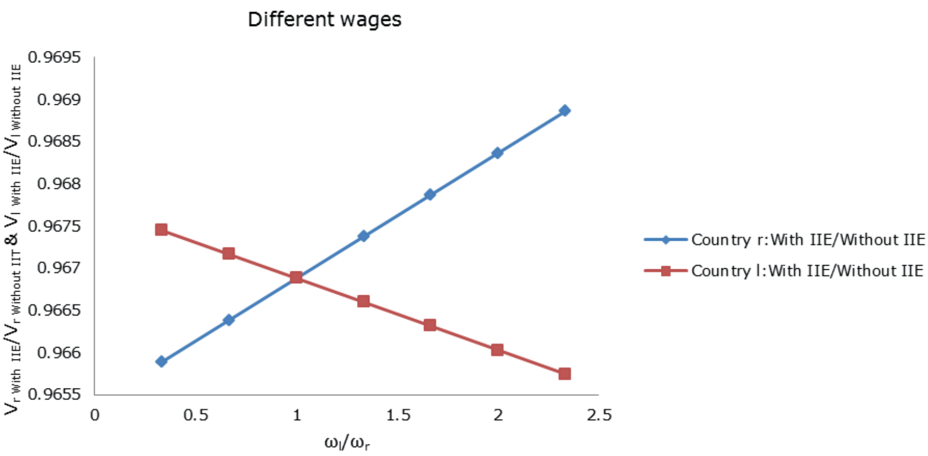
$$p^m = \frac{f^m(2n-1)}{2\theta_m^2} - \frac{\omega}{2f^m(2n-1)} \tag{4.14}$$

2. Countries with an international information exchange regime:

$$p^m = \frac{f^m(2n-1)^2}{2(3n-1)\theta_m^2} - \frac{\omega}{2f^m(3n-1)} \tag{4.15}$$

Comparing (4.14) and (4.15) allows us to conclude that for *homogeneous* countries the money laundering policy variable in countries with an international information exchange regime is less than

Figure 4.4. Comparison of decentralized regimes with each other (heterogeneous wage countries).



Note: Comparison of social loss in countries with heterogeneous wages of workers with an international information exchange regime (With IIE) and without an international information exchange regime (Without IIE).

in countries without an international information exchange regime. Therefore, the cost of *domestic* linking ($\phi_{rr}^{m} = f_r^m p_r^m$) in countries with an international information exchange regime is less than in countries without an international information exchange regime since the domestic money launderers are less likely to be prosecuted. However, when considering the cost of *international* linking in the two regimes regime ($\phi_{rl}^{m} = f_r^m p_r^m$ and $\phi_{rl}^{m} = f_r^m \left(p_r^m + p_l^m \right)$ respectively), we can conclude that these costs are higher in countries with an international information exchange regime than in countries without international information exchange regime.

Next, consider two countries with heterogeneous wages for workers. The optimal probabilities of crime detection and money laundering detection are, respectively:

1. Countries without an international information exchange system:

$$p_r^m = \frac{f^m (2n-1)}{2\theta_m^2} - \frac{\omega_r}{2f^m (2n-1)} \tag{4.16}$$

2. Countries with an international information exchange system:

$$p_r^m = \frac{f^m (2n-1)^2}{2(3n-1)\theta_m^2} - \frac{\omega_r (2n-1) - \omega_l n}{2f^m (n-1)(3n-1)} \tag{4.17}$$

As is evident from equation (4.16), when wages of workers increase, the optimal level of money laundering policy variable decreases. In the first stage of the game, when the wage of workers increases, the number of criminals decreases. Therefore authorities need to invest less to combat money laundering and the optimal level of money laundering policy variables will go down.

Analogously, from (4.17) it follows that when the wage of workers in one country increases, the money laundering policy variable will be lowered in this country, since the number of criminals decreases. However, the optimally money laundering policy variable will be increased in the other country, because the first country will spend less effort to combat money laundering.

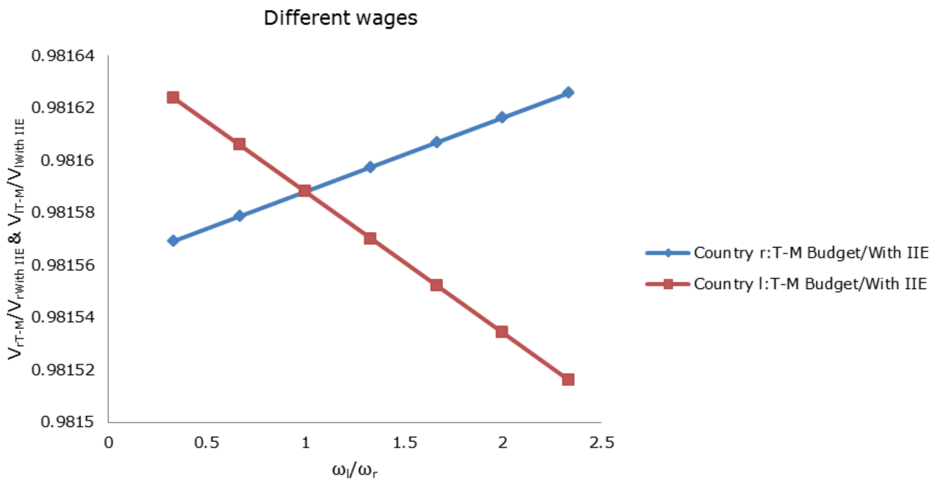
Figure 4.4 shows the comparison of social loss in countries with heterogeneous wages of workers and with decentralized regimes. Since the wage of workers stays the same in country r , the social loss also stays the same in this country, while it decreases in country l , since increasing the wage of workers leads to fewer criminals if countries use no international information exchange system. Figure 4.4 allows to conclude that in countries with either homogeneous or heterogeneous wages of workers, the social loss with an international information exchange regime is less than without an international information exchange regime. This is due to the fact that both countries will benefit from each other's effort to combat money laundering if they apply an international information exchange regime (which confirms Proposition 4.7). The argument that leads to this conclusion is the following: A country could maintain the old policy level which it finds optimal under the system without international information exchange. By using international information exchange the country would be better off than before, because it benefits now from the investment of the other country. However, when the country reduces its investment then it must be even better off, which follows from the argument of revealed profitability.

Regarding the first stage of the game, the number of criminals in the low wage country is higher than in the high wage country. In this case, the authorities in the low wage country will spend more effort to combat money laundering. Therefore the social loss in the low wage country is higher than in the high wage country. Since countries exchange information to combat money laundering, the high wage country will benefit from the increased efforts of the low wage country to fight money laundering. It implies that a high wage country with benefit more from the introduction of an international information exchange system.

Figure 4.5 shows the comparison of social loss in countries with heterogeneous wages of workers with a *tailor-made budget system* and with an *international information exchange system*. This figure allows us to conclude that the social loss with a tailor-made budget system in homogenous countries and in countries with heterogeneous wages is less than with an international information exchange regime. Therefore, we conclude that both countries are better off by using the tailor-made budget system compared to an international information exchange system. This figure also shows that the high wage country will benefit relatively more from the tailor-made budget regime than from international information exchange.

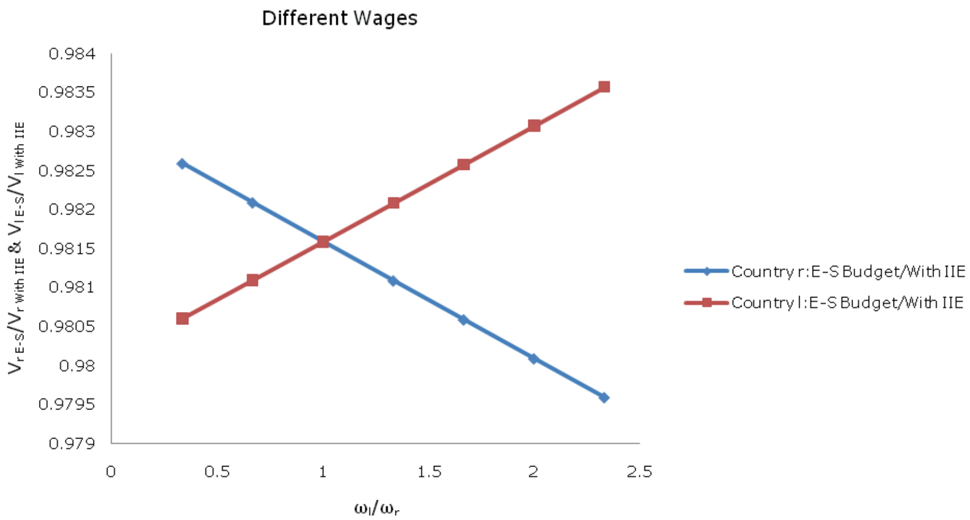
Figure 4.7 shows the comparison of social loss in countries with heterogeneous wages of workers with the two *central authority regimes*. Suppose that the countries use the *evenly split budget*

Figure 4.5. Comparison of a tailor-made budget regime with decentralized regimes (heterogeneous wage countries).



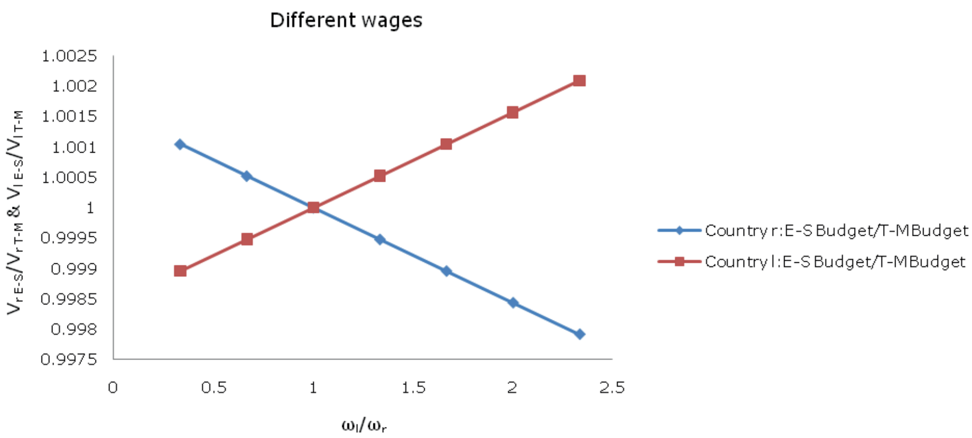
Note: Comparison of social loss in countries with heterogeneous wages of workers with a tailor-made budget system (T-M Budget) and with an international information exchange system (With IIE).

Figure 4.6. Comparison of an evenly split budget regime with decentralized regimes (heterogeneous wage countries).



Note: Comparison of social loss in countries with heterogeneous wages of workers with an evenly split budget system (E-S Budget) and with an international information exchange system (With IIE).

Figure 4.7. Comparison of centralized regimes with each other (heterogeneous wage countries).



Note: Comparison of social loss in countries with heterogeneous wages of workers with centralized authorities (evenly split budget system (E-S Budget) and tailor-made budget system (T-M Budget)).

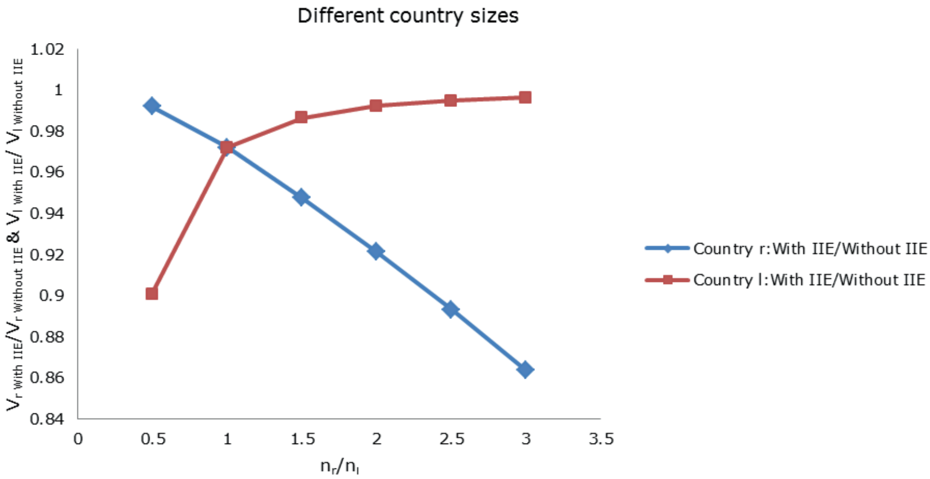
system and the wage of workers is increasing in country l, while it stays the same in country r. Thus, by increasing the wage of workers in country l, social loss will go down in this country. In country r, however, social loss decreases as long as the wage of workers in this country is higher than in the other country, and social loss increases in this country when the wage in the other country is higher and increasing. Therefore, when the countries use the evenly split budget system, social loss in the high wage country is lower than in the low wage country, due to the fact that in the high wage country the number of criminals is lower.

Now, suppose that countries use the *tailor-made budget system* and the wage of workers is increasing in country l, while it stays the same in country r. Since the number of criminals decreases in country l, social loss will go down in this country, but it is increased in country r.

However, this figure also shows that when countries use an evenly split budget system, a rich country (with higher wages) will suffer more than a poor country from using this system: while there are less criminals in the rich country r, this country is committed to invest the same level to combat money laundering.

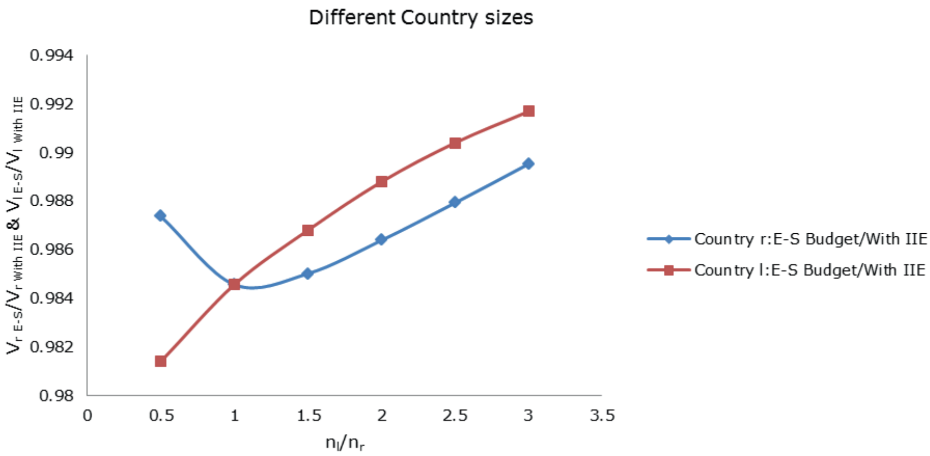
Thus, we conclude that a low wage country will benefit more from the same level of investment induced by using the evenly split budget system compared to the tailor-made budget system. A central authority whose hands are bound to set an evenly split budget will do this in the advantage of a poor country. When the authority is free to implement the tailor-made budget in

Figure 4.8. Comparison of decentralized regimes (heterogeneous country size).



Note: Comparison of social loss in countries with heterogeneous country sizes without (Without IIE) and with international information exchange (With IIE).

Figure 4.9. Comparison of an evenly split budget regime with decentralized regimes (heterogeneous country size).



Note: Comparison of social loss in countries with heterogeneous country sizes with an international information exchange system (With IIE) and with an evenly split budget system (E-S Budget).

different countries, it will be an advantage of a rich country as there is less criminal activity in this country.

Note that a tailor-made budget system regime is more efficient, as also the sum of social losses in both countries is less with a tailor-made budget than with an evenly split budget system.

Next we turn to analyzing the case of countries which are identical in all respects but have **heterogeneous country sizes**, measured by the number of people in a country, to investigate which country will benefit relatively more from changing to another regime: a small country or a large country. Suppose that the size of country r stays the same but increases for country l. In Figures 4.8 and 4.9, the horizontal axis shows the ratio of country sizes while the vertical axis shows the social loss ratio. Countries with point one on the horizontal axis are homogenous, while for all other points they are heterogonous in country size. Suppose that the wages of workers in country r stay the same while they increase in country l.

First, we compare two countries of heterogeneous size when they are using decentral regimes:

1. Countries without an international information exchange:

$$p_r^m = \frac{f^m\left(n_r + n_l - 1\right)}{2\left(\theta^m\right)^2} - \frac{\omega}{2f^m\left(n_r + n_l - 1\right)} \tag{4.18}$$

2. Countries with an international information exchange:

$$p_r^m = \frac{\left(n_r + n_l - 1\right)^2}{\left(n_r + n_l - 1\right)^2 - n_r n_l}\left(\frac{f^m\left(n_r - 1\right)}{2\left(\theta^m\right)^2} - \frac{\omega\left(n_r - 1\right)}{2f^m\left(n_r + n_l - 1\right)^2}\right) \tag{4.19}$$

Equation (4.18) allows us to conclude that when countries use *no international information exchange system*, the optimal level of a money laundering policy variable is independent of the size of the countries.

However, based on the equation (4.19), in countries *with an international information exchange system*, the optimal level of a money laundering policy variable in small countries is lower than in large countries. Small countries benefit from higher investments in the large countries and authorities do not need to invest as much when they use an international information exchange system.

Moreover, by comparing equations (4.18) and (4.19) we can conclude that the money laundering policy variable in countries with an international information exchange system is lower than in countries without an international information exchange system. By using the same method of analysis as before (when considering differences in wages), we reach exactly the same result for differences in country size. Therefore, we conclude that also in countries with different sizes a *tailor-*

made budget system regime is more efficient, as also the sum of social losses in countries with a tailor-made budget system regime is lower than with other regimes.

Figure 4.8 shows that a small country will benefit more from an international information exchange regime compared to a regime without an international information exchange.

Figure 4.9 shows the comparison of social loss in countries with heterogeneous sizes with an international information exchange system and with an evenly split budget system. As can be seen in this figure, the social loss with an evenly split budget system is less than when countries use an international information exchange system. However, when countries use an evenly split budget system, they are committed to invest the same amount in both countries, and in this case the social loss in the small country is increasing when the size of the other country increases. Therefore, we conclude that a small country will benefit more from an evenly split budget system compared to a system with international information exchange. By using numerical simulations[34], we can conclude for countries with different country sizes that the sum of the social loss with a tailor-made budget system is less than with other regimes. Therefore we conclude that the best regime to fight money laundering when countries differ in sizes is using the tailor-made budget system.

Based on Proposition 4.3, Part (ii), criminals prefer to launder their money in rich countries (average income measured by the wage level). This can be explained by Figure 4.4, as the optimal level of money laundering policy variable in rich countries is lower than in poor countries. Therefore, criminals prefer to launder their money in rich countries. Thus, when criminals prefer to launder their money in the rich countries, the crime problem stays in the poor countries, but money from those criminal activities goes to the rich countries. This implies that the social loss decreases in the rich countries, while it will increase in poor countries. Likewise, based on Proposition 4.4, Part (ii), criminals prefer to launder their money in small countries. As shown in Figure 4.8, the optimal level of a money laundering policy variable in big countries is higher than in small countries. Thus, criminals prefer to launder their money in small countries because of the lower chance of being detected. Since criminals in big countries commit crime in their own country but tend to launder their money in small countries, the social loss will increase in the big country, whereas it will decrease in small countries.

4.9 Conclusion

The aim of this chapter was to theoretically assess different options for transnational policy cooperation to fight crime and money laundering. Towards this end, we tried to distill the major elements of the different policy options considered by the European Union concerning the establishment of an EPPO and compare these options in the confines of a two-country extension of the money laundering model introduced in Chapter 3. In the analysis, we considered four regimes to combat money laundering, namely (i) a decentral regime without an international information exchange, (ii) a decentral regime with an information exchange, (iii) a central regime with an evenly

[34] For more details see the numerical simulation to compare the two centralized authority systems in countries with homogeneous and heterogeneous country size in Appendix C.

split budget among the two countries, and (iv) a central regime with a tailor-made budget. We determined the best option from the viewpoint of each country and from the overall viewpoint, considering countries that differ in average income and country sizes.

My main findings are that, as compared to option (i), international information exchange (option ii) allows countries to reduce their investments into combating money laundering, since they will benefit from each other's investments. This results, moreover, in a reduction of the social loss in each country. The comparison of option (ii) with the two central regime approaches (options iii and iv) shows that the best regime to combat money laundering is a central authority with a tailored-made budget (option iv) from the perspective of overall welfare. We also compare the cases of an evenly-split budget (option iii) versus a tailor-made budget (option iv). Our findings show that the first-best regime is to implement a central authority which allocates tailor-made budgets, whereby the high wage country receives most. A central authority which allocates budgets evenly, in contrast, is in the advantage of the low wage country. The reason is that the even split is not in proportion to the criminal activity in the two countries, so that the richer country will effectively subsidize the poorer one. A similar finding applies to an evenly-split budget when the two countries differ in size: the larger country subsidizes the smaller one.

Bibliography

Becker, G. S. (1968). Crime and punishment: An economic approach. In The Economic Dimensions of Crime (pp. 13-68). Palgrave Macmillan UK.

Brettl, J., & Usov, A. (2010). Money Laundering Threat Assessment for EU 27. Mimeo.

Goyal, S., & Joshi, S. (2003). Networks of collaboration in oligopoly. Games and Economic behavior, 43(1), 57-85.

Hamran, L., & Szabova, E. (2013). European Public Prosecutor's Office-Cui Bono. New J. Eur. Crim. L., 4, 40.

Ligeti, K., & Simonato, M. (2013). The European Public Prosecutor's Office: Towards a Truly European Prosecution Service. New J. Eur. Crim. L., 4, 7.

Ligeti, K., & Weyembergh, A. (2015). The European Public Prosecutor's Office: Certain Constitutional Issues. In The European Public Prosecutor's Office (pp. 53-77). TMC Asser Press.

McCarthy, K. J. (2013). 10. Why do some states tolerate money laundering? On the competition for illegal money. Research Handbook on Money Laundering, 127.

Unger, B. (2007). The scale and impacts of money laundering. Edward Elgar Publishing.

Unger, B., & Rawlings, G. (2008). Competing for criminal money. Global Business and Economics Review, 10(3), 331-352.

Unger, B., Ferwerda, J., van den Broek, M., & Deleanu, I. (2014). The Economic and Legal Effectiveness of the European Union s Anti-Money Laundering Policy. Edward Elgar Publishing.

von und zu Liechtenstein, P. M. (2013). 11. Money laundering and small states: the practical experience of Liechtenstein. Research Handbook on Money Laundering, 143.

Walker, J. (1995). Estimates of the extent of money laundering in and through Australia, paper prepared for Australian transaction reports and analysis centre. Queanbeyan: John Walker Consulting Services.

Walker, J. (2011). Measuring money laundering threat. Mimeo.

Weyembergh, A., & Briere, C. (2016). Towards a European Public Prosecutor's Office (EPPO).

Chapter 5

Conclusion

In this chapter we present a summary of the findings discussed in the previous chapters of this dissertation, and discuss possible directions for future research.

5.1 Summary of the Findings

Money laundering is the disguising of the illegal origin of money by bringing it back into the legal financial circuit. It is a relatively new topic in economics, specifically from the perspective of network analysis. Therefore, in this dissertation we try to establish a theoretical framework to understand the role of social networks, and the link between criminals and legal actors in the money laundering process. We focus on the money laundering method called smurfing; the splitting of large criminal proceeds into small inconspicuous amounts, and since this technique typically requires a network, it requires potential criminals to form links with other people and to construct a money laundering network to launder their money.

The research questions are focused on how the networks are formed when criminals strategically form links to launder their money and what the shape of the network is at the macro-level. Moreover, focus is also on optimal policies to fight crime and money laundering, both at the national and the international level. Towards this end, we introduce social network and game theory into the field of money laundering. The study also includes some simulations in order to find the optimal budget for anti-money laundering policy.

Chapter 1 gives a general introduction to this dissertation and an overview of the literature on money laundering and network analysis.

In Chapter 2, we analyze a typical drug-crime scenario by presenting a simple model to study the formation of a money laundering network in this context. Here we assume that there are three types of actors: criminal bosses, foot soldiers selling drugs on the street, and dishonest workers, such as bank employees. In this model, agents first decide whether to become either criminals or workers. Afterwards, criminals divide into criminal bosses and foot soldiers by chance, where we follow Levitt and Dubner (2010) and assume that criminal talent is ex-ante unknown to agents and only a talented criminal will become a criminal boss and earn a fortune. The successful criminals decide afterwards whether they want to launder their money by adding collaboration links to other agents or not. In this chapter, we assume that linking cost is low. Although these links are costly, they help to lower the marginal costs of the criminal activity by replacing the crime proceeds with clean ones. We show that the money laundering network at the macro level has an extended inter-linked star structure in which the talented criminal bosses are fully interconnected. We also show that agents' willingness to become criminals is endogenously dependent on the wage of workers. We conclude this chapter with a number of comparative statics analyses that confirm many of the intuitive ideas about how the size of the criminal pool, wages in the legal sector, and how financial control systems influence the size of the money laundering network.

We use the analysis presented in Chapter 2 as a stepping stone for the further work in this dissertation. We have shown that criminal bosses try to launder their money by forming money laundering ties to other criminal bosses, foot soldiers, and workers. In the following chapters we consider only two groups of agents in our network, potential criminals and workers. After characterizing the network we analyze the national and international policy to combat money laundering. In Chapter 3, we analyze a domestic money laundering network when agents form money laundering networks nationally and we derive a national optimal policy response for this. In Chapter 4, we expand the framework to an international scenario. We analyze an international money laundering network and different regimes to internationally fight money laundering.

Chapter 3 expands on the model from Chapter 2. In this model, agents first decide whether to enter the labor market or become a criminal. Then criminals decide afterwards whether they want to launder their money by adding collaboration links to other agents or not. Finally, criminals choose which crime effort level they wish to provide. We find that for low linking costs, the equilibrium network is, just as in Chapter 2, an inter-linked star in which criminals are fully interconnected. Also again, agents' willingness to become criminals or attend the labor market is endogenously dependent on the wage level in a society. We conclude that an increase in workers' wages leads to lower crime rates and less money laundering operations. In other words, we confirm the conclusions of Engelhard, Rocheteau and Rupert (2008), as our results also show that labor market policies can play a crucial role in reducing crime and money laundering.

In this, we deal with anti-money laundering and anti-crime policy seen from a domestic angle. Here, our focus is on the question how a given budget should be spent on anti-crime and anti-money laundering policies. We define a social loss function, which an authority seeks to minimize by finding the optimal level of crime and money laundering policy. Our analysis suggests that when the money laundering reporting threshold increases, the number of money launderers decreases. Therefore, the optimal level of crime policy variable decreases and money laundering policy becomes more important. We also conclude that by increasing the wage of workers, the number of criminals, crimes and money laundering operations in society decrease. Since each criminal has many money laundering ties, by decreasing the number of criminals, the number of ties among them goes down significantly. In this case the optimal level of money laundering policy decreases and crime detection policy becomes more effective. Furthermore, we conclude that when the costs of implementing anti-crime policies are low or if the prosecution and conviction of criminal acts is easy to enforce, authorities should fight criminals on this ground. In contrast, if money launderers can be effectively prosecuted at low costs, authorities should focus on them.

Finally, at the end of Chapter 3, we empirically implement our model using real world data and calculate the optimal policy response numerically with a macro-level "sufficient statistics'' approach. We apply the model to the Netherlands. Based on the sufficient statistics approach, where we use some macro constructs of parameters and variables that are readily observable in current macro-economic datasets, we find that the share of the budget that should be spent on fighting money laundering in order to optimize crime-fighting results is 30%.

Chapter 4 studies the formation of an international money laundering network. Here, the focus is on comparing different transnational forms of cooperation in the fight against money laundering. The structure of the game is identical to Chapter 3, except that there are now two countries.

A first comparative statics result is that in a high wage country, the number of money laundering links which go to another country is lower than in a low wage county, where criminals prefer to launder their money in the high wage country. Second, comparing population sizes, criminals prefer to launder their crime money in a small country, rather than in a big country. This result is in line with Gnutzmann et al, 2010 (mainly small countries will provide money laundering opportunities).

In this chapter, we also derive policy implications for fighting crime and money laundering at a transnational level. We consider two countries where in each country authorities aim to minimize the social losses consisting of the damage done by domestic crime and of the cost of anti-crime and anti-money laundering policies. Since criminals try to launder their money in their own country as well as abroad, authorities might collaborate in their fight against crime and money laundering. We consider four regimes that are stylized representations of current transnational collaborations, namely: a decentral regime without international information exchange; a decentral regime with international information exchange; a central regime with an evenly split budget; and a central regime with a tailor-made budget. For each regime, we characterize the optimal level of a money laundering policy variable. An example for the decentralized regime is the Egmont Group of the FIUs (Financial Intelligence Units). Egmont Group FIUs meet regularly to find ways to improve the work of FIUs and to cooperate with each other, especially in the areas of information exchange, training and the sharing of expertise (established in 1995). An example for the centralized regime would be the Financial Action Task Force, which regulates money laundering at a global level (established in 1989).

The comparison shows that if countries engage in information exchange, money laundering policies are strategic substitutes, because one country will free ride on the efforts of the other. As a consequence, each country invests less in comparison to a regime without information exchange. However, since the sum of the investments is larger than without information exchange, both countries are clearly better off, whereby the largest benefits accrue in the high wage country. Our comparison between the decentralized and the central regimes shows the following: because a central authority internalizes the positive externality of an anti-money laundering investment, it enforces a higher budget in both countries. As a result, the social losses are lower in each country than in both of the decentralized regimes. We also compare the cases of an evenly-split budget versus a tailor-made budget. Our findings show that the first-best regime is to implement a central authority which allocates tailor-made budgets, whereby the high wage country receives most. A central authority which allocates budgets evenly, in contrast, is to the advantage of the low wage country. The reason is that the even split is not in proportion to the criminal activity in the two countries, so that the richer country will effectively subsidize the poorer one. A similar finding applies to an evenly-split budget when the two countries differ in size: the larger country subsidizes the smaller one.

5.2 Direction for Future Research

Since it is the first time that money laundering is researched by means of a game theoretic network model, we encountered many limitations. Therefore, many possible adjustments and extensions can be thought of. Possibly the biggest limitation in all our models is that we only look at the smurfing technique of money laundering. Technically, we assume that every time a criminal launders money, this comes at a very low linking cost to him. Hence, more money laundering decreases his chance of being detected. Therefore, we reach a corner solution for the model, where all criminals are fully inter-connected and form links to every money launderer.

Yet, in reality, many criminals work together with just one money launderer (like the relationship between the famous Dutch criminal Willem Holleeder and the real estate agent Willem Endstra), simply because they cannot trust anyone. Future research might therefore study a model of network formation, where criminals face trust issues and thus larger costs. This might mean that one has to study a model of incomplete information, where however criminals can learn about the trustworthiness of another person through their existing criminal and/or money laundering ties.

In Chapters 3 and 4, we suppose that authorities aim to minimize total criminal effort, and we assume quadratic costs for crime detection policies, but a linear cost function for anti-money laundering operations. We have tried out several more realistic social loss functions, with total crime proceeds as the target and a more general convex cost function, but never found tractable solutions to work with. Future research might use simulation techniques to explore this avenue further.

Third, in our analysis of optimal international money laundering policies in Chapter 4, we have not considered additional costs of cooperation. Thus, future research might incorporate in each of the four regimes under study the costs of arrangement (e.g. costs of information exchange). Because taking money aboard has advantages for criminals, the government in the destination country has an information disadvantage (they do not know the criminal) which means bringing money across a border reduces transparency and therefore lowers the chances of being caught, but it is a costly process for criminals as well. Finally, we ignored the extra cost of taking money abroad by criminals. Another direction of future research could involve the consideration of this extra cost.

Given these limitations, this dissertation however hopes to inspire future research. It has tried to build a framework in which money laundering networks can further be studied and from which further policy implications can be derived.

Appendix A

Appendix - Chapter 2

Lemma A.1. *Suppose g is a network with n agents where r is the number of criminals, the number of bosses is $0<s<r$, payoff satisfies (2.2), and crime effort level satisfies (2.6).*
Consider any network g and distinct agents $i \in S$ and $j,k \in N \setminus R$, $g_{ij} = g_{ik} = 0$. Then:

$$E\left[\Pi_i \middle| g+g_{ij}+g_{ik}\right]-E\left[\Pi_i \middle| g+g_{ij}\right] > E\left[\Pi_i \middle| g+g_{ij}\right]-E\left[\Pi_i \middle| g\right].$$

Proof. First of all, note that the crime effort of a criminal boss $i \in S$ in different networks is as follows:

$$e_i\left(g\right)=\frac{\alpha-\phi_c-F+s\phi_c\gamma\eta_i(g)-\phi_c\gamma\sum_{j\neq i\in S}\eta_j(g)}{\beta\left(s+1\right)}$$

$$e_i\left(g+g_{ij}\right)=\frac{\alpha-\phi_c-F+s\phi_c\gamma\left(\eta_i(g)+1\right)-\phi_c\gamma\left(\sum_{j\neq i\in S}\eta_j(g)+1\right)}{\beta\left(s+1\right)}$$

$$e_i\left(g+g_{ij}+g_{ik}\right)=\frac{\alpha-\phi_c-F+s\phi_c\gamma\left(\eta_i(g)+2\right)-\phi_c\gamma\left(\sum_{j\neq i\in S}\eta_j(g)+2\right)}{\beta\left(s+1\right)} \qquad j,k\in S$$

Recall that for any network g, the gross profit of $i \in S$ is

$$E\left[\Pi_i \middle| g\right]=e_i^2(g)-2\phi_m\eta_i^S\left(g\right)-\phi_m\eta_i^{N\setminus S}\left(g\right)$$

It follows that:

$$E\left[\Pi_i \middle| g+g_{ij}+g_{ik}\right]-E\left[\Pi_i \middle| g+g_{ij}\right]=e_i^2\left(g+g_{ij}+g_{ik}\right)-$$
$$2\phi_m\left(\eta_i^S(g)+2\right)-\phi_m\eta_i^{N\setminus S}(g)-e_i^2\left(g+g_{ij}\right)+2\phi_m\left(\eta_i^S(g)+1\right)+\phi_m\eta_i^{N\setminus S}(g)=$$
$$\frac{\phi_c\gamma\left(s-1\right)}{\beta\left(s+1\right)}\left[\frac{2\left(\alpha-\phi_c-F\right)+2s\phi_c\gamma\eta_i(g)-2\phi_c\gamma\sum_{j\neq i\in S}\eta_j(g)+3\phi_c\gamma\left(s-1\right)}{\beta\left(s+1\right)}\right]-2\phi_m=$$

$$\frac{\phi_c\gamma\left(s-1\right)}{\beta\left(s+1\right)}\left[e_i(g+g_{ij}+g_{ik})+e_i(g+g_{ij})\right]-2\phi_m$$

$$E\left[\Pi_i\left|g+g_{ik}\right.\right]-E\left[\Pi_i\left|g\right.\right]=e_i^2\left(g+g_{ij}\right)-2\phi_m\left(\eta_i^S(g)+1\right)-\phi_m\eta_i^{N\setminus S}(g)-$$

$$e_i^2\left(g\right)+2\phi_m\eta_i^S(g)+\phi_m\eta_i^{N\setminus S}(g)=$$

$$\frac{\phi_c\gamma\left(s-1\right)}{\beta\left(s+1\right)}\left[\frac{2\left(\alpha-\phi_c-F\right)+2s\phi_c\gamma\eta_i(g)-2\phi_c\gamma\sum_{j\neq i\in S}\eta_j(g)+\phi_c\gamma(s-1)}{\beta(s+1)}\right]-2\phi_m=$$

$$\frac{\phi_c\gamma\left(s-1\right)}{\beta\left(s+1\right)}\left[e_i(g+g_{ij})+e_i(g)\right]-2\phi_m$$

It remains to be seen that $e_i\left(g+g_{ij}+g_{ik}\right)+e_i\left(g+g_{ij}\right)>e_i(g+g_{ij})+e_i(g)$.

Therefore for all $i\in S$ and $j,k\in S$ we have proven the case. Similar calculations prove the cases of $i\in S\,\&\,j,k\in N\setminus S$ and $i,j\in S\,\&\,k\in N\setminus S$.

We know that criminal bosses try to increase their profit by adding links to others in the network of money laundering. We assume that the cost of linking to a criminal boss is twice of cost of linking to a worker or foot soldier. Therefore, it is not a rational decision for criminals to add a link first to either a worker or a foot soldier and then to a criminal. □

Lemma A.2. *In any stable money laundering network we have the following results:*

(i) Criminal bosses form the complete component among each other.

(ii) Workers do not have an incentive to form money laundering collaboration links with each other.

(iii) Foot soldiers do not have an incentive to form any money laundering links among each other.

Proof. Based on the assumption of small linking cost, a criminal's gross payoff increases in a link to all agents independent of the initial network g. Hence, condition (i) of Definition 2.1 can only be satisfied if the present criminals are fully connected. □

Proposition A.1. *Suppose that payoff satisfies (2.2), and crime effort level satisfies (2.6). Network g is stable against transfers if and only if it is an extended inter-linked star.*

Proof. We first show that a stable money laundering network against transfers must be the extended inter-linked star outlined in Proposition A.1. Suppose g is a stable money laundering network. Based on the part (i) of Lemma A.2, criminal bosses form a complete component among each other. Also, following our low linking costs assumption, all criminal bosses will be connected to all workers and foot soldiers since they can compensate the latter for their costs of ϕ_m. Finally, based on Lemma 2.2, workers as well as foot soldiers do not form money laundering ties among each other. Therefore, we can conclude that there are three groups of agents in a stable network g : the first group contains a criminal boss who is linked with all agents in the network and we denote this first group by $h_1(g)$, another group is a group of foot soldiers which form money laundering links with big bosses and denote by $h_2(g)$, and the last group comprises the group of workers who link with criminal bosses who are denoted by $h_3(g)$. Thus it follows that $\eta_i(g) = n-1$, if $i \in h_1(g)$, $\eta_j(g) = s$ for $j \in h_2(g)$ and $\eta_k(g) = s$ for $k \in h_3(g)$. Therefore, a stable network g must be the extended inter-linked star of Proposition A.1.

We now show that for the low linking cost, a transfer stable network, namely the proposed extended inter-linked star network, exists. Suppose that network g is the extended inter-linked star of Proposition A.1. The requirement that two criminal bosses i and j wish to maintain their link may be written as:

$$E\left[\Pi_i \left| g\right.\right] - E\left[\Pi_i \left| g - g_{ij}\right.\right] + E\left[\Pi_j \left| g\right.\right] - E\left[\Pi_j \left| g - g_{ij}\right.\right] > 0 \quad \Leftrightarrow$$

$$2K' \equiv \frac{\phi_c \gamma (s-1)}{\beta^2 (s+1)^2}\left[2(\alpha - \phi_c - F) + \phi_c \gamma (2n - s - 1)\right] > 2\phi_m \qquad \forall i, j \in S \tag{A.1}$$

Also, because a pair of a worker (foot soldier) j and a criminal boss i should not have an incentive to break its money laundering link. The requirement may be written as follows:

$$E\left[\Pi_i \left| g\right.\right] - E\left[\Pi_i \left| g - g_{ij}\right.\right] + E\left[\Pi_j \left| g\right.\right] - E\left[\Pi_j \left| g - g_{ij}\right.\right] > 0 \quad \Leftrightarrow$$

$$2K'' \equiv \frac{\phi_c \gamma s}{\beta^2 (s+1)^2}\left[2(\alpha - \phi_c - F) + \phi_c \gamma (2n - s - 2)\right] > 2\phi_m \tag{A.2}$$

It is obvious that $K'' > K'$. Therefore conditions (A.1) and (A.2) are satisfied if and only if $K' > \phi_m$. By virtue of low linking cost assumption, it is obvious that $K' > \phi_m$. Since foot soldiers do not earn lots of money to launder, they do not have an incentive to form money laundering ties with workers. Finally, based on Lemma 2.2, workers as well as foot soldiers do not have an incentive to form money laundering ties among each other. Therefore we conclude that the proposed extended inter-linked star network is stable against transfers. □

Proposition A.2. *Suppose payoff satisfies (2.8) and crime effort level satisfies (2.6). Then the following properties hold:*

(i) When $\omega \geq E\left[\Pi \middle| r=1\right]$ *then there exists a unique equilibrium in which every agent enters the labor market.*

(ii) When $\omega \leq E\left[\Pi \middle| r=n\right]$ *then there exists a unique equilibrium in which every agent becomes a criminal.*

(iii) When $E\left[\Pi \middle| r=1\right] < \omega < E\left[\Pi \middle| r=n\right]$ *then there exists a unique equilibrium number of criminals* r^* *such that* $E\left[\Pi \middle| r^*\right] \geq \omega$ *and* $E\left[\Pi \middle| r^*+1\right] < \omega$. *The equilibrium number of criminals is:*

$$r^* = \frac{s\left(e_i^2(g) - 2\phi_m(n-1)\right)}{\omega}$$

Proof. Based on (2.7) the payoff of each criminal is:

$$E\left[\Pi_i \middle| r\right] = \frac{s}{r}\left(e_i^2(g) - 2\phi_m(n-1)\right)$$

The crime effort level in extended star network is as follows:

$$e_i = \frac{\alpha - \phi_c - F + \phi_c\gamma\left(n-1\right)}{\beta\left(s+1\right)}$$

Taking the first derivative leads to the following equation:

$$\frac{\partial E\left[\Pi_i \middle| r\right]}{\partial r} = -\frac{s}{r^2}\left(e_i^2(g) - 2\phi_m(n-1)\right) < 0$$

and taking the second derivative leads to the following equation:

$$\frac{\partial^2 E\left[\Pi_i \middle| r\right]}{\partial r^2} = \frac{2s}{r^3}\left(e_i^2(g) - 2\phi_m(n-1)\right) > 0$$

Thus, for $r \geq 1$ we have $\frac{\partial E\left[\Pi_i \middle| r\right]}{\partial r} < 0$ and $\frac{\partial^2 E\left[\Pi_i \middle| r\right]}{\partial r^2} > 0$. The proof of parts (i), (ii), and (iii) now follows from Figure 2.3.

It must hold in equilibrium:

$$E\left[\Pi_i \middle| r\right] = \omega \quad \Rightarrow$$

$$\frac{s}{r}\left(e_i^2(g) - 2\phi_m(n-1)\right) = \omega \quad \Rightarrow \quad s\left(e_i^2(g) - 2\phi_m(n-1)\right) = r\omega \quad \Rightarrow$$

$$r^* = \frac{s\left(e_i^2(g) - 2\phi_m(n-1)\right)}{\omega}$$ □

Proposition A.3. *Suppose payoff satisfies (2.8) and crime effort level satisfies (2.6). Then the equilibrium number of criminal bosses is:*

$$s^* = \frac{\left(\alpha - \phi_c - F + \phi_c\gamma(n-1)\right)\left(\sqrt{\omega^2 + 4\left(\omega + 2\phi_m(n-1)\right)} - \omega\right)}{2\beta\left(\omega + 2\phi_m(n-1)\right)} - 1$$

Proof: Regarding the market-clearing relationship we have the following result:

$$r = se_i + s \quad \Rightarrow$$

$$\frac{e_i^2(g) - 2\phi_m(n-1)}{\omega} = e_i + 1 \quad \Rightarrow$$

$$\beta^2\left(\omega + 2\phi_m(n-1)\right)\left(s+1\right)^2 + \beta\omega\left(\alpha - \phi_c - F + \phi_c\gamma(n-1)\right)\left(s+1\right) -$$

$$\left(\alpha - \phi_c - F + \phi_c\gamma(n-1)\right)^2 = 0 \quad \Rightarrow$$

$$s + 1 = \frac{-\left(\alpha - \phi_c - F + \phi_c\gamma(n-1)\right)\left(\omega - \sqrt{\omega^2 + 4\left(\omega + 2\phi_m(n-1)\right)}\right)}{2\beta\left(\omega + 2\phi_m(n-1)\right)}$$

Therefore, $s^* = \dfrac{\left(\alpha - \phi_c - F + \phi_c\gamma(n-1)\right)\left(\sqrt{\omega^2 + 4\left(\omega + 2\phi_m(n-1)\right)} - \omega\right)}{2\beta\left(\omega + 2\phi_m(n-1)\right)} - 1$. □

Appendix B

Appendix - Chapter 3

Lemma B.1. *Network g with a full component apart from one isolated criminal i is a crucial network.*

Proof. The equilibrium crime effort level of each criminal in the third stage of the money laundering game is as follows:

$$e_i^* = \frac{\alpha - \phi_c + s\phi_c \gamma \eta_i(g) - \phi_c \gamma \sum_{j \in S \setminus \{i\}} \eta_j(g)}{\beta(s+1)}, \qquad \forall i \in S$$

and the gross expected payoff of criminals is equal to $E\left[\Pi_i \middle| g\right] = e_i^2(g)$. It follows that:

$$\frac{\partial^2 E\left[\Pi_i \middle| g\right]}{\partial(\eta_i(g))^2} = 2\left(\frac{s\phi_c\gamma}{\beta(s+1)}\right)^2 > 0 \quad \text{and} \quad \frac{\partial^2 E\left[\Pi_i \middle| g\right]}{\partial \eta_i(g) \partial \sum_{j \in S \setminus \{i\}} \eta_j(g)} = -2s\left(\frac{\phi_c\gamma}{\beta(s+1)}\right)^2 < 0$$

Therefore, we can conclude that each agent's marginal payoff is increasing and convex in its own links but decreasing in the links of others which implies strategic substitutes across others' links.
The critical network g^* can be determined by the following minimization program:

$$\min_{\eta_i(g), \sum_{j \in S \setminus \{i\}} \eta_j(g)} E\left[\Pi_i \middle| \eta_i(g)+1, \left(\sum_{j \in S \setminus \{i\}} \eta_j(g)\right)+1\right] - E\left[\Pi_i \middle| \eta_i(g), \sum_{j \in S \setminus \{i\}} \eta_j(g)\right]$$

with the following linear constraints:

$$0 \le \eta_i(g) \le n-1 \text{ and } 0 \le \sum_{j \in S \setminus \{i\}} \eta_j(g) \le (s-1)(n-1).$$

To find network g^*, it follows from the strategic substitutes property that $\sum_{j \in S \setminus \{i\}} \eta_j(g) \ge (s-1)(n-2)$, because any additional link by a player $j \ne i$ reduces criminal i's incentive of link formation. Thus, g^* must necessarily be in the set of networks where all criminals

$j \in S \setminus \{i\}$ are connected to all other agents $k \in N \setminus \{i, j\}$. Denote this set of networks G^*. The question remains whether criminal i should be connected to other agents as well, or not. Starting from any network $g \in G^*$ (apart from the fully connected network) and adding a link between criminal i and a worker j clearly increases i's incentives to form a link, which follows from the convexity property. If we add a link between criminal i and another criminal j to network g, on the other hand, we again obtain a higher incentive, because:

$$\frac{\partial^2 E\left[\Pi_i \middle| g\right]}{\partial^2 \eta_i(g)} - \frac{\partial^2 E\left[\Pi_i \middle| g\right]}{\partial \eta_i(g) \partial \sum_{j \in S \setminus \{i\}} \eta_j(g)} > 0$$

Therefore, the critical network in G^* is the one with $\eta_i(g) = 0$ and $\sum_{j \in S \setminus \{i\}} \eta_j(g) = (s-1)(n-2)$. □

Lemma B.2. *Suppose g is a network with n agents, the number of criminals is $0 < s < n$, payoff satisfies (3.2), and crime effort level satisfies (3.5). Suppose that criminals add links directly to workers for money laundering purposes or first add links to criminals and then to a worker. Consider any network g and distinct agents $i, j, k \in S$ or $i \in S$ and $j, k \in N \setminus S$ or $i, j \in S$ and $k \in N \setminus S$ such that $g_{ij} = g_{ik} = 0$. Then:*

$$E\left[\Pi_i \middle| g + g_{ij} + g_{ik}\right] - E\left[\Pi_i \middle| g + g_{ij}\right] > E\left[\Pi_i \middle| g + g_{ij}\right] - E\left[\Pi_i \middle| g\right].$$

Proof. First of all note that the crime effort of agent $i \in S$ in different networks is as follows:

$$e_i(g) = \frac{\alpha - \phi_c + s\phi_c \gamma \eta_i(g) - \phi_c \gamma \sum_{j \neq i \in S} \eta_j(g)}{\beta(s+1)}$$

$$e_i(g + g_{ij}) = \frac{\alpha - \phi_c + s\phi_c \gamma (\eta_i(g) + 1) - \phi_c \gamma \left(\sum_{j \neq i \in S} \eta_j(g) + 1\right)}{\beta(s+1)}$$

$$e_i(g + g_{ij} + g_{ik}) = \frac{\alpha - \phi_c + s\phi_c \gamma (\eta_i(g) + 2) - \phi_c \gamma \left(\sum_{j \neq i \in S} \eta_j(g) + 2\right)}{\beta(s+1)} \qquad j, k \in S$$

Recall that for any network g, the gross profit of $i \in S$ is

$$E\left[\Pi_i \left|g\right.\right] = e_i^2(g) - 2\phi_m \eta_i^S(g) - \phi_m \eta_i^{N\setminus S}(g)$$

It follows that:

$$E\left[\Pi_i \left|g+g_{ij}+g_{ik}\right.\right] - E\left[\Pi_i \left|g+g_{ij}\right.\right] = e_i^2\left(g+g_{ij}+g_{ik}\right) -$$
$$2\phi_m\left(\eta_i^S(g)+2\right) - \phi_m\eta_i^{N\setminus S}(g) - e_i^2\left(g+g_{ij}\right) + 2\phi_m\left(\eta_i^S(g)+1\right) + \phi_m\eta_i^{N\setminus S}(g) =$$
$$\frac{\phi_c\gamma(s-1)}{\beta(s+1)}\left[\frac{2(\alpha-\phi_c)+2s\phi_c\gamma\eta_i(g)-2\phi_c\gamma\sum_{j\neq i\in S}\eta_j(g)+3\phi_c\gamma(s-1)}{\beta(s+1)}\right] - 2\phi_m =$$
$$\frac{\phi_c\gamma(s-1)}{\beta(s+1)}\left[e_i(g+g_{ij}+g_{ik})+e_i(g+g_{ij})\right] - 2\phi_m$$
$$E\left[\Pi_i \left|g+g_{ik}\right.\right] - E\left[\Pi_i \left|g\right.\right] = e_i^2\left(g+g_{ij}\right) - 2\phi_m\left(\eta_i^S(g)+1\right) - \phi_m\eta_i^{N\setminus S}(g) -$$
$$e_i^2(g) + 2\phi_m\eta_i^S(g) + \phi_m\eta_i^{N\setminus S}(g) =$$
$$\frac{\phi_c\gamma(s-1)}{\beta(s+1)}\left[\frac{2(\alpha-\phi_c)+2s\phi_c\gamma\eta_i(g)-2\phi_c\gamma\sum_{j\neq i\in S}\eta_j(g)+\phi_c\gamma(s-1)}{\beta(s+1)}\right] - 2\phi_m =$$
$$\frac{\phi_c\gamma(s-1)}{\beta(s+1)}\left[e_i(g+g_{ij})+e_i(g)\right] - 2\phi_m$$

It remains to be seen that the following holds: $e_i\left(g+g_{ij}+g_{ik}\right)+e_i\left(g+g_{ij}\right) > e_i(g+g_{ij})+e_i(g)$.

Therefore for all $i \in S$ and $j,k \in S$ we have proven the case. Similar calculations prove the cases of $i \in S \,\&\, j,k \in N \setminus S$ and $i,j \in S \,\&\, k \in N \setminus S$.

Note that criminals try to increase their profit by adding links to others in the network of money laundering. Assume that cost of linking to a criminal is twice of cost of linking to a worker. Therefore, it is not a rational decision for criminals to add a link first to a worker and then to a criminal. □

Lemma B.3. *When multiple criminals are in a network that is stable, they are fully connected.*

Proof. Based on the small cost of linking assumption, a criminal's gross payoff increases in a link to another criminal or worker independently of the initial network g . Hence, condition (i) of Definition 3.1 can only be satisfied if the present criminals are fully connected. □

Proposition B.1. *Suppose that the payoff satisfies (3.2), and the crime effort level satisfies (3.5). Network g is stable against transfers if and only if it is an inter- linked star. In addition, $h_1(g)$ is the group of cooperating workers and $h_2(g)$ is the group of criminals, also $|h_1(g)| = s$ and $|h_2(g)| = n-1$.*

Proof. We first show that a stable money laundering network against transfers must be the inter-linked star outlined in Proposition B.1. Suppose g is a stable money laundering network. Based on Lemma B.3, criminals form a complete component among each other. Also, following our low linking costs assumption, all criminals will be connected to all workers, because they can compensate the latter for their costs of ϕ_m. Finally, based on Lemma 3.3, workers do not form money laundering ties among each other. Therefore, we can conclude that there are two groups of agents in a stable network g : a group of criminal agents who are each linked to all other agents, which we denote by $h_2(g)$, and another group of working agents, who are each linked only with agents from $h_2(g)$ and which we denote by $h_1(g)$. Thus it follows that $\eta_i(g) = n-1$, if $i \in h_2(g)$ and $N_j(g) = h_2(g)$ for $j \in h_1(g)$. Therefore, a stable network g must be the inter-linked star of Proposition B.1.

Next we show that for the low linking cost, a transfer stable network, namely the proposed inter linked star network, exists. Suppose that network g is the inter-linked star of Proposition B.1. The requirement that two criminals i and j wish to maintain their link may be written as:

$$E\left[\Pi_i \left| g\right.\right] - E\left[\Pi_i \left| g - g_{ij}\right.\right] + E\left[\Pi_j \left| g\right.\right] - E\left[\Pi_j \left| g - g_{ij}\right.\right] > 0 \quad \Leftrightarrow$$

$$2K' \equiv \frac{\phi_c \gamma (s-1)}{\beta^2 (s+1)^2}\left[2(\alpha - \phi_c) + \phi_c \gamma (2n - s - 1)\right] > 2\phi_m \qquad \forall i, j \in S \tag{B.1}$$

Also, because a pair of a worker j and a criminal i should not have an incentive to break its link. The requirement may be written as follows:

$$E\left[\Pi_i \left| g\right.\right] - E\left[\Pi_i \left| g - g_{ij}\right.\right] + E\left[\Pi_j \left| g\right.\right] - E\left[\Pi_j \left| g - g_{ij}\right.\right] > 0 \quad \Leftrightarrow$$

$$2K'' \equiv \frac{\phi_c \gamma s}{\beta^2 (s+1)^2}\left[2(\alpha - \phi_c) + \phi_c \gamma (2n - s - 2)\right] > 2\phi_m \tag{B.2}$$

It is obvious that $K'' > K'$. Therefore conditions (B.1) and (B.2) are satisfied if and only if $K' > \phi_m$. By virtue of the low linking cost assumption, it is obvious that $K' > \phi_m$. Finally, based on Lemma 3.3, workers do not have an incentive to form links among each other. Therefore we conclude that the proposed inter-linked star network is stable against transfers. □

Proposition B.2. *Suppose the payoff satisfies (3.7) and the crime effort level satisfies (3.5). Then the following properties hold:*

(i) When $\omega \geq E\left[\Pi \middle| s=1\right]$ *then there exists a unique equilibrium in which every agent enters the labor market.*

(ii) When $\omega \leq E\left[\Pi \middle| s=n\right]$ *then there exists a unique equilibrium in which every agent becomes a criminal.*

(iii) When $E\left[\Pi \middle| s=1\right] < \omega < E\left[\Pi \middle| s=n\right]$ *then there exists an unique equilibrium number of criminals* s^* *such that* $E\left[\Pi \middle| s^*\right] \geq \omega$ *and* $E\left[\Pi \middle| s^*+1\right] < \omega$*. The equilibrium number of criminals is:*

$$s^* = \frac{\alpha - \phi_c + \phi_c \gamma (n-1)}{\beta \sqrt{\omega + 2\phi_m \left(n-1\right)}} - 1$$

Proof. Based on (3.7) the payoff of each criminal is $E\left[\Pi_i \middle| s\right] = e_i^2 - 2\phi_m \left(n-1\right)$ and crime effort level is as follows:

$$e_i = \frac{\alpha - \phi_c + s\phi_c \gamma \eta_i(g) - \phi_c \gamma \sum_{j \neq i} \eta_j(g)}{\beta\left(s+1\right)} =$$

$$\frac{\alpha - \phi_c + s\phi_c \gamma (n-1) - \phi_c \gamma (s-1)(n-1)}{\beta\left(s+1\right)} = \frac{\alpha - \phi_c + \phi_c \gamma (n-1)}{\beta\left(s+1\right)}$$

Therefore we have $E\left[\Pi_i \middle| s\right] = \left(\frac{\alpha - \phi_c + \phi_c \gamma (n-1)}{\beta\left(s+1\right)}\right)^2 - 2\phi_m \left(n-1\right)$.

Taking the first derivative leads to the following result:

$$\frac{\partial E\left[\Pi_i \middle| s\right]}{\partial s} = 2\left(\frac{\alpha - \phi_c + \phi_c \gamma (n-1)}{\beta\left(s+1\right)}\right)\left(\frac{-\left(\alpha - \phi_c + \phi_c \gamma (n-1)\right)}{\beta (s+1)^2}\right) < 0$$

Thus, for $s \geq 1$ we have $\frac{\partial E\left[\Pi_i \middle| s\right]}{\partial s} < 0$. The proof of parts (i), (ii), and (iii) now follows from Figure 3.3. In particular, s^* such that $1 < s^* < n$ is given by

$$\left(\frac{\alpha - \phi_c + \phi_c \gamma (n-1)}{\beta\left(s+1\right)}\right)^2 - 2\phi_m \left(n-1\right) = \omega \quad \Rightarrow \quad s^* = \frac{\alpha - \phi_c + \phi_c \gamma (n-1)}{\beta \sqrt{\omega + 2\phi_m \left(n-1\right)}} - 1 \qquad \square$$

Proposition B.3. *The optimal policies to combat crime and money laundering satisfy the following properties:*

(i) The optimal level of crime policy variable is given as follows:

$$p_c^* = \frac{f_c\left(1-\gamma(n-1)\right)}{2\beta\theta_c}.$$

(ii) The optimal level of money laundering policy variable operations is given by:

$$p_m^* = \frac{f_m\left(n-1\right)}{2\theta_m^2} - \frac{\omega}{2f_m\left(n-1\right)}.$$

(iii) When the money laundering reporting threshold γ *increases, money laundering policies becomes relatively more important than crime policies. Formally,* $\frac{\partial(p_c^* - p_m^*)}{\partial\gamma} < 0$.

(iv) When wages ω *increase, crime detection policies become relatively more important. Formally,* $\frac{\partial(p_c^* - p_m^*)}{\partial\omega} > 0$.

(v) θ_c *and* p_c*, as well as* θ_m *and* p_m *are substitutes.*

(vi) f_c *and* p_c*, as well as* f_m *and* p_m *are complements.*

Proof. We can prove this proposition as follows:

(i) Differentiation of equation (3.9) with respect to p_c yields the following direct and indirect effects of a change in the crime detection policy:

$$\frac{\partial V}{\partial s}\frac{\partial s}{\partial p_c} + \frac{\partial V}{\partial e}\frac{\partial e}{\partial p_c} + \frac{\partial V}{\partial e}\frac{\partial e}{\partial s}\frac{\partial s}{\partial p_c} + \frac{\partial V}{\partial p_c} =$$

$$\overbrace{\frac{-f_c\left(1-\gamma(n-1)\right)}{\beta}}^{\frac{\partial V}{\partial s}\frac{\partial s}{\partial p_c}} \overbrace{- f_c\left(1-\gamma(n-1)\right) + \frac{f_c\left(1-\gamma(n-1)\right)\sqrt{\omega + 2\phi_m\left(n-1\right)}}{\alpha - \phi_c + \phi_c\gamma\left(n-1\right)}}^{\frac{\partial V}{\partial e}\frac{\partial e}{\partial p_c}} +$$

$$\overbrace{\frac{f_c\left(1-\gamma(n-1)\right)}{\beta} - \frac{f_c\left(1-\gamma(n-1)\right)\sqrt{\omega + 2\phi_m\left(n-1\right)}}{\alpha - \phi_c + \phi_c\gamma\left(n-1\right)}}^{\frac{\partial V}{\partial e}\frac{\partial e}{\partial s}\frac{\partial s}{\partial p_c}} \overbrace{+ 2\theta_c p_c}^{\frac{\partial V}{\partial p_c}} = 0 \quad \Rightarrow$$

$$2\theta_c p_c = \frac{f_c\left(1-\gamma(n-1)\right)}{\beta}$$

Hence, the crime policy variable reaches its optimal point when:

$$p_c^* = \frac{f_c\left(1-\gamma(n-1)\right)}{2\beta\theta_c} \tag{B.3}$$

(ii) Differentiation of equation (3.9) with respect to p_m yields the following direct and indirect effects of a change in the money laundering policy:

$$\frac{\partial V}{\partial s}\frac{\partial s}{\partial p_m}+\frac{\partial V}{\partial e}\frac{\partial e}{\partial p_m}+\frac{\partial V}{\partial e}\frac{\partial e}{\partial s}\frac{\partial s}{\partial p_m}+\frac{\partial V}{\partial p_m}=$$

$$\overbrace{\frac{-f_m\left(n-1\right)\left(\alpha-\phi_c+\phi_c\gamma(n-1)\right)}{\beta\left(\omega+2\phi_m(n-1)\right)}}^{\frac{\partial V}{\partial s}\frac{\partial s}{\partial p_m}}+\overbrace{\frac{f_m\left(n-1\right)\left(\alpha-\phi_c+\phi_c\gamma(n-1)\right)}{\beta\left(\omega+2\phi_m(n-1)\right)}-\frac{f_m\left(n-1\right)}{\sqrt{\omega+2\phi_m\left(n-1\right)}}}^{\frac{\partial V}{\partial e}\frac{\partial e}{\partial s}\frac{\partial s}{\partial p_m}}+\overbrace{\theta_m}^{\frac{\partial V}{\partial p_m}}=0$$

$$\Rightarrow \qquad \frac{f_m\left(n-1\right)}{\sqrt{\omega+2\phi_m\left(n-1\right)}}=\theta_m$$

The money laundering policy variable reaches its optimal point when:

$$p_m^* = \frac{f_m\left(n-1\right)}{2\theta_m^2}-\frac{\omega}{2f_m\left(n-1\right)} \tag{B.4}$$

(iii) Based on equations (3) and (4), when γ increases we have the following result:

$$\frac{\partial p_c^*}{\partial\gamma}-\frac{\partial p_m^*}{\partial\gamma}=\frac{-f_c\left(n-1\right)}{2\beta\theta_c}-0=\frac{-f_c\left(n-1\right)}{2\beta\theta_c}<0$$

(iv) When increasing ω we find the following effect on the optimal policies:

$$\frac{\partial p_c^*}{\partial\omega}-\frac{\partial p_m^*}{\partial\omega}=0-\left(\frac{-1}{2f_m\left(n-1\right)}\right)=\frac{1}{2f_m\left(n-1\right)}>0$$

(v) Regarding to the following derivatives of equations (3) and (4):

$$\frac{\partial p_c^*}{\partial\theta_c}=\frac{-f_c\left(1-\gamma(n-1)\right)}{2\beta\theta_c^2}<0 \quad \text{and} \quad \frac{\partial p_m^*}{\partial\theta_m}=\frac{-f_m\left(n-1\right)}{\theta_m^3}<0$$

(vi) Finally, based on the following derivatives of equations (B.3) and (B.4):

$$\frac{\partial p_c^*}{\partial f_c}=\frac{1-\gamma\left(n-1\right)}{2\beta\theta_c}\geq 0 \quad \text{and} \quad \frac{\partial p_m^*}{\partial f_m}=\frac{n-1}{2\theta_m^2}+\frac{\omega}{2f_m^2\left(n-1\right)}>0$$

□

Appendix C

Appendix – Chapter 4

Proposition C.1. *Suppose that payoff satisfies (4.2), and crime effort level satisfies (4.5). Let g be an international money laundering network. Network g is stable against transfers if and only if it is an inter-linked star.*

Proof. We first show that for the low linking cost, a transfer stable network (inter-linked star network) exists. Suppose that network g is the inter-linked star of Proposition C.1. The requirement that two criminals $i \,\&\, j \in S_r$ wish to maintain their link may be written as:

$$E\left[\Pi_r^i \middle| g\right] - E\left[\Pi_r^i \middle| g - g^{ij}\right] + E\left[\Pi_r^j \middle| g\right] - E\left[\Pi_r^j \middle| g - g^{ij}\right] > 0 \quad \Leftrightarrow$$

$$2K' \equiv \frac{\phi_r^c \gamma_r (s_r - 1)}{\beta_r^2 (s_r + 1)^2}\left[2(\alpha_r - \phi_r^c) + \phi_r^c\left((2n_r - s_r - 1)\gamma_r + n_l \gamma_l\right)\right] > 2\phi_{rr}^m \qquad \forall i, j \in S_r \qquad \text{(C.1)}$$

Also, a pair of a worker $j \in N_r \setminus S_r$ and a criminal $i \in S_r$ should not have an incentive to break its link. This requirement may be written as follows:

$$E\left[\Pi_r^i \middle| g\right] - E\left[\Pi_r^i \middle| g - g^{ij}\right] + E\left[\Pi_r^j \middle| g\right] - E\left[\Pi_r^j \middle| g - g^{ij}\right] > 0 \quad \Leftrightarrow$$

$$2K'' \equiv \frac{\phi_r^c \gamma_r s_r}{\beta_r^2 (s_r + 1)^2}\left[2(\alpha_r - \phi_r^c) + \phi_r^c\left((2n_r - s_r - 2)\gamma_r + 2n_l \gamma_l\right)\right] > 2\phi_{rr}^m \qquad \text{(C.2)}$$

It is obvious that $K'' > K'$. Therefore conditions (C.1) and (C.2) are satisfied if and only if $K' > \phi_{rr}^m$.

By virtue of low linking cost assumption, it is obvious that $K' > \phi_{rr}^m$.

The requirement that a criminal $i \in S_r$ and a worker $j \in N_l \setminus S_l$ wish to retain their link may be written as:

$$E\left[\Pi_r^i \middle| g\right] - E\left[\Pi_r^i \middle| g - g^{ij}\right] + E\left[\Pi_l^j \middle| g\right] - E\left[\Pi_l^j \middle| g - g^{ij}\right] > 0 \quad \Leftrightarrow$$

$$2L' \equiv \frac{\phi_r^c s_r \gamma_l}{\beta_r^2 (s_r + 1)^2}\left[2(\alpha_r - \phi_r^c) + \phi_r^c\left(2(n_r - 1)\gamma_r + (2n_l - s_r)\gamma_l\right)\right] > 2\phi_{rl}^m$$

Moreover, the requirement that two criminals in different countries wish to keep their link may be written for each as:

$$E\left[\Pi_r^i \middle| g\right] - E\left[\Pi_r^i \middle| g - g^{ij}\right] + E\left[\Pi_l^j \middle| g\right] - E\left[\Pi_l^j \middle| g - g^{ij}\right] > 0 \quad \Leftrightarrow$$

$$2L'' \equiv \frac{\phi_r^c s_r \gamma_l}{\beta_r^2 (s_r+1)^2}\left[2(\alpha_r - \phi_r^c) + \phi_r^c\left(2(n_r-1)\gamma_r + (2n_l - s_r)\gamma_l\right)\right] > 2\phi_{rl}^m$$

It is trivial that $L' > \phi_{rl}^m$. Finally, workers do not have an incentive to form links among each other since they do not have dirty money to launder and they do not want to bear a cost of linking. Therefore we can conclude that the proposed inter-linked star network is stable against transfers.

We now show that network g with a full component apart from one isolated criminal i is a critical network.

The equilibrium crime effort level of each criminal in the third stage of international money laundering game is given in (4.5) and the gross expected payoff of criminals is equal to $E\left[\Pi_r^i \middle| g\right] = \left(e_r^i\right)^2$. It follows that:

$$\frac{\partial^2 E\left[\Pi_r^i \middle| g\right]}{\partial\left(\eta_{rr}^i(g)\right)^2} = 2\left(\frac{s_r \phi_r^c \gamma_r}{\beta_r\left(s_r+1\right)}\right)^2 > 0 \quad \text{and} \quad \frac{\partial^2 E\left[\Pi_r^i \middle| g\right]}{\partial\left(\eta_{rl}^i(g)\right)^2} = 2\left(\frac{s_r \phi_r^c \gamma_l}{\beta_r\left(s_r+1\right)}\right)^2 > 0 \tag{C.3}$$

$$\begin{aligned} &\frac{\partial^2 E\left[\Pi_r^i \middle| g\right]}{\partial \eta_{rr}^i(g)\partial \sum_{j\in S_r\setminus\{i\}} \eta_{rr}^j(g)} = -2s_r\left(\frac{\phi_r^c \gamma_r}{\beta_r\left(s_r+1\right)}\right)^2 < 0 \quad \text{and} \\ &\frac{\partial^2 E\left[\Pi_r^i \middle| g\right]}{\partial \eta_{rl}^i(g)\partial \sum_{j\in S_r\setminus\{i\}} \eta_{rl}^j(g)} = -2s_r\left(\frac{\phi_r^c \gamma_l}{\beta_r\left(s_r+1\right)}\right)^2 < 0 \end{aligned} \tag{C.4}$$

Therefore we can conclude that each agent's marginal payoffs are increasing and convex in their own domestic links but decreasing in the domestic links of others, which implies strategic substitution across others links.

The critical network g^* can be determined by the following minimization program:

$$\min_{\eta_{rr}^i(g),\sum_{j\in S_r\setminus\{i\}}\eta_{rr}^j(g)} E\left[\Pi_r^i \middle| \eta_{rr}^i(g)+1, \left(\sum_{j\in S_r\setminus\{i\}} \eta_{rr}^j(g)\right)+1\right] - E\left[\Pi_r^i \middle| \eta_{rr}^i(g), \sum_{j\in S_r\setminus\{i\}} \eta_{rr}^j(g)\right]$$

$$\min_{\eta_{rl}^i(g),\sum_{j\in S_r\setminus\{i\}}\eta_{rl}^j(g)} E\left[\Pi_r^i \middle| \eta_{rl}^i(g)+1, \left(\sum_{j\in S_r\setminus\{i\}} \eta_{rl}^j(g)\right)+1\right] - E\left[\Pi_r^i \middle| \eta_{rl}^i(g), \sum_{j\in S_r\setminus\{i\}} \eta_{rl}^j(g)\right]$$

with the following linear constraints:

$$0 \le \eta_{rr}^i(g) \le n_r - 1 \quad \text{and} \quad 0 \le \sum_{j\in S_r\setminus\{i\}} \eta_{rr}^j(g) \le \left(s_r - 1\right)\left(n_r - 1\right).$$

$$0 \le \eta_{rl}^i(g) \le n_l \quad \text{and} \quad 0 \le \sum_{j\in S_r\setminus\{i\}} \eta_{rl}^j(g) \le \left(s_r - 1\right) n_l .$$

To find network g^*, it follows from the strategic substitutes property (equation C.3) that $\sum_{j \in S_r \setminus \{i\}} \eta_{rr}^j(g) \geq (s_r - 1)(n_r - 2)$, because any additional link by a player $j \neq i$ reduces criminal i's incentive to link formation. Thus, g^* must necessarily be in the set of networks where all criminals $j \in S_r \setminus \{i\}$ are connected to all other domestic agents $k \in N_r \setminus \{i, j\}$. Denote this set of networks G^*. The question remains whether criminal i should be connected to other domestic agents as well, or not. Starting from any network $g \in G^*$ (apart from the fully connected network) and adding a link between criminal i and a worker j clearly increases i's incentives to form a link, which follows from the convexity property (equation C.4). If we add a link between criminal i and another criminal j to network g, on the other hand, we also obtain a higher incentive, because:

$$\frac{\partial^2 E\left[\Pi_r^i \middle| g\right]}{\partial^2 \eta_{rr}^i(g)} - \frac{\partial^2 E\left[\Pi_r^i \middle| g\right]}{\partial \eta_{rr}^i(g) \partial \sum_{j \in S_r \setminus \{i\}} \eta_{rr}^j(g)} > 0$$

Therefore, the critical network in G^* is the one with $\eta_{rr}^i(g) = 0$, $\eta_{rl}^i(g) = 0$ $\sum_{j \in S_r \setminus \{i\}} \eta_{rr}^j(g) = (s_r - 1)(n_r - 2)$ and $\sum_{j \in S_r \setminus \{i\}} \eta_{rl}^j(g) = (s_r - 1) n_l$.

Therefore we have shown that a network with a full component apart from one isolated criminal is the worst network. Thus it follows that criminals have $n-1$ links ;($\eta_{rr}^i(g) + \eta_{rl}^i(g) = n-1$), if $i \in h_2(g)$.

The above reasoning also proves that worker $j \in h_1(g)$ is linked with an agents $i \in h_2(g)$; thus $N_{rr}^j(g) + N_{rl}^j(g) = h_2(g)$, for $j \in h_1(g)$.

It means that each worker has s links in this network. □

Proposition C.2. *Suppose a criminal's payoff satisfies (4.7) and the crime effort level satisfies (4.5) for an inter-linked star network. Then the following properties hold:*

(i) When $\omega_r \geq E\left[\Pi_r^i \middle| s_r = 1\right]$ then there exists a unique equilibrium in which every agent enters the labor market.

(ii) When $\omega_r \leq E\left[\Pi_r^i \middle| s_r = n_r\right]$ then there exists a unique equilibrium in which every agent becomes a criminal.

(iii) When $E\left[\Pi_r^i \middle| s_r = 1\right] < \omega_r < E\left[\Pi_r^i \middle| s_r = n_r\right]$ *then there exist an unique equilibrium number of criminals* s_r^* *such that* $E\left[\Pi_r^i \middle| s_r^*\right] \geq \omega_r$ *and* $E\left[\Pi_r^i \middle| s_r^* + 1\right] < \omega_r$ *. The equilibrium number of criminals has the form of:*

$$s_r^* = \frac{\alpha_r - \phi_r^c + \phi_r^c\left((n_r - 1)\gamma_r + n_l\gamma_l\right)}{\beta_r\sqrt{\omega_r + 2\left(\phi_{rr}^m(n_r - 1) + \phi_{rl}^m n_l\right)}} - 1$$

Proof. Based on (4.8) the payoff of each criminal in country $r \in R$ is $E\left[\Pi_r^i \middle| g\right] = \left(e_r^i\right)^2 - 2\left((n_r - 1)\phi_{rr}^m + n_l\phi_{rl}^m\right)$ and crime effort level is as follows:

$$e_r^i = \frac{\alpha_r - \phi_r^c + \phi_r^c\left((n_r - 1)\gamma_r + n_l\gamma_l\right)}{\beta_r\left(s_r + 1\right)}$$

Therefore:

$$E\left[\Pi_r^i \middle| g\right] = \left(\frac{\alpha_r - \phi_r^c + \phi_r^c\left((n_r - 1)\gamma_r + n_l\gamma_l\right)}{\beta_r\left(s_r + 1\right)}\right)^2 - 2\left(\phi_{rr}^m(n_r - 1) + \phi_{rl}^m n_l\right)$$

Taking the first derivative with respect to s_r leads to the following result:

$$\frac{\partial E\left[\Pi_r^i \middle| g\right]}{\partial s_r} = 2\left(\frac{\alpha_r - \phi_r^c + \phi_r^c\left((n_r - 1)\gamma_r + n_l\gamma_l\right)}{\beta_r\left(s_r + 1\right)}\right)\left(\frac{-\left[\alpha_r - \phi_r^c + \phi_r^c\left((n_r - 1)\gamma_r + n_l\gamma_l\right)\right]}{\beta_r\left(s_r + 1\right)^2}\right) < 0$$

Thus, for $s_r \geq 1$ we have $\frac{\partial E\left[\Pi_r^i \middle| g\right]}{\partial s_r} < 0$. The proof of parts (i), (ii) and (iii) now follows from Figure 4.3, In particular, s_r^* such that $1 < s_r^* < n_r$ is given by

$$\left(\frac{\alpha_r - \phi_r^c + \phi_r^c\left((n_r - 1)\gamma_r + n_l\gamma_l\right)}{\beta_r\left(s_r + 1\right)}\right)^2 - 2\left(\phi_{rr}^m(n_r - 1) + \phi_{rl}^m n_l\right) = \omega_r \Rightarrow$$

$$s_r^* = \frac{\alpha_r - \phi_r^c + \phi_r^c\left((n_r - 1)\gamma_r + n_l\gamma_l\right)}{\beta_r\sqrt{\omega_r + 2\left(\phi_{rr}^m(n_r - 1) + \phi_{rl}^m n_l\right)}} - 1 \qquad \square$$

Proposition C.3. (*Comparative Statics) Suppose that the wage rates in countries* r and l differ*.*

(i) If ω_r *increases, then the number of domestic money laundering collaboration links in country* r *decreases.*

(ii) Suppose $n_r = n_l$, $\gamma_r = \gamma_l$, …. *If* $\omega_r > \omega_l$ *, then the number of international money laundering collaboration links satisfies:*

$$\sum_{i \in Nl} \eta_{lr}^i > \sum_{i \in N_r} \eta_{rl}^i$$

Proof. (i) The number of domestic money laundering connections in country r is:

$$A_1 = \frac{\sum_{i \in N_r} \eta_{rr}^i(g)}{2} = \frac{s_r\left(n_r - 1\right) + \left(n_r - s_r\right)s_r}{2} = \frac{s_r\left(2n_r - s_r - 1\right)}{2}$$

Taking the first derivative with respect to ω_r leads to the following result:

$$\frac{\partial A_1}{\partial s_r}.\frac{\partial s_r}{\partial \omega_r} = \left(\frac{2n_r - 2s_r - 1}{2}\right).\left(\frac{-\left[\alpha_r - \phi_r^c + \phi_r^c\left((n_r - 1)\gamma_r + n_l\gamma_l\right)\right]}{2\beta_r\left(\omega_r + 2\left(\phi_{rr}^m(n_r - 1) + \phi_{rl}^m n_l\right)\right)\sqrt{\omega_r + 2\left(\phi_{rr}^m(n_r - 1) + \phi_{rl}^m n_l\right)}}\right) < 0$$

It proves this part.

(ii) The international money laundering collaboration links are equal to:

$$A_2 = \sum_{i \in N_r \cup N_l} \eta_{rl}^i(g) = \sum_{i \in N_r} \eta_{rl}^i(g) + \sum_{i \in N_l} \eta_{lr}^i(g) = s_r n_l + s_l n_r$$

Taking the first derivative with respect to ω_r and ω_l leads to the following results:

$$\frac{\partial A_2}{\partial \omega_r} = \frac{\partial A_2}{\partial s_r}.\frac{\partial s_r}{\partial \omega_r} + \frac{\partial A_2}{\partial s_l}.\frac{\partial s_l}{\partial \omega_r} = \frac{-\left[\alpha_r - \phi_r^c + \phi_r^c\left((n_r - 1)\gamma_r + n_l\gamma_l\right)\right].n_l}{2\beta_r\left(\omega_r + 2\left(\phi_{rr}^m(n_r - 1) + \phi_{rl}^m n_l\right)\right)\sqrt{\omega_r + 2\left(\phi_{rr}^m(n_r - 1) + \phi_{rl}^m n_l\right)}} < 0$$

$$\frac{\partial A_l}{\partial \omega_l} = \frac{\partial A_l}{\partial s_r}.\frac{\partial s_r}{\partial \omega_l} + \frac{\partial A_l}{\partial s_l}.\frac{\partial s_l}{\partial \omega_l} = \frac{-\left[\alpha_l - \phi_l^c + \phi_l^c\left((n_l - 1)\gamma_l + n_r\gamma_r\right)\right].n_r}{2\beta_l\left(\omega_l + 2\left(\phi_{ll}^m(n_l - 1) + \phi_{lr}^m n_r\right)\right)\sqrt{\omega_l + 2\left(\phi_{ll}^m(n_l - 1) + \phi_{lr}^m n_r\right)}} < 0$$

The proof is completed. □

Proposition C.4. *Suppose* n *is the number of agents who construct the money laundering network and that if* n *is large, also the country size is large. In the case of different country size in* $r \in R = \{\mathrm{r}, 1\}$ *the following holds:*

(i) If n_r *increases then the number of domestic money laundering collaboration links in country* r *increases.*

(ii) *Suppose* $\omega_r = \omega_l$, $\gamma_r = \gamma_l$, …. *If* $n_r > n_l$, *then the number of international money laundering collaboration links is:*

$$\sum_{i\in N_r} \eta^i_{rl} > \sum_{i\in N_l} \eta^i_{lr} \text{ where } r, l \in R.$$

Proof. (i) The number of domestic money laundering collaboration links in country r is:

$$A_1 = \frac{\sum_{i\in N_r} \eta^i_{rr}(g)}{2} = \frac{s_r(n_r-1)+s_r(n_r-s_r)}{2} = \frac{s_r(2n_r-s_r-1)}{2}$$

Taking the first derivative with respect to n_r leads to the following result:

$$\frac{\partial A_1}{\partial s_r}.\frac{\partial s_r}{\partial n_r}+\frac{\partial A_1}{\partial n_r}=$$

$$s_r + \frac{2n_r-2s_r-1}{2\beta_r\sqrt{\omega_r+2\left(\phi^m_{rr}(n_r-1)+\phi^m_{rl}n_l\right)}}\left(\phi^c_r\gamma_r - \frac{\phi^m_{rr}\left[\alpha_r-\phi^c_r+\phi^c_r\left((n_r-1)\gamma_r+n_l\gamma_l\right)\right]}{\omega_r+2\left(\phi^m_{rr}(n_r-1)+\phi^m_{rl}n_l\right)}\right)>0$$

It proves this part.

(ii) The international money laundering collaboration links are equal to:

$$A_2 = \sum_{i\in N_r\cup N_l} \eta^i_{rl}(g) = \sum_{i\in N_r} \eta^i_{rl}(g) + \sum_{i\in N_l} \eta^i_{lr}(g) = s_r n_l + s_l n_r$$

Taking the first derivative with respect to n_r leads to the following results:

$$\frac{\partial A_2}{\partial s_r}.\frac{\partial s_r}{\partial n_r}+\frac{\partial A_2}{\partial s_l}.\frac{\partial s_l}{\partial n_r}+\frac{\partial A_2}{\partial n_r}=$$

$$s_l + \frac{n_l}{\beta_r\sqrt{\omega_r+2\left(\phi^m_{rr}(n_r-1)+\phi^m_{rl}n_l\right)}}\left(\phi^c_r\gamma_r - \frac{\phi^m_{rr}\left[\alpha_r-\phi^c_r+\phi^c_r\left((n_r-1)\gamma_r+n_l\gamma_l\right)\right]}{\omega_r+2\left(\phi^m_{rr}(n_r-1)+\phi^m_{rl}n_l\right)}\right)+$$

$$\frac{n_1}{\beta_l\sqrt{\omega_l+2\left(\phi^m_{ll}(n_l-1)+\phi^m_{lr}n_r\right)}}\left(\phi^c_l\gamma_r - \frac{\phi^m_{lr}\left[\alpha_l-\phi^c_l+\phi^c_l\left((n_l-1)\gamma_l+n_r\gamma_r\right)\right]}{\omega_l+2\left(\phi^m_{ll}(n_l-1)+\phi^m_{lr}n_r\right)}\right)>0$$

By taking the first derivative with respect to n_l we reach to the same results. □

Lemma C.1. *The optimal level of the crime policy variable is given by:*

$$p_r^c = \frac{f_r^c\left[1-\left((n_r-1)\gamma_r + n_l\gamma_l\right)\right]}{2\beta_r\theta_r^c}$$

Proof. Differentiation of equation (4.9) with respect to p_r^c yields the following first order condition:

$$\frac{\partial V_r}{\partial s_r}\frac{\partial s_r}{\partial p_r^c} + \frac{\partial V_r}{\partial e_r}\frac{\partial e_r}{\partial p_r^c} + \frac{\partial V_r}{\partial e_r}\frac{\partial e_r}{\partial s_r}\frac{\partial s_r}{\partial p_r^c} + \frac{\partial V_r}{\partial p_r^c} = \overbrace{\frac{-f_r^c\left[1-\left((n_r-1)\gamma_r + n_l\gamma_l\right)\right]}{\beta_r}}^{\frac{\partial V_r}{\partial s_r}\frac{\partial s_r}{\partial p_r^c}}$$

$$\overbrace{-\frac{f_r^c\left[1-\left((n_r-1)\gamma_r + n_l\gamma_l\right)\right]}{\beta_r} + \frac{f_r^c\left[1-\left((n_r-1)\gamma_r + n_l\gamma_l\right)\right]\sqrt{\omega_r + 2\left(\phi_{rr}^m(n_r-1) + \phi_{rl}^m n_l\right)}}{\alpha_r - \phi_r^c + \phi_r^c\left((n_r-1)\gamma_r + n_l\gamma_l\right)}}^{\frac{\partial V_r}{\partial e_r}\frac{\partial e_r}{\partial p_r^c}}$$

$$\overbrace{+\frac{f_r^c\left[1-\left((n_r-1)\gamma_r + n_l\gamma_l\right)\right]}{\beta_r} - \frac{f_r^c\left[1-\left((n_r-1)\gamma_r + n_l\gamma_l\right)\right]\left(\omega_r + 2\left(\phi_{rr}^m(n_r-1) + \phi_{rl}^m n_l\right)\right)}{\alpha_r - \phi_r^c + \phi_r^c\left((n_r-1)\gamma_r + n_l\gamma_l\right)\sqrt{\omega_r + 2\left(\phi_{rr}^m(n_r-1) + \phi_{rl}^m n_l\right)}}}^{\frac{\partial V_r}{\partial e_r}\frac{\partial e_r}{\partial s_r}\frac{\partial s_r}{\partial p_r^c}}$$

$$\overbrace{+2\theta_r^c p_r^c}^{\frac{\partial V_r}{\partial p_r^c}} = \frac{-f_r^c\left[1-\left((n_r-1)\gamma_r + n_l\gamma_l\right)\right]}{\beta_r} + 2\theta_r^c p_r^c = 0 \Rightarrow$$

$$p_r^c = \frac{f_r^c\left[1-\left((n_r-1)\gamma_r + n_l\gamma_l\right)\right]}{2\beta_r\theta_r^c}$$

Based on equation (4.9), $\frac{\partial V_l}{\partial p_r^c} = 0$. Regarding this result and by virtue of above equation we can conclude that combating money laundering in each country is an independent policy. □

Proposition C.5. *In the absence of an international information exchange regime, the* optimal level of the money laundering policy variable *is given by:*

$$p_r^m = \frac{f_r^m\left(n_r + n_l - 1\right)}{2\left(\theta_r^m\right)^2} - \frac{\omega_r}{2f_r^m\left(n_r + n_l - 1\right)}$$

Proof. Recall that $\phi_{rr}^m = \phi_{rl}^m = f_r^m p_r^m$ in countries without an international information exchange regime. Differentiation of equation (4.9) with respect to p_r^m yields the following first-order condition for the minimization of the social loss:

$$\frac{\partial V_r}{\partial s_r}\frac{\partial s_r}{\partial p_r^m}+\frac{\partial V_r}{\partial e_r}\frac{\partial e_r}{\partial p_r^m}+\frac{\partial V_r}{\partial e_r}\frac{\partial e_r}{\partial s_r}\frac{\partial s_r}{\partial p_r^m}+\frac{\partial V_r}{\partial p_r^m}=\overbrace{\frac{-f_r^m\left(n_r+n_l-1\right)\left(\alpha_r-\phi_r^c+\phi_r^c\left((n_r-1)\gamma_r+n_l\gamma_l\right)\right)}{\beta_r\left(\omega_r+2f_r^m p_r^m(n_r+n_l-1)\right)}}^{\frac{\partial V_r}{\partial s_r}\frac{\partial s_r}{\partial p_r^m}}+$$

$$\overbrace{\frac{f_r^m\left(n_r+n_l-1\right)\left(\alpha_r-\phi_r^c+\phi_r^c\left((n_r-1)\gamma_r+n_l\gamma_l\right)\right)}{\beta_r\left(\omega_r+2f_r^m p_r^m(n_r+n_l-1)\right)}-\frac{f_r^m\left(n_r+n_l-1\right)}{\sqrt{\omega_r+2f_r^m p_r^m\left(n_r+n_l-1\right)}}}^{\frac{\partial V_r}{\partial e_r}\frac{\partial e_r}{\partial s_r}\frac{\partial s_r}{\partial p_r^m}}+\overbrace{\theta_r^m}^{\frac{\partial V_r}{\partial p_r^m}}=0\Rightarrow$$

$$\frac{f_r^m\left(n_r+n_l-1\right)}{\sqrt{\omega_r+2f_r^m p_r^m\left(n_r+n_l-1\right)}}=\theta_r^m$$

The money laundering probability of being caught in countries without an international information exchange regime reaches its optimal point when:

$$p_r^m=\frac{f_r^m\left(n_r+n_l-1\right)}{2\left(\theta_r^m\right)^2}-\frac{\omega_r}{2f_r^m\left(n_r+n_l-1\right)} \qquad \square$$

Lemma C.2. *In the presence of an international information exchange regime, the best response function of the money laundering policy variable is given by:*

$$p_r^m=\frac{f_r^m\left(n_r+n_l-1\right)}{2\left(\theta_r^m\right)^2}-\frac{\omega_r+2n_l f_r^m p_l^m}{2f_r^m\left(n_r+n_l-1\right)}$$

Proof. Recall that in countries with international information exchange regime we have $\phi_{rr}^m=f_r^m p_r^m$ and $\phi_{rl}^m=f_r^m\left(p_r^m+p_l^m\right)$. Differentiation of equation (4.9) with respect to p_r^m yields the following first-order condition for the minimization of social loss:

$$\frac{\partial V_r}{\partial s_r}\frac{\partial s_r}{\partial p_r^m}+\frac{\partial V_r}{\partial e_r}\frac{\partial e_r}{\partial p_r^m}+\frac{\partial V_r}{\partial e_r}\frac{\partial e_r}{\partial s_r}\frac{\partial s_r}{\partial p_r^m}+\frac{\partial V_r}{\partial p_r^m}=\overbrace{\frac{-f_r^m\left(n_r+n_l-1\right)\left(\alpha_r-\phi_r^c+\phi_r^c\left((n_r-1)\gamma_r+n_l\gamma_l\right)\right)}{\beta_r\left[\omega_r+2f_r^m\left((n_r+n_l-1)p_r^m+n_l p_l^m\right)\right]}}^{\frac{\partial V_r}{\partial s_r}\frac{\partial s_r}{\partial p_r^m}}+$$

$$\overbrace{\frac{f_r^m\left(n_r+n_l-1\right)\left(\alpha_r-\phi_r^c+\phi_r^c\left((n_r-1)\gamma_r+n_l\gamma_l\right)\right)}{\beta_r\left[\omega_r+2f_r^m\left((n_r+n_l-1)p_r^m+n_l p_l^m\right)\right]}-\frac{f_r^m\left(n_r+n_l-1\right)}{\sqrt{\omega_r+2f_r^m\left((n_r+n_l-1)p_r^m+n_l p_l^m\right)}}}^{\frac{\partial V_r}{\partial e_r}\frac{\partial e_r}{\partial s_r}\frac{\partial s_r}{\partial p_r^m}}+$$

$$\frac{\partial V_r}{\partial p_r^m}$$

$$\theta_r^m = 0 \quad \Rightarrow \quad \frac{f_r^m\left(n_r + n_l - 1\right)}{\sqrt{\omega_r + 2f_r^m\left((n_r + n_l - 1)p_r^m + n_l p_l^m\right)}} = \theta_r^m$$

The money laundering probability of being caught in countries with an international information exchange regime reaches its optimal point when:

$$p_r^m = \frac{f_r^m\left(n_r + n_l - 1\right)}{2\left(\theta_r^m\right)^2} - \frac{\omega_r + 2n_l f_r^m p_l^m}{2f_r^m\left(n_r + n_l - 1\right)} \qquad \square$$

Proposition C.6. *Comparing the optimal policy levels with and without an international information exchange regime leads to the following result:*

(i) The equilibrium value of the money laundering policy variable in country $r \in R$ *with an* international information exchange regime is as follows:

$$\left(p_r^m\right)^* = \frac{\left(n_r + n_l - 1\right)^2}{\left(n_r + n_l - 1\right)^2 - n_r n_l} \cdot \left[\frac{\omega_l n_l}{2f_l^m\left(n_r + n_l - 1\right)^2} + \frac{f_r^m\left(n_r + n_l - 1\right)}{2\left(\theta_r^m\right)^2} - \frac{\omega_r}{2f_r^m\left(n_r + n_l - 1\right)} - \frac{f_l^m n_l}{2\left(\theta_l^m\right)^2}\right]$$

(ii) Each country invests less when using an international information exchange regime.

(iii) Social loss decreases in each country when using an international information exchange regime.

Proof. The optimal money laundering probability of being caught in countries without an international information exchange regime is as follows:

$$p_r^m = \frac{f_r^m\left(n_r + n_l - 1\right)}{2\left(\theta_r^m\right)^2} - \frac{\omega_r}{2f_r^m\left(n_r + n_l - 1\right)} \qquad \forall r \in R$$

Also the optimal money laundering probability of being caught in countries with an international information exchange regime is as follows:

$$p_r^m = \frac{f_r^m\left(n_r + n_l - 1\right)}{2\left(\theta_r^m\right)^2} - \frac{\omega_r + 2n_l f_r^m p_l^m}{2f_r^m\left(n_r + n_l - 1\right)} \qquad \forall r \in R$$

Substituting p_l^m in above equation yields the following equation of optimal money laundering probability of detection in country $r \in R$ with an international information exchange regime:

$$\left(p_r^m\right)^* = \frac{\left(n_r+n_l-1\right)^2}{\left(n_r+n_l-1\right)^2-n_rn_l} \cdot \left[\frac{\omega_l n_l}{2f_l^m\left(n_r+n_l-1\right)^2}+\frac{f_r^m\left(n_r+n_l-1\right)}{2\left(\theta_r^m\right)^2}-\frac{\omega_r}{2f_r^m\left(n_r+n_l-1\right)}-\frac{f_l^m n_l}{2\left(\theta_l^m\right)^2}\right]$$

By comparing the optimal money laundering probability of being caught in countries without an international information exchange regime and we can conclude from the above equation that the optimal probability of being caught for money laundering in countries with an international information exchange regime is less than in countries without an international information exchange regime since countries would benefit from each other's effort. In this case they do not need to spend much more time and money on international money laundering communications. Also based on the cost of international linking in countries without and with international information exchange regimes, $\phi_{rl}^m = f_r^m p_r^m$ and $\phi_{rl}^m = f_r^m\left(p_r^m + p_l^m\right)$ respectively, we can conclude that cost of linking in countries with an international information exchange regime is more than in countries without an international information exchange regime. Therefore social loss in countries with an international information exchange regime is less than in countries without an international information exchange regime since the optimal probability of being caught from the authorities' perspective decreases and the cost of international linking from the criminals' perspective increases.

In the end and without calculating we can conclude that in the case of the revealed preferences argument each country prefer to work with an international information exchange regime in their own countries since they will benefit from each other's effort to minimize the social loss. □

Proposition C.7. *Consider two countries which are identical in all respects but have heterogeneous wages. Each country invests more to combat money laundering and the social loss will be lower in each country under an evenly split budget regime than under an international information exchange regime.*

Proof. The optimal money laundering probability of detection in homogenous countries with international information exchange regime is as follows:

$$p^m = \frac{f^m\left(2n-1\right)^2}{2\left(3n-1\right)\theta_m^2} - \frac{\omega}{2f^m\left(3n-1\right)} \tag{C.5}$$

The optimal money laundering probability of being caught in homogenous countries with an evenly split budget regime is as follows:

$$p^m = \frac{f^m\left(3n-1\right)}{2\theta_m^2} - \frac{\omega}{2f^m\left(3n-1\right)} \tag{C.6}$$

By comparing equations (C.5) and (C.6) we conclude that when homogenous countries use the evenly split budget regime to combat money laundering, the probability of detection is more than when countries use with international information exchange regime. However, the cost of domestic and international linking in countries with an evenly split budget regime is more than in countries with an international information exchange regime. Therefore, it significantly has a positive effect on decreasing the number of criminals and thus social loss will decrease if countries use an evenly split budget regime.

The optimal money laundering probability of detection in countries where workers earn heterogeneous wages with an international information exchange regime is given as follows:

$$p_r^m = \frac{f^m(2n-1)^2}{2(3n-1)\theta_m^2} - \frac{(2n-1)\omega_r - n\omega_l}{2f^m(n-1)(3n-1)} \tag{C.7}$$

The optimal money laundering probability of being caught in countries where workers earn heterogeneous wages with an evenly split budget regime is as follows:

$$\frac{f^m(3n-1)}{\sqrt{\omega_r + 2f^m(3n-1)p^m}} + \frac{f^m(3n-1)}{\sqrt{\omega_l + 2f^m(3n-1)p^m}} = 2\theta^m \tag{C.8}$$

Since p_m cannot be explicitly calculated from above the equation, we used numerical simulation to solve the problem. Therefore by comparing these two equations in numerical simulations we conclude that if countries use an evenly split budget regime to combat money laundering they will invest more, but the cost of domestic and international linking will increase compared to the situation when they use an international information exchange regime. Therefore, by increasing investment to combat money laundering the number of criminals will go down substantially and in this case social loss will decrease if countries use the evenly split budget regime.

In the numerical simulation we are going to calculate the following equation:

$$V_r + V_l = s_r^* e_r^* + s_l^* e_l^* + \theta_r^c \left(p_r^c\right)^2 + \theta_l^c \left(p_l^c\right)^2 + \theta_r^m p_r^m + \theta_l^m p_l^m$$

We assume that the wage of workers in country r stays the same but it is increasing in country l. We assume the values in the following table for the number of top criminals and dishonest workers they know (n), adjusted reporting threshold (γ), fine for crime (drugs) (f_c), competition effect between criminals (β), correction factor (θ), fine for money laundering (f_m), wage in formal sector (ω), and maximum willingness to pay for drugs (α). The probability to get caught for crime (drugs) for each effort obtains from the following formula:

$$p_r^c = \frac{f_r^c\left[1-\left((n_r-1)\gamma_r + n_l\gamma_l\right)\right]}{2\beta_r\theta_r^c}$$

n	f^c	γ	β	$\theta^c = \theta^m$	p^c	f^m	ω_r	ω_l	α
10	3	0.01	0.2	10	0.02	2	0.3	0.1	5
10	3	0.01	0.2	10	0.02	2	0.3	0.2	5
10	3	0.01	0.2	10	0.02	2	0.3	0.3	5
10	3	0.01	0.2	10	0.02	2	0.3	0.4	5
10	3	0.01	0.2	10	0.02	2	0.3	0.5	5
10	3	0.01	0.2	10	0.02	2	0.3	0.6	5
10	3	0.01	0.2	10	0.02	2	0.3	0.7	5

The effort level (e) and the number of top criminals (s) is calculated through the following formulas:

$$e_r = \frac{\alpha_r - \phi_r^c + \phi_r^c\left((n_r-1)\gamma_r + n_l\gamma_l\right)}{\beta_r\left(s_r+1\right)} \qquad s_r = \frac{\alpha_r - \phi_r^c + \phi_r^c\left((n_r-1)\gamma_r + n_l\gamma_l\right)}{\beta_r\sqrt{\omega_r + 2\left(\phi_{rr}^m(n_r-1) + \phi_{rl}^m n_l\right)}} - 1$$

To calculate the money laundering probability of being caught when countries using an international information exchange regime we use the following formula:

$$\left(p_r^m\right)^* = \frac{\left(n_r+n_l-1\right)^2}{\left(n_r+n_l-1\right)^2 - n_r n_l}\cdot\left[\frac{\omega_l n_l}{2f_l^m\left(n_r+n_l-1\right)^2} + \frac{f_r^m\left(n_r+n_l-1\right)}{2\left(\theta_r^m\right)^2} - \frac{\omega_r}{2f_r^m\left(n_r+n_l-1\right)} - \frac{f_l^m n_l}{2\left(\theta_l^m\right)^2}\right]$$

Therefore $V_r + V_l$ in countries using an international information exchange regime to fight money laundering is calculated in the following table:

p_r^m	p_l^m	s_r	s_l	e_r	e_l	V_r	V_l	V_r+V_l
0.11998	0.12554	3.636546	3.63655	3.8	3.8	18.709246	18.7648	37.474047
0.12094	0.12372	3.636546	3.63655	3.8	3.8	18.718824	18.7466	37.465427
0.1219	0.1219	3.636546	3.63655	3.8	3.8	18.728403	18.7284	37.456806
0.12285	0.12008	3.636546	3.63655	3.8	3.8	18.737982	18.7102	37.448185
0.12381	0.11826	3.636546	3.63655	3.8	3.8	18.74756	18.692	37.439565
0.12477	0.11644	3.636546	3.63655	3.8	3.8	18.757139	18.67381	37.430944
0.12573	0.11462	3.636546	3.63655	3.8	3.8	18.766717	18.65561	37.422323

To calculate the money laundering probability of being caught when countries using an evenly split budget regime we use the following formula:

$$\frac{f_r^m\left(n_r+2n_l-1\right)}{\sqrt{\omega_r+2f_r^m\left(n_r+2n_l-1\right)p^m}}+\frac{f_l^m\left(2n_r+n_l-1\right)}{\sqrt{\omega_l+2f_r^m\left(2n_r+n_l-1\right)p^m}}=\theta_r^m+\theta_l^m$$

Therefore V_r+V_l in countries using an evenly split budget system to fight money laundering is calculated in the following table:

p^m	s_r	e_r	s_l	e_l	V_r	V_l	V_r+V_l
0.28828	2.033222	5.80863	2.0423	5.791	18.383582	18.40082	36.784405
0.28785	2.03548	5.80431	2.04	5.796	18.383577	18.3922	36.775775
0.28741	2.037737	5.8	2.0377	5.8	18.383575	18.38358	36.767151
0.28698	2.039995	5.79569	2.0355	5.804	18.383577	18.37496	36.758533
0.28655	2.042252	5.79139	2.0332	5.809	18.383582	18.36634	36.749922
0.28613	2.04451	5.7871	2.031	5.813	18.38359	18.35773	36.741318
0.2857	2.046767	5.78281	2.0287	5.817	18.383601	18.34912	36.732719

By comparing V_r+V_l in these two regimes we prove the results. □

Proposition C.8. *Consider two countries which are identical in all respects but have heterogeneous wages. In countries with homogenous wages as well as with heterogeneous wages for workers, each country invests more to combat money laundering and social loss will lower in each country with a tailor-made budget regime than under an international information exchange regime.*

Proof: The proof of the homogenous wages countries is as the same of Proposition C.7.

The optimal money laundering probability of detection in countries where workers earn heterogeneous wages in countries with an international information exchange regime is given in equation (C.7).

Now we are going to calculate the optimal money laundering probability of detection in countries with heterogeneous wages of workers and the tailor-made budget system. Money laundering probability of detection in country r is as follows:

$$\frac{f^m\left(2n-1\right)}{\sqrt{\omega_r+2f^m\left((2n-1)p_r^m+np_l^m\right)}}+\frac{f^m n}{\sqrt{\omega_l+2f^m\left((2n-1)p_l^m+np_r^m\right)}}=\theta^m \quad \text{(C.9)}$$

Money laundering probability of detection in country l is as follows:

$$\frac{f^m\left(2n-1\right)}{\sqrt{\omega_l+2f^m\left((2n-1)p_l^m+np_r^m\right)}}+\frac{f^m n}{\sqrt{\omega_r+2f^m\left((2n-1)p_r^m+np_l^m\right)}}=\theta^m \quad \text{(C.10)}$$

Regarding to equations (C.9) and (C.10) we conclude the following result:

$$\frac{f^m(2n-1)}{\sqrt{\omega_r+2f^m\left((2n-1)p_r^m+np_l^m\right)}}+\frac{f^m n}{\sqrt{\omega_l+2f^m\left((2n-1)p_l^m+np_r^m\right)}}=$$

$$\frac{f^m(2n-1)}{\sqrt{\omega_l+2f^m\left((2n-1)p_l^m+np_r^m\right)}}+\frac{f^m n}{\sqrt{\omega_r+2f^m\left((2n-1)p_r^m+np_l^m\right)}}\Rightarrow$$

$$\frac{f^m(n-1)}{\sqrt{\omega_r+2f^m\left((2n-1)p_r^m+np_l^m\right)}}=\frac{f^m(n-1)}{\sqrt{\omega_l+2f^m\left((2n-1)p_l^m+np_r^m\right)}}\Rightarrow$$

$$\omega_r+2f^m\left((2n-1)p_r^m+np_l^m\right)=\omega_l+2f^m\left((2n-1)p_l^m+np_r^m\right)\Rightarrow$$

$$\omega_r+2f^m(n-1)p_r^m=\omega_l+2f^m(n-1)p_l^m \quad \Rightarrow \quad p_r^m=p_l^m+\frac{\omega_l-\omega_r}{2f^m(n-1)} \tag{C.11}$$

Substituting p_r^m in equation (C.9) yields:

$$\frac{f^m(3n-1)}{\sqrt{\frac{(2n-1)\omega_l-n\omega_r}{n-1}+2(3n-1)f^m p_l^m}}=\theta^m \qquad \Rightarrow$$

$$p_l^m=\frac{f^m(3n-1)}{2\left(\theta^m\right)^2}-\frac{(2n-1)\omega_l-n\omega_r}{2f^m(n-1)(3n-1)} \tag{C.12}$$

By comparing equations (C.7) and (C.12) we can conclude that if countries use a tailor-made budget system to combat money laundering they will invest more, but the cost of domestic and international linking will increase compared to using an international information exchange regime. Therefore, by increasing investment to combat money laundering the number of criminals will go down substantially and in this case social loss will decrease if countries use a tailor-made budget system. □

Proposition C.9. *Consider two countries with wage levels ω_r and ω_l and a centralized authority.*

(i) In countries with homogenous wage levels, each country invests the same to fight money laundering in both central authority regimes i.e. with an evenly split budget or a tailor-made budget. Likewise, social loss will be the same under both regimes.

(ii) In countries with heterogeneous wages levels, the low wage country spends more to fight money laundering and also social loss is higher under a tailor-made budget than under an evenly split budget regime. However, the high wage country will spend less and also social loss will be less under a tailor-made budget than under an evenly split budget regime.

(iii) If countries use the tailor-made budget regime, the total social loss in these countries is less that when they use an evenly split budget system.

Proof. (i) The optimal money laundering probability of detection in homogenous countries with an evenly split budget system and tailor-made budget system is as follows:

$$p^m = \frac{f^m(3n-1)}{2\theta_m^2} - \frac{\omega}{2f^m(3n-1)} \tag{C.13}$$

Thus we can conclude that both countries will spend the same and social loss also will be the same in both regimes.

(ii) The optimal money laundering probability of detection in countries where workers earn heterogeneous wages with the evenly split budget system is given in equation (C.8).The optimal money laundering probability of detection in countries where workers earn heterogeneous wages with the tailor-made budget system is given in equation (C.12). Since we could not calculate p_m explicitly through the equation (C.8), we used the numerical simulation to solve the problem. With this numerical simulation we prove the results.

In the numerical simulation we are going to calculate the following equation:

$$V_r + V_l = s_r^* e_r^* + s_l^* e_l^* + \theta_r^c \left(p_r^c\right)^2 + \theta_l^c \left(p_l^c\right)^2 + \theta_r^m p_r^m + \theta_l^m p_l^m$$

We assume that the wage of workers in country r stays the same but it is increasing in country l. We assume the values in the following table for the number of top criminals and dishonest workers they know (n), adjusted reporting threshold (γ), fine for crime (drugs) (f_c), competition effect between criminals (β), correction factor (θ), fine for money laundering (f_m), wage in formal sector (ω), and maximum willingness to pay for drugs (α). The probability to get caught for crime (drugs) for each effort obtains from the following formula:

$$p_r^c = \frac{f_r^c\left[1-\left((n_r-1)\gamma_r + n_l\gamma_l\right)\right]}{2\beta_r\theta_r^c}$$

n	f^c	γ	β	$\theta^c = \theta^m$	p^c	f^m	ω_r	ω_l	α
10	3	0.01	0.2	10	0.02	2	0.3	0.1	5
10	3	0.01	0.2	10	0.02	2	0.3	0.2	5
10	3	0.01	0.2	10	0.02	2	0.3	0.3	5
10	3	0.01	0.2	10	0.02	2	0.3	0.4	5
10	3	0.01	0.2	10	0.02	2	0.3	0.5	5
10	3	0.01	0.2	10	0.02	2	0.3	0.6	5
10	3	0.01	0.2	10	0.02	2	0.3	0.7	5

The effort level (e) and the number of top criminals (s) is calculated through the following formulas:

$$e_r = \frac{\alpha_r - \phi_r^c + \phi_r^c\left((n_r - 1)\gamma_r + n_l\gamma_l\right)}{\beta_r\left(s_r + 1\right)} \qquad s_r = \frac{\alpha_r - \phi_r^c + \phi_r^c\left((n_r - 1)\gamma_r + n_l\gamma_l\right)}{\beta_r\sqrt{\omega_r + 2\left(\phi_{rr}^m(n_r - 1) + \phi_{rl}^m n_l\right)}} - 1$$

To calculate the money laundering probability of being caught when countries using an evenly split budget regime we use the following formula:

$$\frac{f_r^m\left(n_r + 2n_l - 1\right)}{\sqrt{\omega_r + 2f_r^m\left(n_r + 2n_l - 1\right)p^m}} + \frac{f_l^m\left(2n_r + n_l - 1\right)}{\sqrt{\omega_l + 2f_r^m\left(2n_r + n_l - 1\right)p^m}} = \theta_r^m + \theta_l^m$$

Therefore $V_r + V_l$ in countries using an evenly split budget system to fight money laundering is calculated in the following table:

p^m	s_r	e_r	s_l	e_l	V_r	V_l	$V_r + V_l$
0.28828	2.03	5.8086335	2.042	5.791392	18.383582	18.4008232	36.78440505
0.28785	2.04	5.8043133	2.04	5.795693	18.383577	18.39219772	36.77577476
0.28741	2.04	5.8000003	2.038	5.8	18.383575	18.38357543	36.76715086
0.28698	2.04	5.795693	2.035	5.804314	18.383577	18.37495635	36.75853338
0.28655	2.04	5.7913922	2.033	5.808634	18.383582	18.36634048	36.7499223
0.28613	2.04	5.7870979	2.031	5.81296	18.38359	18.35772784	36.74131762
0.2857	2.05	5.7828102	2.029	5.817293	18.383601	18.34911845	36.73271936

To calculate the money laundering probability of being caught when countries using a tailor-made budget regime we use the following formula:

$$\frac{f_r^m\left(n_r + n_l - 1\right)}{\sqrt{\omega_r + 2f_r^m\left((n_r + n_l - 1)p_r^m + n_l p_l^m\right)}} + \frac{f_l^m n_r}{\sqrt{\omega_l + 2f_l^m\left((n_r + n_l - 1)p_l^m + n_r p_r^m\right)}} = \theta_r^m$$

Therefore $V_r + V_l$ in countries using a tailor-made regime to fight money laundering is calculated in the following table:

p_r^m	p_l^m	s_r	e_r	s_l	e_l	V_r	V_l	$V_r + V_l$
0.2854981	0.2910536	2.03774	5.8	2.0377371	5.8	18.36442	18.419974	36.78439224
0.2864559	0.2892337	2.03774	5.8	2.0377371	5.8	18.374	18.401775	36.77577155
0.2874138	0.2874138	2.03774	5.8	2.0377371	5.8	18.38358	18.383575	36.76715086
0.2883716	0.2855939	2.03774	5.8	2.0377371	5.8	18.39315	18.365376	36.75853017
0.2893295	0.2837739	2.03774	5.8	2.0377371	5.8	18.40273	18.347177	36.74990948
0.2902874	0.281954	2.03774	5.8	2.0377371	5.8	18.41231	18.328978	36.74128879
0.2912452	0.2801341	2.03774	5.8	2.0377371	5.8	18.42189	18.310778	36.7326681

By comparing $V_r + V_l$ in these two regimes we prove the results. □

Numerical simulation to compare the two centralized authority systems in countries with homogeneous and heterogeneous country size:

In the numerical simulation we are going to calculate the following equation:

$$V_r + V_l = s_r^* e_r^* + s_l^* e_l^* + \theta_r^c \left(p_r^c\right)^2 + \theta_l^c \left(p_l^c\right)^2 + \theta_r^m p_r^m + \theta_l^m p_l^m$$

We assume that the size of country r stays the same but it is increasing in country l. We assume the values in the following table for the number of top criminals and dishonest workers they know (n), adjusted reporting threshold (γ), fine for crime (drugs) (f_c), competition effect between criminals (β), correction factor (θ), fine for money laundering (f_m), wage in formal sector (ω), and maximum willingness to pay for drugs (α). The probability to get caught for crime (drugs) for each effort obtains from the following formula:

$$p_r^c = \frac{f_r^c\left[1-\left((n_r-1)\gamma_r + n_l\gamma_l\right)\right]}{2\beta_r\theta_r^c}$$

n_r	n_l	γ_r	γ_l	f^c	β	$\theta^c = \theta^m$	f^m	ω	α_r	α_l	p_r^c	p_l^c
10	5	0.046	0.09	3	0.2	10	2	0.3	5	2	0.102	0.135
10	10	0.046	0.046	3	0.2	10	2	0.3	5	5	0.0945	0.0945
10	15	0.046	0.023	3	0.2	10	2	0.3	5	8	0.18075	0.1635
10	20	0.046	0.015	3	0.2	10	2	0.3	5	11	0.2145	0.19125
10	25	0.046	0.01	3	0.2	10	2	0.3	5	14	0.252	0.225
10	30	0.046	0.007	3	0.2	10	2	0.3	5	17	0.282	0.25275

The effort level (e) and the number of top criminals (s) is calculated through the following formulas:

$$e_r = \frac{\alpha_r - \phi_r^c + \phi_r^c\left((n_r - 1)\gamma_r + n_l\gamma_l\right)}{\beta_r\left(s_r + 1\right)} \qquad s_r = \frac{\alpha_r - \phi_r^c + \phi_r^c\left((n_r - 1)\gamma_r + n_l\gamma_l\right)}{\beta_r\sqrt{\omega_r + 2\left(\phi_{rr}^m(n_r - 1) + \phi_{rl}^m n_l\right)}} - 1$$

To calculate the money laundering probability of being caught when countries using an evenly split budget system we use the following formula:

$$\frac{f_r^m\left(n_r + 2n_l - 1\right)}{\sqrt{\omega_r + 2f_r^m\left(n_r + 2n_l - 1\right)p^m}} + \frac{f_l^m\left(2n_r + n_l - 1\right)}{\sqrt{\omega_l + 2f_r^m\left(2n_r + n_l - 1\right)p^m}} = \theta_r^m + \theta_l^m$$

Therefore $V_r + V_l$ in countries using an evenly split budget system to fight money laundering is calculated in the following table:

s_r	e_r	s_l	e_l	p^m	V_r	V_l	$V_r + V_l$
5.137	4.03952	1.12642	4.531	0.2107592	22.964	7.39402	30.3581
3.28	5.8	3.27955	5.8	0.2874138	21.9848	21.98484	43.9697
2.229	7.54002	4.60361	7.043	0.3625118	20.7584	36.31495	57.0734
1.598	9.26954	5.55935	8.273	0.4368594	19.6389	50.72937	70.3683
1.159	10.9929	6.26394	9.497	0.5107829	18.4798	65.10433	83.5842
0.841	12.7124	6.81222	10.72	0.584442	17.3367	79.48876	96.8255

To calculate the money laundering probability of being caught when countries using a tailor-made budget system we use the following formula for country r :

$$\frac{f_r^m\left(n_r + n_l - 1\right)}{\sqrt{\omega_r + 2f_r^m\left((n_r + n_l - 1)p_r^m + n_l p_l^m\right)}} + \frac{f_l^m n_r}{\sqrt{\omega_l + 2f_l^m\left((n_r + n_l - 1)p_l^m + n_r p_r^m\right)}} = \theta_r^m$$

Therefore $V_r + V_l$ in countries using a tailor-made budget system to fight money laundering is calculated in the following table:

s_r	e_r	s_l	e_l	p_l^m	p_r^m	V_r	V_l	$V_r + V_l$
2.396	7.3	1.96985	3.244	-0.662209	1.18275	29.42349	-0.0488	29.37471
3.28	5.8	3.27955	5.8	0.2874138	0.28741	21.98484	21.9848	43.96967
3.001	6.08571	3.16888	9.467	1.0424104	-0.2688	15.89917	40.6901	56.58929
2.569	6.74737	2.8098	14.24	2.1151531	-1.0688	7.104144	61.5413	68.64546
2.143	7.55	2.42653	20.13	3.6436844	-2.2622	-5.80754	85.7973	79.98973
1.78	8.42069	2.08559	27.13	5.7319236	-3.9566	-23.7815	114.547	90.76558

By comparing $V_r + V_l$ in these two regimes we prove the results. □

Nederlandse samenvatting

Witwassen van geld is de vermomming van de illegale herkomst van geld door het terug te brengen in het legale financiële circuit.

Het is een relatief nieuw onderwerp in de economie, met name vanuit het perspectief van netwerkanalyse. Daarom trachten we in dit proefschrift een theoretisch kader vast te stellen om de rol van sociale netwerken te begrijpen en de band tussen criminelen en rechtspersonen in het witwassenproces. We richten ons op de geldwassingsmethode genaamd smurfing; De splitsing van grote criminele opbrengsten gaat in kleine onopvallende bedragen, en aangezien deze techniek typisch een netwerk vereist, moeten potentiële misdadigers banden met andere mensen vormen en een geldwassennetwerk opzetten om hun geld te wassen.

De onderzoeksvragen zijn gericht op hoe de netwerken worden gevormd wanneer criminelen strategisch links vormen om hun geld te wassen en wat de vorm van het netwerk op macro-niveau is. Bovendien is de focus ook gericht op het optimale beleid om misdaad en witwassen van geld te bestrijden, zowel op nationaal als internationaal niveau. Voor dit doel introduceren we sociale netwerk- en game theorie op het gebied van het witwassen van geld. De studie bevat ook enkele simulaties om de optimale begroting te vinden voor het beleid tegen het witwassen van geld.

Hoofdstuk 1 geeft een algemene inleiding tot dit proefschrift en een overzicht van de literatuur over het witwassen van geld en netwerkanalyse.

In hoofdstuk 2 analyseren we een typisch drugscriminaliteit scenario door een simpel model te presenteren om de vorming van een witwasnetwerk in deze context te bestuderen. Hierbij gaan we ervan uit dat er drie soorten actoren zijn: criminele bazen, lopers die drugs op straat verkopen, en oneerlijke werknemers, zoals bankmedewerkers.

In dit model beslissen agenten eerst of ze criminelen of werknemers worden. Vervolgens verdelen criminelen zich bij toeval in een criminele baas of loper, waar we Levitt en Dubner (2010) volgen en ervan uitgaan dat crimineel talent vooralsnog onbekend is voor agenten en alleen een getalenteerde crimineel wordt een criminele baas en verdient een fortuin. De succesvolle criminelen beslissen daarna of ze hun geld willen wassen door samenwerkingsverbanden met andere agenten toe te voegen of niet.

In dit hoofdstuk gaan we ervan uit dat de koppeling van de kosten laag is. Hoewel deze koppelingen kostbaar zijn, helpen ze de marginale kosten van de criminele activiteit te verlagen door de misdaad te vervangen met schone opbrengsten. Wij tonen aan dat het netwerk voor het witwassen van geld op macroniveau een uitgebreide inter-linked sterstructuur heeft waarin de getalenteerde criminele bazen volledig onderling verbonden zijn. We tonen ook aan dat de bereidheid van agenten om criminelen te worden, eindeloos afhankelijk is van het loon van werknemers. We sluiten dit hoofdstuk met een aantal vergelijkende statistische analyses die veel van de intuïtieve ideeën bevestigen over hoe de omvang van de criminele pool, de lonen in de juridische sector en hoe de financiële controlesystemen de omvang van het witwassen van geld beïnvloeden.

We gebruiken de analyse in hoofdstuk 2 als een stap voor het verdere werk in deze proefschrift. We hebben aangetoond dat criminele bazen hun geld winnen doormiddel van netwerken, voor het witwassen van geld, met andere criminele bazen, lopers en werknemers. In de volgende hoofdstukken beschouwen we slechts twee groepen agenten in ons netwerk, potentiële criminelen en werknemers. Na het karakteriseren van het netwerk analyseren wij het nationale en internationale beleid ter bestrijding van het witwassen van geld. In hoofdstuk 3 analyseren wij een binnenlands netwerk, wanneer agenten een nationaal netwerk vormen voor het witwassen van geld en we ontlenen hierbij een nationaal optimale beleidsreactie. In hoofdstuk 4 breiden we het kader uit naar een internationaal scenario. We analyseren een internationaal netwerk en verschillende regimes om het witwassen van geld internationaal te bestrijden.

Hoofdstuk 3 breidt uit op het model uit hoofdstuk 2. In dit model besluiten agenten eerst of ze de arbeidsmarkt betreden of een misdadiger worden. Vervolgens beslissen criminelen of zij hun geld willen wassen door samenwerkingsverbanden met andere agenten toe te voegen of niet. Tenslotte kiezen criminelen welk midsdaadinspanningsniveau zij willen bieden. We vinden dat, voor de lage koppelingskosten, het evenwichtnetwerk net zoals in hoofdstuk 2 een interlinkende ster is waarin criminelen volledig onderling verbonden zijn. Ook de bereidheid van agenten om misdadigers te worden of de arbeidsmarkt bij te wonen is nog eens afhankelijk van het loonniveau in een samenleving. We concluderen dat een stijging van de lonen van werknemers leidt tot lagere criminaliteit en minder witwassen van geld. Met andere woorden, we bevestigen de conclusies van Engelhard, Rocheteau en Rupert (2008), aangezien onze resultaten ook aantonen dat arbeidsmarktbeleid een cruciale rol kan spelen in het verminderen van misdaad en witwassen van geld.

Hierbij gaat het om anti-witwassen van geld en anti-misdaadbeleid vanuit een binnenlandse hoek. Hierbij richten we ons op de vraag hoe een bepaald budget moet worden besteed aan anti-criminaliteit en anti-witwassen beleid. We definiëren een sociale verliesfunctie, die een autoriteit wil minimaliseren door het optimale niveau van misdaad- en witwassenbeleid vast te stellen. Onze analyse suggereert dat wanneer de aanmeldingsdrempel voor het witwassen van geld stijgt, het aantal geldwassers afneemt. Daarom wordt het optimale niveau van de criminele beleidsvariabele afgenomen en geldbeleid wordt belangrijker. We concluderen ook dat door het loon van werknemers te verhogen, het aantal criminelen, misdrijven en witwassen van geld in de maatschappij zal afnemen. Aangezien elke crimineel veel banden in het netwerk heeft, zal door het aantal criminelen te verminderen, het aantal banden onder hen aanzienlijk afnemen. In dit geval neemt het optimale niveau van het witwassen van geld af en wordt het beleid op het gebied van de bestrijding van misdrijven effectiever. Verder concluderen we dat wanneer de kosten van het implementeren van anti-criminaliteit beleid laag zijn of de vervolging en veroordeling van criminele handelingen makkelijk te handhaven is, de autoriteiten op dit terrein criminelen zouden moeten bestrijden. In tegenstelling, als geldwassers effectief kunnen worden vervolgd tegen lage kosten, zouden de autoriteiten zich daarop moeten concentreren.

Ten slotte, aan het eind van hoofdstuk 3, implementeren wij ons model empirisch met behulp van echte wereldgegevens en wordt de optimale beleidsreactie numeriek berekend met een macro-niveau 'voldoende statistiek' benadering. Wij passen het model toe op Nederland. Op basis van de voldoende statistische aanpak, waar we gebruik maken van enkele macroconstructen van parameters en variabelen die gemakkelijk zichtbaar zijn in de huidige macro-economische datasets, vinden we dat het aandeel van de begroting die moet worden besteed aan het bestrijden van het witwassen van geld om criminaliteit- vechtresultaten te optimaliseren 30% is.

Hoofdstuk 4 bestudeert de vorming van het internationaal witwassen van geld. Hierbij ligt de nadruk op het vergelijken van verschillende transnationale vormen van samenwerking in de strijd tegen het witwassen van geld. De structuur van het spel is identiek aan hoofdstuk 3, behalve dat er nu twee landen zijn. Een eerste vergelijkend statisch resultaat is dat in een hoge-loonland het aantal bindingen die naar een ander land gaan, lager is dan in een lageloonland, waar criminelen hun geld liever wit wassen in een hoge-loonland. Ten tweede, bij vergelijking van de bevolkingsgroottes, wassen criminelen hun geld liever wit in een klein land, in plaats van in een groot land. Dit resultaat is in lijn met Gnutzmann et al., 2010 (voornamelijk kleine landen zullen mogelijkheden bieden voor het witwassen van geld).

In dit hoofdstuk ontlenen we ook beleidsimplicaties voor de bestrijding van misdaad en witwassen van geld op transnationaal niveau. We beschouwen twee landen waar in elk land de autoriteiten erop gericht zijn de sociale verliezen te verminderen die bestaan uit de schade die door de binnenlandse criminaliteit wordt veroorzaakt en van de kosten van anti-criminaliteit en anti-witwassen beleid. Aangezien criminelen hun geld in hun eigen land en in het buitenland proberen te winnen, kunnen autoriteiten samenwerken in hun strijd tegen criminaliteit en witwassen van geld.

We beschouwen vier regimes die gestileerde representaties van huidige transnationale samenwerkingen zijn, namelijk: een decentraal regime zonder internationale informatie-uitwisseling; Een decentraal regime met internationale informatie-uitwisseling; Een centraal regime met een gelijkmatig gesplitste begroting; En een centraal regime met een op maat gemaakte begroting. Voor elk regime karakteriseren we het optimale niveau van een beleidsparameter voor het witwassen van geld. Een voorbeeld voor het gedecentraliseerde regime is de Egmont Groep, bestaande uit FIU's (Financial Intelligence Units). De FIU's ontmoeten elkaar regelmatig om manieren te vinden om het werk van FIU's te verbeteren en met elkaar samen te werken, met name op het gebied van informatie-uitwisseling, opleiding en het delen van deskundigheid (opgericht in 1995). Een voorbeeld voor het gecentraliseerde regime is de Financial Action Task Force, die het mondiale witwassen van geld regelt (opgericht in 1989).

Uit de vergelijking blijkt dat, als landen deelnemen aan informatie-uitwisseling, geldwisselingbeleid strategische substituten zijn, omdat één land profiteert van de inspanningen van het andere land. Als gevolg hiervan belegt elk land minder in vergelijking met een regime zonder informatie uitwisseling. Aangezien de som van de investeringen groter is dan zonder informatie uitwisseling, zijn beide landen duidelijk beter af, waardoor de grootste voordelen in het hoge-loonland komen. Onze vergelijking tussen de gedecentraliseerde en de centrale regimes toont het volgende:

omdat een centrale autoriteit de positieve externiteit van een belegging tegen geldwassing internaliseert, wordt in beide landen een hoger budget gehandhaafd. Als gevolg hiervan zijn de sociale verliezen lager in elk land dan in beide gedecentraliseerde regimes. We vergelijken ook de gevallen van een evenwichtige begroting tegenover een op maat gemaakte begroting. Uit onze bevindingen blijkt dat het eerste beste regime is om een centrale autoriteit uit te voeren die op maat gemaakte begrotingen toewijst, waarbij het hoge-loonland het meest ontvangt. Een centrale autoriteit die de begrotingen gelijkmatig toewijst, is daarentegen ten voordeel van het lage-loonland. De reden is dat de gelijkmatige splitsing niet in verhouding staat tot de criminele activiteiten in de twee landen, zodat het rijkere land de arme een effectieve subsidie zal geven. Een vergelijkbare bevinding geldt voor een gelijkmatig gesplitste begroting wanneer de twee landen verschillen in grootte: het grotere land subsidieert de kleinere.

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