Illicit Drug Seizures and Drug Consumption: Evidence from Italy

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January 23, 2018

Abstract

Using Italian province-year panel for the years 2010-2014, this paper examines the impact of illicit drug seizures on drug consumption. Specifically, we focus on cocaine market and aim to uncover the relationship and the causal effect of cocaine seizures on cocaine consumption proxied by cocaine-related hospitalization rates. The paper contributes to the existing literature in several ways. Firstly, we build a new panel dataset that has some favourable features as opposed to those used in the previous studies. Secondly, unlike the existing literature that barely touches the endogeneity issue, we address it by resorting to the instrumental variable estimation, using seaports turnover as an instrument for seizures. Our results suggest that there is a stable statistically significant relationship between cocaine seizures and consumption: on average, a one standard deviation increase in a province's cocaine seizures rate is associated with a 0.033 standard deviation decrease in related hospitalization rates; with an instrumental variables approach this effect reaches about 0.093 standard deviation. Finally, we also explore spatial interaction between provinces and find a negative relationship between seizures in key entry points and consumption in the rest of the country, as well as a negative relationship between seizures in neighbouring provinces and consumption in a home province.

JEL classification: I18, C23, C26.

Keywords: illicit markets, drug consumption, anti-drug policies, fixed effects, endogeneity, spatial econometrics.

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1 Introduction

Drug consumption has been an important issue all over the world for several decades, not only because of the obvious adverse health effects both directly from substance abuse and concomitant diseases, but also due to being a catalyst for other types of crimes. According to United Nations World Drug Report of 2015, the total estimated number of illicit drug consumers has been growing from 2008 and reached 246 million worldwide in 2013, out of which 27.4 million were problem drug users.

In tackling the issue, the governments put in practice antidrug policies, which can be divided into two main directions: supply reduction and demand reduction policies. While both directions are generally considered important, in some countries there is a bias towards supply-side reduction measures (for instance, in the US the supply-side policies have always prevailed over the demand-side, occupying a larger share of the Office of National Drug Control Policy budget until recently). The large debate around supply reduction efficiency and the increasing evidence of its failure to decrease supply and/or adverse side effects (e.g. increase in violence (Dell, 2015) incentivized the turn to demand reduction, and also contributed to raising the discussion on decriminalization, depenalization and legalization issues. The evidence is controversial, and the supply-side policies still account for about a half of the budgets in many countries[1]. This paper aims to provide another piece of evidence regarding one of the supply-reduction measures: drug seizures.

According to the general trend, on world-wide and even country level consumption tends to rise together with the amounts seized (see UNODC et al. (2009)). This fact is both intuitive and counterintuitive at the same time. On one hand, theory would suggest that if seizures decrease supply, ceteris paribus the amount consumed should also decrease. On the other hand, if seizures account for a very small share of the drug available in the market (which is more likely to be true on aggregated levels) then the rise in volumes seized should be viewed as a signal that the amount of drug available in the market is increasing. Thus, seizures are commonly referred to as an indicator of market size and not as an effective measure to reduce drug availability. This project makes an attempt to answer the question, whether drug seizures, under certain circumstances, could actually be effective as a policy measure to reduce consumption, and are not only an indicator of market size.

[1]The current study is focused on Italy; according to the most recent figures available (for 2012) the supply-reduction policies account for 43% of public expendiure related to illicit drugs (EMCDDA, 2012).

The paper is structured as follows. Section 2 provides a review of related literature and outlines how this study contributes to what has been done before, followed by Sections 3, which discusses the motivation to use Italian data and focus specifically on cocaine market, and Section and 4 that motivates the choice of consumption proxy. In Section 5 we provide the baseline results and outline methodological challenges, which we tackle in Section 6 by proposing different instrumental variable approaches, and explore spatial interactions in Section 7. We then provide some robustness analysis in Section 8. Finally, Section 9 summarizes the findings and outlines directions for future research.

2 Literature review

Supply-side policies are very diverse and include crop eradication in producer countries, incarceration of drug dealers and players of higher hierarchical level, seizures of drugs on any stage of production, seizures of property, transport, cash, sites, forfeiture of any other assets used for operating drug business, for synthetic drugs' - regulations of the main constituents market, etc.

Theoretically, the link between supply disruption and consumption should be the prices: if the policy leads to a substantial shift in the supply curve, ceteris paribus it will lead to an increase in price and a decrease in the quantity consumed. Most of the existing empirical literature examines separately the two phases of the process: effect of the enforcement on price, and the relation between price and consumption. Concerning the price-consumption interconnection, the research commonly finds a negative relation. Schifano and Corkery (2008) report that crack cocaine death mentions are negatively correlated with prices. Caulkins (2001), Caulkins (2007), and Dave (2006) find that cocaine and heroin prices are negatively related to hospital admissions due to poisoning by cocaine and heroin. T. Brunt et al. (2010) study the Dutch market and also find that lower cocaine prices are associated with higher numbers of addiction treatment and hospital admissions, whereas for amphetamine only the relation with addiction treatment was confirmed.

Weatherburn et al. (2003) and Smithson et al. (2004) investigate the effects of heroin shortage in Australia in late 2000. A large increase of heroin price was observed, while purity and consumption, measured by hospital admissions for overdoses, decreased as a result of the shortage. No substantial evidence of an increase in negative outcomes due to heroin users switching to other drugs was found, but a remarkable increase in methadone treatment pro-

gram enrolments took place.

Other papers exploit the drop in prices due to decriminalization and legalization[2]. Model (1993) finds an increase of hospital admissions due to cannabis intoxication and a decrease of that from other types of drugs as a result of marijuana decriminalization in 12 US states between 1973 and 1978. Anderson et al. (2013) analyze the effect of medical marijuana legalization on traffic fatalities. They show that legalization was associated with a sharp decline in prices and also a decrease in traffic fatalities, which they attribute to the substitution effect: consumers moved from alcohol to marijuana and the net effect on traffic fatalities turned out to be negative. This evidence can be viewed as supportive of the prediction that illicit drugs consumption is in general negatively related to prices, and also depends on the quality expectations of consumers.

Most of these studies are analyzing the relations between purity-adjusted prices and health outcomes. Applying supply-reduction strategies requires the policymaker to take into account purity. It is well-known that illicit drugs, especially hard drugs, are mixed with other substances and are never sold in absolutely pure form. If these adulterants adversely affect health outcomes, it could be the case that although per-pure-gram price rises, the actual price, not adjusted for purity but the one the consumers pay, does not change or increases only unsubstantially, so that the amount of deals stays the same, but while drug poisonings due to active substance will decrease, this positive effect might be offset by the increased damage due to adulterants. However, if cutting with poisonous agents was a common practice, the negative relationship between per-pure-gram prices and drug-related hospital admissions would not be as distinct as it appears from the studies mentioned above. While there is some evidence that adverse substances are sometimes found in the samples (T. M. Brunt et al., 2009), it is important to note that consumers' demand, especially of non-dependent users, is sensitive not only to price, but also to quality given the price fixed (J. C. Cole et al., 2008). Even if consumers can not observe quality before actually using drugs, the reputation mechanism plays a big role.

Galenianos et al. (2012) with their search-theoretic model for illicit drugs retail market show that enforcement, increasing the sellers' costs, may reinforce long run relationships and will

[2] There is mixed evidence on whether decriminalization leads to an increase in availability and decrease in prices: for instanse, Félix and Portugal (2017), analyzing the effect of drug decriminalization in Portugal in 2001 on prices for opiates and cocaine, find that no price decrease took place.

not lead to a decrease in purity. Rose (2016) builds a theoretical model (as opposed to Galenianos et al. (2012), it allows sellers to choose purity and per-gram-price in each period) and also empirically assesses the effects of supply disruption on purity and prices. The model predicts that seizures result in dilution, which, in turn, reduces future demand. GMM estimation of a time-series for Washington DC confirmed that seizures negatively affect purity in the same period and the price in the future period. Testing the impact on consumption was not conducted due to absence of reliable consumption data.

Thus, the users could adjust their consumption depending on their quality expectations. Due to the fact that illicit drugs market is characterized by repeated purchases, reputation matters, which makes it unlikely for sellers to use adulterating substances that have immediate severe health effects (Coomber, 2006). This is supported by a review of empirical evidence on adulterants by C. Cole et al. (2011), according to which critically poisonous substances are rarely found in drug samples.

Regarding existing literature on the enforcement effect on prices, the findings only partially support theoretical predictions, and the results depend on the type of enforcement applied. For example, according to Kuziemko and Levitt (2004), harsher punishments for drug offenders are associated with higher drug prices. Dobkin and Nicosia (2009) study the effect of exogenous policy change which imposed tough restrictions on distributors of ephedrine, one of the most common methamphetamine precursors. Analyzing monthly data on price, purity, related hospital admissions and methamphetamine use by arrestees in California's counties, they find that the policy led to the rise of price and a decrease in purity, hospital admissions and arrestees' consumption. Following this study, Cunningham and Finlay (2016)) investigate the further state and federal interventions into the US precursor market and find that each subsequent intervention had a weaker effect on the market than the previous one. The effects on the prices and hospital admissions are significant but temporary. There is also a range of studies that try to capture the effect of enforcement on consumption without directly incorporating prices. Chaloupka et al. (1999) argue that sanctions for the possession of cocaine and marijuana have a negative impact on youth cocaine and marijuana use. On the contrary, sanctions for the sale, manufacture or distribution of cocaine and marijuana have little impact on youth consumption of these drugs. Callaghan et al. (2009) study precursor availability restrictions in Canada, a setting similar to the one in Dobkin and Nicosia (2009). Having conducted time-series analysis on country-level monthly data, the authors

conclude that, contrary to what was expected, those restrictions were associated with a rise in methamphetamine-related admissions.

Finally, to the best of our knowledge there is no empirical evidence of a robust negative relationship between drug seizures and consumption. DiNardo (1993), having constructed a state-year panel for the US, finds an insignificant positive interrelation between cocaine seizures and per-pure-gram price, also without any impact on consumption. Yuan and Caulkins (1998) study a national level monthly time-series and conclude that there is no Granger-causal relationship between seizures and cocaine and heroin prices. Similarly Wan et al. (2016) analyzing drug market in New South Wales, Australia via ARDL model, report generally insignificant or positive relation between seizures of cocaine, heroin, amphetamine substances and hospital admissions related to these substances.

Our paper contributes to the existing literature in several ways. First, a vast majority of studies uses the US STRIDE data, which is understandable because this dataset is large and provides information on price, purity and seizures. Using a different, not previously explored, dataset could provide new insights. This study is using data on drug seizures and hospital admissions in Italy to study the effect of supply disruption, measured by seizures, on consumption, proxied by hospital admissions, so the data on prices is not necessary to conduct the analysis. Some additional advantages and motivations to resort to the Italian case are provided in the next section. Second, the properties of these data allow overcoming an important drawback of a large part of the existing literature: aggregation among space and time masks the existing effects. For instance, Arkes et al. (2008) claims that drug markets are localized and prices and purity vary substantially among the US cities within the same region. The data we use allows disaggregation up to provincial level. Having a panel dataset has an obvious advantage over cross-sections as it makes it possible to observe the units over time and use internal instruments. Compared to time-series a panel allows for a more accurate inference of the model parameters (due to higher number of observations), and in our setting makes it possible to analyze spatial relationships between the variables of interest. This is a reasonable and necessary extension, since the phenomenon under investigation is clearly spatial by nature. Finally, unlike the existing literature that barely touches the endogeneity issue, we address it by resorting to the instrumental variable estimation, using seaports turnover as an instrument for seizures in the external instruments approach, which is compared with results

yielded by Arellano-Bond and Spatial 2SLS methodologies.

3 Market peculiarities and key characteristics

The motivation to study the case of Italy is driven by several factors. Firstly, the prevalence of drug use is one of the highest in Italy among other European countries. According to data provided by the European Monitoring Centre for Drugs and Drug Addiction (EMCDDA), Italy ranks 4th in last year and last month prevalence among all adults aged 15-64, 3rd in last year prevalence among young adults (15-34) and 2nd in last month prevalence among young adults (use of any illegal drugs considered). Although the general trend of drug use is declining, in parallel the alarming tendency of increasing usage among the student population (aged 15-19) is observed (according to 2013 Italian National Report to EMCDDA). This makes drug consumption an important issue from the policy-makers point of view, requiring substantial budgets[3].

Secondly, a peculiar feature is Italy's geographic position: located at the center of the Mediterranean Sea and possessing a long coastline, Italy is an entry and transit area for the traffickers delivering drugs to Europe. This characteristic results in considerable quantities seized, which is necessary to capture the effect on consumption, and, importantly, makes the seizures less endogenous with respect to the local market features. From the technical point of view, a big advantage of Italian data is its availability and substantial spatial disaggregation level (up to provinces), which is crucial, since the effects of the seizures, if any, are likely to be localized.

Throughout the paper we are focusing on the cocaine market, and this is also not by chance. Firstly, despite the fact that the prevalence of soft drugs (marijuana and hashish) use is much higher than that of hard drugs (cocaine and heroin), which makes the use of cannabiods a relatively more relevant policy issue, for the problem at hand it makes sense to focus on hard drugs markets, since the demand for hard drugs is more price-elastic. In his overview of studies Gallet (2014) finds that price elasticity is smallest for marijuana, compared to cocaine and heroin. Although it is plausible that hard drug users are more addicted which should make their demand inelastic, they are also more experienced and often polydrug users, and

[3]According to EMCDDA (2008), for 2008 the social cost of illicit drug use was estimated at EUR 6.5 billion, with law enforcement activities accounting for the largest share (43%), and the remainder divided between healthcare and social services (27%) and loss of productivity of drug users and people indirectly affected by drug use (30%).

so can find substitutes rather easily. If the demand is price-inelastic, seizures would have a negligible, if any, effect on consumption. Another possibility is that even though confiscations of marijuana and hashish do have an impact on street prices, users might find a way to substitute by resorting to home-growing, which is quite a widespread phenomenon in Italy, and so consumption will remain unaffected, while for cocaine and heroin it is not an issue. Secondly, when considering cocaine and heroin, the demand elasticity might be higher for cocaine, since it is less addictive then heroin, more expensive and is generally considered as a luxury good. Not surprisingly consumption expenditures on cocaine accounted for 43% of total 14.2 billion euros spent by Italians on all types of drugs in 2014[4]. Another advocation for focusing on the market for cocaine rather than heroin is the abovementioned consideration on purity and adulterants/diluents present in the final product when it reaches the consumer. Although we cannot exclude completely the possibility that the seller might use harmful substances for dilution, this issue is much less of a concern for cocaine as compared to heroin. The avreage purity of cocaine is twice as high as that of heroin, and is around 60%[5]. Due to the fact that cocaine users are those who provide highest profits, the reputation mechanism in this market works very well. A series of papers summarizing the findings of Addiction and Lifestyles in Contemporary Europe: Reframing Addictions Project (ALICE RAP) provide interesting insights about peculiaruties of cocaine and heroin markets in Italy. Tzvetkova et al. (2014) have inerviewed imprisoned drug dealers in Italy, discussing the how dealers handle risks, customers, competitors, etc. It emerged that dealers prefer cocaine users to heroin users, because the latter have lower purchasing power, are likely to suffer from addiction, thus attracting unnecessary law enforcement attention and even willing to cooperate with them and denounce the dealer for a reward. Cocaine users, in contrast, were described as wealthy and easy to deal with. Moreover, as revealed by the study, by committing to quality cocaine dealers aim to maintain a regular pool of trustworthy customers who are ready to pay.

Before proceeding to the analysis it may be useful to have some indication of whether the effects we are after are possible to capture, or the local markets are so resilient and flexible[6], that market participants do not change their behaviour and market outcomes are barely affected. The abovementioned study on dealers' business strategies sheds some light on this

[4]Estimation carried out by ISTAT and provided in 2017 Annual Report of Antidrug Policy Department. For a review of alternative estimates of Italian drug market size see Giommoni (2014).

[5]According to Annual Reports of Antidrug Policy Department for the years 2010-2014

[6]As highlited in the literature, drug market players have the capability to adjust to temporary shocks very quickly and replace the lost resources (Caulkins and Reuter, 2010).

issue.

Dealers do appear to have several suppliers, which makes them more resistant towards supply disruption and allows to adjust within a short time lapse. However, since commitment to quality generally prevents sellers from cutting the drug below a certain level of purity[7], shortages, though not long-lasting, do occur. In the periods of lack of supply some dealers would take a vacation, switch off their phones and leave the city where they operate, others would ask the customers to wait or refer them to fellow dealers in other locations. One of the interviewees explicitly stated: *"If there is a seizure or a police operation, then the amount available decreases and prices go up"*. This qualitatlive evidence suggests that while local markets are reslient and adaptive, the theoretically predicted effect of law enforcement on prices is indeed present.

4 Consumption proxy

Due to illicit nature of the phenomenon under consideration, measuring drug consumption is a challenging task. While a direct measure does not exist, several proxies are commonly resorted to in the literature depending on the research objective. For descriptive analysis of trends survey data is used most often. Those, however, are subject to the usual weaknesses of survey data, magnified by the sensitive nature of the issue. The two main surveys conducted in Italy are the General Population Survey and Student Population Survey where respondents are asked questions on the habits of substance use. These, however, do not allow for substantial disaggregation and rigorous approximation of the *quantity* of the substance consumed. The questions typically asked are "Have you ever used ... ?", "Did you use ... in the previous month/year?" and "How many times, approximately, did you use ... in the past month/year?", thus requiring respondents to think retrospectively and fit their replies in the intervals provided for the answer.

Quite a recent tool for measuring community-level drug consumption is wastewater analysis, that in principle can provide daily estimates (though there might be concerns about precision[8]) of substances consumed in a given area by examining their residuals present in

[7]Reputation plays a role at all dealing levels and, in fact, is not the only factor that explains preference for selling lower volumes of a more pure substance, rather than a cut drug in greater volumes. Important considerations are the need for storage, labor required for repackaging (these are relevant for high quantity dealers) and the time involved in selling, which are higher in the latter case and increase risks of being caught.

[8]For a critical analysis of sewage epidemiology see Nuijs et al. (2011).

wastewater. The main disadvantage, however, are high costs: in practice, the equipment is installed in selected stations for a short period of time. In Italy, the analysis is conducted by Mario Negri Institute in 17 Italian cities[9] and provides an estimate for the city-level consumption in a given year (the wastewater samples are taken during 1 week in a year). However, having only 17 spatial units in the sample is not sufficient to provide robust inference. We therefore resort to drug-related hospitalization rates as a proxy for drug consumption. The main advantages of this measure are objectivity, full coverage in the space dimension on a sufficiently disaggregated level (we chose provincial partition), and availability on yearly basis. The main disadvantages are the low numerosity of the data (indeed, very few users would be hospitalized, as compared to the total number of consumers) and some ambiguity in relation to purity (if it is the case that diluents are harmful substances per se, seizures may result in hospitalization rates changing in the opposite direction). Since we are not trying to estimate the total amount of drug consumed or the total amount of users (these are captured relatively well by wastewater analysis and population survey respectively), but rather the response of consumption to the decrease of supply, the proxy we resort to is appropriate. Regarding the the purity issue, the evidence from chemical analysis and drug dealers interviews suggests that the use of poisonous cutting agents as response to lack of supply (and even substantial increase in dilution per se[10]) is highly unlikely. Thus, we believe that drug-related hospitalization rates, though having their own drawbacks, are the best proxy available to answer the question of interest.

5 Data and analysis

5.1 Data sources, variables and descriptive statistics

As data on cocaine street prices is not available on province-year level for Italy, this study resorts to the reduced form approach to investigate how cocaine seizures affect the dependent variable of interest: cocaine consumption.

The data on drug seizures is openly available on the Italian National Police website (poliziadistato.it). The province-level time-series are available from 2008 until the current moment (al-

[9] An interested reader may refer to Zuccato, Castiglioni, Tettamanti, et al. (2011) and Zuccato and Castiglioni (2012) for the description of the procedure and results, and Zuccato, Castiglioni, Senta, et al. (2016) for comparison of wastewater analysis with evidence from the abovementioned General Population Survey.

[10] This, however, does not invalidate our proxy by any means. Even if the drug is sold at the same price, but is less pure, the amount of active substance is relatively lower, which should result in a decrease of related hospital admissions

though there is an issue of data quality in the early years of collection and in the most recent ones, which should be considered as provisionary) and contain information on the volume of seizures in kilograms for heroin, cocaine, marijuana, hashish, cannabis plants and amphetamines, number of operations, number of people arrested, released and not captured, and the number of minors and foreigners out of total number of persons denounced (the persons reported to the Judicial Authority for drug-related offences). Thus, the data would allow not only to identify the effect of drug seizures, but also control for the number of arrests and number of operations, which could be contaminating factors and need to be accounted for. The main independent variable of interest is seizures rate, which is expressed in tens of kilograms of cocainne seized in a given year in a given province per 100.000 inhabitants ($seizr$).

The main indicator for consumption are the most frequently used in the literature drug-related hospital admissions. Italian Ministry of Health upon request provides micro-level data on hospital admissions and dismissals by ICD-9 diagnosis codes; these data allow constructing our dependent variable: province-year cocaine-related hospital admission rate per 100.000 inhabitants (HAr). A range of other important variables is adopted as a set of province-level baseline controls: per capita income ($income$), unemployment rate ($unemp$), rate of foreign residents ($stranr$), criminal associations crime rate ($crmr$), and the share of men aged 35-39 in the population ($men3539r$), as this demographic category is the most prone to cocaine consumption.

The perfectly balanced province-year panel used in the analysis consists of 5 years (2010-2014) and 103 units (provinces), which yields 515 observations in total. Table 1 provides summary statistics for the selected variables.

Table 1: Summary statistics (2010-2014)

Variable	Obs	Mean	Std. Dev.	Min	Max	P1	P10	P25	P50	P75	P90	P99
HAr	515	4.04	5.93	0	43.78	0	.32	.91	2.1	4.74	8.95	31.9
seizr	515	.72	3.89	0	47.11	0	0	.01	.06	.18	.57	21.19
income	515	12.96	2.89	7.28	20.25	7.84	8.77	10.01	13.68	15.21	16.11	18.43
unemp	515	10.7	5.22	2.69	27.81	3.73	5.28	6.8	9.15	13.45	18.53	25.66
crmr	515	1.4	2.2	0	31.04	0	.19	.52	.95	1.56	2.5	9.03
stranr	515	.07	.03	.01	.16	.01	.02	.04	.07	.1	.11	.14
men3539r	515	.06	.1	0	1.3	0	.01	.02	.04	.07	.13	.45

In columns P1-P99 the corresponding percentiles are reported.

5.2 Baseline model

We assume that the partial equilibrium in a province market for cocaine is formed by the interaction of supply and demand, so that when there is a seizure substantial enough to shift the supply curve, per-pure-gram price rises and quantity consumed decreases[11]. A reduced-form equation for the quantity consumed, which we proxy by the rate of cocaine-related hospital admissions, takes the following form:

$$HAr_{it} = a_i + \tau_t + \gamma S_{it} + \delta X_{it} + \varepsilon_{it} \tag{1}$$

Here a_i is the province fixed effect, τ_t is the time (year) fixed effect, common for all the provinces, S_{it} is the amount of drug seized in province i in year t, X_{it} is a set of controls and ε_{it} is the idiosyncratic disturbance. Our main coefficient of interest is γ. Before entering the discussion on endogeneity problem and possible solutions, let us look at the results of the fixed-effects estimation of equation (1) presented in Table 2. The coefficient of seizures rate is negative and statistically significant at all conventional levels, and does not change in magnitude with inclusion of different controls. To the best of our knowledge, this is the first evidence of a stable, statistically significant negative relationship between cocaine seizures and consumption.

[11] In principle, it is possible that enforcement activity makes consumers more cautious, affecting also demand. This impact would operate in the same direction, reinforcing the idea that more intense enforcement should be related to lower quantity consumed. However, in the analysis the seized volumes are considered, and it is unlikely that they have a clear effect on demand, since they are ambiguously linked to percieved enforcement presence.

Table 2: Including various controls

	(1) b/se	(2) b/se	(3) b/se	(4) b/se	(5) b/se	(6) b/se	(7) b/se
seizr	-0.061***	-0.063***	-0.061***	-0.063***	-0.062***	-0.061***	-0.061***
	(0.008)	(0.008)	(0.008)	(0.009)	(0.009)	(0.010)	(0.010)
income		1.074**		1.207**	1.212**	1.313**	1.311**
		(0.516)		(0.530)	(0.533)	(0.627)	(0.623)
unemp			0.011	0.041	0.036	0.046	0.045
			(0.038)	(0.038)	(0.038)	(0.038)	(0.037)
crmr					0.039	0.035	0.036
					(0.034)	(0.035)	(0.035)
stranr						29.582	29.533
						(47.671)	(47.631)
men3539r							0.236
							(0.952)
constant	4.674***	-9.355	4.527***	-11.627	-11.690	-15.419	-15.393
	(0.164)	(6.698)	(0.558)	(7.042)	(7.064)	(11.119)	(11.070)
Obs	515	515	515	515	515	515	515
Nclust	103	103	103	103	103	103	103
R2	0.076	0.083	0.076	0.084	0.086	0.088	0.089

* p<0.1, ** p<0.05, *** p<0.01. Cluster robust standard errors in parentheses.

While endogeneity of seizures and ways to tackle it will be discussed in the remainig sections, it is useful to comment on potential endogeneity of selected controls. At the individual level income (as well as unemployment) and cocaine consumption are very likely to be related in both directions, so reverse causality would be an issue; however, here we are working with macro-level data and it is reasonable to believe that cocaine-related hospitalization rates (which are, in fact, rather low, as seen from Table 1) do not cause changes in province-level income or unemployment. Regarding crime rate for criminal associations and the rate of foreign residents, it is possible that markets with expanding demand (provinces with higher cocaine-related hospitalization rates) attract more supply, which in the case of illicit drugs markets is tightly likned to organized crime and foreigners involved in the business (as required by trafficking and distribution networks). We believe, however, that diffusion of criminal networks and their members' ethnicity is largely determined by other factors, such as historical routes, institutional quality, which change slowly and are unlikely to alter significantly from on year to another, while drug consumption should play a smaller role; thus, though with caution, it is plausible to assume crime rates for criminal association and rate of foreign residents not driven by cocaine consumption. We therefore argue that the list of controls in the baseline

model is as exogenous as possible in the given setting.

At this point a brief discussion on the main drivers of results could be of interest. While the literature fails to find a significant negative relationship between seizures and consumption, we are able to capture it with our data. This could be explained by substantial disaggregation in space and Italy's geographic features discussed in Section 3, which allows to observe very high volumes of cocaine seized in some provinces. Additionally, most of the provinces with exceptionally high cocaine seizures rates are not the ones with highest hospitalization rates, which suggests that simultaneity problem is not as severe as often is in other settings, where due to data availability issues only big cities are considered. This could be an indication that the result is driven by provinces with high seizures rates: indeed, if those are excluded from the sample, the relationship of interest is insignificant (Column 2 in Table 3, in contrast to the baseline results presented in Column 1). It does not mean, however, that bulk seizures are the only drivers of the result, since simultaneity could still be responsible for masking the true relationship. To check if this is the case, we split the remaining sample (without top-10 provinces with highest average volumes seized) in two roughly equal parts: with high and low average consumption levels. Columns 3 and 4 of Table 3 provide results for high- and low-consumption provinces respectively: while the negative relationship holds for low-consumption areas, enforcement in high-consumption ones is much more likely to be driven by local market conditions. This finding provides evidence of reverse causality present in the data. In the remaining part of the paper we discuss other sources of endogeneity and propose ways to solve it.

Table 3: Baseline on different subsamples

	(1)	(2)	(3)	(4)
	b/se	b/se	b/se	b/se
seizr	-0.06***	-0.08	0.47*	-0.20***
	(0.01)	(0.19)	(0.26)	(0.05)
Controls	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Obs	515	465	210	255
Nclust	103	93	42	51
R2	0.089	0.095	0.166	0.141

* p<0.1, ** p<0.05, *** p<0.01. Cluster robust standard errors in parentheses.

5.3 Methodological challenges

The relationship discovered in the baseline model is likely to be biased due to endogeneity of seizures rate. With the data at hand the endogeneity may emerge from all three possible sources, which are briefly described below:

1. Simultaneity: areas with higher consumption attract more enforcement. It may partly be alleviated by inclusion of the fixed effects, but it would be unrealistic to assume that local market features, enforcement and their relationship are time-invariant. Some evidence of the presence of simultaneity bias was brovided in the previous subsections.

2. Measurement error: since the data on purity is not available, the quantities of the pure substance seized are likely to be measured with error. It is, however, less of a concern for bulk seizures, as wholesale seizures are generally high-purity ones[12]. We will assume that the "true" measure and the error in measurement, if present, are uncorrelated, leaving us with an attenuation bias that drives the coefficient towards zero.

3. Omitted variable bias: other variables, correlated with both seizures and hospitalization rates, may produce an upward or a downward bias of the seizures coefficient. Corruption, other enforcement activities and seizures in other provinces may be relevant omitted variables. Most importantly, the actual amount of the drug available in the market is unobserved, and so, we do not know whether an increase in seizures is a signal of increased or decreased supply.

5.4 Solutions to methodological challenges

In the first attempt to alleviate endogeneity stemming from omitted variable bias we try including additional possibly relevant controls: corruption and other enforcement activities. For instance, failing to account for arrests of drug sellers, which could be the true channel that influences consumption and are positively related to seizures at the same time, will produce a downward bias of the coefficient of interest, overstating the impact of seizures. Corruption, on the other hand, may be negatively related to seizures, as corrupt officials would allow the traffickers and dealers to operate more freely, turning a blind eye on growing consumption; this would produce a bias towards zero.

[12]Data on cross-country differences in prices and purity of cocaine at wholesale and retail levels are available from UNODC (https://data.unodc.org/)

The data from the Ministry of Interior allows controlling directly for the number of drug-related arrest anti-drug operations: as evident from Column 4 of Table 4, including these enforcement measures does not alter the coefficient of the seizures rate as compared to the baseline case in Column 3, while they themselves are insignificant. The reason why these variables are not included in the baseline is that they are also endogenous, so, if one needs to identify their true coefficients, a separate instrument for each of them would be necessary. Nevertheless, it is crucial to show that their inclusion does not alter the coefficient of interest.

Regarding corruption, if it is thought of as a time-invariant feature, it is already controlled for by inclusion of the fixed effect. It is plausible, however, that corruption is not constant over time, which requires a time-variant measure of it. The best available province level corruption proxy that is time-variant is an indicator constructed for the Institutional Quality Index for Italy[13] (Nifo and Vecchione, 2014). The main drawback of this measure is that it is available only for the years no later than 2012; we thus rerun the baseline on the 2010-2012 subsample (Column 1 of Table 4). The results in Columns 1 and 2 suggest that including the time-variant corruption proxy does not alter the coefficient of interest. Since the time-variant proxy is not available for the whole timespan, it is not included in the baseline model.

[13] An index built in a similar manner as the World Government Indicator and consists of several dimensions: voice and accountability, government effectiveness, regulatory quality, rule of law and corruption.

Table 4: Controlling for corrupion and other enforcement measures

	(1) b/se	(2) b/se	(3) b/se	(4) b/se
seizr	-0.035***	-0.035***	-0.061***	-0.060***
	(0.012)	(0.012)	(0.010)	(0.012)
corrup		-0.486		
		(3.091)		
arrest				-0.003
				(0.003)
oper				0.010
				(0.007)
constant	-6.467	-6.581	-15.306	-14.571
	(13.864)	(14.308)	(10.280)	(9.852)
Controls	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Obs	309	309	515	515
Nclust	103	103	103	103
R2	0.039	0.039	0.089	0.110

* p<0.1, ** p<0.05, *** p<0.01. Cluster robust standard errors in parentheses.

We are still left with other possible omitted variables and other sources of endogeneity to deal with. To address this set of problems instrumental variables are commonly used. In crime literature external instruments were traditionally applied, however, since finding an external instrument which is both exogenous and relevant is problematic, more and more studies use internal instruments, providing evidence that they can even outperform their external counterparts (Bun, 2015, Bun et al., 2016). We try to apply and compare results from both approaches, with cargo turnover in ports serving as external instrument, and using lags of seizures as internal instruments in the Arellano-Bond framework, as well as spatial lags of exogenous variables applying Spatial 2SLS to estimate a SAR model. Finally, we resort to spatial analysis that differs from traditional spatial econometrics approaches and explore the relationship between seizures in the main trafficking hubs and consumption in other provinces, and also the relation between consumption in a given province and seizures in its' neighbours.

6 Instrumental variables estimation

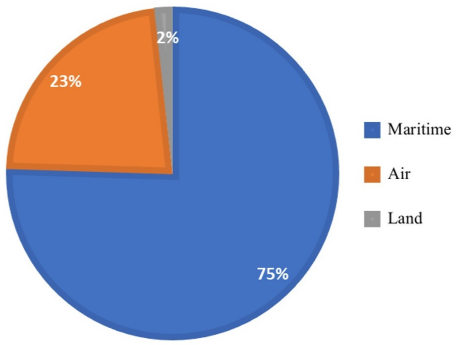
In this section we propose several ways to instrument for the seizures variable: cargo turnover in western coast seaports (an external instrument), time lags of explanatory variables (internal

instruments in Arellano-Bond framework) and spatial lags of exogenous variables within a SAR model (internal instruments in Spatial 2SLS framework).

6.1 External Instrument

The largest volumes seized and the highest variation in seizures rates occurs either in high consumption areas (large local markets, such as Milan and Rome), or in logistically convenient trafficking points (here seizures are roughly exogenous with respect to local market conditions), which are mostly border areas and vital transportation knots (ports, airports, train stations). Figures 2 and 3 provide a visualization of the seizures and consumption patterns; while the highest hospitalization rates cluster in the North (the richest macroregion), the largest amounts seized are observed in the border areas, in particular, in the western part of the country. Given that maritime transportation is cheaper and allows transporting much higher volumes of cargo than aerial, it is often preferred by the traffickers. Thus, it is not surprising that maritime seizures account for the majority of border seizures (Figure 1).

Figure 1: Distribution of seizures in customs areas by border type (average shares)



Since cocaine is coming from the western side of the world, where it is produced, ceteris paribus it is optimal to ship it to the Western coastline of the country (as compared to the Eastern). This is exactly why we observe very high amounts seized in the provinces with maritime borders and located in the West.

Figure 2: A map of kilograms of cocaine seized in provinces
(average for 2010-1014)

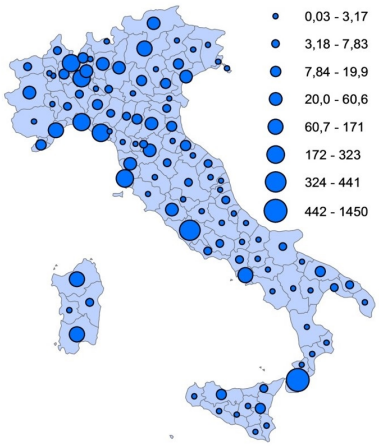
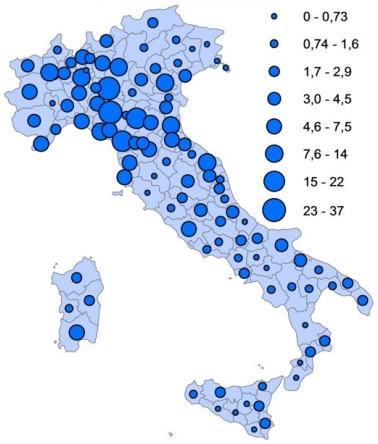


Figure 3: A map of cocaine-related hospitalization rate in provinces
(average for 2010-1014)



For these reasons, we adopt maritime cargo turnover in the ports of 16 western provinces[14] (Figure 4 depicts the centroids of selected provinces) as an instrument for seizures rates. As can be seen from Table 5, cocaine seizures in these ports amount for 60-80% of the country's total throughout the given period[15].

[14]The total number of ports is, of course, larger than 16, but the data for port-level turnover exists only for the large ports, and those also happen to be the main trafficking hubs. In fact, restricting the number of port provinces to 9 with highest seizures yields identical results. However, in this section we prefer to keep the cargo values for all the available western coast provinces, since they are already very few, accounting for around 16% of the sample. For all other provinces the value of cargo is taken as zero. Datasource: reports of Italian Port Association (assoporti.it).

[15]According to the yearly reports of the Central Directorate for the Antidrug Services (Ministry of Interior).

Figure 4: The 16 selected provinces and their share in total volume of cocaine seized

Table 5: Share of 16 selected provinces in total volume of cocaine seized

2010	2011	2012	2013	2014
60%	81%	65%	65%	75%

The cargo turnover in the selected provinces is strongly and positively associated with cocaine seizures (Column 2 of Table 5). This is of little surprise, since if enforcement intensity at the port facilities is fixed and the share of cocaine in the cargo is also fixed, higher cargo turnover will be associated with higher amounts seized. However, after running a FE regression of seizure rates on cargo turnover and controlling for all other covariates and time fixed effects it turned out that elasticity at the mean is 4.7, thus, on average, a 1% increase in cargo turnover is associated with 4.7% increase of seizures. This can have 2 possible explanations:

- If enforcement intensity is fixed, such pattern can only be observed if, for some reason, higher cargo turnover contains higher *share* of cocaine, conditioning on all other controls. This may be true if higher volumes of licit trade provide more opportunities for traffickers to smuggle. On the other hand, higher turnover implies lower speed of the process of going through the customs, which increases risks of being caught[16]. Our analysis hinges upon an assumption that the composition of trade (both licit and illicit) remains stable: imposing this condition ensures that higher turnover rate is associated with higher enforcement intensity, and this is the channel that yields an increase in seizures. Additionally, this assumption implies that the shares of other goods, most importantly, those complementary to cocaine, remain stable, and so cargo turnover only affects cocaine consumption through seizures and possible other controls.
- If the share of cocaine in total cargo is fixed (conditioning on all other covariates), then the reason why seizure rates rise *disproportionally* compared to cargo turnover should

[16] Dell (2015) also points out that congestion costs at the bottlenecks, such as ports and terrestrial borders, play a big role and are taken into account in the traffickers' optimization problem for finding the optimal route.

be higher enforcement intensity. One of the reasons to increase vigilance are taxation revenues: the customs would be interested to check whether all the goods on board are properly declared and all the necessary duties are paid. The authorities are also aware of the fact that higher freight turnover can make smuggling easier, and respond correspondingly by increasing monitoring. Finally, it could be higher amount of cargo from specific source countries (e.g. Latin American region) that makes the authorities more cautious[17]. All these considerations could be present, and if this is true that it is enforcement intensity driving the result, decreasing the actual amount available in the local market and not just mirroring supply, cargo turnover can be used as an instrument for cocaine seizures.

The bottomline of the discussion above is the following: in order for the exclusion restriction to hold, cargo turnover rate should have an impact on cocaine hospitalization rates only through seizures; additionally, the positive relationship between the instrument and the seizures rate should be exclusively due to increased enforcement intensity, and not because of an increase in the volumes smuggled.

Note that cargo turnover rate can be viewed as a proxy for economic activity, and so can affect consumption not only through seizures, but also through income, for instance. If we believe that the variables in our main equation are all exogenous, this is not an issue, since we control for income and unemployment. Table 5 provides the results of a fixed effects estimation with the cargo turnover rate in the western coast ports used as an instrument. Column 1 has the baseline result, and Columns 2 and 3 represent the first and the second stages respectively (variable *sea* stands for the cargo turnover rate). The coefficient of the seizures rate is about 2.8 times higher than that of the fixed effect baseline model and is significant on 1% confidence level. Due to the instrument taking non-zero values only for the 16 selected provinces, that are concurrently the ones with high volumes seized, this result is again driven by provinces with high seizures. However, an important difference is that we were now able to capture the variation in seizures that corresponds to the actual decrease of supply.

6.2 Internal instruments

Since the nature of the problem and lack of data prevent us from directly proving the validity of the assumptions made for the external instrument to satisfy the exclusion restrictions,

[17]Unfortunately, decomposition of maritime trade voulmes by types of good and source countries on port or province level is not available.

we resort to internal instruments and compare the results with those obtained using cargo turnover as an instrument. The Arellano-Bond methodology (Arellano and Bond, 1991) proposes using lags of exogenous explanatory variables as instruments for the endogenous and predetermined ones. This approach is typically applied to first-differenced specifications with the lagged value of the dependent variable present in the right handside of the equation; the lag is predetermined by construction, so, in order to identify its' coefficient, there is a need for additional moment conditions. Those are created via using lags of exogenous variables as instruments. Moreover, by the same means this approach allows identifying also the coefficients of endogenous variables, if those are present. In our setting the empirical model is not concerned with the impact of consumption in the previous year on that in the current year, but there is an endogenous variable which effect is of interest. Therefore, the relevance of internal instruments with respect to the seizures rate variable determines the choice of the lag depth of controls. Column 4 of Table 5 provides results of Arellano-Bond estimation of the equation in first differences:

$$\Delta HAr_{it} = \Delta HAr_{it-1} + \tau_t + \gamma \Delta S_{it} + \delta \Delta X_{it} + \Delta \varepsilon_{it} \tag{2}$$

The model passes formal tests but there appears to be a problem of weak instruments: the standard error of the seizures coefficient is quite high, yielding significance only at 10% level, and insignificant estimate in some cases, depending on the instruments specification. The magnitude of the effect, however, is similar to what was found with an external instrument.

6.3 SAR model

Finally, we apply the same principle and exploit spatial lags of exogenous variables as internal instruments. In classical spatial econometrics literature[18], both theoretical and applied, the main issue has been in identifying the coeficient of the spatial lag of the dependent variable, although spatial components are present in those models in other forms as well (e.g. Spatial Error Model accounts for the spatial component in the error terms, and Spatial Durbin Model allows for spatial lags of both dependent and independent variables to be present). By analogy with the Arellano-Bond case, we apply the Spatial 2SLS methodology (Kelejian and Prucha, 1998) aiming to identify the point estimate of seizures, while the spatial lag of

[18]For an overview of different types of spatial models see Elhorst (2010).

hospital admission rates is not the main focus[19]. Spatial interactions, however, are also of great interest, and we provide the corresponding analysis in Section 7.

We estimate a Spatial Autoregressive (SAR) model of the following form:

$$HAr_{it} = \rho WHAr + a_i + \tau_t + \gamma S_{it} + \delta X_{it} + \varepsilon_{it} \tag{3}$$

Here, in addition to spatial lag order and number of variables chosen as instruments, it is necessary to choose also the underlying spatial structure: the weight matrix W. Results presented in Column 5 of Table 5 are obtained with the second order contiguity row-standardized spatial matrix. As in the previous case, the obtained coefficient is marginally significant and sometimes insignificant depending on the spatial lags and type of W chosen, but point estimate is similar throughout different specifications and to the two previously obtained.

Table 5: Baseline FE and instrumental variable specifications

	FE b/se	FS b/se	IV b/se	AB b/se	SAR b/se
seizr	-0.061***		-0.177***	-0.176*	-0.172*
	(0.010)		(0.031)	(0.098)	(0.090)
sea		0.007**			
		(0.003)			
HAr_{t-1}				0.087	
				(0.12)	
$WHAr$					0.974**
					(0.438)
Controls	Yes	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Obs	515	515	515	515	515
Nclust	103	103	103	103	103

* p<0.1, ** p<0.05, *** p<0.01. Cluster robust standard errors in parentheses.

The results of the baseline model suggest that a one standard deviation increase in a province's cocaine seizures rate is associated with a 0.033 standard deviation decrease in related hospitalization rates; with an instrumental variables approach this effect reaches about 0.093 standard deviation (the effects are calculated at the mean).

[19]Inclusion of temporal/spatial lags is useful, however, since they are possibly accounting for omitted variables. In our case these specifications can be viewed as robustness checks.

7 Spatial interactions

Until now we focused on uncovering the relationship between cocaine consumption and seizures in the same province. However, it is clear that the observations are not independent in space: seizures in a province may impact consumption also in neighbouring provinces. Most importantly, seizures anywhere less are much more exogenous than those in the same province. In this section we aim to explore spatial interactions in two complementary ways: first we simply study how seizures in entry points affect consumption in other provinces, whereas the second approach investigates relationship between seizures in the neighbouring provinces and consumption in a given province in a more general way.

7.1 Relation to seizures in selected provinces

We get back to the western coast provinces with high volumes of cocaine seized and analyze how seizures in these provinces affect consumption in the rest of the country[20]. We focus on the 9[21] western coast port provinces (Reggio Calabria, Roma, Livorno, Genova, Savona, La Spezia, Napoli, Sassari, and Cagliari) and study how consumption elswhere responds to cocaine seizures in these provinces, estimating the following fixed effects specification:

$$HAr_{it} = a_i + \tau_t + \gamma_0 S_{it} + \gamma_1 Snearest_{it} + \gamma_2 Snearest_{it} * dist_i + \delta X_{it} + \varepsilon_{it} \tag{4}$$

Here $Snearest_{it}$ stands for seizures in one of the 9 provinces that is closest to a given province i, and $Snearest * dist$ - interaction with distance[22] to that province. Columns 1-2 of Table 6 contain results for equation 6 without including interaction with distance, for the whole sample, and for the case when the selected 9 provinces are excluded, respectively. Without accounting for distance, seizures in the nearest port appear to be insignificant, and excluding the 9 provinces yields an insignificant coefficient of the own seizures rate in the remaining subsample. Estimation results for the full equation are presented in Columns 3 and 4 of the table: accounting for distance yields significant estimates of γ_1 and γ_2 (also jointly significant).

[20] In Section 8.2 we do several robustness checks and provide results of the same analysis but with alternative groups of provinces chosen as key provinces that influence consumption everywhere else.

[21] Out of the 16 provinces whose port turnover was used as instrument, these 9 provinces are the ones with largest seizures (among the top 12 by average volumes seized) and are the drivers of the previous result.

[22] In Section 8.1 other distance/proximity measures are also explored.

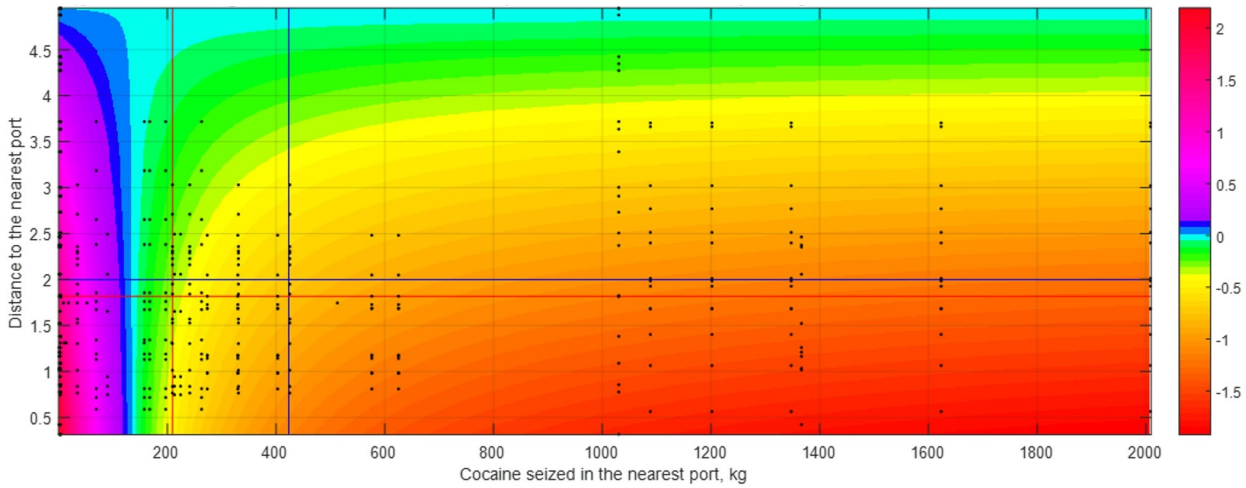
Table 6: Relation with seizures in 9 port provinces

	(1) b/se	(2) b/se	(3) b/se	(4) b/se	(5) b/se	(6) b/se
seizr	-0.0603***	0.0465	-0.0573***	0.0407	-0.0608***	0.0499
	(0.0097)	(0.0987)	(0.0097)	(0.0910)	(0.0121)	(0.0998)
Snearest	-0.0001	-0.0001	-0.0010**	-0.0011**		
	(0.0003)	(0.0003)	(0.0005)	(0.0005)		
Snearest*dist			0.0004**	0.0004***		
			(0.0002)	(0.0002)		
Avg_dist					0.0000	-0.0000
					(0.0000)	(0.0000)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Obs	515	470	515	470	515	470
Nclust	103	94	103	94	103	94
R2	0.089	0.087	0.098	0.097	0.089	0.087

* p<0.1, ** p<0.05, *** p<0.01. Cluster robust standard errors in parentheses.

In order to interpret them we depict the effects predicted by the model on a colormap (Figure 5). On the horizontal axis the volume of cocaine seized in the nearest port province is plotted (the maximum value corresponds to the maximum volume of yearly seizures in one of the 9 provinces (Reggio Calabria) observed in the data), while on the vertical axis we put distance to this province, so that low values mean higher proximity.The dots represent the data points, and red and blue lines correspond to the median and mean values respectively. An interesting pattern emerges: while it is true that higher volumes seized have a negative impact on consumption, which is more pronounced for closer provinces, the relationship is reversed for relatively low seizure values. Our interpretation of this finding is the following: when the volumes seized are relatively low, they are, in fact, the mirror of supply, and so are *positively* related to consumption in the nearby provinces. However, really huge amounts seized, that we are lucky to observe in the data, are able to decrease the actual amount of cocaine available in the local markets, and are, therefore, substantial to decrease cocaine consumption.

Figure 5: The total effect of seizures in nearest port province depending on the volume seized and distance



For a province located at the mean, an increase of cocaine seized in the nearest port by 500 kilograms (a standard deviation in volumes seized of the selected 9 provinces) would correspond to a decrease of the hospitalization rates by about 0.018 standard deviation. An analogous decrease would occur if an average province would have been located 40 kilometers closer to the nearest port province. For a mean value of kilograms seized in a nearest port, which is around 420 kilograms, the effect of this seizure varies from -0.46 for the closest possible province (about 35 km) and becomes zero for the provinces located more than 180 km from this nearest port.

Finally, we try to check if local markets are supplied through more than one key province. As was revealed by the study of Tzvetkova et al. (2014), dealers at all levels usually have multiple suppliers; therefore, we adopt a measure that takes into account proximity to all the key provinces: $Avg\_dist = \sum_{i=1}^{9} S_i * dist_i$, which is the sum of seizures in all the 9 selected provinces by, weighted by distances. We estimate equation 6 with the Avg_dist variable instead of $Snearest$ and $Snearest * dist$. According to the results presented in Columns 5 and 6 of Table 6, the variable is not significant; it does not imply, however, a contradiction with the qualitative evidence from drug dealers' interviews: the interchangeability of suppliers might be present on a local level, but not on the country level. This is very reasonalble, since due to the illigal nature of the business long-distance travelling is minimized to reduce risks. Thus, while dealers may resort to several suppliers, all those suppliers (or most of them) might be sourced through the same major entry point. Another reason could be the tight

interconnection between drug business and organized crime[23]: in certain cases local markets are clearly divided between groups and subgroups, so that freedom to choose any supplier may be limited.

7.2 The SLX model

In this final section we make an attempt to account for spatial interactions in a more unified way. Differently from the largest part of spatial econometric literature, we adopt an SLX model, originally proposed by Gibbons and Overman (2012) and further developed in the applied direction by Halleck Vega and Elhorst (2015). They highlight that the SLX approach is more flexible in modelling spatial spillover effects as compared to other spatial econometrics models (SAR, SEM, SAC, SDM), and should be preferred or at least taken as a point of departure in the emperical analysis when there is no underlying theory suggesting to opt for a particular specification (as in Ertur and Koch, 2007). For our setting an SLX model is, in fact, the most intuitive choice: one would be interested in the relationship between consumption in a given province and seizures in neighboring provinces, rather than focusing on the relationship between consumption in a given province and that of the neighbours. In fact, seizures in neighbouring provinces are an important variable per se that should be included, since it is potentially related to both seizures and consumption in a given province, and at the same time is much more exogenous as compared to own province seizures. Additionally, an advantage of the SLX approach is that it allows to parametrize the spatial weight matrix W, while other models do not. Most commonly W is chosen based on geographical proximity of units, since it is generally true that neighboring units are interrelated with each other. However, in specific contexts this assumption seems too restrictive, and Halleck Vega and Elhorst (2015) suggest parametrizing W, unless, again, there is a theory pointing at a particular W to be adopted (as in Buonanno et al., 2012).

The SLX specification in our case will take the form:

$$HAr_{it} = a_i + \tau_t + \beta S_{it} + \theta WS + \delta X_{it} + \varepsilon_{it}, \tag{5}$$

[23]Another curious feature of drug markets in Italy is coexistence of two business models: a vertically integrated monopoly is present in the areas where Camorra is in power, while rather free competition is common for northern areas where no dominating criminal group exists.

where WS is the spatial lag of seizures rates. Following Halleck Vega and Elhorst, we adopt an inverse distance spatial wight matrix, with zeros on the main diagonal and the off-diagonal elements taking value $w_{ij} = 1/d_{ij}$, also normalized by maximum eigenvalue. In the course of estimation the matrix is parametrized in the following way:

$$w_{ij} = 1/d_{ij}^{\gamma} \tag{6}$$

where γ is an additional parameter that is also estimated, together with β, θ, δ and the fixed effects. The estimate of γ will provide an understanding of how fast the effects actually fade away with distance.

We also make an attemt to extend the external IV approach and use the spatial lag of cargo turnover as an additional instrument. Table 7 is organized as follows. Columns 1 and 2 contain results of the baseline and IV estimate[24] from Section 6; in Column 3 we used two variables as instruments for the seizures rate: the previously adopted cargo turnover in key ports and its' spatial lag, and the point estimates are quite similar. Column 4 contains the output from the pure SLX model (all variables considered exogenous) estimation, with the seizures spatial lag point estimate equal to -0.39, which is similar to the one obtained when seizures rate in own province is treated as endogenous and instrumented with cargo turnover only (Column 5). Though merginally significant, the coefficient is of expected (negative) sign, indicating that higher seizures in neighboring provinces are assosiated with a decrease in hospitalization rates in a given location. Next, Column 6 represents the IV estimation of the SLX equation with endogenous S, now instrumented with both sea and $Wsea$. Ineterestingly, the point estimate of WS jumps drastically by more than 10 times, as compared to previous cases, which could suggest that it is also endogenous. To take this possibility into account, we estimated the SLX model taking both seizures in own province and spatial lag as endogenous, instrumenting them with cargo turnover and its' spatial lag (Column 7). The point estimate of WS is now -1.09, which might seem more reasonable as compared to the previous case.

Given these point estimates, we can quantify the relationships and effects: a baseline SLX model suggests that a one standard deviation increase in WS is associated with a 0.036 standard deviation decrease in local consumption (very similar to the relationship with seizures rate in own province, where this effect is 0.033). The magnitude of the effect of one standard

[24] A slight difference of results with respect to those previously obtained is due to using 9 key provinces as opposed to 16. This is done because in the current section we now use 2 instruments, so that reduction in the first instrument's variation is compensated by adopting its' spatial lag.

Table 7: SLX model

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	b/se	b/se	b/se	b/se	b/se	b/se	b/se
seizr	-0.061***	-0.162***	-0.198***	-0.062***	-0.159***	-0.191***	-0.155***
	(0.010)	(0.029)	(0.035)	(0.010)	(0.030)	(0.067)	(0.036)
Wseizr				-0.390*	-0.416*	-5.989**	-1.093*
				(0.219)	(0.217)	(2.922)	(0.602)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
γ			0.63	1.01	1.01	0.15	1.09
Obs	515	515	515	515	515	515	515
Nclust	103	103	103	103	103	103	103
R2	0.089	0.062	0.040	0.094	0.070	0.070	0.046

* p<0.1, ** p<0.05, *** p<0.01. Cluster robust standard errors in parentheses.

deviation increase in WS implied by results in Column 6 is the highest and reaches 0.37 standard deviation decrease in hospitalization rates, while a point estimate in Column 7 implies this effect to be 0.1.

Whether the spatial lag of seizures should be considered as endogenous itself, is, in fact, an open question. In the abovementioned paper Vega and Elhorst suggest to test for endogeneity of the spatial lag by regressing the dependent variable on residuals from the first step. This way, however, may yield illogical results (e.g. pointing at WS endogenous and S itself exogenous - in fact, this is what they get in their case, and suggest to opt for a model with the spatial lag treated as exogenous; interestingly, with our data we get the same outcome). From the formal testing point of view, model in Column 6 outperforms other specifications presented by improving substantially both the strength and exogeneity of the instrument set. Another thing worth noting is that in this specification the optimal value of γ was estimated to be 0.15. This is very much in line to what we now show in the following section, suggesting that the effects of seizures in neighbouring provinces fade with distance much slower, than a plain inverse distance function would suggest.

8 Robustness checks

8.1 Different distance functions

Table 8 below provides results of estimating equations with distance interactions (eq. 6) for the full (Columns 1-3) and restricted (Columns 4-6) samples using inverse instead of plain distances. The results are different from what was obtained before: seizures in nearest port are still insignificant and their interaction with inverse distance is negative and marginally significant, and these two variables are not significant jointly. The average weighted by distance is now negative and marginally significant. It appears that plain invertion punishes distance too much, assuming the effect of port provinces seizures to be less far-reaching than it really is. This would also explain why the Avg_invd coefficient has the same sign and significance level as $Snearest * invd$: since the effect decays rapidly with distance, the most relevant constituent of the average weighted by distance is still the nearest port province.

Table 8: Using inverse distances as a proximity measure

	(1)	(2)	(3)	(4)	(5)	(6)
	b/se	b/se	b/se	b/se	b/se	b/se
seizr	-0.060***	-0.061***	-0.061***	0.046	0.032	0.036
	(0.010)	(0.010)	(0.011)	(0.099)	(0.088)	(0.092)
Snearest	-0.000	0.000		-0.000	0.000	
	(0.000)	(0.000)		(0.000)	(0.000)	
Snearest*invd		-79.828*			-83.877*	
		(41.491)			(45.082)	
Avg_invd			-35.219*			-36.083*
			(20.397)			(20.842)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Obs	515	515	515	470	470	470
Nclust	103	103	103	94	94	94
R2	0.089	0.096	0.093	0.087	0.095	0.091

* p<0.1, ** p<0.05, *** p<0.01. Cluster robust standard errors in parentheses.

With a different proximity measure, that allows the decay not to diminish as fast as a pure inverse would propose, the results are very similar to the plain distance case. Tables 9 and 10 contain estimation outputs using $distance^{-0.05}$ and $exp^{-alpha*distance}$ proximity measures respectively.

Table 9: Using $distance^{-0.05}$ as a proximity measure

	(1) b/se	(2) b/se	(3) b/se	(4) b/se
seizr	-0.059***	0.033	-0.030	0.045
	(0.010)	(0.086)	(0.033)	(0.097)
Snearest	0.017**	0.019**		
	(0.007)	(0.007)		
Snearest*$dist^{-0.05}$	-0.032**	-0.034**		
	(0.013)	(0.014)		
avg_$dist^{-0.05}$			55.034	65.987
			(51.760)	(81.927)
Controls	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Obs	515	470	515	470
Nclust	103	94	103	94
R2	0.100	0.099	0.090	0.088

* p<0.1, ** p<0.05, *** p<0.01. Cluster robust standard errors in parentheses.

Table 10: Using exponential discounting with $alpha = 10^{-6}$

	(1) b/se	(2) b/se	(3) b/se	(4) b/se
seizr	-0.057***	0.040	-0.062***	0.048
	(0.010)	(0.090)	(0.010)	(0.099)
Snearest	0.004**	0.005***		
	(0.002)	(0.002)		
Snearest*$e^{-alpha*d}$	-0.006**	-0.006***		
	(0.002)	(0.002)		
avg_$e^{-alpha*d}$			-0.000	-0.000
			(0.000)	(0.000)
Controls	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Obs	515	470	515	470
Nclust	103	94	103	94
R2	0.099	0.098	0.089	0.087

* p<0.1, ** p<0.05, *** p<0.01. Cluster robust standard errors in parentheses.

8.2 Different key province groupings

Here we provide results of spatial analysis in terms of relation with seizures in key provinces using slightly different groupings. In Section 7 we used 9 provinces of the western coast. Table 11 contains results for the top 9 provinces by average yearly amount of cocine seized. Since the majority of seizures is anyway made in western coastline provinces with ports, the top-9 group is very similar to the 9 ports group, with the exceptions of Milan and Varese now replacing Savona and Cagliari. Perhaps, this is the reason why the results are almost the same: both signs and absolute values of the pount estimates are identical to those of the 9 ports case.

Table 11: Relation to seizures in top-9 provinces by average amount seized

	(1) b/se	(2) b/se	(3) b/se	(4) b/se	(5) b/se	(6) b/se
seizr	-0.0602***	-0.0634	-0.0615***	-0.0639	-0.0585***	-0.0642
	(0.0102)	(0.1099)	(0.0105)	(0.1054)	(0.0125)	(0.1105)
Snearest	-0.0001	-0.0000	-0.0009*	-0.0011**		
	(0.0003)	(0.0003)	(0.0005)	(0.0005)		
Snearest*dist			0.0004**	0.0005**		
			(0.0002)	(0.0002)		
Avg_dist					0.0000	0.0000
					(0.0000)	(0.0000)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Obs	515	470	515	470	515	470
Nclust	103	94	103	94	103	94
R2	0.089	0.095	0.096	0.105	0.089	0.095

* p<0.1, ** p<0.05, *** p<0.01. Cluster robust standard errors in parentheses.

Table 12 contains the results for the case with top 9 provinces by average seizure *rates* selected as a key province group. In this grouping, as compared to the 9-ports case, we have Varese, Trento and Pisa instead of Roma, Cagliari and Napoli. It appears that absolute volumes rather that rates are more relevant in determining which provinces seizures have an impact on consumption in the rest of the country.

Table 12: Relation to seizures in top-9 provinces by seizure rates

	(1) hapop b/se	(2) hapop b/se	(3) hapop b/se	(4) hapop b/se	(5) hapop b/se	(6) hapop b/se
seizr	-0.0615***	0.1701	-0.0611***	0.1607	-0.0591***	0.0186
	(0.0103)	(0.2769)	(0.0108)	(0.2763)	(0.0125)	(0.0891)
Snearest	-0.0004*	-0.0004	-0.0006	-0.0008		
	(0.0002)	(0.0003)	(0.0006)	(0.0008)		
Snearest*dist			0.0001	0.0001		
			(0.0002)	(0.0002)		
Avg_dist					0.0000	0.0000
					(0.0000)	(0.0000)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Obs	515	470	515	470	515	470
Nclust	103	94	103	94	103	94
R2	0.093	0.085	0.093	0.086	0.089	0.081

* p<0.1, ** p<0.05, *** p<0.01. Cluster robust standard errors in parentheses.

9 Conclusion

Studying illicit markets is extremely facinating but intrinsically difficult. Due to the clandestine nature of the phenomenon, our knowledge of it, at least at the general public level, is very limited. Currently existing and openly available data is sparse and often of low quality. This hinders the possibility to rigorously study many policy-relevant questions and suggests that any results obtained should be treated with caution. This paper is concerned with studying the relationship and effects of law enforcement, specifically, illicit drug seizures, on drug consumption, proxied by drug-related hospital admission rates, using the case of cocaine market in Italy. To the best of our knowledge, our results are the first evidence of a stable negative relationship between cocaine seizures and cocaine consumption. As opposed to the existing studies, we tackle the endogeneity of seizures by resorting to an instrumental variable approach, using both internal and external (western coast provinces' cargo turnover in ports) instruments. According to our findings, according to results obtained, a one standard deviation increase in cocaine seizure rates leads, on average, to a decrease in hospitalization rates by about 3.3% in the baseline case, and by 10% of standard deviation if endogeneity is properly addressed. This result, however, is driven by a relatively small group of provinces with high

volumes of cocaine seized. In order to explore how those bulk seizures affect consumption in the rest of the country, we conduct an analysis of spatial interactions by studying how cocaine consumption is related to seizures in seaport provinces and neighbouring provinces. Our results suggest that when seizures in nearest port province are large enough, their impact on consumption elsewhere is negative, and more pronounced for closer units. We do not, however, find any significant relationship between seizures in nearest port province and seizures in other provinces. Finally, we propose an SLX model to investigate how cocaine consumption is related to seizures in neighbouring provinces in general. The results vary depending on the exact specification, but all suggest that the relationship is negative, and at least as considerable in magnitude as that with seizures in own province.

There are several possible directions for future research. Firstly, in this work we focused on cocaine markets. Studying markets for other types of drugs in the analysis may provide insights of whether seizures of heroin, hashish and marijuana are related to consumption of those drugs in a similar way as was discovered for the cocine market. Additionally, incorporating all types of drugs in a single empirical model will allow to investigate their substitution/complementarity for Italian users. Secondly, the unique Italian setting potentially allows to study the effectiveness of law enforcement on differently organized drug markets (located, however, within the same country): the mafia-controlled vertically integrated monopoly with strict rules for the participants, and the relatively free competition in the areas with no dominating criminal group present. Finally, similar analysis on cross-country level might provide insights for antidrug supply-side policies on a global scale.

References

Anderson, Mark, Benjamin Hansen, and Daniel I Rees (2013). "Medical marijuana laws, traffic fatalities, and alcohol consumption". In: *The Journal of Law and Economics* 56.2, pp. 333–369.

Arellano, Manuel and Stephen Bond (1991). "Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations". In: *The review of economic studies* 58.2, pp. 277–297.

Arkes, Jeremy et al. (2008). *Why the DEA Stride data are still useful for understanding drug markets*. Tech. rep. National Bureau of Economic Research.

Brunt, Tibor M et al. (2009). "An analysis of cocaine powder in the Netherlands: content and health hazards due to adulterants". In: *Addiction* 104.5, pp. 798–805.

Brunt, Tibor et al. (2010). "The relationship of quality and price of the psychostimulants cocaine and amphetamine with health care outcomes". In: *Drug and alcohol dependence* 111.1, pp. 21–29.

Bun, Maurice JG (2015). "Identifying the impact of deterrence on crime: internal versus external instruments". In: *Applied Economics Letters* 22.3, pp. 204–208.

Bun, Maurice JG, Vasilis Sarafidis, Richard Kelaher, et al. (2016). *Crime, Deterrence and Punishment Revisited*. Tech. rep. Universiteit van Amsterdam, Dept. of Econometrics.

Buonanno, Paolo, Giacomo Pasini, and Paolo Vanin (2012). "Crime and social sanction". In: *Papers in Regional Science* 91.1, pp. 193–218.

Callaghan, Russell C et al. (2009). "Impact of Canadian federal methamphetamine precursor and essential chemical regulations on methamphetamine-related acute-care hospital admissions". In: *Drug and alcohol dependence* 105.3, pp. 185–193.

Caulkins, Jonathan P (2001). "Drug prices and emergency department mentions for cocaine and heroin". In: *American Journal of Public Health* 91.9, pp. 1446–1448.

— (2007). "Price and purity analysis for illicit drug: data and conceptual issues". In: *Drug and Alcohol Dependence* 90, S61–S68.

Caulkins, Jonathan P and Peter Reuter (2010). "How drug enforcement affects drug prices". In: *Crime and Justice* 39.1, pp. 213–271.

Chaloupka, Frank J, Michael Grossman, and John A Tauras (1999). "The demand for cocaine and marijuana by youth". In: *The economic analysis of substance use and abuse: An integration of econometrics and behavioral economic research*. University of Chicago Press, pp. 133–156.

Cole, Claire et al. (2011). "Adulterants in illicit drugs: a review of empirical evidence". In: *Drug testing and analysis* 3.2, pp. 89–96.

Cole, Jon C et al. (2008). "The effects of perceived quality on the behavioural economics of alcohol, amphetamine, cannabis, cocaine, and ecstasy purchases". In: *Drug and alcohol dependence* 94.1, pp. 183–190.

Coomber, Ross (2006). *Pusher myths: Re-situating the drug dealer*. Free Assn Books.

Cunningham, Scott and Keith Finlay (2016). "Identifying demand responses to illegal drug supply interdictions". In: *Health economics* 25.10, pp. 1268–1290.

Dave, Dhaval (2006). "The effects of cocaine and heroin price on drug-related emergency department visits". In: *Journal of Health Economics* 25.2, pp. 311–333.

Dell, Melissa (2015). "Trafficking networks and the Mexican drug war". In: *The American Economic Review* 105.6, pp. 1738–1779.

DiNardo, John (1993). "Law enforcement, the price of cocaine and cocaine use". In: *Mathematical and computer Modelling* 17.2, pp. 53–64.

Dobkin, Carlos and Nancy Nicosia (2009). "The war on drugs: methamphetamine, public health, and crime". In: *The American economic review* 99.1, pp. 324–349.

Elhorst, J Paul (2010). "Applied spatial econometrics: raising the bar". In: *Spatial Economic Analysis* 5.1, pp. 9–28.

EMCDDA (2008). "Annual report". In:

— (2012). "Italy: Country Drug Report". In:

Ertur, Cem and Wilfried Koch (2007). "Growth, technological interdependence and spatial externalities: theory and evidence". In: *Journal of applied econometrics* 22.6, pp. 1033–1062.

Félix, Sónia and Pedro Portugal (2017). "Drug decriminalization and the price of illicit drugs". In: *International Journal of Drug Policy* 39, pp. 121–129.

Galenianos, Manolis, Rosalie Liccardo Pacula, and Nicola Persico (2012). "A search-theoretic model of the retail market for illicit drugs". In: *The Review of Economic Studies* 79.3, pp. 1239–1269.

Gallet, Craig A (2014). "Can Price Get The Monkey Off Our Back? A Meta-Analysis Of Illicit Drug Demand". In: *Health economics* 23.1, pp. 55–68.

Gibbons, Stephen and Henry G Overman (2012). "Mostly pointless spatial econometrics?" In: *Journal of Regional Science* 52.2, pp. 172–191.

Giommoni, Luca (2014). "The retail value of the illicit drug market in Italy: a consumption-based approach". In: *Global Crime* 15.1-2, pp. 27–50.

Halleck Vega, Solmaria and J Paul Elhorst (2015). "The SLX model". In: *Journal of Regional Science* 55.3, pp. 339–363.

Kelejian, Harry H and Ingmar R Prucha (1998). "A generalized spatial two-stage least squares procedure for estimating a spatial autoregressive model with autoregressive disturbances". In: *The Journal of Real Estate Finance and Economics* 17.1, pp. 99–121.

Kuziemko, Ilyana and Steven D Levitt (2004). "An empirical analysis of imprisoning drug offenders". In: *Journal of Public Economics* 88.9, pp. 2043–2066.

Model, Karyn E (1993). "The effect of marijuana decriminalization on hospital emergency room drug episodes: 1975–1978". In: *Journal of the American Statistical Association* 88.423, pp. 737–747.

Nifo, Annamaria and Gaetano Vecchione (2014). "Do institutions play a role in skilled migration? The case of Italy". In: *Regional Studies* 48.10, pp. 1628–1649.

Nuijs, Alexander LN van et al. (2011). "Illicit drug consumption estimations derived from wastewater analysis: a critical review". In: *Science of the Total Environment* 409.19, pp. 3564–3577.

Rose, Christiern (2016). *The War on Drugs: An Analysis of the Effects of Supply Disruption on Prices and Purity*. Tech. rep. Toulouse School of Economics (TSE).

Schifano, Fabrizio and John Corkery (2008). "Cocaine/crack cocaine consumption, treatment demand, seizures, related offences, prices, average purity levels and deaths in the UK (1990—2004)". In: *Journal of Psychopharmacology* 22.1, pp. 71–79.

Smithson, Michael et al. (2004). "The impact of illicit drug supply reduction on health and social outcomes: the heroin shortage in the Australian Capital Territory". In: *Addiction* 99.3, pp. 340–348.

Tzvetkova, Marina et al. (2014). "Dealing with Cocaine and Heroin in Italy: Business Strategies and Operations". In: *Reframing addiction: policies,processes and pressures (p. 103-117). The ALICE RAP project. ISBN: 978-84-697-1647-2 Available online: www.alicerap.eu.*

UNODC, IDS et al. (2009). "World drug report". In: *United Nations New York, NY*.

Wan, Wai-Yin et al. (2016). "Do drug seizures predict drug-related emergency department presentations or arrests for drug use and possession?" In: *International Journal of Drug Policy* 27, pp. 74–81.

Weatherburn, Don et al. (2003). "Supply control and harm reduction: lessons from the Australian heroin "'". In: *Addiction* 98.1, pp. 83–91.

Yuan, Yuehong and Jonathan P Caulkins (1998). "The effect of variation in high-level domestic drug enforcement on variation in drug prices". In: *Socio-Economic Planning Sciences* 32.4, pp. 265–276.

Zuccato, Ettore and Sara Castiglioni (2012). "Consumi di sostanze stupefacenti nelle città europee". In: *Ricerca E Pratica* 3, pp. 252–260.

Zuccato, Ettore, Sara Castiglioni, Ivan Senta, et al. (2016). "Population surveys compared with wastewater analysis for monitoring illicit drug consumption in Italy in 2010–2014". In: *Drug and alcohol dependence* 161, pp. 178–188.

Zuccato, Ettore, Sara Castiglioni, Mauro Tettamanti, et al. (2011). "Changes in illicit drug consumption patterns in 2009 detected by wastewater analysis". In: *Drug and alcohol dependence* 118.2, pp. 464–469.