Università Commerciale Luigi Bocconi

BAFFI CAREFIN
Centre for Applied Research on International Markets, Banking, Finance and Regulation

Working Paper

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DRUG TRAFFICKING, MONEY LAUNDERING AND THE BUSINESS CYCLE: DOES SECULAR STAGNATION INCLUDE CRIME?

BAFFI CAREFIN Centre Research Paper Series
No. 2017- 47

DRUG TRAFFICKING, MONEY LAUNDERING AND THE BUSINESS CYCLE: DOES SECULAR STAGNATION INCLUDE CRIME?

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Abstract

The aim of the paper is to analyze theoretically and empirically the impact the macroeconomic cycle has on the accumulation of capital by organized crime, using estimates for the global drug market. So far the economic literature has neglected the relationships existing between illegal markets, money laundering, and the business cycle. We propose a dynamic model where the business cycle influences the criminal economy via two different channels. On the one side, illegal markets grow at variable rates, depending on the health of the legal economy. Secondly, a pass-through effect can exist, since the business cycle affects the legal markets which criminal operators use to launder their revenues. Furthermore, we analyze the consequences of a "saturation effect" limiting maximum accumulation of illegal capital. We find that overall illegal capital is affected by the business cycle through a capital multiplier; in addition to this, the dynamics of interest rates in financial markets can influence such multiplier.

♦ Department of Law, University of Salento, Lecce. The author acknowledges Regione Puglia and ARTI for founding FIR project no. DBLV3J3 through the action co-funded by the Development and Cohesion Fund 2007-2013 - APQ search Apulia Region "Regional program in support of smart specialization and social and environmental sustainability - FutureInResearch".

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1. Introduction

In recent macroeconomics, the issue of secular stagnation – the hypothesis that the advanced economies could be trapped in a prolonged phase of anemic economic growth – is taking a crucial role in research, as well as in the policy agenda[1]. At the same time, thus far economic literature has completely overlooked the role of the business cycle in explaining the features of and trends in illegal markets and money laundering, while facts and anecdotal evidence suggest that such a relationship exists. If the business cycle matters, the assumption that a structural slowdown is characterizing advanced economies becomes a relevant topic in explaining the current state of affairs both in the legal and illegal spheres of the economic system.

In this paper, we propose a model where it is assumed that the business cycle can influenceillegal markets via two different channels. On the one side, illegal markets grow at varying rates depending on the status of the legal economy. Secondly, a pass-through effect can occur, since the business cycle influences legal markets that illegal operators make use of to reinvest their profits. Furthermore, we introduce the hypothesis of a saturation effect (or "carrying capacity"[2]) for maximum illegal capital that the corresponding market can sustain. The model is tested using international data on drug trafficking from 1998 to 2008.

The paper is organized as follows: after a review of the literature in Section 2, which shows how existing studies address the relationship between illegal markets, money laundering (ML) and the business cycle, inn section 3 we present the dynamic model that underlines how interactions between illegal markets, money laundering activities and legal sector are shaped by external macroeconomic factors. In Section 4, the model is fitted against a dataset related to global drug trafficking in the 1998–2008 period. Section 5 concludes.

2. Illegal Markets, Money Laundering and the Business Cycle: The Missing Link

Providing an estimate for the financial laundering of illicit gain is undoubtedly a daunting task. In effect, it would be easy to conclude that by its very shadowy nature, data on money laundering are hard to come by. However, this does not imply that it is impossible to provide an answer to this empirical question. In this regard, social scientists have lined up on two fronts: on the one hand, those who are in favor of the production of estimates, albeit partial and not error-proof. On the other, those who oppose it on grounds of unreliability.

Nevertheless, in these analyses there has been limited interest in the relationship between illegal markets, money laundering and the business cycle. Indeed, the main topic addressed by researchers has been the link between the unemployment rate and property crime[3]. In any case, the relationship between money laundering, illicit drug markets and the business cycle has been neglected. Nevertheless, it is known that "*inter-bank loans were funded by money that originated from the drugs trade and other illegal activities... There were signs that some banks were rescued that way*"[4], in the post-2008 banking crisis[5]. As Antonio Maria Costa said there is evidence that the

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[1] See Summers L. (2013), Eggertsson G.B. and Mehrotra N.R. (2014), Eichengreen B. (2015), Lo S.H. and Rogoff K. (2015), Favero C.A. and Galasso V. (2015), Eggertsson G.B. et al. (2016); for a survey see Pagano P. and Sbracia M. (2015).

[2] Banks (1994).

[3] See for example: Hale, C. (1998), Gould et al. (2002), Raphael, S., and Winter Ebmer, R. (2001). For a survey see Scheider et al. (2012).

[4] *Drug money saved banks in global crisis, claims UN advisor*, The Guardian, December 13, 2009. https://www.theguardian.com/global/2009/dec/13/drug-money-banks-saved-un-cfief-claims. On money laundering, banks and regulation see also Chong A. and Lopez de Silanes F. (2006).

proceeds of organized crime were "the only liquid investment capital" available to some of the banks that were on the brink of collapse in 2008. According to him, the majority of drug profits was absorbed into the economic system as a result. In addition, in 2011[6] Victor Ivanov arrived at the same conclusions. However, what it goes without doubt that drug markets continue to be one of the most profitable areas of activity for organized crime groups (OCGs), and it is estimated that every year EU citizens alone spend in the range of € 21 to 31 billion to buy illicit drugs[7].

At a general level, available literature on money laundering proposes both theoretical models and quantitative estimates. Pioneering studies were those of Tanzi (1996, 1997) [8], Quirk (1996, 1997) and Walker (1999). Quirk estimated that an increase of 10% in Money Laundering (ML) produced a 0.1% reduction in annual GDP. Michel Camdessus, at that time IMF Managing Director, provided the same indication in a 1998 speech, in which he claimed that estimates of ML transactions were 2–5% of global GDP. Unfortunately, IMF never explained how these conclusions were reached[9].

John Walker proposed an economic model of crime, which resembles an interregional input-output economic model, using a range of publicly available crime statistics to estimate the amount of money generated by illegal activities in each country around the world. Later, he used various socio-economic indicators to estimate the proportion of dirty money that is laundered, and the destination countries the corresponding funds are sent for laundering. He defined an "attractiveness index to money launderers", based on several factors, that express the attitude of countries towards ML, the level of corruption, and GNP. Other things being equal, geographic distance and linguistic or cultural differences are considered as deterrents to money launderers. Initial output of the model suggested an estimate for global money laundering of $2.85 billion a year, heavily concentrated in Europe and North America. The author admitted that these estimate were just interim results.

Unger (2007) noted that Walker's formula resembles Tinbergen's gravity model. She compared Walker's formula to the original gravity model and she modified the attractiveness index, including additional variables (the amount of financial deposits, and being a member of Egmont group or not). In 2009, Unger and Walker[10] used the revised formula to estimate the percentage of dirty money flowing to the Netherlands from several countries. It resulted that Netherlands would be more attractive for launderers based in foreign countries if it had a higher GDP per capita, if it had high bank secrecy, if it had the technological means to transfer money quickly and if it had low conflict and corruption so that criminals do not have to fear losing their laundered money. Indeed, the lower the distance between countries, the higher is ML. According to their analysis Unger et al. (2006), showed in 2005 that the total money laundered in the Netherlands was €14.783 billion. Considering also the laundering of the proceeds of Dutch crime, we must add another 4 billion euros. In other words, Netherlands is confronted with about €18.5 billion Euro of ML each year (about 5 percent of Dutch GDP).

Schneider (2010) estimated the turnover of organized crime during the years 1995-2006 for 20 OECD countries. He used an indirect method, applying a MIMIC procedure based on the statistical theory of unobservable latent variables (turnover of organized crime, in this case). To estimate criminal turnover, the author used eight causing variables (five of which are statistically significant; namely: criminal activities such as drug traffic, illegal weapon selling, trafficking of human beings, the faking of products, and the functioning of the legal system) and three indicators (confiscated money, number of prosecuted persons, cash used in criminal activities). For the variables, he

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5 The role of financial sector in the money laundering process is a well discussed both in the academic context and in institutional documents (see for example Masciandaro et al. 2007, Europol 2006, 2007, 2008). Nevertheless, in the existing literature there isn't any analysis of money-laundering activities and actors during the economic crisis.

6 Ivanov V. (2011).

7 Europol (2016), *EU Drug Markets Report 2016*, European Monitoring Centre for Drugs and Drug Addiction.

8 Tanzi V. (1997), pp. 91–104.

9 Camdessus M. (1998).

10 Walker and Unger (2009).

assumed that the turnover of organized crime was higher dependent on the frequency criminal activities take place in a country; the quality of the legal system. For the indicator variables, he assumed that the turnover of organized crime was positively correlated with the amount of confiscated money, the cash used in criminal activities, and the number of prosecuted persons. The results were that the turnover of organized crime activities increased from $270 billion in 1995 to $614 billion in 2006 in the total of 20 OECD countries considered. In the same work, he wrote, however, that "*these are very rough, preliminary calculations*".

Ardizzi et al. (2014) tried to estimate ML for Italy, observing 91 provinces over the period 2005-2008. In particular, they intended to answer the question: "*How much cash deposited in legal financial institutions can be traced back to criminal activities?*" Their idea was firstly to separate the money deposited in legal financial institution in three parts: the amount of dirty money proceeding from criminal activities (ML component), legal deposits, and illegal money coming from tax evasion. In order to do this separation, they borrowed a theoretical model from Masciandaro et al. (2007). Secondly, they defined the criminal activities that generate the illegal profits to be laundered. They included illegal traffics and extortion. The results showed that dirty money accounts for a 7.5% share of GDP in the North, and 5.1% in the South. In particular, the percentage of dirty money to be laundered resulting from illegal traffics amounted to 6.3% in the North and 3.4% in the South. In the case of extortion, the results were reversed, with 1.2% in Northern Italy and 1.7% in Southern Italy.

Among skeptics are Reuter (2007) and Van Duyne (2006, 2007)[11] who believe that any attempt to estimate ML is weak because of the lack of data. Levi (2012)[12] criticizes the estimates of ML for being nothing more than "*speculative guesstimates*". However, in 1994 Levi, in a joint paper with Gold[13] tried to estimate financial ML analyzing suspicious financial operations. Despite of criticism, as Kruisbergen et al. (2015) have observed, many of these estimates are frequently cited, becoming "*facts by repetition*" (Levi and Reuter 2009).[14]

With respect to previous literature, we propose an innovative model based on the assumption of a "saturation effect" for illegal capital, providing a realistic analysis of the money laundering phenomenon. Furthermore, the same model gives an assessment of the impact of the business cycle on both the growth of illegal revenue and the camouflage of dirty money in the legal economy.

3. Illegal and Illegal Markets, Money Laundering and the Role of Macroeconomic Constraints

Let us suppose that a criminal committs a crime that gives him a capital K_0 at time t_0. Then, he faces two different problems. First, he has to decide whether and how much money he wants to launder[15]. This decision will be influenced both by the corresponding transaction costs, linked to the probability of crime discovery and therefore incrimination, and by the overall economic situation. Secondly, given these microeconomic decisions, it is possible to show the macroeconomic relationship between illegal profits, ML and illegal capital owned by organized crime in the different macroeconomic scenarios.

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11 Van Duyne P. C. (2006), pp. 177–205; Van Duyne P. C. (2007), pp. 69–98.

12 Levi M. (2012), pp. 595–622.

13 Levi M. and Gold M. (1994), "Money-Laundering in the UK: An Appraisal of Suspicion-Based Reporting", London: Police Foundation.

14 Levi M. and Reuter P. (2009), pp. 356–380

15 As for the supply of money laundering services, the financial industry acquires a peculiar role for two key attributes: a greater than normal degree of 'opacity' (information asymmetry), since the exchanges and flows of purchasing power are filtered, coordinated and administered by specialized operators (financial intermediaries); the privileged position of such operators. For criminal parties, the presence of intermediaries that collude with them (crooked intermediaries) and/or honest but inefficient in protecting their integrity (lax intermediaries) increases the possibility of using financial markets for their concealment objectives. See Takatz (2007), Masciandaro et al. (2007), Picard and Pieretti (2009), Dalla Pellegrina and Masciandaro (2010).

Transaction costs can be minimized through effective laundering action, by means of concealment that separates financial flows from their illegal origin (Masciandaro 1999, Masciandaro et al. 2007). Since ML is not a free lunch, each agent will choose his/her optimal behavior, choosing how to use concealing procedures[16].

As we already reported in the previous section, in economic crises banks are less prone to question the origin of the money they handle (Unger and Van der Linde, 2013). Consequently, it is reasonable to consider that the business cycle influences the amount of money that is laundered. We assume that the criminal sector launders at least a fraction $0 \leq y < 1$ of its illegal revenues, while the remainder will be reinvested in illegal markets, at the rate of return r_i. Even such rate could be influenced by the business cycle[17]. We also assume that each laundering operation has a cost *c* for the criminal sector, represented by the price of money-laundering services.

A share *f* of cleaned money will be invested in the legal market at a rate r_l, while the remaining (1 – *f*) will be spent in consumption. ML is the channel thorough which criminal profits are funneled into the legitimate economic sector for business investments or for sustaining the lifestyle of members of organized crime groups[18].
Organized crime groups are increasingly employing legal business structures and respected experts, using different methods for controlling and influencing them, among which resorting to bribes and threats[19]. Exploitation of real and financial sectors is used for reinvestment of criminal proceeds[20].
At the same time, a portion of illegal capital must be reinvested in the lawless market prior to being laundered and consequently invested in the legal market. Reinvestment in criminal markets is an increasingly feature of actual organized crime groups, given their tendency toward specialization. Organized crime tends to acquire specialized functions to improve the profitability of illegal business[21]. Nevertheless, we assume the existence of an upper limit to illegal capital gathered by criminal sector[22]. In Barone and Masciandaro (2011), a constituting relation for illegal capital $K(t)$ is given by the differential equation:

$$K'(t) = \alpha K(t) \quad (1)$$

with $\alpha = \ln\left[(1-y)(1+r_i)\right]$, leading to the exponential growth $K(t) = K_0 e^{\alpha t}$. Indeed, such a behavior has to be considered valid for a limited number of years since the origin of the process. In a resource-constrained system, it seems more realistic to assume a limitation to this growth. As an example, the probability of being discovered and convicted, for the early crime and ML, increases with the amount of illegal capital controlled. In order to take account of this, we propose to consider the growth rate as a function of illegal capital itself, i.e. $\tilde{\alpha}(t;K(t))$. In particular, we allow for a decrease of the growth rate as illegal capital increases. To this purpose, we assume that there is a horizontal asymptote (K^*, a "maximum carrying capacity" for total profits that a criminal organization can attain. Consequently, the simplest choice for the growth rate is

[16] Microeconomic models of illegal activities and money laundering are presented in Masciandaro (2007), Siva Moreira (2007), Argentiero et al. (2008), Ferwenda (2008).
[17] Economic theory suggests that the presence of an income effect that negatively affects consumption of controlled substances during economic downturns. Indeed, addicted users tend to do drugs more frequently as their personal income rises. Substance use in the general population tends also to rise with personal income. For this observation see (Ritter and Chalmers, 2011).
[18] Europol 2009.
[19] Europol 2006, 2007,2009 and SOCTA (2013).
[20] Europol 2006.
[21] Europol 2006.
[22] The economic crisis has not led to an increase in activity from organized crime, instead it has resulted in shifts among criminal markets. SOCTA (2013).

$$\tilde{\alpha}\,(t;K(t)) = \alpha(t)\left(1 - \frac{K(t)}{K^*}\right) \tag{2}$$

leading to the so called logistic growth equation[23]

$$K'(t) = \alpha(t)\left(1 - \frac{K(t)}{K^*}\right)K(t) \tag{3}$$

with the initial condition $K(t_0) = K_0$. Although the latter is a non-linear differential equation, its general solution could be expressed as[24]

$$K(t) = \frac{\exp\left[\int_{t_0}^{t} \alpha(s)\,ds\right]}{\frac{1}{K_0} + \frac{1}{K^*}\int_{t_0}^{t} \alpha(s)\exp\left[\int_{t_0}^{s} \alpha(z)\,dz\right]ds}. \tag{4}$$

Conversely, if $K^* \to +\infty$, equation (3) obviously reduces to the previous model, given by equation (1).

We embody in the model the idea that growth of illegal capital is linked to the business cycle. In order to consider this assumption within the framework of our model, we assume that the growth rate of illegal capital depends on time as

$$\alpha(t) = \log\left[(1 + r_i)(1 - y)\right] + \beta\, f(t) = \alpha_0 + \beta\, f(t) \tag{5}$$

where $f(t)$ is a function indicative of the business cycle. In particular, for this purpose we obtained an interpolating function using the time series of the OECD *Normalized Composite Leading Indicator* (CLI)[25] from January 1962 to August 2016. Furthermore, we forecasted the indicator up to January 2020, as we did for the legal interest rate r_l (see below). Elaborating equation (4) thanks to definition (5) and suppressing the subscript in α_0, we obtain

$$K(t) = \frac{K^*}{1 + \frac{K^* - K_0}{K_0}\exp\left[-\alpha(t - t_0) - \beta\,(F(t) - F(t_0))\right]} = \frac{K^*}{1 + a\exp\left[-\alpha t - \beta\, F(t)\right]}, \tag{6}$$

where $F(t) - F(t_0) = \int_{t_0}^{t} f(s)ds$ and $a = \frac{K^* - K_0}{K_0}\exp\left[\alpha t_0 + \beta F(t_0)\right]$. With this new formulation, the amount of legal capital is related to $K(t)$ by equation

$$L'(t) = yf(1 - c)\frac{1 + r_l(t)}{1 - f(1 + r_l(t))}K'(t) \tag{7}$$

which yields

[23] Mettere un legame con biologia

[24] Banks (1994).

[25] OECD (2016), Composite leading indicator (CLI) (indicator). doi: 10.1787/4a174487-en

$$L(t) = yf(1-c)\int_{t_0}^{t} \frac{1 + r_l(s)}{1 - f(1 + r_l(s))} \frac{dK(s)}{ds} ds \quad (8)$$

where $r_l(t)$ is the legal interest rate at time t. The *c* variable represents the overall cost of the ML procedures[26]. Resorting to specialist money launderers – with their explicit or implicit fees – is an increasing trend. These operators use their expertise to launder criminal proceeds[27]. In general, financial professionals may be witting or unwitting accomplices[28]; but in any case, going through overall procedure represents a cost.
As it could be seen from equations (7)-(8), we foresee a net effect of the business cycle on resulting legal capital. This comes both indirectly from the use of OECD's CLI in $K(t)$, and directly from the inclusion of a function representing the legal interest rate in the definition of legal capital.

4. Drug Trafficking, Money Laundering and the Legal Sector

In the previous section, we shed light on the influence that the business cycle exerts both on the illegal capital growth rate and on legal capital. Therefore, we evaluated the relationship between illegal revenues, ML and legal assets held by the criminal sector. The proposed model can be a useful device for estimating this relationship also for a particular country or region, provided that the necessary data are available.
The framework is simple: starting from an initial criminal activity that produces an amount of dirty revenue, the laundering process allows such capital – minus some laundering costs – to be reinvested in the legal sectors of the economy, minimizing the risk of prosecution. The share that is apportioned to the illegal sector will produce additional dirty revenues that will undergo the laundering process; the ML cycle is into full operation and at each repetition – provided that no obstacle hinders the process – there is an increase in total legal assets held by the criminal sector. We could use as estimate of illegal revenues those from the underground economy. Choosing the overall underground economy could be consistent with the definition of the ML activity. As we stressed in the above section, the demand of ML is potentially generated by the revenues of any activity characterized by probability of discovery, and consequently of prosecution. The broadest definition of underground economy[29] includes those economic activities and the income derived from them that circumvent government laws and regulations. Therefore, at least from a theoretical point of view – the revenues of each underground activity can need to be cleaned.

However, in order to produce a conservative estimation, let us consider just the criminal revenues resulting from drug trafficking (opiates, cocaine, cannabis herbs and resin, ATS, ecstasy). In effect, it is the main activity producing illegal funds that need to be laundered. Drug trafficking remains the leading criminal market[30]. Through an elaboration of the data provided by UNODC World Drug Reports from 1998 to 2011, we estimated the annual global revenues from the trafficking of each drug.

[26] We assume that in general money laundering procedures represent a cost to organized crime, notwithstanding the fact that criminal groups can also establish legal businesses (fast-cash businesses such as restaurants, bars, gaming halls, supermarkets) for the concealment of their illegal proceeds – Europol 2006, 2007 and 2009 - and that these businesses can produce profits.
[27] Europol (2006, 2007, 2008).
[28] Europol (2006).
[29] Schneider (2005).
[30] Europol (2006, 2008, 2009).

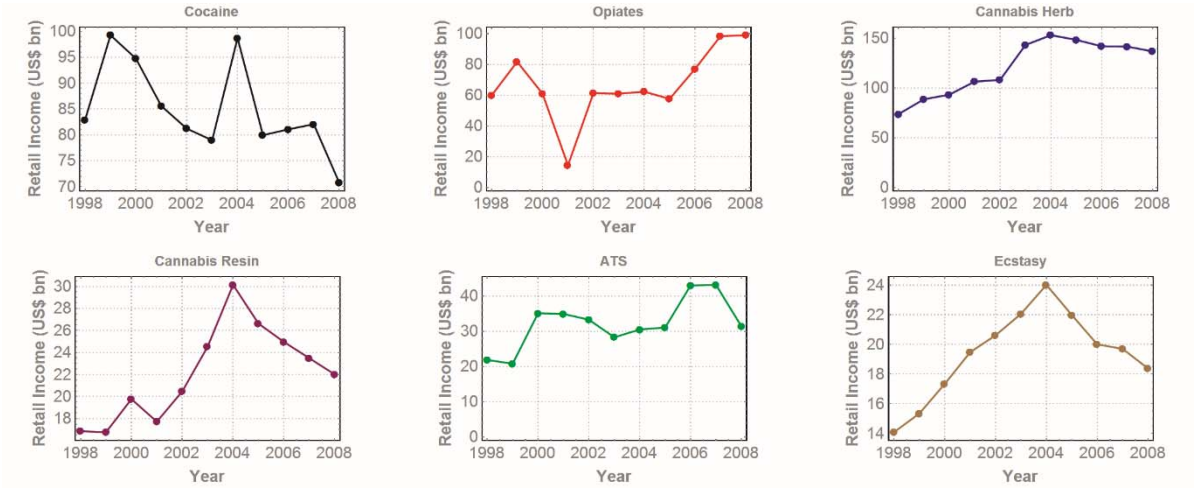

Fig. 1. *The retail income coming from the sale of each drug considered.*

The data of Fig. 1 are obtained considering the annual production of each drug, net of corresponding seizures. The resulting values are then multiplied by the opportune retail price, as reported by the UNODC World Drug Report 2005[31]. Since the early 1990s, retail drug prices have experience a falling trend. Consequently, we decided to refer to yearly price data in order to obtain a prudent estimate of the corresponding drug market. Summing up the values of the six time serieses, we obtained an estimate of the global black economy of drug trafficking for the 1998-2008 period. Such values represent the annual revenues from the illegal drug market, which according to our model are described by

$$\frac{dK(t)}{dt} = \frac{aK^{*}\exp\left[-\alpha t-\beta F(t)\right](\alpha+\beta f(t))}{(1+a\exp\left[-\alpha t-\beta F(t)\right])^{2}} \quad (9)$$

Given equation (9), we set up a fitting procedure for its derivative against the values obtained from UNODC World drug reports. This method enabled us to estimate the unknown parameters of the model (a, K^{*}, α and β). The values resulting from the analysis are listed in Table 1, while the $\overline{R}^{2}$ of the fit amounted to 0.992783.

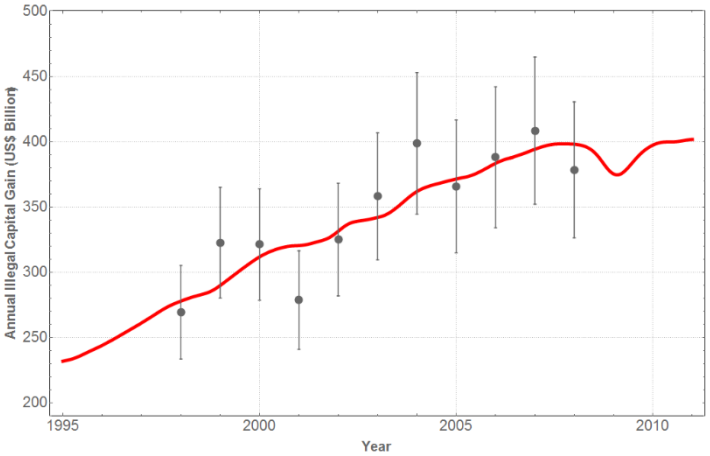

Fig. 2. *The values of illegal capital based on UNODC data together with the estimated fit of function* $dK(t)/dt$.

Table 1. Model parameters as obtained by fit.

Parameter	Value	Error
a *(a.u.)*	1.5×10^{88}	3.6×10^{-8}

[31] See the Appendix for more details.

K^* *(US$ Billion)*	15753	1258
α *(a.u.)*	0.101	0.001
β *(a.u.)*	0.001	0.003

It is worth noticing the significant error on the β parameter. This is obviously an undesirable result. Despite of this, the scarcity of available data makes this a result we have to live with. The use of function (9) where some of the original parameters were grouped (a and α) enabled us to avoid an unreliable fit. Indeed, generally the use of over-parametrized functions leads to unrealistic estimates. This obviously has a cost that we pay in terms of the impossibility of the simultaneous knowledge of all the original parameters of the model. In effect, the grouping in the a and α parametera implies some indeterminacy, for example, in the knowledge of r_i and y, and of K_0 and t_0,respectively. Therefore, fixing the value of the illegal interest rate at 2.5% (as it emerges from the available literature), solving the definition of α for y we obtained $y \sim 0.68$, which is again a value consistent with what reported in the literature[32]. Instead, setting $K_0 = 100$ US billion dollars, we obtained from a an estimate for the start time $t_0 \sim 1962$, (see the Supporting Information file for more details).

In summary, the amount of drug trafficking described by the data is consistent with an origin near 1962, with an initial capital about US$ 100 billion, while we will see a limiting value of 15.7 US$ trillion far in the future after 2020. To understand the dynamics of the phenomenon, it is interesting to look at the cumulative value of illegal capital, i.e. to $K(t)$. In order to check the estimate, we consider the study published by UNODC in 2011. In particular UNODC estimated the magnitude of illicit funds generated by drug trafficking and organized crime. It further investigated to what extent these funds are laundered[33]. Considering only flows related to drug trafficking, criminal proceeds would have been equivalent to some 0.6% of global GDP in 2009 (i.e. US$ 350 billion). As shown from Fig. 2, our prediction is well comparable with UNODC estimates. However, as FATF pointed out[34], these estimates should be treated with caution. Due to the illegal nature of these transactions, it is impossible to produce a definitive estimate of the amount of money that is laundered across the globe each year.

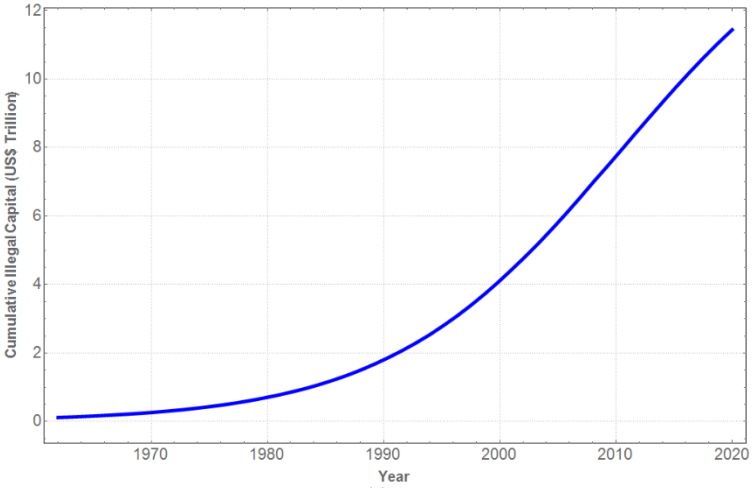

Fig. 3. *Cumulative illegal capital $K(t)$ obtained from the fit parameters of Table 1. The period represented ranges from 1974 to 2050.*

As shown by Fig. 3, the years from 1962 to 2010 see exponential growth, as predicted by the model in equation (1). Then, due to the constraints imposed by the "environment" (such as the

[32] Barone and Masciandaro (2011).
[33] UNODC (2011).
[34] FATF, *How much money is laundered per year?*, http://www.fatf-gafi.org/faq/moneylaundering/

global economic crisis), $K(t)$ has assumed a concave shape that will lead in the future to a limiting value K^* , i.e. the maximum amount of illegal capital that the black economy could sustain. Starting from the illegal capital, we can estimate both the annual and the cumulative amount of legal capital gained through ML activities, as predicted by equation (5) and (6). For this purpose, we have to select the values for the f and c parameters, and the legal interest rate "function". Consistently with existing literature, we assume that the portion f of laundered money reinvested in the legal market amounts to 85%.[35] The ML technical cost ranges from 5% to 15% of the money that needs to be laundered, according to the primary crime committed [36]. For the ML of drug trafficking proceeds, the fee claimed by launderers is 7%-10%, so in the following we will assume that c is equal to 0.1. The legal rate takes a different value in each year. [37] In our analysis r_l is obtained as the annual average of long-term interest rates for OECD member countries, for the period ranging from 1970 to 2015. Data from 2016 to 2020 have been forecasted through an ARIMA process based on previous data. The complete dataset has then been approximated through an interpolation function.

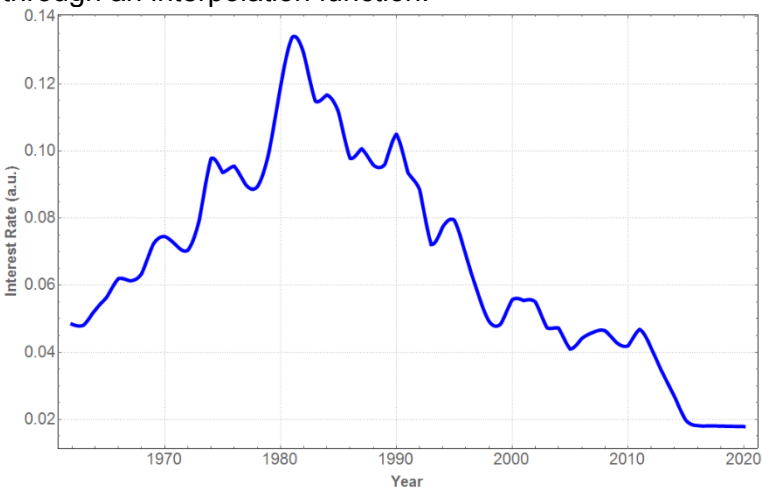

Fig. 4. *The averaged long-term interest rate for OECD countries.*

After the substitution of the parameters in the legal capital equations, we obtained that annual legal capital is highly dependent on the legal interest rate. Starting from 2011, interest rates took a dive due to the economic crisis. The effect of such trend is clearly observable in the following plot (see figure 5).

[35] We calculate this percentage using data of Unger (2007a) on the share of laundered money spent on consumption, which s roughly equal to 15%.

[36] Famous launderers were Stephen Saccoccia, who in 1993 was discovered to have laundered in the range of US$ 200 to US$ 750 million, charging to his clients a 10% commission, German Cadavid who laundered $50-60 million pounds in 1995, charging his clients a commission of 7%, and others such as Robert Hirsch, Richard Spence, Harvey Weinig: see Reuter and Truman (2004).

[37] A launderer can invest in capital markets to wash his dirty money, however he usually prefers safe assets like bonds and other low-risk securities, in order to minimize the probability of losing money (see Unger 2007a).

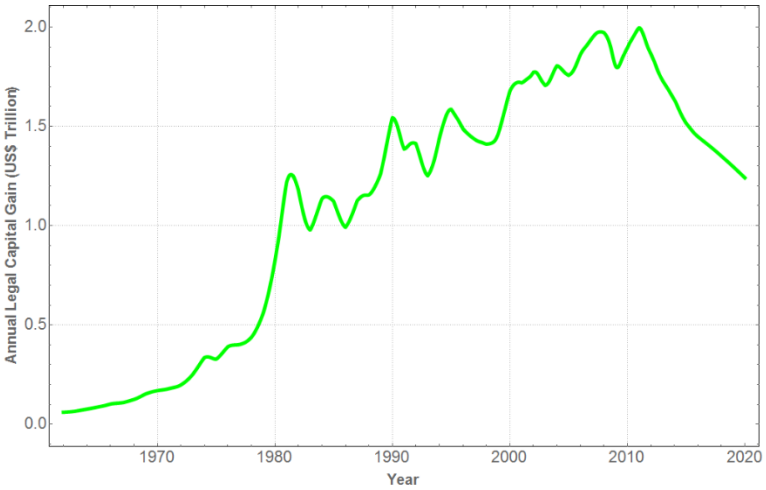

Fig. 5. *Annual legal capital resulting from laundering of the global drug trafficking*.

According to our estimates annual legal capital ranges between US$ 60 billion in 1962 and the maximum level of US$ 2 trillion in 2011. After this maximum, values started to drop, as a result of the fall in the legal interest rate. For example, annual illegal capital to be laundered amounted to slightly less than US$ 400 billion in 2011. Whit a multiplier at near 4.5, infiltration in the legal economy is valued at US$ 1.8 trillion for that year. In the next figure, we plot the multiplier over a span of several years. In each period, the value of the factor changes depending on the corresponding value of the legal interest rate. The values of the multiplier range between a minimum of 4 (forecasted) in 2020 to a maximum value close to 16.5 in 1981.

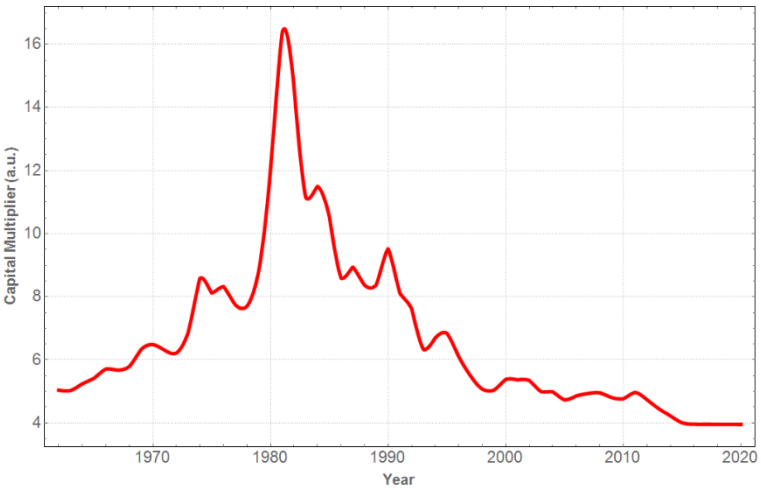

Fig. 6 *The money laundering multiplier, i.e. the part before* $K'(t)$ *on the right hand side of equation (7)*.

In figure 7 we plotted the amount of legal capital accumulated by organized crime, in other words we evaluated the level of criminal penetration affecting the legal economy . The result is that taking 1962 as starting date, it is possible to forecast the 2020 level of legal capital. Such value is about to US$ 120 trillion. The behavior of legal capital is not affected by the negative impact of economic crisis. Therefore, the trend is growing without any symptom of a future horizontal asymptote. This is the consequence of the intrinsic nature of the business of organized crime: there is no year without a profit.

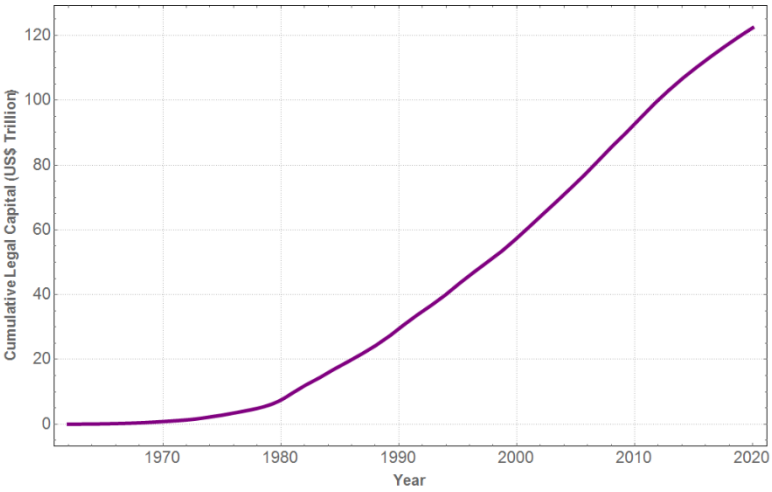

Fig. 7. *Cumulative legal capital accumulated by organized crime since 1962*.

5. Conclusions

In this paper we analyze the influence of the business cycle on illicit capital, money laundering and legal investment at the macro level. We used a dynamic model that simulates logistic growth for cumulative illegal capital collected by organized crime in drugs markets. In particular, we allow for a growth coefficient that depends on the business cycle, and for a saturation effect that sets a maximum to illegal capital that can be cumulatively gained by the criminal sector. Starting from such assumptions, we estimated both the annual and the cumulative level of penetration in the legal economy reached by criminal sector through money laundering activities. The simulation is based on the systematic collection of a dataset on annual drug trafficking revenues obtained from the available literature for the years 1998-2008. Analyzing this dataset by means of our theoretical framework, we found that growth in cumulative illegal capital is currently decelerating. In particular, *sic stantibus rebus*, it will reach its limiting value of nearly US$ 16 trillion very far into the future.

We also showed that, by means of money cleaning operations, the illegal sector is annually able to disguise criminal proceeds in the legal market for an amount equal to a multiplier of corresponding illegal capital. This factor ranges between a maximum value near 16.5 in 1981 and a minimum of 4 forecasted for 2020, corresponding to legal capital due to criminal activities of nearly US$ 1.2 trillion (about the GDP of Spain in 2015, at current prices) for that year. All in all, we found that as legal capital accumulated by organized crime shows a decelerating growth trend, the stagnation assumption can be said to hold also for the illegal economy. We forecast that it will reach a value of nearly US$ 120 trillion in 2020. Overall, we found that illegal capital is affected by the business cycle mainly through the capital multiplier, which in turn depends on the interest rate path.

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7. Appendix

Model Parameters Estimation

Using function (9) for the fit purposes allows us to obtain the parameters for our model at the cost of some indeterminacy. In effect, our full model for $K(t)$ uses the parameters r_i, y, β, K_0, K^* and t_0 (the full parameters set). The fit function has, instead, a reduced parameters set, namely α, β, a and K^* (where β and K^* are the same as in the previous set). We have only two constitutive relations that link the different parameters, i.e.

$$\begin{cases} \alpha = \log\left[(1+r_i)(1-y)\right] \\ a = \dfrac{K^* - K_0}{K_0}\exp\left[\alpha t_0 + \beta F(t_0)\right] \end{cases} . \tag{12}$$

Obviously, the system of equations in (11) is not enough to reconstruct the full parameters set. In order to proceed, we have to fix two parameters in the full set and then obtain the others from the values obtained from the fit. Before going on, we note that $K^* \gg K_0$ and $\beta F(t_0) \ll \alpha\, t_0$, consequently we could rewrite the last equation in (11) as $a \sim \left(\dfrac{K^*}{K_0}\right)\exp\left[\alpha\, t_0\right]$. If we set r_i and K_0, we obtain to a good approximation the corresponding values for y and t_0 as

$$\begin{cases} y = 1 - \dfrac{e^{\alpha}}{1+r_i} \\ t_0 = \dfrac{1}{\alpha}\log\left[\dfrac{a\,K_0}{K^*}\right] \end{cases} . \tag{13}$$

We note that t_0 increases only logarithmically with K_0, while y is in inverse proportion with r_i, as shown by Fig. SI2-SI3, where the remaining parameters are taken directly from the fit against the data obtained by UNODC.

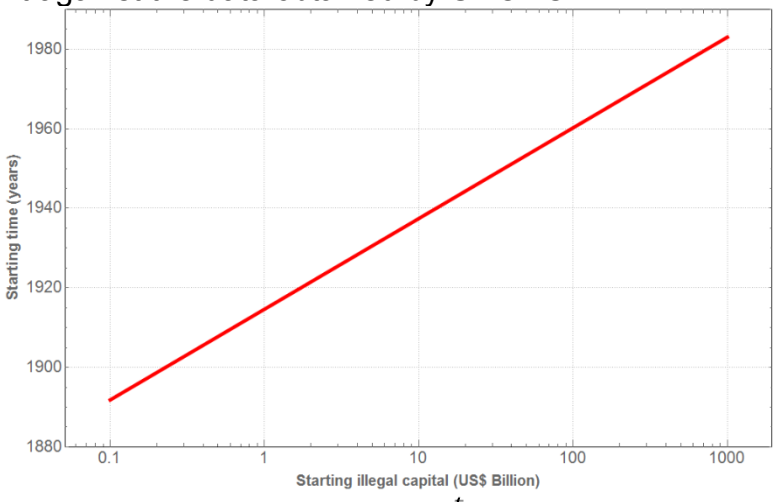

Fig SI2: log-linear plot of starting time t_0 against initial illegal capital K_0.

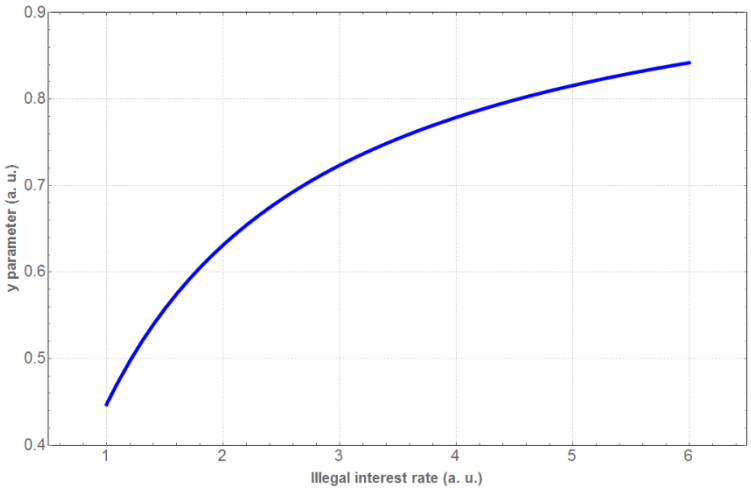

Fig. SI3: plot of the y parameter against the value of the illegal interest rate r_i, in the value range cited in literature.

In particular for this paper we fixed $K_0 = 100\ US\$\ bn$ and $r_i = 2.5$. This corresponds respectively to $t_0 \sim 1962$ and $y \sim 0.683$, the latter being a value consistent with the available literature.