Organized crime and Technology

Preliminary work. Please do not quote/circulate

Mustafa Caglayan* Alessandro, Flamini† Babak Jahanshahi‡

May 1, 2016

Abstract

This paper investigates the relation between the presence of organized crime and the technology level in the northern Italian provinces. We ground the identification strategy on the episode of forced exile to northern provinces for criminals belonging to clans, a natural experiment occurred in the 1960s-1990s. Our analysis propose two indexes at the province level. The first portrays technology at a fine-grained industrial sector level from a whole firms population standpoint. The second describes mafia-type organizations in line with the investigation approach currently used by Italian National Anti-mafia Directorate (DNA) and Antimafia District Directorate (DDA). It is therefore equipped to detect the new *silent mafia* intimidation method developed by organised crime outside the head office located in south Italy. By using these indexes, we provide empirical evidence that in northern Italy provinces, the larger the presence of organized crime, the less technological the industrial fabric.

Keywords: Organized crime, *silent mafia*, technology, north Italy

JEL Classification Numbers: R11, K14, K42, O17, O30

*Heriot Watt University

†University of Pavia, alessandro.flamini@unipv.it. Most of this paper was written while Alessandro Flamini was visiting the Department of Economics at Harvard University, whose kind hospitality is gratefully acknowledged. We are particularly indebted to Alberto Alesina for support, advice and useful discussions. We also benefited from useful discussions with Philippe Aghion, May Chiabrera, Marina Corti, Giuseppe De Feo, Andrea Fracasso, Lorenzo Frigerio, Claudia Goldin, Lawrence Katz, Luigi Zingales.

‡University of Pavia

I Introduction

Every day, all over the world, society experiences criminal offences committed by mafia-type organizations. Drug trafficking, murders, slaughters, arsons, illegal disposal of toxic wastes, polluted elections are examples, just to name few. These daily frequency crimes may strike public attention, and do ruin or end the life of the victims directly involved. But does organized crime hurt the society at lower time frequency too? Can it have long-lived effects and negatively impact on the evolution of the society? These questions can be addressed by different standpoints. We choose to start analysing this issue by focusing on the relation between organized crime and technology. It is well known that technology is a key driver of economic growth. And growth occurs through years. Hence, if organized crime were to adversely impact technology, it should also slow growth down. This hypothesis motivates our interest in investigating to what extent, if any, mafia-type organisations impact technology.

To tackle this issue the paper looks at how organized crime affects the industrial structure of the municipality in which it operates. Our conjecture is that mafia-type organisations cause a harmful mutation in the industrial fabric of the territory. Specifically, the presence of organized crime in a municipality diverts the firms distribution towards low-tech industrial sectors. A byproduct of this change is squandering of public resources and distortion in their allocation.

The mechanics of this mutation works through various channels. Intuitively, all of them are associated with some type of competition which turns out to be corrupted by mafia-type organisations. By recycling illegal profits in specific industrial sectors, the remaining sectors can no longer fairly compete for resources. Commercial centers or restaurants, which are low-tech and among the main sectors controlled by organized crime (Transcrime, 2013), can easily grow due to easy access to illegal profits that need to be laundered. Instead, high-tech startups need to struggle on the market to get financed. This directly changes the industrial structure of the territory. But the transmission mechanism from organized crime to the change in the industrial structure can be more complex. Although transmission channels tend to be entangled, it would be useful to present them separately. One channel works through supplying or imposing private protection to firms.[1] Firms that for example buy services like illegal disposal of toxic wages, threats to competitors, suppliers imposition, unfairly compete with their peers. Generally, a fall in competition leads to a fall in innovation (Aghion et al., 2014) and productivity (Nickell, 1996; Blundell et al., 1999; Aghion et al., 2004, 2009). Innovation and productivity, in turn foster technological progress. Thus, we can expect that the private protection industry run by organized crime reduce technological progress. Another channel works by altering public procurement. Firstly mafia-type associations distort the competition between alternative projects that are financed with public money. Secondly, they distort the competition between bidding firms. Thirdly, if we look at competing incentives for entrepreneurs to start business in different sectors, they distort these incentives making the sectors which are more closely related to public procurement more attractive. All this affects the industrial fabric in that favors industries which are associated with organized crime in detriment to the others.[2]

A further channel works by altering public elections (Alesina et al., 2016; Buonanno et al., 2014; De Feo and De Luca, 2013). In this way organized crime hurts competition between candidates, establishes a convenient partnership with the winners elected thanks to the clans' support, and also tends to intimidate the other politicians elected without the clans' support.[3] Clearly, this is a channel that amplifies the scope of the previous ones. This, in turn, biases politics in favor of mafia-type organizations by means of laws and influence on courts on the one hand, and via decisions and behaviours that favor their economic activities on the other hand.

To examine the effect of organized crime on technology, we scrutinize data from Italy,

[1]See Gambetta (1996) for a brilliant understanding of organised crime as the business of private protection.

[2]Using seized and confiscated assets to organized crime as a proxy of its investments in the legal economy, Transcrime (2013) finds that, with respect to companies the preferred sectors seem to be wholesale and retail (29.4 percent) and construction (28.8 percent), followed by hotels and restaurants (10.5 percent) and real estate companies (8.9 percent).

[3]Alesina et al. (2016) show that in Sicily, for the period 1945-2013, mafia-type murders occurring in the electoral season generally deter appointed politicians to openly talk about mafia in the following legislature.

as this country has been experiencing mafia-type associations extensively since the 19th century. We look specifically at the northern provinces for two reasons.

First, massive presence of organized crime in a rich and highly developed area is a new interesting phenomenon.[4] Northern Italy, indeed, is the richest and most productive area of the country, and also ranks highly above the median in the European Union. This surprising news seems to have a good explanation in the so called *silent mafia* approach. This is a novel expression of the intimidation method that avoids striking acts like murders and slaughters, but is effective due to the criminal fame of the head office (Cassazione, 2015; DNA, 2014). The silent mafia approach, thus, contributes to explain why only in the last five years, northern Italy public has started realizing that organized crime has spread its roots in this part of the country. We are hence facing a new phenomenon with organised crime rooted in that part of the country featuring the most active and developed industrial structure. A natural question that arises, therefore, is how this impacts on its productive fabric.

Second, northern Italy experienced an interesting natural experiment with respect to organized crime. On the basis of two laws dating back to 1954 and 1965, southern Italy courts convicted criminals suspected to belong to clans to forced internal exile in the northern provinces. This special institution remained in force until 1990 so that for decades criminals that *de facto* belonged to organized crime were sent to the northern provinces. This natural experiment is useful to describe the causal impact of organized crime on technology.

To test our conjecture, we examine the relationship between mafia-type associations and technology using both annual data and aggregate data at the province level.

To carry out our empirical investigation, we initially estimate our model aggregating the data at the province level. Although implementing this approach we will be using

[4]The main investigations (*Infinito* in Lombardy and *Minotauro* and *Alba Chiara* in Piedmont) resulted in 198 convictions by the Court of Cassation in the last year. Only for *Infinito* this implied more than 8 centuries of prison. As to current investigations like *Maglio 3* in Liguria or *Aemilia* in Emilia-Romagna the Supreme Court has not issued its judgment yet, but the number of arrested defendants is impressive, 160 only for *Aemilia*. Regarding organised crime in Veneto, Luana et al. (2015) provide an interesting and well-documented journalistic probe.

less information due to aggregation, it will allow us portraying the basic relation between organized crime and technology. Next, we continue our investigation adopting pooled linear models and estimate the effect of organized crime on technology as we allow for within-province correlation of errors. With both aggregate data model and pooled models we also employ the instrumental variable approach. Lastly, we use quantile and instrumental quantile regression methodology and estimate the link between mafia-type associations and technology at different deciles. In each case, we employed several control variables including the number of patents and high tech patents applications by companies to the European Patent Office, the number of new university graduates, one-year-change in exports, and net value added. All our models yield a similar view: organized crime has a negative impact on technology. This finding, which is significant across all methodologies that we used, provides support to our conjecture.

The use of an instrumental variable approach is essential in a study such as ours as the endogeneity problem may affect the results. The novelty proposed here consists of instrumenting organised crime via the number of criminals belonging to clans who faced forced exile to provinces in northern Italy per province population. This ratio gives the concentration of exiled convicted criminals per province allowing us gauging the initial viral load of mafia-type associations in a province. To the best of our knowledge the previous literature has not studied the relationship between organized crime and technology. So the closer literature this paper relates to regards organized crime and economic growth. Pinotti (2015) compares the actual development of two regions in southern Italy exposed to organized crime after the 1970s with their estimated counterfactual development in the absence of organized crime. He shows that the presence of mafia reduces the rate of growth of these regions. Barone and Mocetti (2014) find that long-term impact of earthquakes on GDP in two different Italian areas in 1976 and 1980 were opposite. Although they interpret the results in terms of pre-quake institutional quality, it is interesting to note that before the quake one area has been strongly permeated by organized crime.

This paper also relates to mafia transplantation, defined by Varese (2011) as the ability of a mafia group to operate an outpost over a sustained period outside its region of origin and routine operation. This author identifies a special combination of factors that favour the emergence of organised crime in new territories. Specifically, the presence of members of the organisation in the territory, the absence of other established organised crime groups, and the sudden emergence of new markets where the state is not able to protect property rights. Scognamiglio (2015) used forced exile to study the diffusion of organised crime in northern Italy and finds a positive impact of organised crime on the construction sector.

With respect to the previous literature, a first contribution of our paper lies in providing an index of technology at the province level based on the technology level of the whole population of firms. Its relevance is therefore in taking a fine-grained shooting of the evolution in the technological content of the industrial fabric.

A second contribution consists in developing a mafia-index able to capture the new *silent mafia* profile of organised crime outside the head office located in south Italy. The innovation here is to employ the operating procedure followed by specialised antimafia prosecutors at DNA and DDAs to address the evolution of organised crime in northern Italian provinces. An operating procedure that turned out to be successful as ratified by hundreds of convictions sentences issued by the Supreme Court.

Beyond these methodological contributions, the current work provides empirical evidence that organized crime has exerted a negative impact on technology in a wealthy and highly developed European Area. In particular, the larger the presence of organized crime in a province, the more low-tech the industrial structure in that province. We think that this is the major contribution of our work.

The rest of the paper is organised as follows. Section 2 describes the data and presents, step-by-step, our new indexes of technology and organized crime, both of which are measured at the province level. Section 3 lays out the empirical model and the identification strategy. Section 4 provides the results and section 5 concludes the study.

II Data, organized crime index and technology index

We assembled a new annual dataset covering 40 provinces from northern Italy and spanning the period between 2005 and 2012. The reason why we focus on provincial data is that provinces are the minimal territorial aggregations for which we can gather sufficient information to characterize the presence of organized crime. We collect data for three groups of variables. The first group is used to portray technology and consists of firms revenues per industrial sector, extracted by Orbis, and census data extracted by IPMUS on the university degree that each person in the sample holds and the type of establishment in which the person works.[5] The second group of variables captures the presence of organised crime. It consists of crimes reported by the security force to judicial authorities extracted by ISTAT, exiled criminals data made available by Ministry of Interior, and specific arsons data made available by Corpo Nazionale dei Vigili del Fuoco. The third group contains the covariates which have been extracted by Unioncamere (Change in Exports, Applications to European Patent Office (EPO), Value Added, Total University Graduates), and by Eurostat (High-tech Patent Applications to EPO).

A Technology revenue index

To portray the technology level of each province we introduce a technology index consisting of the average of the sectoral technologies weighted by sectoral relative revenues. We build this measure in the three steps. First, we associate each industrial sector with its own level of technology in a way that is province-indipendent. Such a step was crucial and is detailed below. We thus obtained a set of industrial sectors ordered by technology. This ordered set acts as a support for a distribution of industrial of industrial sectors in terms of their technology level. Second, each element of this support, i.e. each technology level corresponding to a specific sector, is associated with a weight that aims to capture the mass

[5] The set of establishment types is based on INDNAICS industrial codes according to the North American Industrial Classification System developed in 1997.

of that sector.[6] We use as a weight the revenues of the sector divided by the total revenues of the province. For each sector, then, what we obtain is a sector technology level weighted by its own relative revenues. Third, by summing over sector technology levels weighted by relative revenues we obtain a weighted average of the technology for a province given the year. This is our dependent variable.

Going back to the first step, the motivation to build our own set of sectors ordered by technology is that it was not available in the literature such a set at a description of sectors sufficiently fine-grained for the phenomenon we were investigating. Surveying the literature, Heckler (2005) considers industries to be high-tech if employment in both research and development, and all technology-oriented occupations account at least twice as much as the average of all industries.[7] Separately, OECD Directorate for Science and Industry (2011) classified the manufacturing industries into four categories based on R&D intensities.[8]

With respect to the OECD methodology, the key drawback is that one cannot rank services' activities based on direct R&D intensities. Therefore, the ranking is only available for manufacturing industries. Instead, in the methodology adopted by Heckler (2005) the service industries are ranked as well, but they have been sorted into two categories only.

Researchers has used both methodologies in the past.[9] For instance, Raymond et al.

[6]Since data were not available for Italy to build a fine-grained support for a distribution of industrial sectors ordered in terms of technology level, we follow Ciccone and Papaioannou (2009) and use the US census data to build that support.

[7] Heckler (2005) updated the list of high-tech industries for the three-digit industrial group level in the 1987 edition of the Standard Industrial Classification Manual.

[8]The division of manufacturing industries into high-technology, medium-high-technology, medium-low-technology and low-technology groups was made after ranking the industries according to their average over 1991-99 against aggregate OECD R&D intensities.

[9]Other researchers have also developed their own metodology to classify industries (or firms), or used different sources in comparison with the ones discussed above. Bustos (2011), in her firm level analysis, constructed a direct measure of spending on technology to study the impact of a regional free trade agreement, MERCOSUR, on technology upgrading by Argentinean firms. This measure included i) spending on computers and software; ii) payments for technology transfers and patents; and iii) spending on equipment, materials, and labor related to innovation activities performed within the firm. Carpenter and Petersen (2002) used the set of high-technology industries based on the United States Department of Commerce classification of high-technology. The list of industries in the sample consisted of drugs and medicinals (SIC 283); office and computing equipment (SIC 357); communications equipment (SIC 366); electronics components (SIC 367); industrial measuring instruments (SIC 382); and surgical instruments (SIC 384), which are highly R& D intensive, in comparison to the rest of the US manufacturing sectors.

(2010) used OECD's four-group classification to study the persistence of innovation in Dutch manufacturing. Kearns and Ruane (2001) used the OECD sectorial classification to aggregate sectors into four groups and then studies the role of the technology level in the relationship between foreign direct investment and economic growth in Ireland. Fallah et al. (2014) used the Heckler (2005) definition of high-technology industries to investigate the role of geography in high-tech employment growth across US counties.

In this paper, we deviated from the two main aforementioned ranking methodologies in order to obtain a comprehensive ranking index covering all the industrial sectors. Therefore, we identified high-tech oriented occupations[10] following Heckler (2005) and we computed the ratio of employees who held a degree related to those occupations with respect to all the other employees in each industrial sector.[11]

Figures 1-4 present our own industrial classification based on US using the 2009 version of IPUMS. The vertical axis shows the ratio of employees with high-tech degrees to all the employees in each sector. The horizontal axis covers all the industries in NAICS, and each figure focuses on 65 industries.

B Organized crime index

B.1 Selecting variables

The origin of organised crime in Italy dates back to the nineteen century. It was only in 1982, however, that mafia-type association was considered as a distinguished offence with the introduction of article 416-bis in the Italian Penal Code (P.C.). Since then, the use of indexes that capture the presence of criminal organizations increased in the literature. Clearly, being illegal, mafia-type associations cannot go public and thus are invisible. Nevertheless, they leave tracks of their presence on the territory by committing crimes that could be detected by

[10] Computer and Information Systems; General Engineering; Engineering Technologies; Biology; Physical science; Nuclear, Industrial Radiology, and Biological Technologies; General Social Sciences

[11] This approach is close to Heckler (2005) , the main difference being that we do not include employment in R&D as fine-grained sectoral data are not available

the security force, and which then possibly lead to sentences issued by the judicial authorities. Indexes then have been built using these crimes. Calderoni (2011) used mafia-type murders, mafia-type association, city council dissolved for mafia infiltration, and asset confiscated from organized crime. Transcrime (2013) added variables distilled by open sources (DNA and DIA reports[12]) to the ones contained in Calderoni (2011).[13] By adding to mafia-type murders other features of the organised crime phenomenon, these indexes represent an important innovation. Indeed, they allow revealing, at least partially, the presence of organised crimes also in the centre or north Italy. Here, organised crime is present (as shown for instance by the sentences stemmed by the investigation called *Infinito* in Lombardy, or *Minotauro* and *Albachiara* in Piedmont), but mafia-type murders, a distinctive feature of organised crime in southern Italy, are not that common.

Nonetheless, in general, mafia-type crimes can be severely under-reported due to *omerta* and intimidations (Pinotti, 2015), while this problem seems negligible for homicides (Fajnzylber et al., 2002). For this reason Pinotti (2015) uses mafia-type murders looking at southern regions where homicides have been a common practice.[14]

Both approaches however are not fit to capture *changes* in mafia-type organisations in particular outside southern Italian provinces. In northern regions, last decade of investigations and sentences have shown a massive spreading of 'ndrangheta, which kept its genotype of *unitary organization* over the country, but mutated its fenotype in *silent mafia* outside the area of origin.[15]

It is interesting, in this respect, what remarked by DNA (2015) regarding a deep and

[12]DIA stands for Antimafia Investigation Directorate and belongs to the police forces.

[13]These variables describe clans belonging to mafia-type organisations in city and province. They are the presence of clans, the number of clans, the name of the clans, the number of clans for each organised crime association.

[14]Pinotti (2015) finds that mafia-type murders and the crime of mafia-type association for Italian regions and for the period 1983-2007 are positively related. Although the crime of mafia-type association can be unreported, extrapolating backward this relationship allows the author capturing organised crime also before 1982 when the mafia-type association crime did not exist yet.

[15]For a definition of 'silent mafia' as a particular expression of the intimidation method characterising mafia-type organisations, which avoids striking offences like murders and/or slaughters, see sentence n. 436/2015 delivered by Court of Cassation, Cassazione (2015). Sparagna (2015) offers an interesting discussion of the recent jurisprudence of the Court of Cassation on silent mafia and the mafia-type method.

irreversible mutation of the ways in which the mafia-type intimidation roots in the territory. Recent Perugia DDA investigation called *Quarto Passo* shows that 'Ndrangheta fellows had simply to qualify as members of that criminal association to get the subjugation of the victims. And the thousands of murders required in Calabria through decades to consolidate the force of intimidation were unnecessary as few violent actions like damages and arsons quickly caused intimidation due to the criminal reputation of the organisation.[16]

This mutation implies that organised crime looks a very inertial phenomenon in the northern area when is described with previous indexes. Instead, sentences based on both concepts of unitary nature of the mafia association and *silent mafia* turned out being very effective to convict criminals belonging to the clans.

To overcame this problem, we propose an index which is a sensitive as possible to changes in the presence of organised crime. We thought that a natural and effective way to construct this index is to adopt the investigation standpoint of the National Anti-mafia Directorate, (DNA), and the District Anti-mafia Directorates, (DDAs), the judicial authorities that, respectively, coordinates and carry out anti-mafia investigations in Italy.

We thus focus on the same set of crimes that are currently considered most revealing by these institutions to detect mafia-type organisations. Specifically, according to art. 51 c. 3 bis of Italian Code of Penal Procedure, C.P.P., there is a set of crimes whose exclusive competence belongs to DDA.[17] This set of crimes has been continuously enlarging since 1991 when art. 51 c. 3 bis first appeared in the Code. Such expansion reflects the evolution of the antimafia investigation techniques that need to adapt to tactical changes of mafia-type organisations. Indeed, as suggested by DNA and DDAs, there are other crimes which are tell-tale crimes and therefore should be included in art. 51 c. 3 bis.[18] Or, as argued in DNA

[16]See also the sentence of the Turin Court of Appeal delivered in the *Minotauro* trial which considers as mafia-type method, and therefore that art. 416 bis C.P. is applicable, the mere use of the "criminal fame" of the syndicate even without the ascertainment of concrete intimidations. This method is different from what used in the southern provinces from which the criminal association originates.

[17]The crimes belonging to this set for which provincial data are available for the whole period 2005-2012 are the following: Mafia-type murders; slaughters; kidnappings; drugs trafficking; mafia-type associations; criminal associations.

[18]See DNA (2014, p. 895-896 and p. 375-379) as to manufacturing and sale of goods made by usurping

(2014, p. 428-437), there should be cooperation between the DDA prosecutors, the ordinary prosecutors, and other institutions working in the same district for the prompt recognition of tell-tale crimes. Two cases clearly make the point. While there are few criminal proceedings for slavery and human trafficking, which are exclusive competence of the DDAs, there is a considerable amount of criminal proceedings for pimping and pandering, whose competence instead belongs to ordinary prosecutors. Yet the two groups of crimes are highly connected as maintained by ONGs working in this field and reported by DNA. Also, according to DDAs Prosecutors, arsons are very revealing tell-tale crimes. Interestingly, they cannot be under-reported as it is impossible to hide them. In fact, when they occur they have to be professionally switched off by the fire brigade. Although not necessarily any arson is a mafia-type arson, when it happens security forces and judicial authorities attribute a high chance that it is. The reason is that arsons are an effective tool used by mafia-type organisations, perfectly consistent with their own essence as it is captured by art. 416 bis, c. 3.[19]

For this reasons, whenever data were available, we followed the DNA and DDAs operating procedure and so included in our set of variables also tell-tale crimes.[20] We think that this approach offers a substantial innovation in crafting mafia-type indexes.

industrial property titles (art. 517 ter in P.C.) and counterfeiting of geographical indications or appellations of origin of food products (art. 517 quater in P.C.), which are tell-tale crimes for the more serious crimes of counterfeit, alteration or use of distinctive signs of original works or industrial products (art. 473 in P.C. and referred by art. 51 c. 3 bis in C.P.P.) and introduction in the country and commerce of false signs products (art. 474, P.C. and referred by art. 51 c. 3 bis in C.P.P.). Similarly for activities of unauthorized waste management (art. 256 in D.Lgs. 152/2006) and Illegal trafficking of waste (art. 259 in D.Lgs. 152/2006), which are the most significative tell-tale crimes for the more serious crime of organised activities for the Illegal trafficking of waste (art. 260 in D.Lgs. 152/2006 and referred by art. 51 c. 3 bis in C.P.P.)

[19]Art. 416 bis, c. 3 reads: "The organisation is considered mafia-related when those members who take part in the organisation use force of intimidation as the member encumbrance and the condition of subjugation and the code of silence that it derives from for committing offences, to directly or indirectly acquire the management and, therefore, control of economic activities, concessions, authorisations, tenders, and public services or to gain profits or unjust advantages for the organisation itself or for others."

[20]The tell-tale crimes we managed to include are: extorsions; trafficking in stolen goods; usury; criminal damages; criminal damages by arsons; arsons; threats; pimping and pandering. These crimes appear often in the sentences and the official documentation produced by antimafia institutions.

B.2 Synthesizing variables

Following this approach, we gathered 14 observed variables which provide tracks of a latent variable, organised crime, and tend be correlated. It is therefore possible to describe their variability in terms of a smaller number of underlying unobserved variables which, finally, can be condensed in one index. We find convenient to proceed in this way and use factor analysis as follows. First we identify the underlying factors that explain the pattern of correlation within our set of organized crime related variables. Next, we verified the validity of factor analysis using Bartlett and KMO measures. Then Varimax rotation was carried out to minimize complexity of factors by maximizing the variance of loading on each factor. In the next step based on various criteria (e.g. Kaiser Criteria) we extracted the first two factors which explained more than 80% of the total variation. Corresponding factor scores are then produced for each province-year by means of regression method. The importance of the factors depends on the percentage of variance explained by each of them; hence a composite index is eventually developed as a weighted sum of the scores for each year-province where the weight is the percentage of the variation explained by the factors. Finally, in order to compute the log transformation of the index we standardized the index to the scale of 0 to 100 to eliminate the negative values as follow:

$$OC\_Index_{igt} = (S_{py} - S_{min})/(S_{max} - S_{min}) \tag{1}$$

Where py denotes for province-year and S is the score value of each province-year with S_{min} and S_{max} denote for minimum and maximum values of aforementioned score.

C Coovariates

Following the literature in the field of technology and innovation, we control for several variables in our empirical analysis. Acemoglu et al. (2006) investigate the distance to the technology frontier effect on economic growth and consider education, which is proxied by the average years of schooling for over 25 males at the country level, as their control variable; in our paper we control for the total number of new university graduates in order to proxy education. We also control for change in exports as this variable is considered as one of the important control variables in the literature (Aghion et al., 2009; Blundell et al., 1999). Furthermore, we control for value added as a proxy for production related variables (Aghion et al., 2009; Bustos, 2011) as well as time fixed effect (Aghion et al., 2009; Acemoglu et al., 2006). Our other control variables in equation (1) are the number of applications a the European Office (EPO) for both patents and high-tech patents . We control for these variables in order to catch investments in R&D.

III Empirical Model

To examine the impact of organized crime on technology, we estimate several variants of the following model as we introduce different control variables which can affect the extent of technology:

$$Tech = \alpha + \beta_1 OC\_index + \beta_2 Control + \epsilon \tag{2}$$

In this model, we focus on the impact of organized crime (OC_index) on technology ($Tech$).[21] The technology index, which is based on the share of employees with a degree related to high-tech occupations, and actual relative revenues on a sectoral basis, is the dependent variable. Here, we expect to find that the coefficient associated with organized crime index, β_1, will take a negative sign: an increase in the organized crime will reduce the extent of technology by changing the industrial structure in the area where organized crime exists.

In evaluating the impact of organized crime on technology, we introduce several control variables into Equation (1). These variables relate to those that earlier research has shown

[21] Organized crime index is a synthesis of several variables which are currently used by DNA (National Anti-mafia Directorate) in anti-mafia investigations.

to be relevant in explaining the level of sectoral technology. For instance, the number of patents can be a good proxy for research and development, the number of university graduates suggests the extent of the available skilled labor force value added carries useful information about the efficiency of employees and fixed capital stock in generating quality products, exports finally indicate the level of technology embedded in the products.

We estimate Equation (1) several times using both ordinary least squares (OLS) and instrumental variables (IV) methodologies. The use of an instrumental variable approach is essential in a study such as ours as the endogeneity problem may affect the results due to the potential correlation between the explanatory variables and the disturbance term. If the residual in Equation 1 (ϵ) is correlated with the organized crime index due to reasons such as omitted variable bias or reverse causality, the use of OLS approach would lead to biased parameter estimates. For instance, one would arrive at a biased estimate for the effect of organized crime if one were not able to properly control for all of the determinants of technology at the province level, such as the efficiency of local provincial institutions, which may also affect the presence of organized crime. Furthermore, since we are interested in estimating the contemporaneous effects of the presence of organized crime on technology, there may be the problem of reverse causality: in this case, results could be biased because some specific provinces could attract more organized crime due to the speciality of their industrial technology profile. Hence, we also estimate our models using the two stage least squares (2SLS) approach. Although similarity of the estimates between OLS *versus* IV (2SLS) models strengthen the support for our claims, we put more trust in the 2SLS results due to above reasonings.

Given that the data are available on a province basis covering the period between 2005 and 2012, the next decision relates to whether we will use non aggregated data over several years or simple cross sectional analysis. We follow both approaches. We initially estimate Equation (1) after aggregating the data at the province level. More specifically, we estimate the relation based on the averages of the variables that constitute the model. Results from this approach will naturally use less information due to aggregation, but will allow us to portray the basic relation between organized crime and technology. In estimating the model based on aggregate data, we use both ordinary least squares as well as the two stage least squares approaches. After this initial exercise which allows us to demonstrate that the effect of organized crime on technology, we, next, exploit the panel aspect of the data.

Our second set of results are based on pooled linear models. Because the data are collected for each province, on an annual basis, one may suggest that the fixed effects panel data approach would be desirable. However, given that the time variation in organized crime within a province is small, introduction of fixed effects dummies into the model could easily shadow the true impact of organized crime on the dependent variable.[22] Hence, we employ pooled linear regression model by implementing the ordinary least squares approach and then using instrumental variable technique. It should be noted that when we took advantage of the panel context of the data, we always introduced year dummies into the model to capture the impact of annual events that the control variables we introduce fail to do so.

Our instrumental variable approach adopts the episode of forced exile to instrument the organized crime variable. As in Scognamiglio (2015), we employ information on the *concentration* of exiled convicted members of clans in each province. Specifically, we use as an instrument the number of convicted criminals who faced forced exile to provinces in northern Italy per province population. This ratio is a precious information in that allows gauging the organized crime viral load that was initially responsible for the subsequent low-tech mutation in the industrial fabric of the province.[23] The first stage regressions show that this variable is highly significant in explaining organized crime in northern Italy.

Lastly, we estimate Equation (1) using quantile regression models. Quantile regression models provide a more complete picture of the conditional distribution of the dependent

[22]We also estimated Equation 1 using fixed effects and IV FE methods. Results from these models showed that the effect of organized crime on technology is negative but when all control variables are added the significance of the organized crime index usually disappeared.

[23]It is worth noticing that this forced internal exile from the south to the north of the country took place between 1954 and 1990.

variable (technology) given the level of the independent variable (organized crime) when various deciles may be of interest. Here, too, we introduce all of the aforementioned control variables as well as year effects. We carry out the estimation with and without IV methods.

IV Empirical Results

Table 1 presents our initial results for the aggregate data. These results are obtained using both OLS and 2SLS methodologies. The first three columns present the results obtained from the OLS approach where the first column provides the benchmark model which does not contain any control variables. In column two and three we introduce our control variables. Columns two adds the number of high-tech patents received in a province per year. Column three introduces the number of new university graduates, one-year-change in exports, value added and the number of patents applications at the European Patent Office (EPO). In all there columns we observe that the effect of organized crime is negative. However, the effect of organized crime index in the first column is not significant. This insignificance may be due to lack of controls in the model. Indeed, this coefficient becomes significant at the 5% level in columns two and three when we introduce the control variables. Columns 7-9 provide results when we use 2SLS method where organized crime is instrumented by the concentration of force exiled convicted criminals per province. While column 7 presents again the benchmark model for IV estimates, the latter two columns include control variables in the order as noted earlier. All three columns show that the effect of organized crime is negative and significant at the 5% or 10% level. These results are interesting, as for all models we can demonstrate that the effect of organized crime is negative. Moreover, the results are significant.

It is worth noting that columns 4-6 provide the first stage regression results for which we instrumented organized crime with the concentration of force exiled convicted criminals per province, $Exiled\_Criminals$. In all three columns, the variable $Exiled\_Criminals$ is significant at the 5% level and the parameter estimates are similar across all cases. We should note that the same pattern repeats itself in Table 2.

Table 2 presents the results for the pooled models where we use the panel aspect of the data. Hence, we can exploit the information in the data better. We should note that in implementing the pooled regression models, we allow for within-province correlation such that standard errors of coefficient estimates are robust to clustering by province. In this table, columns 1-3 provide results when we estimate the model using the ordinary least squares approach. The last three columns provide estimates when we use 2SLS estimation technique for which we use the concentration of force exiled convicted criminals per province to instrument for organized crime.[24] Similar to Table 1, regardless of the estimation method, we observe that organized crime has a negative impact on technological progress. The effect is insignificant in column 1, which presents the benchmark model results. Again, the insignificance of the coefficient of organized crime may be due to missing variables. Indeed, as we add the number of high-tech patents applications as an instrument to column two, crime takes a significant negative coefficient. For the rest of the columns, columns 4 and 7-9, the effect is significant at the 5% level. As depicted in the tables, all models contain year dummies, which absorb the impact of annual events that the control variables would not capture.

In Table 3 we present three different panels of results based on quantile regression models. In constructing the results using quantile regression, we use the panel aspect of the data and present the parameter estimates for the first and the ninth deciles to capture the extremes as well as the second fourth and sixth deciles. Panels A and B provide the coefficient estimates without and with the control variables, respectively. panel C depicts the instrumental variable quantile regression (IVQR) results. As a consequence, differently from the first two panels, results in Panel C also accounts for the potential endogenity of the organized crime variable.

[24]First-stage F-statistics in different model specifications are between 10.24 and 16.96 which comfortably exceeds the Staiger and Staiger and Stock (1994) rule of thumb of 10, indicating that weak instrument are unlikely to be a concern in these specifications.

In all panels of the table, we see that organized crime takes a negative coefficient regardless of the decile that we inspect. The weakest results are observed for Panel A, the naive model which does not allow any control variables. The effect of organized crime for the eighth and ninth decile is insignificant but for other deciles presented here the coefficient is highly significant. For the case of Panel B the model yields insignificant results for the ninth decile only. When we inspect Panel C we observe that all coefficients are significant at the 1% level. The parameter estimates across different quantiles are remarkably similar around 10%.

A closer look at the quintile regressions presented in Table 3 implies that the effect of organized crime on technology may be nonlinear. In particular, the effect of organized crime is larger for the lower quantiles of the technology-revenue distribution. Although it is difficult to claim that the relation is monotonic, in the last panel the parameters displays a non-monotonic evolution with the progression of the deciles.

When we rank the difference in the extent of organized crime between provinces we come across a substantial range between areas that experience the least (index at .0375) and highest (index at .9312) crime levels. If we were to carry out a back of the envelope calculation, we see that a one percent increase in organized crime index leads to a 0.1% drop in the technology index. This is substantial. Overall, the results provide consistent evidence that there is a significant effect of organized crime on technological progress.

V Conclusions

In this paper, we examine the effects of organized crime on the technology level of northern Italy provinces. Our conjecture is that organized crime negatively affects technology as its interaction with entrepreneurs, politicians, and labor force diverts resources towards low-tech firms. To test this hypothesis, we craft indexes that portray the technology level and the presence of organised crime, and we design an identification strategy grounded on a natural experiment occurred in northern Italy: forced exile from south Italy of criminals belonging to clans. The technology index that we build offers a fine-grained description of the industrial sectors in terms of technology; this follows from using data for the whole firms population. The mafia-index captures the recent evolution of organised crime outside the head office; this is possible by employing the operating procedure followed by specialised DNA and DDAs anti-mafia prosecutors. In this context our investigation is unique as focuses on the richest part of the country, which experienced the forced exile of convicted criminals belonging to mafia-type associations. We use this information as an instrument to identify organized crime.

We pursue our empirical investigation using ordinary least squares, pooled linear regression models and quintile regression methods with and without the instrumental variables approach. The results, which are based on provincial level aggregate data and pooled data analysis, consistently provide support for the view that an increase in organized crime in a province leads to a fall of the technological level of that province. Specifically, we find that on average a 1% change in the organized crime index leads to a 0.1% fall in the technology index.

Our findings thus contribute to show that the damage caused by mafia-type organisations is not limited to the criminal offences hurting individual victims directly. Indeed, it also imposes a burden to the technological progress, which is a main determinant of economic growth, and thus hurts each member of the society.[25]

Arguably, these results can bear a social implication. Whenever there is evidence that organised crime harms each member of the society, and not just the victims directly offended, public awareness of organised crime as public bad can increase. This matters as lack of public awareness increases the likelihood that organised crime will keep spreading in rich and developed areas in general, which in turn is a key step to determine the role that mafia-type associations will play in the future (DallaChiesa, 2016).

[25] We guess that organised crime imposes a break to human capital accumulation too, and we are currently exploring this issue.

References

Acemoglu, D., P. Aghion, and F. Zilibotti (2006). Distance to frontier, selection, and economic growth. *Journal of the European Economic association 4*(1), 37–74.

Aghion, P., S. Bechtold, L. Cassar, and H. Herz (2014). The causal effects of competition on innovation: Experimental evidence. Technical report, National Bureau of Economic Research.

Aghion, P., R. Blundell, R. Griffith, P. Howitt, and S. Prantl (2004). Entry and productivity growth: Evidence from microlevel panel data. *Journal of the European Economic Association 2*(2-3), 265–276.

Aghion, P., R. Blundell, R. Griffith, P. Howitt, and S. Prantl (2009). The effects of entry on incumbent innovation and productivity. *The Review of Economics and Statistics 91*(1), 20–32.

Alesina, A., S. Piccolo, and P. Pinotti (2016). Organized crime, violence, and politics. Technical report, National Bureau of Economic Research.

Barone, G. and S. Mocetti (2014). Natural disasters, growth and institutions: a tale of two earthquakes. *Journal of Urban Economics 84*, 52–66.

Blundell, R., R. Griffith, and J. Van Reenen (1999). Market share, market value and innovation in a panel of british manufacturing firms. *The Review of Economic Studies 66*(3), 529–554.

Buccirossi, P., L. Ciari, T. Duso, G. Spagnolo, and C. Vitale (2013). Competition policy and productivity growth: an empirical assessment. *Review of Economics and Statistics 95*(4), 1324–1336.

Buonanno, P., G. Prarolo, and P. Vanin (2014). Organized crime and electoral outcomes in sicily.

Bustos, P. (2011). Trade liberalization, exports, and technology upgrading: Evidence on the impact of mercosur on argentinian firms. *The American economic review 101*(1), 304–340.

Calderoni, F. (2011). Where is the mafia in italy? measuring the presence of the mafia across italian provinces. *Global Crime 12*(1), 41–69.

Carpenter, R. E. and B. C. Petersen (2002). Capital market imperfections, high-tech investment, and new equity financing. *The Economic Journal 112*(477), F54–F72.

Cassazione (2015). Sentence n. 436. *Sez. 2*.

Ciccone, A. and E. Papaioannou (2009). Human capital, the structure of production, and growth. *The Review of Economics and Statistics 91*(1), 66–82.

DallaChiesa, N. (2016). *Passaggio a Nord - La colonizzazione mafiosa*. Edizioni Gruppo Abele.

De Feo, G. and G. De Luca (2013). Mafia in the ballot box.

DNA (2012). Relazione annuale sulle attività svolte dal procuratore nazionale antimafia e dalla direzione nazionale antimafia nonché sulle dinamiche e strategie della criminalità organizzata di tipo mafioso.

DNA (2014). Relazione annuale nel periodo 1 luglio 2012 - 30 giugno 2013.

DNA (2015). Relazione annuale nel periodo 1 luglio 2013 - 30 giugno 2014.

Fajnzylber, P., D. Lederman, and N. Loayza (2002). What causes violent crime? *European Economic Review 46*(7), 1323–1357.

Fallah, B., M. D. Partridge, and D. S. Rickman (2014). Geography and high-tech employment growth in us counties. *Journal of Economic Geography 14*(4), 683–720.

Gambetta, D. (1996). *The Sicilian Mafia: the business of private protection*. Harvard University Press.

Heckler, D. E. (2005). High-technology employment: a naics-based update. *Monthly Lab. Rev. 128*, 57.

Kearns, A. and F. Ruane (2001). The tangible contribution of r&d-spending foreign-owned plants to a host region: A plant level study of the irish manufacturing sector (1980–1996). *Research Policy 30*(2), 227–244.

Luana, D. F., U. Dinello, and G. Rossi (2015). *Mafia a Nord-est.* Rizzoli.

Nickell, S. J. (1996). Competition and corporate performance. *Journal of political economy*, 724–746.

Pinotti, P. (2015). The economic costs of organised crime: evidence from southern italy. *The Economic Journal 125*(586), F203–F232.

Raymond, W., P. Mohnen, F. Palm, and S. S. Van Der Loeff (2010). Persistence of innovation in dutch manufacturing: Is it spurious? *The Review of Economics and Statistics 92*(3), 495–504.

Scognamiglio, A. (2015). When the mafia comes to town. *CSEF working paper 404.*

Sparagna, R. M. (2015). Metodo mafioso e c.d. mafia silente nei più recenti approdi giurisprudenziali. *Diritto Penale Contemporaneo*.

Staiger, D. O. and J. H. Stock (1994). Instrumental variables regression with weak instruments. *National Bureau of Economic Research Cambridge, Mass., USA*.

Transcrime (2013). *Progetto PON Sicurezza 2007-2013: Gli investimenti delle mafie. Rapporto Linea 1.* Milano: Ministero dellInterno. www.investimentioc.it.

Varese, F. (2011). *Mafias on the Move.* Princeton University Press.

Figure 1: Industrial Sectors' technological classification based on US NAICS 2009 (1)

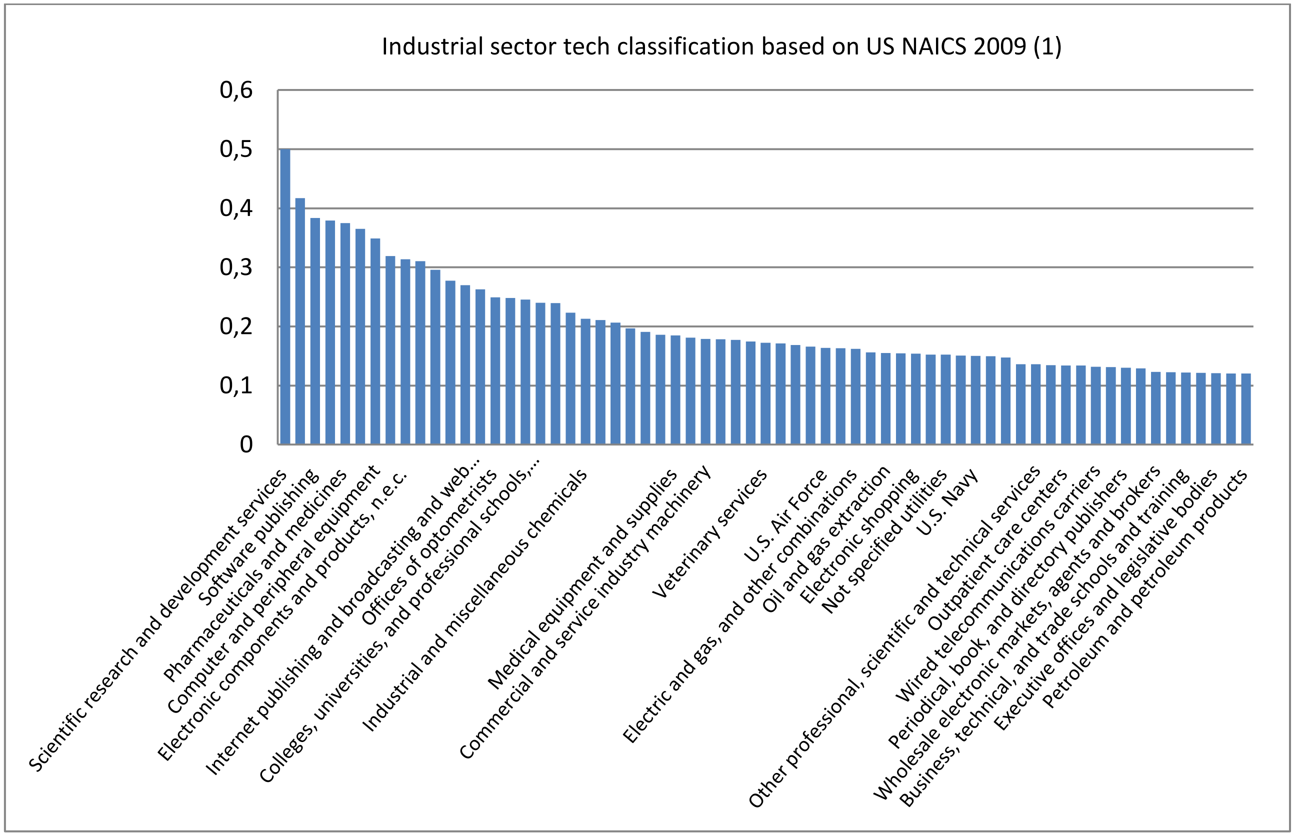

Figure 2: Industrial Sectors' technological classification based on US NAICS 2009 (2)

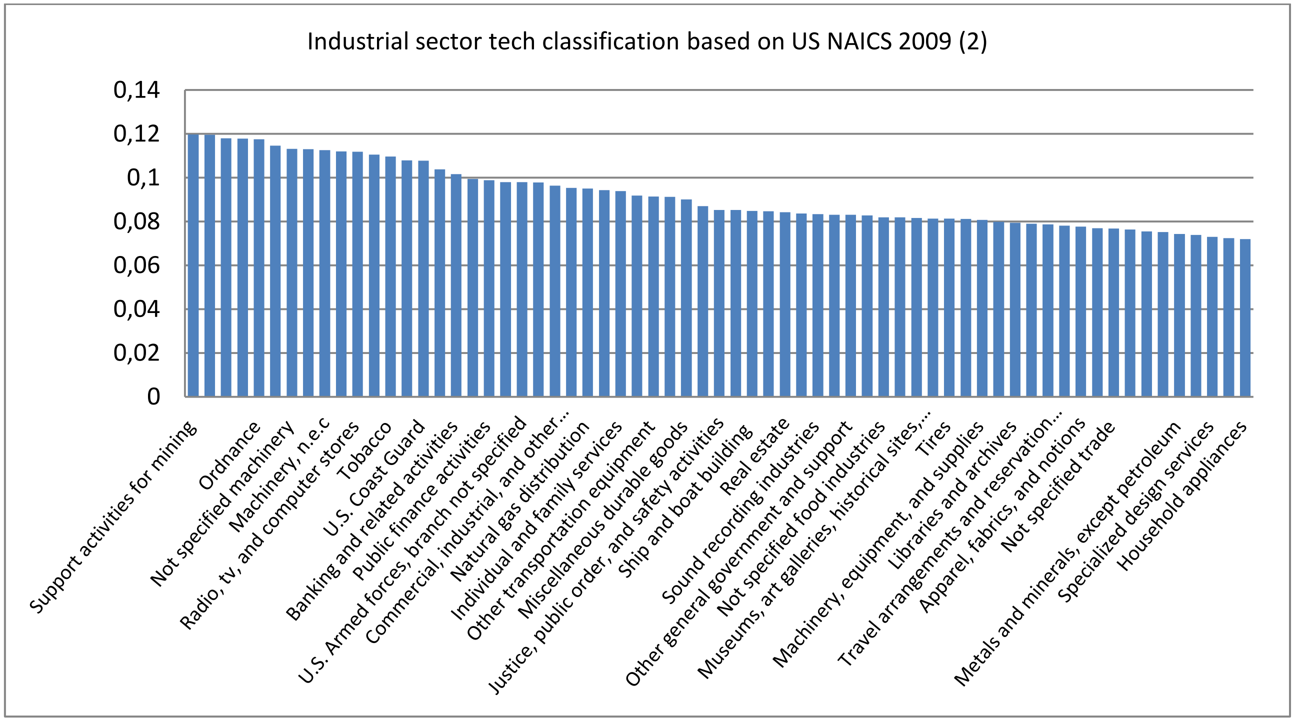

Figure 3: Industrial Sectors' technological classification based on US NAICS 2009 (3)

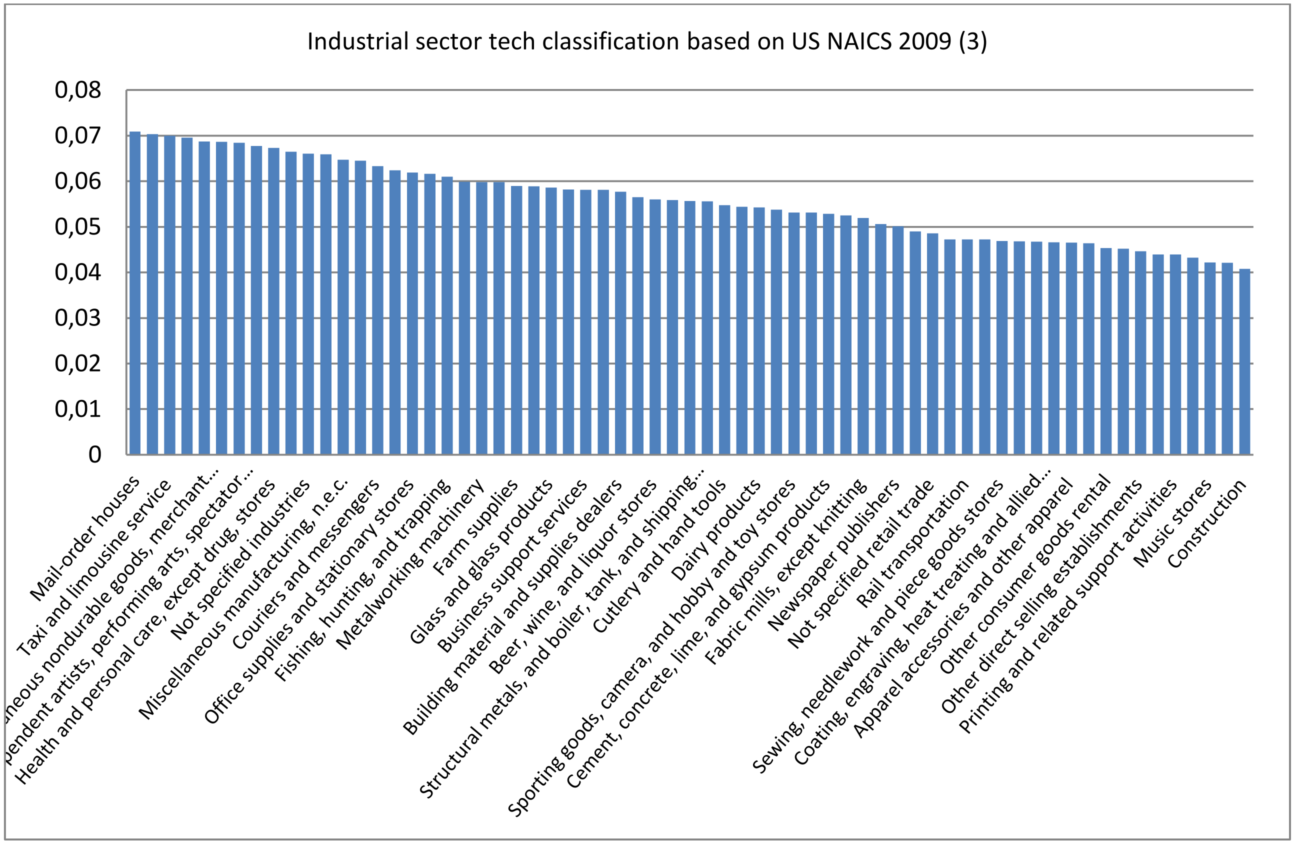

Figure 4: Industrial Sectors' technological classification based on US NAICS 2009 (4)

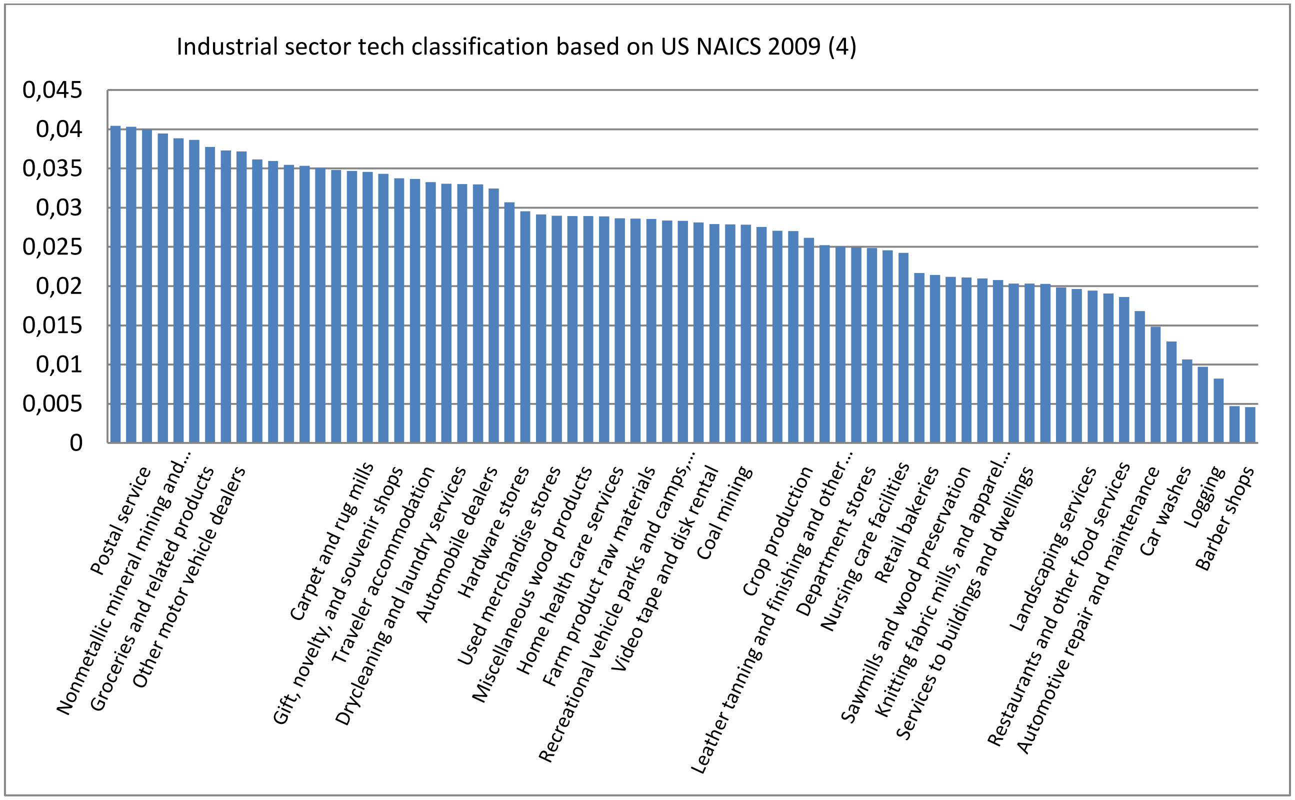

Table 1: Organized crime and average technology level in provinces, OLS and 2SLS estimates (aggregate data)

	(1) OLS	(2) OLS	(3) OLS	(4) FS	(5) FS	(6) FS	(7) IV	(8) IV	(9) IV
log_oc_index*	-0.054	-0.073***	-0.078***				-0.23***	-0.09*	-0.08*
	(0.04)	(0.028)	(0.027)				(0.09)	(0.05)	(0.05)
Exiled Criminals				0.1***	0.13***	0.13***			
				(0.05)	(0.05)	(0.05)			
High-tech Patents		0.008***	0.01***					0.008***	0.013***
		(0.001)	(0.004)					(0.002)	(0.005)
Other Controls			Yes						Yes
N.Observations	39	39	39	39	39	39	39	39	39

Notes. Robust standard errors cluster at province level are in parenthesis. Significance levels: *** p<0.01, ** p<0.05, * p<0.1. Other controls are One-year-change in Exports, Patent Applications to EPO, Value Added and Total University Graduates.

Table 2: Organized crime and average technology level in provinces, OLS and 2SLS estimates

	(1) OLS	(2) OLS	(3) OLS	(4) FS	(5) FS	(6) FS	(7) IV	(8) IV	(9) IV
log_oc_index*	-0.051	-0.057***	-0.058***				-0.24***	-0.13*	-0.1*
	(0.035)	(0.02)	(0.03)				(0.09)	(0.06)	(0.05)
Exiled Criminals				0.1***	0.11***	0.12***			
				(0.04)	(0.04)	(0.04)			
First stage F-stat				14.39	16.96	10.24			
High-tech Patents		0.006***	0.006***					0.007***	0.013*
		(0.001)	(0.002)					(0.001)	(0.007)
Other Controls			Yes						Yes
N.Clusters	40	40	39	40	40	39	40	40	39
N.Observations	319	292	254	319	292	254	319	292	254
Year fixed effects	yes	yes	yes	yes	yes	yes	yes	yes	yes

Notes. Robust standard errors cluster at province level are in parenthesis. Significance levels: *** p<0.01, ** p<0.05, * p<0.1. Other controls are One-year-change in Exports, Patent Applications to EPO, Value Added and Total University Graduates.

Table 3: Organized crime and average technology level in provinces, QR and IVQR

	(1) 1^{st} decile	(2) 2^{nd} decile	(3) 4^{nd} decile	(4) 6^{th} decile	(5) 8^{th} decile	(6) 9^{th} decile
A: Quantile						
log_oc_index	-0.1***	-0.11***	-0.07***	-0.08***	-0.02	-0.002
	(0.01)	(0.02)	(0.02)	(0.02)	(0.017)	(0.02)
year fixed effects	yes	yes	yes	yes	yes	yes
N.Observations	319	319	319	319	319	319
B: Quantile						
log_oc_index	-0.1***	-0.1***	-0.06***	-0.065***	-0.04***	-0.02
	(0.02)	(0.02)	(0.02)	(0.019)	(0.015)	(0.03)
year fixed effects	yes	yes	yes	yes	yes	yes
Controls	yes	yes	yes	yes	yes	yes
N.Observations	254	254	254	254	254	254
C: IVQREG						
log_oc_index	-0.1***	-0.1***	-0.05***	-0.084**	-0.1***	-0.09***
	(0.008)	(0.007)	(0.006)	(0.006)	(0.007)	(0.008)
Controls	yes	yes	yes	yes	yes	yes
year fixed effects	yes	yes	yes	yes	yes	yes
N.Observations	286	286	286	286	286	286

Notes. Robust standard errors in parenthesis. Significance levels: *** p<0.01, ** p<0.05, * p<0.1. Controls include High-tech Patent Applications, One-year-change in Exports, Patent Applications to EPO, Value Added and Total University Graduates.