Prices, Policing and Policy
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The Dynamics of Crime Booms and Busts

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Abstract

In many historical episodes, criminal activity displays booms and busts. One clear example is the case of metal crime in the UK (and elsewhere) where, in the face of big increases in value driven by world commodity prices, thefts rose very sharply in the 2000s, after which they fell. This paper studies the respective roles of prices, policing and policy in shaping this crime boom and bust. Separate study of each reveals metal crime being driven up via sizeable and significant metal crime-price elasticities and driven down by changes in policing and policy. A regression-based decomposition analysis confirms that all three of the hypothesised factors considered in the paper – prices, policing and policy – were empirically important in the different stages of metal theft's boom and bust.

1. Introduction

In many historical episodes, criminal activity displays booms and busts. At different times variations in crime rates in society arise from interactions between the supply and demand of crime, namely between potential offenders and their environment (Cook, 1986). Both exogenous and endogenous shocks affect potential offenders and their environment such that the expected returns to crime and crime rates vary over time. Potential factors influencing crime dynamics include the direct returns to crime, labour market circumstances, as well as endogenous responses to crime by potential victims and institutions. In recent decades, increases in criminal activity have been observed in Western developed economies in the 1960s and 1970s (Cohen and Felson, 1979) and in China and Eastern Europe in the 1990s (Van Dijk, 2008), followed by a decrease in the US and other Western economies since the 1990s (Van Dijk and Vollaard, 2012). Generating an understanding of the reasons behind these fluctuations in criminal activity is a first order research question in the economics of crime.

One recent, very clear, example of crime boom and bust has been the case of metal crime. In the last ten to fifteen years, there were spectacular increases in metal crimes in many countries.[1] In the UK, starting from the mid-2000s metal theft more than doubled, reaching unprecedented levels by 2011. However, as with other (crime) booms, a bust followed this, at least in the context of the UK. Metal theft has fallen very rapidly since near the start of the current decade.

These swift and steep fluctuations in metal theft occurred in the context of a relatively stable population of potential offenders, which suggests that changes in the inherent propensity

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[1] Examples from recent years include the theft of more than 700 meters of iron from the Longfellow Bridge in Boston, MA, United States in 2008, the theft of power transmission wires that caused a four-hour power outage in Canada in 2011, and the theft of a 10-ton bridge in Czech Republic in 2012 (see, respectively: http://archive.boston.com/news/local/massachusetts/articles/2008/09/12/case_of_the_purloined_ironwork/; http://www.thepeteroroughexaminer.com/2011/09/01/power-outage-north-of-city-caused-by-wire-theft; and http://www.telegraph.co.uk/news/newstopics/howaboutthat/9235705/Czech-metal-thieves-dismantle-10-ton-bridge.html).

of potential offenders to abide by the law are unlikely to explain the full scale of this boom and bust. Moreover, the broader crime dynamics observed in Western economies since the 1990s did not follow the same trajectory (see Van Dijk and Vollaard, 2012), showing that specific crimes can display sudden booms and busts that need not co-evolve with those of other crimes. While many crimes may have reduced since the 1990s, such as domestic burglary, car theft and theft of smartphones, other crimes followed their own trajectory, with metal theft being one of them.

This paper researches the dynamics of metal crime. The crime movements embodied in the boom and bust are studied to more generally consider how crime dynamics are determined by the interaction of economic incentives, policing and policy interventions. The metal crime boom and bust in England and Wales is, in fact, one extreme example of how both exogenous and endogenous idiosyncratic shocks in the potential offenders' environment can shape crime dynamics. The UK setting offers a particularly good testing ground, first because of the scale of the crime changes, and second because the big crime increases generated policing and policy responses that can be analysed as quasi-experiments that can potentially affect crime. As such, this paper provides rare empirical evidence for what Philipson and Posner (1996) referred to as the "self-correcting character of crime epidemics".

Over and above the boom and bust, metal theft is a particularly useful crime to study in economic research for several reasons.[2] First, from a purely economic perspective, one defining characteristic of metal crimes is their motivation for the prospective criminal. Whereas other property items are generally stolen for their extrinsic value, items involved in metal theft are stolen for their intrinsic value as raw materials or commodities. Indeed, these thefts often have

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[2] The terms "metal crime" and "metal theft" are used interchangeably throughout the paper. Both terms refer to thefts of items for the value of their constituent metals, rather than the acquisition of the item. Apart from precious metals like gold and silver, the metals most commonly stolen are non-ferrous metals such as copper, lead, aluminium, brass, and bronze. However, even cast iron and steel have experienced higher rates of theft which coincided with increased scrap metal prices.

negative externalities much greater than the value of the metal stolen, such as the destruction of valuable statues, power interruptions, and the disruption of railway traffic. Additional indirect costs generated by metal theft (e.g. in the forms of higher costs of insurance) are also estimated to be in the order of several millions of British pounds every year.[3] Second, there is a liquid market with public market prices for both new and scrap metal. Third, much of the price fluctuations seen in the 2000s was driven by a surge in commodity prices as the rapid economic development of China that has increased its demand for metals unfolded, with copper being a striking case in point. Therefore, in all likelihood, the extraordinary increase in prices for some of those (scrap) metals provided an economic incentive to steal more metal from the railway network, other utilities and beyond.

The empirical analysis starts by examining whether the changing prices of metals affect the level of crime over time. Administrative records of metal crime from the British Transport Police (BTP) and the Metropolitan Police Service (MPS) of London were combined with data on international metal prices and local scrap metal prices in the UK from 2007 to 2015. Sizeable crime-price elasticities emerge from this analysis, revealing a strong sensitivity of metal crimes to scrap metal prices. Big increases in commodity prices, in particular in the prices of metals, occurred worldwide in the 2000s. This substantively increased metal values, and in line with models where the economic returns to crime matter for people's decisions on whether or not to engage in crime (Becker, 1968, Ehrlich, 1973, 1996), it increased metal crime too. Draca et al. (2018) reveal there to be sizeable metal crime-price elasticities in London in this wave of metal crime.

The subsequent parts of the paper investigate the impact on metal crime of the responses by the institutions in the UK. By 2011, the scale of metal theft in the UK had reached

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[3] As an example, the insurance cost for the Church of England hit approximately £10 million pounds in 2011 as a result of metal theft (http://www.telegraph.co.uk/news/uknews/crime/9126648/Metal-theft-costs-Church-of-England-10-million.html).

unprecedented levels.[4] As a response, the BTP introduced an anti-metal crime policy called "Operation Tornado". The UK government also responded by introducing the Scrap Metal Dealers Act of 2013, which came into force in England and Wales in October 2013. Whether these policing and policy interventions affected the path of metal crime is therefore studied.

The second main part of the empirical analysis focuses on the impact of policing on metal theft. This analysis exploits exogenous variation in the intensity of policing across a panel of police force areas induced by a novel initiative of the BTP, called Operation Tornado (OT). Since OT was introduced gradually across police force areas in England and Wales from January to September 2012, a difference-in-differences specification is defined where the late adopters of OT are used as controls for the early adopters. This analysis uncovers a significant negative effect of OT on metal crime, showing the critical role of policing in shaping crime dynamics.[5]

The paper then moves on to study the third question, by looking at the impact of the Scrap Metal Dealers Act (SMDA) of 2013 on both the economic activity of Scrap Metal Dealers (SMDs) and on metal crime. The SMDA 2013 came into force in October 2013 and it superseded the SMDA of 1964. Amongst other things, the SMDA 2013 introduced new provisions for the issuance and revocation of a scrap metal licence, for the verification of scrap metal suppliers' identities and it introduced the offence of buying scrap metal for cash. By regulating the economic activity of SMDs, this policy intervention *de facto* increased the risk of being apprehended and punished for selling stolen metal to SMDs. This part of the paper utilises a panel of firm-level data to exploit variation across firms in the intensity of the exposure

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[4] Figure A1 in the Appendix shows that media coverage of metal theft in UK National Newspapers increased dramatically in 2011 and 2012 from previous years, and it returned to the pre-2011 levels from 2013 until today.

[5] Morgan et al. (2015) constitute an early attempt to evaluate the effectiveness of Operation Tornado in reducing metal theft. However from their analysis, since they use data post the Scrap Metal Dealers Act (SMDA) 2013 without properly controlling for it, it is impossible to separate out the impact of Operation Tornado from the impact of the SMDA 2013 on metal theft. Moreover, they do not present any evidence of statistically indistinguishable pre-treatment trends in metal crime between their treatment and control group regions.

to the provisions of the SMDA 2013. A difference-in-differences specification is defined comparing the economic activity of SMDs with the economic activity of pawnshops and other firms involved in the collection of non-hazardous waste, in the recovery of sorted materials, in the wholesale of metals and metal ores, and in the wholesale of waste.

The results show that, following the SMDA 2013, SMDs in England and Wales experienced a significant reduction in their economic activity, as measured by their turnover, turnover per employee and profit margin. A genuine reduction in metal crime brought about by the new stricter regulation regime of the SMDA 2013 may be behind this slowdown in the economic activity of SMDs; however, the SMDA 2013 may have as well just added a bureaucratic burden to SMDs, without actually affecting metal crime. For example, it may have simply resulted in a large additional amount of paperwork for SMDs to comply with, that may have discouraged small transactions and, in turn, that may have reduced their economic activity.

The final piece of evidence develops a common regression-based decomposition framework to assess the respective impacts of prices, policing and policy (i.e., metal prices, OT and the SMDA 2013) on the surge and decline in metal crime rates in the UK. More generally, this common regression-based decomposition framework of analysis documents the critical roles of economic incentives, policing and legislation by policymakers in shaping the evolution of crime dynamics. All three of the hypothesised factors considered in the paper influenced the environment in which potential metal thieves operated in the last decade. This is a relevant finding not only for the market of metals, as lessons can be learnt also on the likely crime-reduction effects of institutional responses (e.g. stricter regulation) in other industries, such as for cars, smartphones and credit cards.

The rest of the paper is structured as follows. Section 2 describes the aggregate time series data, offer some descriptive analysis and present estimates of metal crime-price elasticities. Section 3 shows the statistical results on policing and metal crime using a police

force area panel, and Section 4 presents the results of the firm-level analysis of how specific legislation affected SMDs. Section 5 offers a common regression-based decomposition framework of analysis of the determinants of crime dynamics, as well as an interpretation and discussion of the findings of this paper. Section 6 concludes.

2. Metal Crime and Prices

The empirical analysis begins with an investigation of the impact of metal prices on the incidence of metal theft. In the analysis of the determinants of crime dynamics, this is a natural departure point since prices represent the direct benefit from engagement in property crime. In the case of metals (unlike for other prices, like some of the consumer goods studied in Draca et al., 2018), the resale price is likely to be the actual price when selling on to a scrap metal merchant. These prices (e.g. for copper, lead or aluminium) are largely determined on international commodity markets and, thus, the exogenous nature of international metal prices allows identification of the causal impact of changes in scrap metal prices on metal crime.

To date, only a few studies have investigated the impact of prices on crime. Using British data, Reilly and Witt (2008) show that the fall in the real price of audio-visual goods led to a reduction in domestic burglary. D'Este (2014) presents evidence from the US on the positive link between the size of the local market for the trade of stolen property and the responsiveness of burglars to changes in prices. In particular, he shows that the predetermined stock of pawnshops in a county increases the consequences of variations in gold prices for burglaries. Draca et al. (2018) use data from the Metropolitan Police Service (MPS) of London to present evidence of significant positive crime-price elasticities for a panel of 44 consumer goods and for commodity related goods (jewellery, fuel and metal crimes). Draca (2016) also points to the role of prices in explaining the fall in crime in the UK since the early 1990s. Braakmann et al. (2017) show that increases in the price of gold lead to disproportionate

increases in property crime in neighbourhoods in the UK with a large share of South Asian population, the rationale for this finding being due to the perception that South Asians keep a substantial amount of gold in their properties. Thus, the expected return to property crime increases in these neighbourhoods when the price of gold rises. In criminology, there are a number of case studies that focused on goods such as copper cable (Sidebottom et al., 2011; and Sidebottom et al., 2014), electrical equipment (Wellsmith and Burrell, 2005) and livestock (Sidebottom, 2013).

This section of the paper sets up an empirical framework to study the role of prices in the metal crime boom and bust. First, metal crime-price elasticities are estimated using different data sources. Then the robustness of the estimated metal crime-price elasticities to the inclusion of additional variables, notably male unemployment to reflect labour market incentives and lagged metal crime to model crime dynamics, is probed.

Research Design

To investigate metal crime-price elasticities, and their robustness to the inclusion of additional controls in the analysis, a time series analysis is conducted. In formal terms, the following log-log specification is estimated:

$$Log(MT_t) = \alpha_1 + \beta_1 Log(SP_t) + \gamma_1 X_t + f(t) + v_{1t} \tag{1}$$

where MT_t is the count of metal crime incidents in England and Wales in month t and SP_t are local scrap metal prices in month t. X_t is a vector of controls that includes male unemployment in month t and MT_{t-1}, i.e., the value of metal crime in month $t-1$, while f(t) represents a time control. This is modelled either through a linear time trend or a set of year fixed effects. Controlling for male unemployment aims to estimate the effect of labour market conditions on metal crime. Since potential offenders are likely to be males and to hold low levels of educational attainment and labour market attachment, male unemployment proxies the crime-work choice for the bulk of potential offenders. The one-month-lag value of metal crime was

also included in the equation to test the robustness of the estimated metal crime-price elasticities to the inclusion of past levels of metal crime in the equation. This is relevant due to the potential serial correlation in metal crime and its potential correlation with metal prices.

Equation (1) forms a baseline specification with the key parameter of interest being β_1, the metal crime-price elasticity. There are at least two reasons why one might worry about the estimate of β_1 being biased. First, it may not reflect a causal impact of metal prices on metal crime if simultaneity bias arises from some unobserved factors specific to England and Wales that may have an effect on both the dependent variable and the key explanatory variable of interest. For example, a well-known problem of omitted variable bias would derive from the potential presence of unobserved UK-specific economic shocks during the study period that may have influenced metal prices in the UK as well as may have had an independent effect on metal crime. To circumvent this, international metal prices are used to instrument local scrap metal prices.

In formal terms, the instrumental variable (IV) approach can be described in terms of the two reduced forms:

$$Log(SP_t) = \alpha_2 + \beta_2 Log(IP_t) + \gamma_2 X_t + f(t) + v_{2t} \tag{2}$$

$$Log(MT_t) = \alpha_3 + \beta_3 Log(IP_t) + \gamma_3 X_t + f(t) + v_{3t} \tag{3}$$

where IP_t is the international price of metals in month t.

In the first stage (2), estimates of β_2 show the impact of international metal prices on local scrap metal prices in England and Wales. Equation (3) is the reduced form regression of log metal theft on the instrument. The IV local average treatment effect (LATE) estimate of the metal crime-price elasticity is then the ratio of the reduced form to the first stage coefficient, β_3/β_2.

The second modelling issue arises because of the highly seasonal nature of crime. Thus, seasonally differenced versions of equations (1) to (3) are also presented where all variables are

transformed by the 12-month operator, Δ_{12}, to remove systematic month-specific unobservable effects from the data. For example, equation (1) now becomes:

$$\Delta_{12}Log(MT_t) = \alpha_4 + \beta_4\Delta_{12}Log(SP_t) + \gamma_4\Delta_{12}X_t + f(t) + \Delta_{12}v_{4t} \qquad (4)$$

Data

Information on metal crime comes from two data sources. The first is the administrative dataset of criminal offences collected by the British Transport Police (BTP). This contains detailed information on all crimes recorded by the BTP from January 2007 until December 2015. Among the categories of crime recorded, it includes information on metal crime and scrap metal dealer offences. Detailed information on the precise nature, time (i.e., hour and date) and location (i.e., latitude and longitude) of each crime incident is collected.

The BTP data covers the regions of England, Wales and Scotland. In total, it contains detailed information on 940,227 crime incidents that occurred in these regions from January 2007 to December 2015 and that were recorded by the BTP. The BTP administrative microdata were aggregated up at the monthly level in order to obtain the count of stolen metals in each month from January 2007 to December 2015.

A second source of data on metal crime comes from the administrative records of the Crime Record Information System (CRIS) of the Metropolitan Police Service (MPS). The CRIS contains information on the type and count of metal stolen in thefts, burglaries and robberies. It constitutes the standard crime recording system of the MPS, with stolen properties grouped by type at the two-digit level. The CRIS provides metal crime records separately for seven categories of metal - gold, silver, copper, lead, brass, aluminium and a residual group of other metals. Data are used from January 2005 to December 2015 for some descriptive analysis, and from January 2007 to December 2015 when used alongside the BTP data in the statistical modelling. For a given month, the metal crime records indicate the count of a stolen metal across all incidents in that month. Thus, for example, if a set of metals were stolen in a given

incident, each of the different metals would be recorded separately as a stolen item by the CRIS of the MPS. The MPS crime records for different metals were also summed to obtain monthly counts of metal crime in the London area covered by the MPS.

The administrative time series records of metal crime from the BTP and the MPS were combined with monthly time series data on scrap metal prices and labour market dynamics. Direct data on scrap metal prices were collected from www.letsrecycle.com, a trade industry media outlet for the waste management and recycling sector. On www.letsrecycle.com, monthly scrap metal prices are available for the period 2007 to now for many types of ferrous and nonferrous metals. These are the prices metal thieves are likely to view as the true resale value from metal crime.

Data on world prices from international commodity markets were also collected for this study due to the potential endogeneity of local scrap metal prices in the determination of metal crime. International metal prices were collected from the online platform "Index Mundi", where data on international metal prices are measured in pounds sterling and are available at the monthly frequency.

Finally, data on labour market conditions were extracted from the UK Quarterly Labour Force Survey (QLFS) data from 2007 to 2015. The QLFS covers the whole of the UK and it was used for this analysis as it collects nationally representative information on demographics and labour market conditions of the working-age population in England and Wales.

To permit seasonal differencing, the empirical analysis presents results for monthly data running from January 2008 to December 2015, so that the analysis is conducted on a total of 96 months of data.[6] Results for a range of empirical specifications are presented for the whole of England and Wales based upon the BTP data, and for London only using both the BTP data and the MPS data.

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[6] Data from 2007 were only used to retrieve the 12-month differenced value of metal crime in 2008.

Descriptive Analysis

Figure 1 shows the monthly count of metal crime incidents in England and Wales from BTP data from January 2007 to December 2015 and from January 2005 to December 2015 in London from MPS data. The Figure very clearly shows the metal crime's boom and bust. A rapid increase occurs from 2005 which runs through to 2011 (notwithstanding a drop down when the Great Recession hit). In 2010 and 2011 the incidence of metal crime hit a record high. After this, metal crime fell rapidly.

Figure 2 shows the temporal evolution of log values of metal crime in England and Wales and log values of scrap metal prices in England and Wales. Two distinct features are noticeable about the time series displayed in Figure 2. First, the Figure shows that metal prices also grew in those years, and they too hit a record high in 2011. Up until 2012, Figure 2 shows metal prices and metal crime to follow very similar trends over time, arguably reflecting the responsiveness of metal crime to metal prices. One interpretation of Figure 2 is that, from 2007 to 2011, metal crime dynamics were driven by the fluctuating, mostly growing, incentives to steal and sell metal.

By 2011, the scale of metal crime in the country reached unprecedented levels, and a sense spread across politicians, police forces and the media that metal crime had become a major problem. It cost the lives of some thieves trespassing on the railways, it carried large financial costs for the Network Rail (NR), it disrupted transport services, it caused large costs for cultural heritage, at the same time generating large financial costs for insurers. For these reasons, anti-metal crime policing and policy interventions started to be viewed as necessary to tackle "Britain's most annoying crime wave" (BBC, 28 September 2011[7]).

The second noticeable feature of Figure 2 is the negative trend in metal crime from 2012 to 2015. Although metal prices did not continue on the positive trend experienced from 2007

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[7] See http://www.bbc.co.uk/news/magazine-15062064

to 2011, they remained quite stable after 2011. In contrast, starting from 2012, metal crime fell sharply. Figure 3 shows the residual (log) metal crime after (log) metal prices have been taken into account. In Figure 3 a clear difference appears in the residual incidence of metal crime between the periods before and after January 2012. This is after prices have been taken into account in the determination of metal crime, thus it suggests that the fall in metal crime from 2012 to 2015 cannot be explained entirely by the interruption of the pre-2012 positive trend in metal prices.

Figure 4 provides an additional piece of evidence that is consistent with this claim. In Figure 4, the predicted evolution of metal crime based on pre-2012 metal prices is added to Figure 2. To this end, data on metal crime and metal prices was used from January 2007 to October 2011 – this choice of data timing ensures that it is prior to the Chancellor George Osborne's announcement of the UK government's intention to use £5 million of Treasury funding to set up a nationwide metal crime taskforce.[8]

Figure 4 very clearly suggests that, based on the pre-2012 metal prices, metal crime should have remained relatively stable until the end of 2013, with only a marginal decline between 2014 and 2015. The actual evolution of metal crime in England and Wales looks different from this prediction, as it shows a steeper fall starting from 2012. This was possibly the result of the anti-metal crime policing and policy interventions implemented in England and Wales starting from 2012.

Sections 3 and 4 below respectively subject these descriptive observations on policing and policy to a rigorous statistical testing exercise that defines coherent sets of treatment and control groups to evaluate the plausibility of the hypothesised statements. The remainder of this section evaluates the first hypothesis on the crime-price relation in a more formal statistical analysis.

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[8] See http://researchbriefings.files.parliament.uk/documents/SN06150/SN06150.pdf

Statistical Results on Crime and Prices

Tables 1 and 2 show the results from the time series analysis that estimates metal crime-price elasticities. Results are presented for three data sources - the BTP data for the whole of England and Wales; the BTP data for London only; and the London MPS data. In Table 1, columns (1) to (4) show metal crime-price elasticities without seasonal differencing and columns (5) to (8) show the seasonal differencing equivalents. Either a linear time trend control or year fixed effects were included in all estimates, and Newey-West standard errors with serial correlation of order one (i.e., one month) were used for inference and are reported in parentheses.[9]

Throughout the Table, the estimated metal crime-price elasticities are statistically significant and sizeable, with magnitudes greater than unity. Seasonal differencing slightly decreases the size of the estimated elasticities, but they remain above unity in all but one case (where an OLS estimate is 0.90) and statistically significant at all conventional levels. Comparisons of the OLS elasticities in columns (1) and (5) with the IV elasticities in columns (4) and (8) show the OLS estimates to be downward biased. This may be due to potential measurement error in local scrap metal prices in England and Wales, or due to the presence of relevant omitted factors that may be correlated with local scrap metal prices.

The results in Table 1 also show metal crime-price elasticities to be greater in London than in the rest of England and Wales. The seasonally-adjusted metal crime-price elasticities in London appear very similar whether they are calculated using the BTP data or the MPS data. Greater metal crime-price elasticities appear in London both when comparing the estimates from the BTP data for England and Wales with estimates from the BTP data for London only, and when comparing the estimates for England and Wales with those derived from the MPS data.

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[9] Use of Newey-West standard errors with serial correlation of order 12 (i.e., 12 months) gave very similar results leading to entirely consistent conclusions. Tables A1 and A2 in the appendix display these results.

Table 2 shows the robustness of the estimated IV metal crime-price elasticities to estimating a richer Becker economics of crime specification. The analysis is again based upon analysis of the three datasets used in Table 1 (i.e. BTP data for England and Wales, BTP data for London and MPS data), and controls are added for male unemployment and lagged metal crime to the IV metal crime equation. These results are shown in the upper panel of Table 2. The estimated coefficients for metal prices appear smaller in all specifications compared to Table 1, although they remain large and statistically significant at the one percent level. However, for a direct comparison between the metal crime-price elasticities reported in Table 1 and those in Table 2, when lagged values of metal crime are additionally included in the set of covariates, long run crime-price elasticities are calculated as $\beta_k/(1 - \lambda_k)$, where β_k is the estimated coefficient for Log(Scrap Price) and λ_k is the estimated coefficient on the lagged dependent variable. These long run elasticities are directly comparable with those in Table 1. They are reported below the list of estimated coefficients in each column of Table 2, and are of very similar magnitude to those from the static models reported in Table 1. Male unemployment appears to be a positive predictor of metal crime, suggesting that deteriorating labour market conditions and increased joblessness may induce an increase in metal crime. A word of caution is in order though, since the crime-unemployment elasticities do not appear statistically significant when seasonal differencing is applied to the analysis.[10] The estimates for lagged metal crime suggest there is strong serial correlation in the incidence of metal crime, as the estimated coefficients are positive and significant in all reported specifications.

The lower panel of Table 2 shows what happens to these results when the linear time trend is replaced with year fixed effects in the estimated equation. While male unemployment

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[10] This finding is entirely in line with Freeman's (1999) observation that the crime-unemployment relationship across the whole population is often sensitive to specification choice. More recent reviews confirm this, arguing that one should focus more on data on youths to uncover unemployment effects on crime (for example, see Mustard, 2010, and Buonnano et al., 2011). For the purposes of the analysis here, it is reassuring that the price elasticities are not sensitive to the presence or otherwise of an unemployment impact on metal crime.

no longer appears to predict significantly metal crime, the lagged value of metal crime still appears as a positive and significant predictor of metal crime. The estimated crime-price elasticities also appear robust to the inclusion of year fixed effects in the equation. In some cases, the estimated crime-price elasticities appear even larger than in the upper panel.

Table A3 in the Appendix presents a series of falsification tests based upon identical IV specifications to Table 2, but where instead the incidence of all other thefts (total thefts excluding metal thefts) is used as dependent variable. Some predictive power of scrap metal prices emerges when male unemployment and lagged values of other thefts are omitted from the analysis. However, no significance ever appears when the covariates are included. Moreover, regardless of specification, these other theft-price elasticities are tiny when compared to the metal theft-price elasticities of Tables 1 and 2. This offers a good placebo test to show the strongly significant coefficients in Tables 1 and 2 are not the spurious result of an underlying aggregate crime trend. In contrast, it supports the notion that metal crime is highly responsive to its direct economic incentives.

Thus, the general conclusion that emerges throughout the estimates reported in this section is that metal crime is highly responsive to fluctuations in metal prices. This is the case regardless of whether labour market conditions or past metal crime are taken into account. It strongly suggests that potential thieves are highly responsive to changes in the direct incentive to engage in this type of property theft[11].

3. Metal Crime and Policing

The second main part of the empirical analysis studies the impact of policing on metal crime. To this end, exogenous variation arising from changes in the intensity of policing across police force areas (PFAs) of England and Wales induced by a policing initiative called

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[11] Table A9 shows this conclusion to be robust to the inclusion in the estimated equation of separate time trends for the 2008-11 and 2012-15 periods, which represent the pre- and post-institutional responses periods in our study.

"Operation Tornado" is analysed. Operation Tornado was a novel form problem-oriented policing initiative implemented by the BTP in England and Wales at the beginning of 2012 when metal crime was hitting a record high in the country.[12]

Starting from Levitt (1997), a number of studies have exploited sources of plausibly exogenous variation in police workforce to document a causal crime-reducing effect of police staffing (Levitt, 2002; Evans and Owens, 2007; and Lin, 2009)[13]. Multiple studies have also exploited natural experiments to assess the crime-reducing effect of police deployment and tactics (Cohen and Ludwig, 2003; Di Tella and Schargrodsky, 2004; Klick and Tabarrok, 2005; Draca et al., 2011; and MacDonald et. al., 2016). These studies show consistent evidence from different cities of the crime-reducing effect of police deployment.[14] A large criminology literature also presents evidence of the crime-reducing effects of a variety of programs, policies and practices in the criminal justice system (Weisburd et al., 2017). Telep and Weisburd (2016), for example, document the impact of various policing strategies on crime reduction and citizen satisfaction, ranging from hot-spots policing to directed patrol and focused deterrence approaches. However, very few studies exist in the economics literature on problem-oriented policing initiatives, and concerns regarding identification suggest caution in the interpretation of the existing evidence (Skogan and Frydl, 2004; Chalfin and McCrary, 2017).

Operation Tornado

As metal crime rapidly rose, there was an increasing recognition that the Scrap Metal Dealers Act 1964 had become an out of date and ineffective piece of legislation that was failing to stem the increases in metal crime. As a result, in April 2011 the Association of Chief Police Officers (ACPO), the BTP and the Home Office (HO) entered into negotiations with the British

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[12] "Problem-oriented" policing initiatives include all focused deterrence strategies that aim to modify the behaviour of specific groups of offenders or to be successful in particular regions (Chalfin and McCrary, 2017).

[13] Chalfin and McCrary (2017) provide a comprehensive review of this literature.

[14] A different conclusion appears in Mastrobuoni (2013), who finds that criminals are not responsive to large regular shift changes among the different police forces in Milan.

Metals Recycling Association (BMRA) and Directors from the three largest recyclers within the UK. One key dimension of the talks was to try and negotiate that cashless transactions be introduced for metal sellers dealing with scrap metal merchants.

Following Chancellor Osborne's announcement in November 2011, the first intervention that came about was Operation Tornado (OT), which was designed to support the police in tackling metal crime and to make it easier to trace sellers and dealers of stolen metals. It required participating scrap metal dealers in England and Wales to request identification documentation (UK driving licence, passport or utility bill) for every cash sale and retain copies for twelve months for inspection by the police. Dealers were requested to ensure CCTV systems covered entrances and weighbridges of recycling centres and the images to be of sufficient quality to enable identification of vehicle registration numbers and secure facial recognition. Posters describing the identification measures in force were prominently displayed to sellers. From the perspective of scrap metal dealers, OT can be thought of as a sudden negative cost shock. From the perspective of metal thieves, OT is likely to reduce the earnings returns and/or to impose an increased difficulty to sell stolen metal.

A Red, Amber, Green (RAG) standardisation of dealer categorisation was adopted within police force areas as part of the OT implementation process. This enabled policing activity to be directed, focused and efficient in terms of tackling criminality within a standardised framework. According to BTP, over 80 percent of scrap metal dealers signed up to OT and all police forces introduced the national RAG status as part of the roll out of the project. These voluntary measures were acknowledged as an effective means of reducing metal crime and formed the backbone that supported the introduction of cashless trading in December 2012.

Although the measures were widely accepted, the absence of a legislative requirement to enforce the measures did allow participants to drop in and out with no penalties. In addition,

one of the larger partners withdrew from the program, and this may have resulted in many others following, and thus in a reduction in the overall effectiveness of the measures. These risks brought a degree of uncertainty in terms of sustainability, which was one of the factors that supported the inclusion of identification in a new Scrap Metal Bill in December 2012. Even though, as shown in Figure 4, metal crime after 2012 dropped by much more than it would have been predicted at the end of 2011, the absence of a legislative requirement to enforce the measures of OT implies that its effectiveness is not obvious *a priori*.

Research Design

Operation Tornado (OT) was piloted in January 2012 in the North East regions of England, in the police force areas of Durham, Cleveland and Northumbria, and then progressively extended to other regions. Variation in the timing of adoption of OT is exploited in the research design as "late adopters" of OT are used as controls for the "early adopters".

The timing of adoption of OT across PFAs was determined by the risk that OT may result in the displacement, rather than reduction, of metal crime in the PFA. Therefore, selection into the early adopters' and late adopters' groups is not random. However, insofar as parallel trends appear in the incidence of metal crime between these groups of PFAs prior to the start date of OT, a difference-in-differences specification plausibly retrieves the causal impact of OT on metal crime.

Table 3 provides a timeline of OT adoption between the beginning of 2012, when no PFA had adopted OT yet, and September 2012, when the national rollout of OT was complete. As Table 3 shows, OT was piloted in the North East PFAs of Cleveland, Durham and Northumbria. In April 2012 the programme was extended to PFAs in the Yorkshire, the Humber and East Midlands regions. OT was introduced in the North Western PFAs of England in May 2012 and in the Eastern and Southern regions of the country in June 2012. PFAs in London,

Wales and the West Midlands did not adopt OT until the end of the summer 2012, when they introduced it in their respective jurisdictions.

The precise approach taken is to compare metal crime in PFAs that adopted OT before the summer with metal crime in PFAs that adopted OT only at the end of the summer. The time window between January and September 2012 is used to evaluate the causal impact of OT on metal crime. Scotland is excluded from the analysis here since OT was not implemented there, and comparable provisions were not adopted until September 2016.[15]

Restricting the analysis to PFAs where OT was adopted within a relatively short period of time ensures that treated and comparison PFAs share unobservable common reasons to adopt OT (like ethos or urgency to tackle metal crime). As Table 3 shows, 33 police forces introduced OT before the summer, while 10 police forces introduced it after the summer. The set of PFAs that adopted OT before the summer is labelled 'early adopters', and the set of PFAs that adopted OT after the summer is labelled 'late adopters'. Since the control PFAs in our analysis receive the treatment in September 2012, BTP data on metal crime by PFA is used from January 2007 to August 2012. Metal crime in the set of 'early adopters' is then compared with metal crime in the set of 'late adopters' in the time window from January to August 2012.

The unit of observation of the analysis is the PFA, p, over time and metal crime is measured with monthly frequency. In formal terms, the basic difference-in-differences set up is:

$$MT_{pt} = \theta_p + \beta_5 SP_t + \pi_5 POST_t + \varphi_5 POST_t * OT_p + \theta_t + v_{5t} \qquad (5)$$

Equation (5) is specified in the levels of MT_{pt} and SP_t (rather than in logarithmic form) because there is a relatively high frequency of zeros in MT in the monthly PFA level data. MT_{pt} is the monthly count of metal theft incidents in PFA p in month t per 10,000 population, SP_t is

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local scrap metal prices in month t, and OT_p is a binary variable that takes up value 1 if PFA p is an 'early adopter' of OT and value 0 otherwise. $Post_t$ is a binary variable that takes up value 1 starting from January 2012, i.e., from the beginning of OT, and value 0 in the previous month-years. θ_p denotes a set of PFA fixed effects (which also absorbs the time invariant OT_p levels variable, which is not shown in (5)) and θ_t is a set of time fixed effects.

Insofar as, prior to the policing intervention, metal crime displayed similar trends in treatment and control PFAs, the interaction between these variables $Post_t * OT_p$ identifies a causal effect of OT on metal crime and, in doing so, φ_5 is the key coefficient of interest. Given the possibility that there may be unobservable PFA-specific trends in crime that may affect our results, a more stringent specification additionally includes PFA-specific linear time trends, θ_p*t. Equation (5) is estimated with and without seasonal differencing to control for seasonality in metal crime. Finally, standard errors were clustered at the PFA level and, due to the relatively small number of clusters (i.e. 43 PFAs) the wild cluster bootstrap approach suggested by Cameron et al. (2008) was used for this analysis.[16]

For this analysis, microdata from the BTP were aggregated up at the PFA-level with monthly frequency. These data were combined with data on metal prices in the UK from www.letsrecycle.com and with data on international metal prices from the online platform "Index Mundi".

Descriptive Difference-in-Differences

Table 4 shows unconditional difference-in-differences estimates comparing metal crime in early adopters of OT with metal crime in late adopters of OT. Considering first early adopters of OT in Table 4, on average across the 33 PFAs, 0.032 incidents of metal crime per 10,000 population occurred per month in the years prior to January 2012, and this dropped to 0.020 in

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[16] In all cases, OLS estimation and 1,000 bootstrap replications were conducted for inference.

the time window from January to August 2012. There is much less change in the 10 late adopters

PFAs where, if anything, metal crime decreased only slightly in 2012 compared to previous

years (by 0.001 from a pre-OT baseline of 0.028). By taking the difference between these 'pre'

and 'post' metal crime rates, and then differencing across these yields the difference-in-

differences (DiD) estimate shown in column (3). This is sizeable at -0.011 for the early adopters,

showing that they did experience a reduction in metal crime during the implementation period

of OT. Since the average count of metal crime per 10,000 population per month prior to 2012

was 0.031, this statistically significant drop represents a 35 percent decrease in metal crime

following the introduction of OT.[17]

Figure 5 shows treated and control PFAs displayed highly similar metal crime trends in

the years prior to the implementation of OT. Figure 5 shows this very clearly for metal crime

trends after seasonal adjustment was applied. Until the end of 2011 both the levels and the

trends of metal crime appear very similar between early adopters and late adopters of OT.

Starting from January 2012, however, a discrepancy appears, with treatment regions

experiencing a drop in metal crime compared to control regions. This is particularly pronounced

in the March to June period, when all the early adopters gradually adopted OT.

Results

This section turns to the main statistical estimates that look at the causal effect of OT on

metal crime. Table 5 shows estimates in levels in columns (1) to (3) and in seasonal differences

in columns (4)-(5). Overall, the results reiterate and confirm the conclusions from the

unconditional DiD estimates of the previous section, showing a reduction in metal crime of the

order of 35 percent.

Column (1) of Table 5 shows results without controlling for month-year fixed effects,

thereby allowing prices to enter the estimated specification. There is a positive and significant

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[17] The seasonally differenced equivalent is numerically almost identical showing a 0.012 reduction in metal crime, although the estimate is somewhat less precisely determined (with an associated standard error of 0.009).

impact of international metal prices on metal crime, which is consistent with the results from the previous section. It shows the importance of price incentives for potential thieves to engage in metal crime also once the causal impact of policing on metal crime is taken into account. Column (2) shows that inclusion of month-year fixed effects has no effect on the estimate of the effect of OT on metal crime. Controlling for PFA-specific time trends, as shown in column (3), results in a slightly smaller estimate of the impact of OT, and whilst the estimated effect of OT on metal crime loses a little precision (p-value = 0.11), the estimates prove reassuringly very resilient to their inclusion. Column (4) shows that seasonal differencing increases the size of the estimated effect of OT on metal crime a little (in absolute terms).

This conclusion that there was a reduction in metal crime as a result of the introduction of OT is further corroborated by the results in column (5) of Table 5, which displays seasonally-adjusted event study difference-in-differences estimates of the impact of OT on metal crime. Figure 6 provides a graphical representation of these results. The event study generates separate estimates of OT impact months since January 2012, but also allows examination of possible pre-2012 differences in trends between treatment and control PFAs. To be precise, each coefficient represents the interaction between treatment status (i.e., OT_p in equation (5)) and a dummy for two months of observation in our study period. Thus, 'OT x Pre 1' tests whether there were any differential crime trends between treatment and control PFAs in November and December 2011 (i.e., two months prior to the start date of OT). 'OT x Pre 2' tests whether there were any differential crime trends between treatment and control PFAs in September and October 2011. 'OT x Pre 3' tests the presence of differential pre-trends between treatment and controls in July and August 2011, and 'OT x Pre 4' tests this in May and June 2011. By the same token, OT x Post 1 shows the impact of OT in January and February 2012, OT x Post 2 shows the impact of OT in March and April 2012, OT x Post 3 shows the impact of OT in May

and June 2012, and OT x Post 4 shows the impact of OT in July and August 2012, just before the control PFAs also introduced OT.

There are two notable features. First, there are very clearly parallel pre-2012 trends between treatment and control PFAs. This is reflected by the joint insignificance of the estimated differential pre-trends that is displayed in Figure 6. This suggests that treated PFAs were not experiencing differential trends in metal crime prior to the introduction of OT, and thus any negative discrepancy between treatment and controls after the start of OT can be safely interpreted as the impact of the adoption of OT on metal crime. Second, there is a drop in the count of metal crime incidents per 10,000 population starting from March/April 2012 in the treated PFAs.[18] Figure 6 shows the estimated treatment effects after January 2012 to be jointly significant at the five percent level, and the impact of OT on metal crime appears to be concentrated in May and June 2012, when all treated PFAs had started OT. This makes intuitive sense, as it reflects the importance of policing in deterring crime also in the presence of strong economic incentives to engage in such illicit activities.

4. Metal Crime and Policy

The third part of the empirical analysis assesses the impact of the Scrap Metal Dealers Act 2013 (SMDA) on the economic activity of Scrap Metal Dealers (SMDs) in England and Wales. The SMDA 2013 came into force in October 2013 and it superseded the Scrap Metal Dealers Act 1964. Amongst other things, the SMDA 2013 introduced new provisions for the issuance and revocation of a scrap metal licence, for the verification of scrap metal suppliers' identities and it introduced the offence of buying scrap metal for cash.[19] This part of the paper

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[18] The results in Figures A2 and A3 show the robustness of this conclusion to the alternative use of Newey-West standard errors, either with serial correlation of order one (i.e., one month) or order 12 (i.e., 12 months).

[19] A complete description of the provisions of the SMDA 2013 is publicly available here: http://www.legislation.gov.uk/ukpga/2013/10/enacted.

investigates the extent to which these provisions affected the economic activity of SMDs in England and Wales that were the target of this reform.

The Scrap Metal Dealers Act 2013

The SMDA 2013 was enacted on the 28 February 2013 and its implementation was carried out by October 2013. The SMDA followed Operation Tornado and it superseded the Scrap Metal Dealers Act 1964, as it aimed to provide a more effective regulatory framework to the scrap metal and recycling industry in England and Wales. By generating a tougher licensing regime that was run by local authorities, the SMDA 2013 aimed to support legitimate SMDs while hindering the activities of unscrupulous dealers. As a result of the SMDA 2013, local authorities were given the power to grant or refuse a licence upon application, depending on whether or not they were persuaded that the applicant was a suitable person to run an SMD. The SMDA 2013 also enabled local authorities to revoke a licence at any time, as well as to shut down SMDs that operate without a licence.

Local authorities can grant two types of licences to SMDs, namely a site licence or a mobile collector licence. The site licence requires identification of all the sites within the local authority where the SMD intends to operate and the identification of a manager for each of them, as it allows the SMD to operate only at the sites listed on the licence. The mobile collector licence allows the SMD to collect both domestic and commercial scrap metal in the area of the issuing local authority. This licence does not permit to operate at a fixed site, nor to collect scrap metal from any other local authority area. For this, an additional licence from another local authority ought to be obtained by the mobile collector. SMD licences normally last for a period of three years starting from the date of issuance of the licence. In line with Operation Tornado, the SMDA 2013 also posed a legal obligation on SMDs to keep records of all transactions and to request a proof of identity from their counterparts in every transaction.

Research Design

A natural question to ask is whether the provisions of the SMDA 2013 affected the economic activity of pre-existing SMDs in England and Wales? This section of the paper exploits the differential intensity in the exposure to the SMDA 2013 across different firms to define a difference-in-differences specification to investigate this question. Since the SMDA 2013 introduced strict regulations to the activity of SMDs, while it did not alter the laws governing the activity of other similar businesses, the latter can be used as a control group for the former. In order to compare the economic activity of SMDs with the economic activity of firms that share similar observable and unobservable features, the control group includes pawnshops and firms involved in the collection, recovery and wholesale of other waste (i.e., not scrap metal).

For this analysis, firm-level data from the Fame website were used from the fiscal year 2010 to 2015 with yearly frequency.[20] The analysis includes firms which are still active at the time of writing, and for which complete information was available from the Fame website for the fiscal years 2010 to 2015. This results in a balanced panel of firms for six years.[21] The unit of observation in this analysis is the firm, f, over time and economic activity is measured with yearly frequency. In formal terms, the basic difference-in-differences set up can be expressed as follows:

$$Y_{ft} = \theta_f + \beta_6 SMD_f + k_6 POST_t + \tau_6 POST_t * SMD_f + \theta_t + v_{6t}, \qquad (6)$$

where Y_{ft} is an annual measure of economic activity of firms in England and Wales. Three measures of economic activity are used – sales turnover, sales turnover per employee and the

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[20] Fame is a database of more than two million companies in the UK and Ireland, containing information on financials, adverse filings, directors and managers, financial strength metrics including credit scores and ratings and CCJs, shareholders and subsidiaries and corporate structures and families, M&A deals and rumours, industry descriptions, SIC codes and research, news, original, as filed accounts and documents as filed at Companies House and the Companies Registration Office in Ireland. See https://www.bvdinfo.com/en-apac/our-products/company-information/national-products/fame).

[21] This sampling restriction is relaxed below. In particular, all firms observed consistently from 2010 to 2013 were included in the analysis, regardless of whether they exited the market after the SMDA 2013 was enacted. This resulted in an unbalanced panel of firms, but it did not alter the conclusions.

firm profit margin (defined as pre-tax profits divided by sales). In (6), SMD_f is a binary variable that takes up value 1 if the firm is a scrap metal dealer and value 0 for control firms, $Post_t$ is a binary variable that takes up value 1 starting from the fiscal year 2014 (i.e. after the SMDA 2013 came into force in October 2013) and value 0 in previous years. θ_f denotes a set of firm fixed effects (which also absorbs the time invariant SMD_f levels variable) and θ_t is a set of fiscal year fixed effects.

Insofar as, prior to the SMDA 2013, our outcomes of interest were on similar trends in treatment and control firms, the estimate of τ_6 in equation (6) identifies the causal impact of the SMDA 2013 on the economic activity of SMDs in England and Wales. Similarly to what was done in the previous section, this proposition was tested formally for every outcome variable with the inclusion in equation (6) of a set of interactions between pre-treatment time dummies and the treatment status (i.e., SMD_f).

Descriptive Difference-in-Differences

Table 6 shows the results from an unconditional difference-in-differences exercise comparing the economic activity measures for SMDs with the same measures for control firms. All three measures fall significantly before and after SMDA 2013 in treatment relative to control firms.

Considering first firm sales in panel A of Table 6, column (1) reveals that, on average, sales turnover of SMDs decreased after the introduction of the SMDA 2013. Column (2) shows that much less variation occurred in control firms, where, if anything, sales increased slightly after 2013. The difference-in-differences comparison between treatment and control firms shows a negative and significant coefficient, suggesting that sales revenues of SMDs were significantly hindered by the provisions of the SMDA 2013. Analysis of sales per employee, shown in panel B of Table 6, reveals a very similar effect again uncovering a significant, negative difference-in-differences.

Panel C of Table 6 shows unconditional difference-in-differences results for profit margins. Both treatment and control firms saw declines in margins before and after SMDA introduction, but the decline was significantly more pronounced in the former. The resulting difference-in-differences estimate is negative and statistically significant, and shows a sizable decline in profit margins of scrap metal dealers. Visual inspection of Figure 7, which shows the evolution of average profit margin for SMDs and control firms from 2010 to 2015, confirms this pattern. While similar patterns are observed in treatment and control firms until 2013, SMDs recorded a lower average profit margin and a larger discrepancy appears compared to control firms after 2013.

Results

Table 7 subjects these descriptive findings to more stringent statistical analysis that additionally takes into account fiscal year- and firm-specific unobserved fixed effects. Columns (1) to (3) show results for sales, columns (4) to (6) for sales per employee and columns (7) to (9) for profit margins. The overall nature of the descriptive analysis is reconfirmed, with SMDs taking a significant hit to their economic performance after SMDA introduction. This is shown throughout the Table, for all three outcomes, irrespective of whether the estimation is undertaken on the balanced panel with all observations on a given outcome (in (1), (2), (4), (5), (7) and (8)) or only on firms for which complete data is available on all outcome variables of interest (in (3), (6) and (9)). The same is true if the analysis is undertaken on an unbalanced panel of firms (see Appendix Table A8).

The magnitudes of the economic hit are big. For sales, depending on specification, there is around a 20 percent fall, and for sales per employee around a 16-18 percent reduction. Profit margins fell by 2.3 percentage points as a result of the SMDA 2013. Column (9) shows that, also in this case, a slightly larger effect appears when the analysis is restricted to firms for which complete data on all outcome variables of interest is available.

Table 8 shows event-study estimates for the three economic outcomes of interest. In all cases, there is no evidence of differential pre-treatment trends, with the estimated effects of the SMDA 2013 on our outcomes of interest appearing negative and significant, and larger in magnitude in 2015. These results confirm that the SMDA 2013 had a negative effect on the economic activity of SMDs, and they also reflect the moderate time lag with which the economic activity of SMDs started to be affected by the provisions of the act.[22]

Table A8 in the Appendix shows the results of this analysis when all firms that could be consistently observed from 2010 to 2013 are included in the analysis, regardless of whether they exited the market after the SMDA 2013. Thus, this analysis allows for firms' exit from the market as a result of the SMDA 2013. The results in Table A8 indicate that this modification to the sampling restriction affects neither the estimated impact of the act on the economic activity of SMDs, nor the presence of parallel pre-SMDA 2013 trends between treatment and control firms.

5. Interpretation and Discussion

The results of Tables 6, 7 and 8 provide evidence that the stricter regulation regime introduced by the SMDA 2013 had a negative effect on the economic activity of SMDs. Based on this result only, however, one cannot conclude whether the SMDA 2013 was effective or not to reduce metal crime. It is plausible that the tougher legislation implied by the SMDA 2013 reduced metal crime, as the new regulatory regime reduced scope for selling stolen metal to SMDs for potential thieves. However, it is also possible that the SMDA 2013 may have not had any impact on crime. Rather, it may have simply introduced an additional bureaucratic burden to the activities of SMDs (e.g. additional paperwork) that in turn led to a reduction in the number

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[22] The results in Tables A4 to A7 show the robustness of this conclusion to the alternative use of Newey-West standard errors, whether with serial correlation of order one or order two, as well as to the alternative use of the wild cluster bootstrap approach for inference suggested by Cameron et al., (2008).

of transactions for these businesses with the negative implications for their economic activity documented in Section 4.

This section of the paper shows results from a common regression-based decomposition framework that can be used to simultaneously appraise the impact of prices, policing and policy on the boom and bust of metal crime in the UK. The few existing studies on the effect of changes in the legislation on property theft include Morgan et al., (2016) and Van Ours and Vollaard (2016). Morgan et al., (2016) show the negative link between vehicle theft and the pace at which electronic immobilisers were mandated on new vehicles in Europe, Australia, the US and Canada. Van Ours and Vollaard (2016) document the crime-reducing impact of the compulsory application in new passenger cars in the European Union of the electronic engine immobiliser.[23] The channel through which the diffusion of electronic immobilisers reduced crime was by making vehicle theft more difficult. The introduction of the SMDA 2013 constitutes a rather different kind of natural experiment because the SMDA 2013 did not make metal crime more difficult; rather, it made stolen metal harder to sell and, thus as a direct consequence, made metal crime unlikely to be as profitable as it was before.

The analysis uses all the available BTP monthly data from 2008 to 2015 at the PFA level. Since the SMDA 2013 became effective in October 2013 in England and Wales only, this analysis also now includes Scotland so as to generate cross-sectional variation in the exposure to the change in legislation. The sample of PFAs was divided in three groups: early adopters of Operation Tornado (OT), late adopters of OT and Scotland. The definitions of early adopters and late adopters of OT are unchanged from Section 3, while Scotland constitutes a natural control region for the analysis of the effect of the SMDA 2013 on metal crime.

As the aim is to develop a common regression-based framework of analysis of the effects of prices, OT and SMDA 2013 on metal crime, the time periods used in this analysis

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[23] Ayres and Levitt (1998) and Gonzalez-Navarro (2013) previously studied the vehicle theft deterrence effect of the Lojack, a small device hidden inside a vehicle that allows it to be tracked after a theft occurs.

are: prior to OT (i.e., the omitted category); during OT (January-August 2012); pre-SMDA 2013 (September 2012 – September 2013); and during SMDA 2013 (from October 2013 onwards). A separate time trend for each of these periods was included in all regressions. Standard errors were clustered at the PFA level. Due to the relatively small number of clusters (44 PFAs in this case) the wild cluster bootstrap approach suggested by Cameron et al. (2008) was used again for inference.

Results are shown in Table 9. They suggest a number of conclusions. First, international metal prices were strong drivers of metal crime during the study period. While this did not change during the policing intervention, the introduction of the SMDA 2013 did strongly weaken the responsiveness of potential thieves to price fluctuations. Since the change in legislation rendered some key provisions of the policing intervention legally binding, it is possible that the new regulatory regime permanently decreased the fungibility of stolen metal as it reduced the market size for potential thieves to sell stolen metal.

Second, OT appears to have had a large and significant crime reducing effect in "early adopter" PFAs also when Scotland is used as a control region. The interaction between late adopters and OT (i.e., "Late Adopters x OT") retrieves a non-significant coefficient, confirming that OT reduced, and did not displace, metal crime in early adopter PFAs.

Finally, the interaction between late adopters and the SMDA 2013 shows that the policy response in England and Wales had a strong metal crime reducing effect in these PFAs, though not as large as OT did in early adopter PFAs. This negative and significant effect of the SMDA 2013 on metal crime can be interpreted as causal due to the lack of significance in the coefficients associated with the interactions between late adopters and previous time periods (i.e., "Late Adopters x OT" and "Late Adopters x Pre-SMDA").

In sum, the results in this section reconfirm, and additionally quantify, the conclusions from Sections 2 and 3, as they provide further evidence on the critical role of economic

incentives and policing in shaping crime dynamics. They show that all three of the hypothesised factors considered in the paper – prices, policing and policy – were empirically important in the different stages of metal theft's boom and bust.

In addition, the results also document the importance of policy and regulatory interventions, over and above policing, for the deterrence of crime in the presence of strong economic incentives to engage in illicit activities. This is an important conclusion that extends beyond the market of metals, as it is of immediate relevance for the regulation and security of other markets, such as the market for cars, smartphones and credit cards.

6. Conclusion

This paper studies the roles of prices, policing and policy in shaping crime dynamics. The metal crime boom and bust that occurred in the UK in the nine years between 2007 and 2015 is studied to develop an understanding of how the interactions between potential offenders, economic incentives and institutions act to determine the observed level of crime in society.

Focusing on prices, policing and policy shows that all three of these hypothesised factors considered were empirically important in the different stages of metal theft's boom and bust. First, the analysis documents important metal crime-price elasticities that are big in magnitude. This very much confirms that economic motives lie behind the metal crime fluctuations. Secondly and thirdly though, it seems like the reaction to the boom by the authorities (police and government) brought about the bust. A difference-in-differences analysis shows that a novel anti-metal crime operation led by the British Transport Police led to significant consequences – and so did the UK government's introduction of the Scrap Metal Dealers Act 2013, which is exploited to study the impact of policy on the economic activity of scrap metal dealers in England and Wales.

The reported estimates document that metal crime is highly responsive to metal price dynamics. However, the policing response of the BTP in England and Wales reduced metal crime by an estimated 35 percent. The ensuing introduction of the SMDA 2013 caused a fall in the turnover of scrap metal dealers operating in England and Wales of almost 20 percent between 2014 and 2015. Turnover per employee of SMDs also fell by more than 15 percent, suggesting that the drop in turnover is not explained by disproportionate rates of dismissal of employees in SMDs. The profit margin of SMDs also reduced by a sizeable amount. This was, at least in part, the result of the reduced scope for potential metal criminals to sell what they have stolen to SMDs, and by association reflects the diluted economic returns to metal crime under the new, stricter, regulatory regime.

In conclusion, the evidence reported in the paper shows that prices, policing and policy all played a significant role in shaping the metal crime dynamics observed in the period of study. In the case of UK metal crime, its initial rapid rise into a crime boom was driven by big rises in commodity prices. Then police intervention and government policy quelled the rise, bringing about a crime bust. This is probably one of the more extreme cases of crime boom and bust that one can study, but the basic notion that crime dynamics embodied in the boom and bust apply is very likely to be a broader one that is relevant for other crimes, and one that future research should certainly investigate in other contexts and settings.

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Figure 1. BTP and MPS Levels of Metal Theft in England and Wales
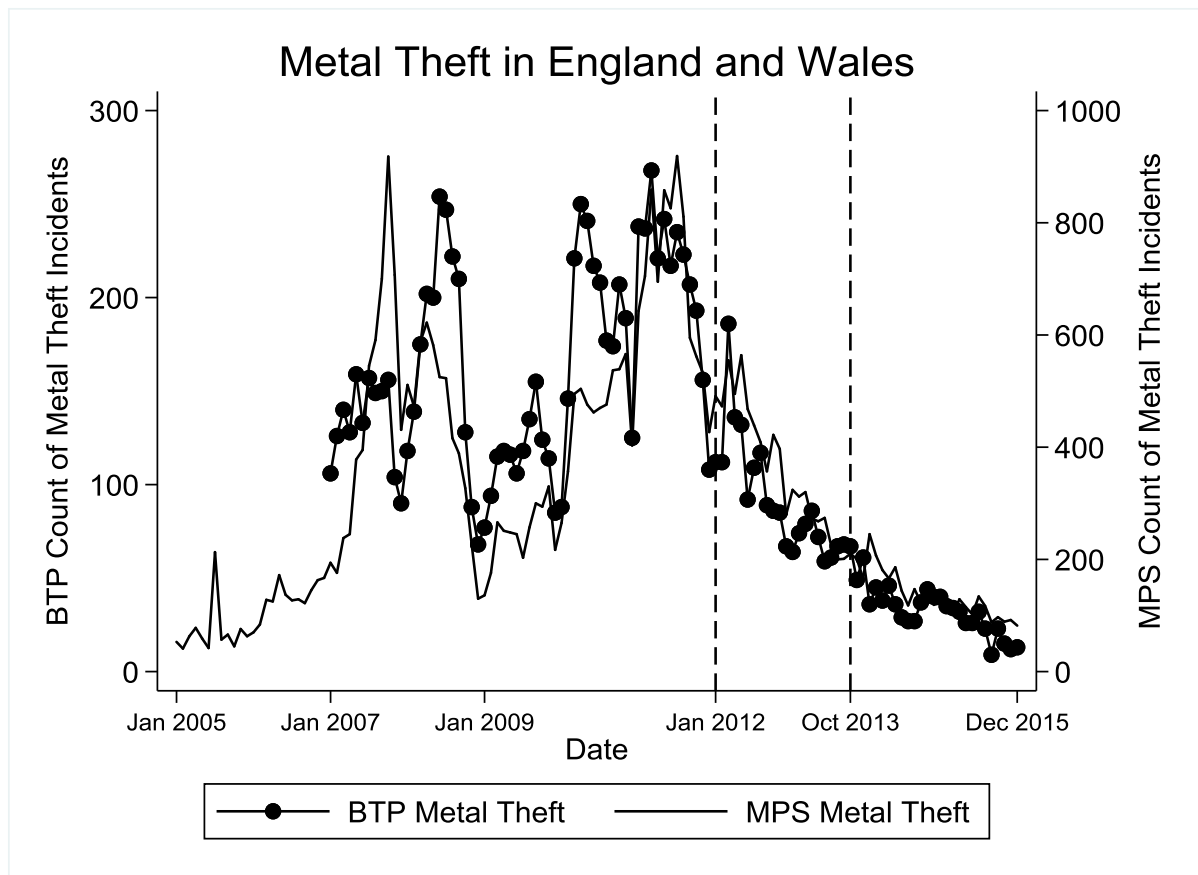
Notes: Monthly counts of metal theft were calculated using metal crime records from the British Transport Police (BTP) in England and Wales and from the Metropolitan Police Service (MPS) of London. Data from the BTP was available from January 2007 to December 2015. Data from the MPS was available from January 2005 to December 2015. The 'Jan 2012' dotted line represents the time of the introduction of Operation Tornado, while the 'Oct 2013' dotted line represents the time of the introduction of the Scrap Metal Dealers Act 2013.

Figure 2. BTP Logs of Metal Theft and Metal Prices in England and Wales
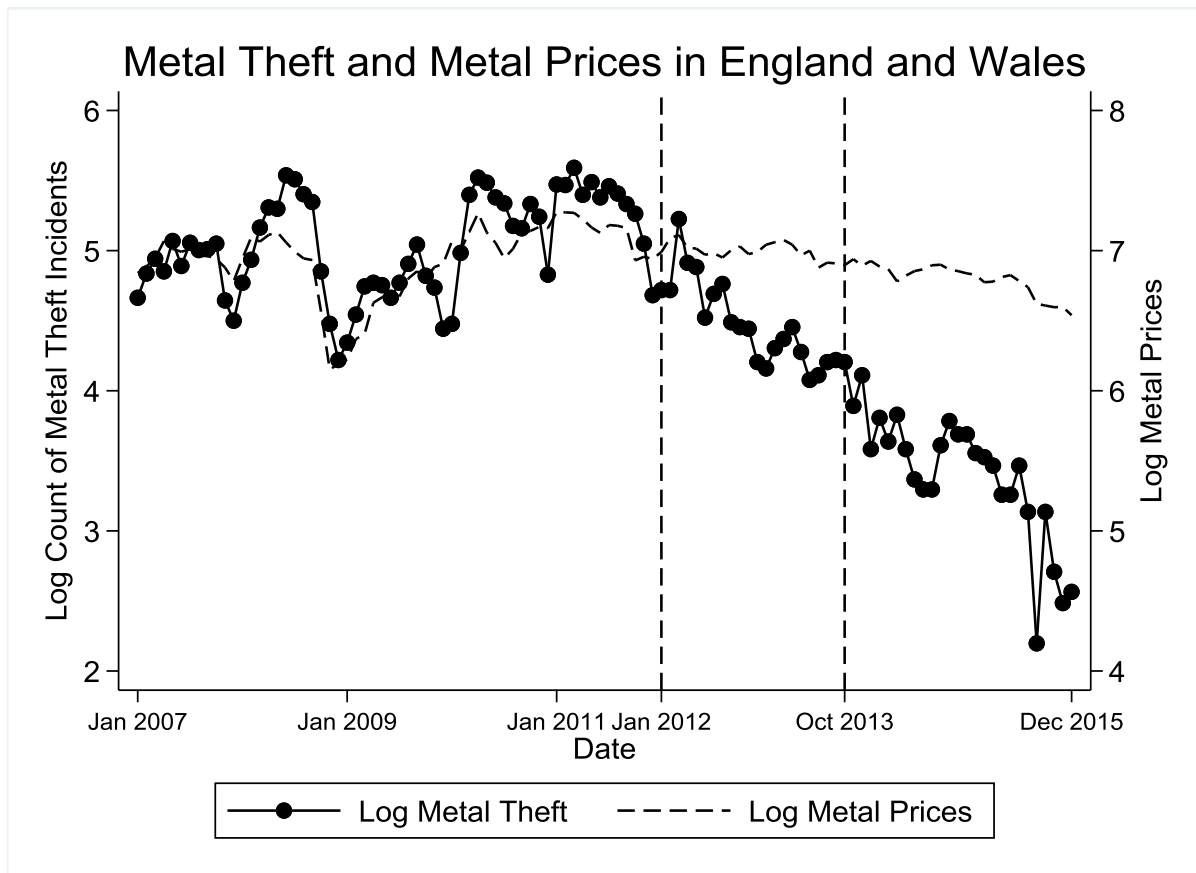
Notes: Monthly counts of metal theft were calculated using metal crime records from the British Transport Police (BTP) in England and Wales. Data from the BTP was available from January 2007 to December 2015. Data on local scrap metal prices in England and Wales was collected from www.letsrecycle.com. The 'Jan 2012' dotted line represents the time of the introduction of Operation Tornado, while the 'Oct 2013' dotted line represents the time of the introduction of the Scrap Metal Dealers Act 2013.

Figure 3. BTP Logs of Metal Theft Residuals after Metal Prices in England and Wales
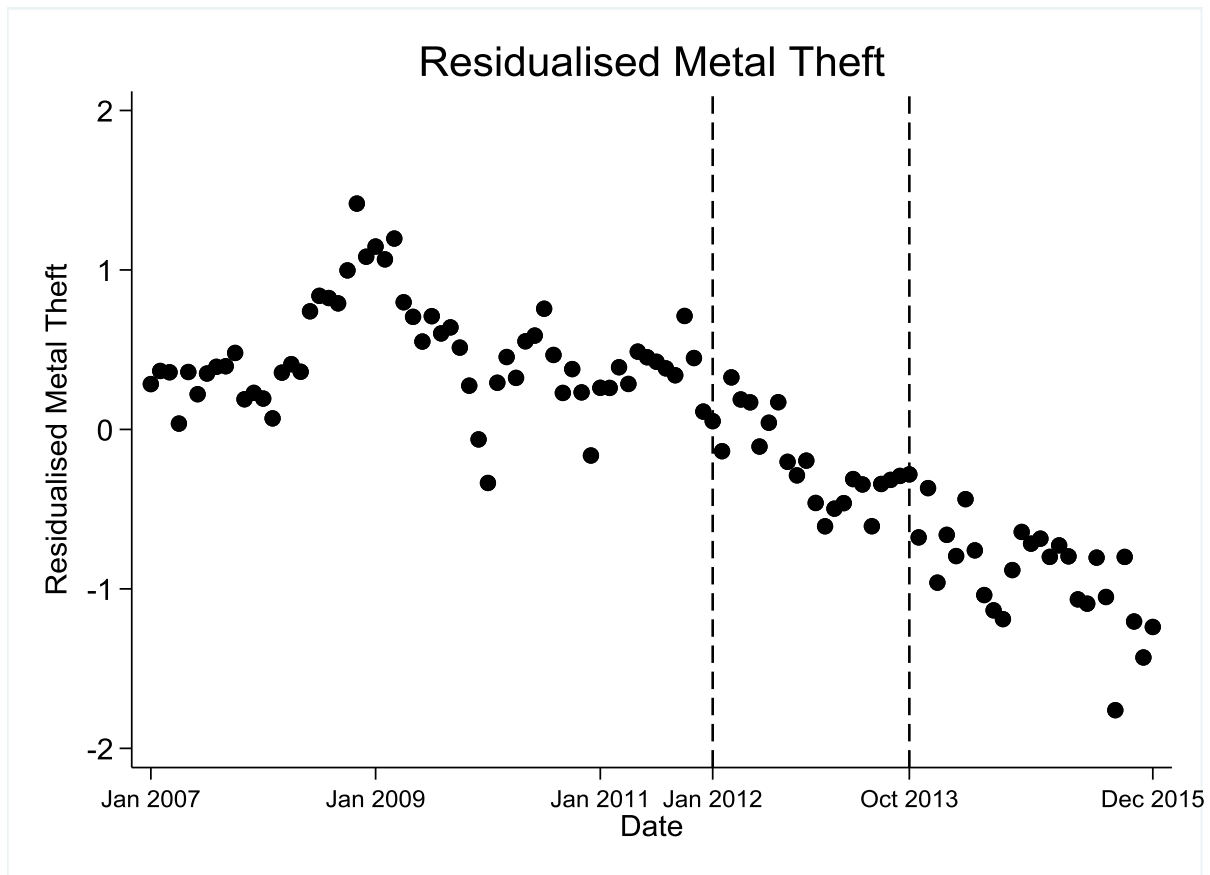
Notes: Figure 3 shows the predicted residual monthly counts of metal theft in England and Wales in the regression of monthly counts of metal theft on local scrap metal prices in England and Wales from January 2007 to December 2015. Monthly counts of metal theft were calculated using metal crime records from the British Transport Police (BTP) in England and Wales. Data from the BTP was available from January 2007 to December 2015. Data on local scrap metal prices in England and Wales was collected from www.letsrecycle.com. The 'Jan 2012' dotted line represents the time of the introduction of Operation Tornado, while the 'Oct 2013' dotted line represents the time of the introduction of the Scrap Metal Dealers Act 2013.

Figure 4. BTP Log of Metal Theft, Forecasted Log of Metal Theft and Log Metal Prices in England and Wales
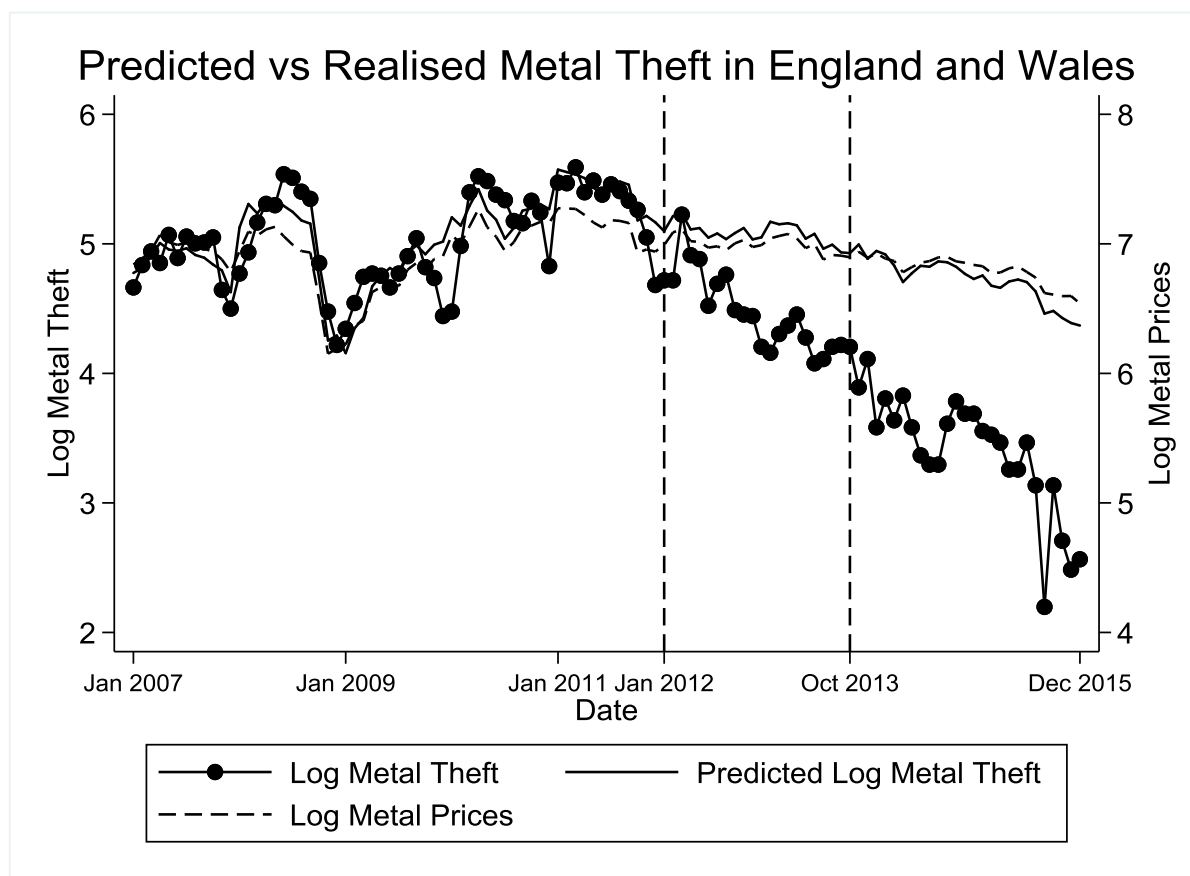
Notes: Monthly counts of metal theft were calculated using metal crime records from the British Transport Police (BTP) in England and Wales. Data from the BTP was available from January 2007 to December 2015. Data on local scrap metal prices in England and Wales was collected from www.letsrecycle.com. The 'Jan 2012' dotted line represents the time of the introduction of Operation Tornado, while the 'Oct 2013' dotted line represents the time of the introduction of the Scrap Metal Dealers Act 2013. Predicted Metal Crime was calculated using data from January 2007 to October 2011, i.e., before any anti-metal crime policing and policy intervention was announced.

Figure 5. Metal Theft, Difference-In-Differences, 2008 – August 2012.
(With Seasonal Differencing)
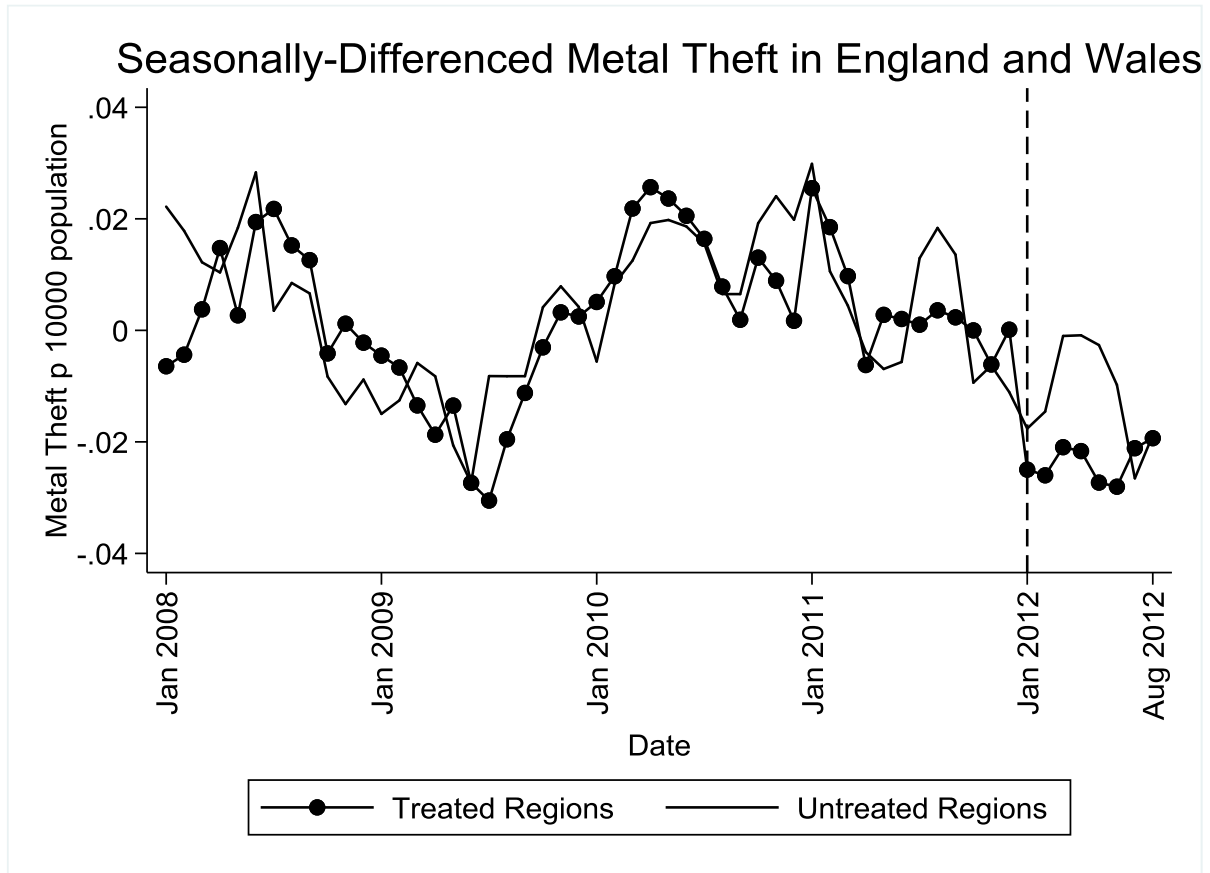
Notes: Number of observations: 2408. Post-period defined as starting from January 2012, i.e., the earliest date of adoption of Operation Tornado. Treatment regions (T = 1) defined as police force areas (PFAs) of Cleveland, Durham, Northumbria, Humberside, North Yorkshire, South Yorkshire, West Yorkshire, Norfolk, Derbyshire, Leicestershire, Lincolnshire, Northamptonshire, Nottinghamshire, Cheshire, Cumbria, Greater Manchester, Lancashire, Merseyside, Bedfordshire, Cambridgeshire, Essex, Hertfordshire, Suffolk, Hampshire, Kent, Surrey, Sussex, Thames Valley, Avon and Somerset, Devon and Cornwall, Dorset, Gloucestershire, Wiltshire. Untreated Regions (T = 0) defined as PFAs of Dyfed-Powys, Gwent, North Wales, South Wales, Staffordshire, Warwickshire, West Mercia, West Midlands, Metropolitan Police Service and City of London. Metal theft defined as 12-month differenced total monthly counts of metal thefts per 10,000 population at the PFA level.

Figure 6. Event-Study OLS Estimates of Impact of Operation Tornado on Metal Theft, 2008 – Aug 2012.

Notes: Post-period defined as starting from January 2012, i.e., the earliest date of adoption of Operation Tornado. Treatment group (T = 1) defined as police force areas (PFAs) of Cleveland, Durham, Northumbria, Humberside, North Yorkshire, South Yorkshire, West Yorkshire, Norfolk, Derbyshire, Leicestershire, Lincolnshire, Northamptonshire, Nottinghamshire, Cheshire, Cumbria, Greater Manchester, Lancashire, Merseyside, Bedfordshire, Cambridgeshire, Essex, Hertfordshire, Suffolk, Hampshire, Kent, Surrey, Sussex, Thames Valley, Avon and Somerset, Devon and Cornwall, Dorset, Gloucestershire, Wiltshire. Comparison group (T = 0) defined as PFAs of Dyfed-Powys, Gwent, North Wales, South Wales, Staffordshire, Warwickshire, West Mercia, West Midlands, Metropolitan Police Service and City of London. Metal theft defined as total monthly counts of metal thefts per 10,000 population at the PFA level. Regressions weighted by population at the PFA level. Reported dots are point estimates and capped bars are 95 percent confidence intervals.

Figure 7. Average Profit Margin for Scrap Metal Dealers and Control Firms in England and Wales, 2010 – 2015.
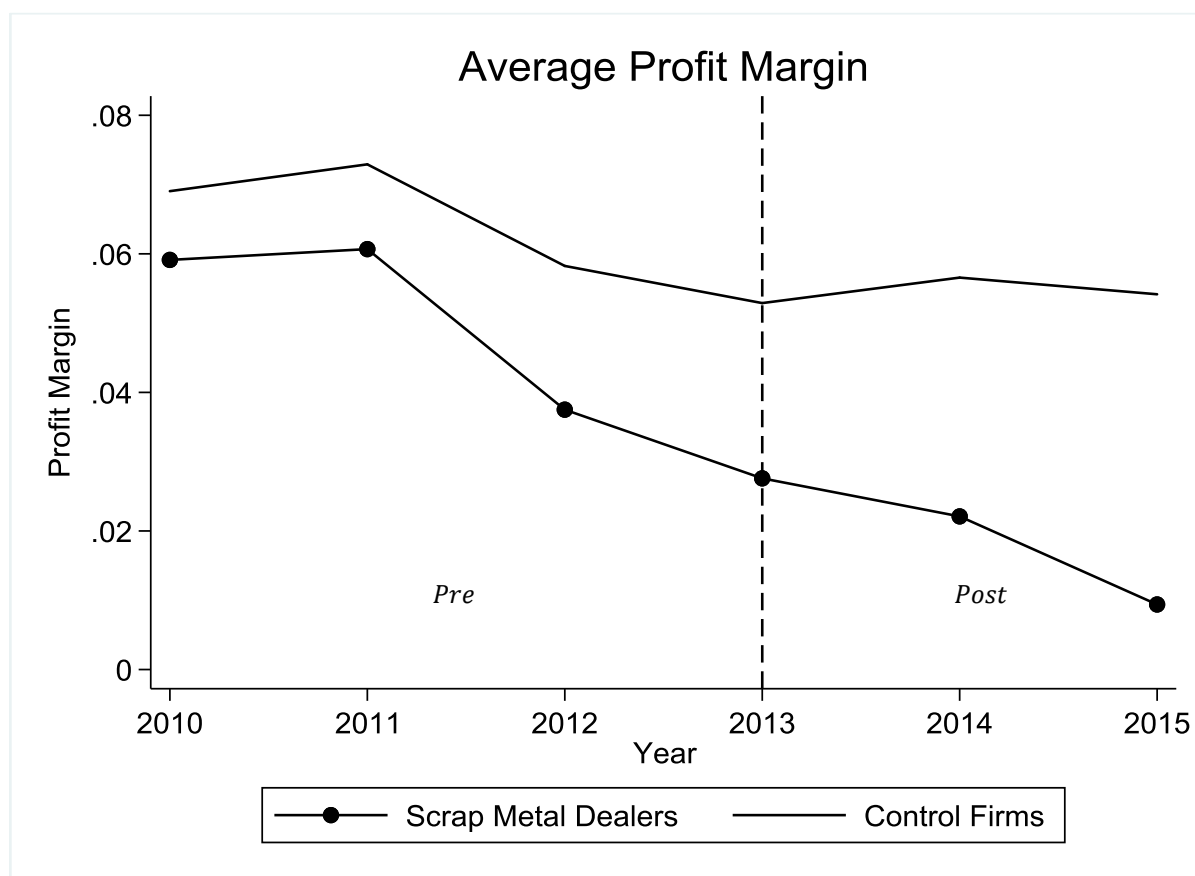
Notes: Figure 7 reports average Profit Margin for treatment and control firms by year. Treatment group (T = 1) defined as scrap metal dealers. Comparison group (T = 0) defined as pawnshops and all other businesses involved in the collection of non-hazardous waste, recovery of sorted materials, wholesale of metals and metal ores and wholesale of waste. Only firms that were still active at the time of writing, i.e., early 2018, and for which complete data was available from 2010 to 2015 were included in the analysis. Profit Margin was calculated as Operating Profit / Turnover. Operating Profit equals Gross Profit - Administration Expenses + Other Operating Income/Costs pre OP + Exceptional Items pre OP. Turnover includes both national and international turnover.

Table 1. Estimates of Metal Crime-Price Elasticities, 2008 to 2015.

	Levels				Seasonal Differences			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS Reduced Form	First Stage	IV Structural Form	OLS	OLS Reduced Form	First Stage	IV Structural Form
	Log(Crime)	Log(Crime)	Log(Scrap Price)	Log(Crime)	Log(Crime)	Log(Crime)	Log(Scrap Price)	Log(Crime)
A. BTP Data, England and Wales								
Log(Scrap Price)	1.673***			1.875***	0.900***			1.044***
	(0.168)			(0.190)	(0.146)			(0.164)
Log(World Price)		2.090***	1.115***			1.146***	1.098***	
		(0.150)	(0.090)			(0.131)	(0.096)	
B. BTP Data, London								
Log(Scrap Price)	2.181***			2.524***	1.473***			1.645***
	(0.252)			(0.295)	(0.196)			(0.248)
Log(World Price)		2.813***	1.115***			1.805***	1.098***	
		(0.290)	(0.090)			(0.260)	(0.096)	
C. MPS Data, London								
Log(Scrap Price)	1.849***			2.018***	1.435***			1.449***
	(0.173)			(0.185)	(0.166)			(0.183)
Log(World Price)		2.250***	1.115***			1.591***	1.098***	
		(0.165)	(0.090)			(0.207)	(0.096)	
F-Statistic			127.94				74.99	
Linear Time Trend	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Δ_{12} Differenced	No	No	No	No	Yes	Yes	Yes	Yes
Number of Months	96	96	96	96	96	96	96	96

Notes: Metal theft defined as (Log) total monthly counts of total thefts. Newey-West standard errors are reported in parentheses. *** indicates significance at the 1 percent level. ** indicates significance at the 5 percent level. * indicates significance at the 10 percent level.

Table 2. Estimates of Metal Crime, Price and Labour Market Elasticities, 2008 to 2015.

	BTP Data, England and Wales		BTP Data, London		MPS Data, London	
	(1)	(2)	(3)	(4)	(5)	(6)
	IV Structural Form	IV Structural Form	IV Structural Form	IV Structural Form	IV Structural Form	IV Structural Form
	Log(Crime)	Log(Crime)	Log(Crime)	Log(Crime)	Log(Crime)	Log(Crime)
Log(Scrap Price)	0.907***	0.527***	1.299***	0.977***	0.741***	0.449***
	(0.170)	(0.119)	(0.371)	(0.315)	(0.123)	(0.112)
Log (Male Unemployment)	0.495***	-0.037	0.502	0.308	0.272***	0.008
	(0.166)	(0.199)	(0.305)	(0.370)	(0.087)	(0.101)
Log (Lagged Metal Theft)	0.477***	0.580***	0.419***	0.447***	0.623***	0.749***
	(0.103)	(0.078)	(0.111)	(0.110)	(0.053)	(0.057)
Long Run Log(Scrap Price)	1.734***	1.255***	2.235***	1.767***	1.966***	1.786***
	(0.226)	(0.244)	(0.412)	(0.418)	(0.304)	(0.299)
Linear Time Trend	Yes	Yes	Yes	Yes	Yes	Yes
Δ_{12} Differenced	No	Yes	No	Yes	No	Yes
Number of Months	96	96	96	96	96	96
Log (Scrap Price)	0.905***	0.555***	1.788***	1.511***	0.860***	0.351**
	(0.206)	(0.144)	(0.504)	(0.389)	(0.144)	(0.139)
Log (Male Unemployment)	0.566	-0.066	0.363	0.585	0.165	-0.131
	(0.382)	(0.315)	(0.469)	(0.482)	(0.138)	(0.136)
Log (Lagged Metal Theft)	0.388***	0.404***	0.235*	0.265**	0.414***	0.768***
	(0.125)	(0.105)	(0.133)	(0.113)	(0.070)	(0.101)
Long Run Log(Scrap Price)	1.479***	0.932***	2.336***	2.054***	1.469***	1.516***
	(0.279)	(0.244)	(0.544)	(0.492)	(0.235)	(0.383)
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Δ_{12} Differenced	No	Yes	No	Yes	No	Yes
Number of Months	96	96	96	96	96	96

Notes: Metal theft defined as (Log) total monthly counts of total thefts. Newey-West standard errors are reported in parentheses. *** indicates significance at the 1 percent level. ** indicates significance at the 5 percent level. * indicates significance at the 10 percent level.

Table 3. Timeline of Roll Out of Operation Tornado.

Start Date	Region
	(Local Police Forces)
03 January 2012	**North East**
	(Cleveland, Durham, Northumbria)
02 April 2012	**Yorkshire and the Humber**
	(Humberside, North Yorkshire, South Yorkshire, West Yorkshire, Norfolk).
03 April 2012	**East Midlands**
	(Derbyshire, Leicestershire, Lincolnshire, Northamptonshire, Nottinghamshire).
09 May 2012	**North West**
	(Cheshire, Cumbria, Greater Manchester, Lancashire, Merseyside).
11 June 2012	**Eastern**
	(Bedfordshire, Cambridgeshire, Essex, Hertfordshire, Suffolk).
25 June 2012	**South East and South West**
	(Hampshire, Kent, Surrey, Sussex, Thames Valley, Avon and Somerset, Devon and Cornwall, Dorset, Gloucestershire, Wiltshire).
01 September 2012	**Wales**
	(Dyfed-Powys, Gwent, North Wales, South Wales)
10 September 2012	**West Midlands**
	(Staffordshire, Warwickshire, West Mercia, West Midlands)
17 September 2012	**London**
	(Metropolitan Police Service, City of London)

Table 4. Metal Theft, Difference-In-Differences, 2008 – August 2012.

	Metal Theft Incidents per 10,000 Population, Early Adopters vs Late Adopters		
	Pre	Post	Difference
	(1)	(2)	(3)
Treated Police Forces	0.032	0.020	-0.012
Late Adopters	0.028	0.027	-0.001
Difference-in-differences			-0.011* (0.005)

Notes: Number of observations: 2408. Post-period defined as starting from January 2012, i.e., the earliest date of adoption of Operation Tornado. Treatment group (T = 1) defined as the 33 police force areas (PFAs) of Cleveland, Durham, Northumbria, Humberside, North Yorkshire, South Yorkshire, West Yorkshire, Norfolk, Derbyshire, Leicestershire, Lincolnshire, Northamptonshire, Nottinghamshire, Cheshire, Cumbria, Greater Manchester, Lancashire, Merseyside, Bedfordshire, Cambridgeshire, Essex, Hertfordshire, Suffolk, Hampshire, Kent, Surrey, Sussex, Thames Valley, Avon and Somerset, Devon and Cornwall, Dorset, Gloucestershire, Wiltshire. Comparison group (T = 0) defined as the 10 PFAs of Dyfed-Powys, Gwent, North Wales, South Wales, Staffordshire, Warwickshire, West Mercia, West Midlands, Metropolitan Police Service and City of London. Metal theft defined as total monthly counts of metal thefts per 10,000 population at the PFA level. Standard errors clustered at the PFA level from Wild Cluster Bootstrap are reported in parentheses. *** Difference-in-Differences statistically significant at the 1 percent level. ** Difference-in-Differences statistically significant at the 5 percent level. * Difference-in-Differences statistically significant at the 10 percent level.

Table 5. OLS Estimates of Impact of Operation Tornado on Metal Theft, 2008 – August 2012.

	Metal Theft Incidents per 10,000 population				
	(1)	(2)	(3)	(4)	(5)
OT x Post	-0.011*	-0.011*	-0.009	-0.013	
	(0.005)	(0.005)	(0.005)	(0.008)	
International Metal Price (X 100)	0.001***				
	(0.000)				
OT x Pre 4					0.009
					(0.010)
OT x Pre 3					-0.014**
					(0.007)
OT x Pre 2					-0.001
					(0.006)
OT x Pre 1					0.005
					(0.008)
OT x Post 1					-0.010
					(0.010)
OT x Post 2					-0.021
					(0.013)
OT x Post 3					-0.022***
					(0.008)
OT x Post 4					0.001
					(0.013)
Pre-OT Mean of Dependent Variable	0.031	0.031	0.031	0.031	0.031
PFA Fixed Effects	Yes	Yes	Yes	Yes	Yes
Month-Year Fixed Effects	No	Yes	Yes	Yes	Yes
PFA-Specific Trends	No	No	Yes	Yes	Yes
Seasonal Differencing	No	No	No	Yes	Yes
Sample Size	2408	2408	2408	2408	2408
Number of PFAs	43	43	43	43	43

Notes: Post-period defined as starting from January 2012, i.e., the earliest date of adoption of Operation Tornado. Treatment group (T = 1) defined as police force areas (PFAs) of Cleveland, Durham, Northumbria, Humberside, North Yorkshire, South Yorkshire, West Yorkshire, Norfolk, Derbyshire, Leicestershire, Lincolnshire, Northamptonshire, Nottinghamshire, Cheshire, Cumbria, Greater Manchester, Lancashire, Merseyside, Bedfordshire, Cambridgeshire, Essex, Hertfordshire, Suffolk, Hampshire, Kent, Surrey, Sussex, Thames Valley, Avon and Somerset, Devon and Cornwall, Dorset, Gloucestershire, Wiltshire. Comparison group (T = 0) defined as PFAs of Dyfed-Powys, Gwent, North Wales, South Wales, Staffordshire, Warwickshire, West Mercia, West Midlands, Metropolitan Police Service and City of London. Metal theft defined as total monthly counts of metal thefts per 10,000 population at the PFA level. Regressions weighted by population at the PFA level. Standard errors clustered at the PFA level from Wild Cluster Bootstrap are reported in parentheses. *** Difference-in-Differences statistically significant at the 1 percent level. ** Difference-in-Differences statistically significant at the 5 percent level. * Difference-in-Differences statistically significant at the 10 percent level.

Table 6. Difference-in-Differences Before and After the SMDA 2013.

	Scrap Metal Dealers	Control Firms	Difference	Unconditional DiD
	(1)	(2)	(3)	(4)
A. Sales (Log)				
Pre-	9.943	9.823	0.120	-0.190***
Post-	9.812	9.882	-0.070	(0.057)
Post – Pre	-0.131	0.059		
Number of Firms	31	307		
B. Sales per Employee (Log)				
Pre-	6.370	6.199	0.171	-0.160***
Post-	6.159	6.148	0.011	(0.053)
Post – Pre	-0.211	-0.051		
Number of Firms	26	255		
C. Profit Margin				
Pre-	0.048	0.063	-0.015	-0.024**
Post-	0.016	0.055	-0.039	(0.010)
Post – Pre	-0.032	-0.008		
Number of Firms	30	258		

Notes: Table 6 shows the results of an unconditional difference-in-differences exercise comparing outcomes of interest before and after the Scrap Metal Dealers Act 2013 in scrap metal dealers and control group firms. Post-period defined as starting from the fiscal year 2014. Treatment group (T = 1) defined as scrap metal dealers. Comparison group (T = 0) defined as pawnshops and all other businesses involved in the collection of non-hazardous waste, recovery of sorted materials, wholesale of metals and metal ores and wholesale of waste. Only firms that were still active at the time of writing, i.e., early 2018, and for which complete data was available from 2010 to 2015 were included in the analysis. Panel A shows the result of this exercise for Turnover (Log). Panel B shows the result of this exercise for Turnover per Employee (Log). Panel C shows the result of this exercise for EBITDA Margin. EBITDA Margin was calculated as Operating Profit / Turnover. Turnover includes both national and international turnover. Operating Profit (OP) equals Gross Profit - Administration Expenses + Other Operating Income/Costs pre OP + Exceptional Items pre OP. Standard errors clustered at the firm level are reported in parentheses. * indicates significance at 10 percent, ** indicates significance at 5 percent, *** indicates significance at 1 percent.

Table 7. OLS Estimates of Impact of SMDA 2013 on the Economic Activity of Scrap Metal Dealers in England and Wales, 2010 – 2015.

	Log(Sales)			Log(Sales Per Employee)			Profit Margin		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
SMD x Post	-0.190***	-0.190***	-0.217***	-0.159***	-0.159***	-0.180***	-0.023**	-0.023**	-0.027**
	(0.057)	(0.057)	(0.050)	(0.053)	(0.053)	(0.050)	(0.010)	(0.010)	(0.011)
Pre-SMDA Mean of Dependent Variable	9.834	9.834	10.146	6.215	6.215	6.195	0.062	0.062	0.060
Year Fixed Effects	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sample Size	2028	2028	1506	1686	1686	1506	1728	1728	1506
Number of Firms	338	338	251	281	281	251	288	288	251

Notes: Post-period defined as starting from the fiscal year 2014. Treatment group (T = 1) defined as scrap metal dealers. Comparison group (T = 0) defined as pawnshops and all other businesses involved in the collection of non-hazardous waste, recovery of sorted materials, wholesale of metals and metal ores and wholesale of waste. Only firms that were still active at the time of writing, i.e., early 2018, and for which complete data was available from 2010 to 2015 were included in the analysis. Turnover includes both national and international turnover. Operating Profit (OP) equals Gross Profit - Administration Expenses + Other Operating Income/Costs pre OP + Exceptional Items pre OP. Standard errors clustered at the firm level are reported in parentheses. *** Difference-in-Differences statistically significant at the 1 percent level. ** Difference-in-Differences statistically significant at the 5 percent level. * Difference-in-Differences statistically significant at the 10 percent level.

Table 8. Event-Study Estimates of Impact of SMDA 2013 on the Economic Activity of Scrap Metal Dealers in England and Wales, 2010 – 2015.

	Log(Sales)		Log(Sales Per Employee)		Profit Margin	
	(1)	(2)	(3)	(4)	(5)	(6)
SMD x Pre 2	0.081	0.081	0.033	0.033	-0.010	-0.010
	(0.053)	(0.053)	(0.056)	(0.056)	(0.007)	(0.007)
SMD x Pre 1	-0.045	-0.045	-0.065	-0.065	-0.015	-0.015
	(0.063)	(0.063)	(0.057)	(0.057)	(0.012)	(0.012)
SMD x Post	-0.181**		-0.167**		-0.030***	
	(0.074)		(0.068)		(0.011)	
SMD x Post 1		-0.106*		-0.111		-0.024**
		(0.064)		(0.068)		(0.011)
SMD x Post 2		-0.255***		-0.222***		-0.035**
		(0.095)		(0.079)		(0.015)
Pre-SMDA Mean of Dependent Variable	9.779	9.779	6.204	6.204	0.070	0.070
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Sample Size	2028	2028	1686	1686	1728	1728
Number of Firms	338	338	281	281	288	288

Notes: Post-period defined as starting from the fiscal year 2014. Treatment group (T = 1) defined as scrap metal dealers. Comparison group (T = 0) defined as pawnshops and all other businesses involved in the collection of non-hazardous waste, recovery of sorted materials, wholesale of metals and metal ores and wholesale of waste. Only firms that were still active at the time of writing, i.e., early 2018, and for which complete data was available from 2010 to 2015 were included in the analysis. Turnover includes both national and international turnover. Operating Profit (OP) equals Gross Profit - Administration Expenses + Other Operating Income/Costs pre OP + Exceptional Items pre OP. Standard errors clustered at the firm level are reported in parentheses. *** Difference-in-Differences statistically significant at the 1 percent level. ** Difference-in-Differences statistically significant at the 5 percent level. * Difference-in-Differences statistically significant at the 10 percent level.

Table 9. Estimates of Impact of Metal Prices, Policing and Policy on Metal Theft, 2008 – 2015.

	Metal Theft per 10,000 population				
	(1)	(2)	(3)	(4)	(5)
Log (International Price) X 100	0.001***	0.001***	0.001***	0.001***	
	(0.000)	(0.000)	(0.000)	(0.000)	
Log (International Price) X 100 x OT		0.000		-0.000	
		(0.000)		(0.000)	
Log (International Price) X 100 x SMDA		-0.001***		-0.001***	
		(0.000)		(0.000)	
Early Adopters x OT			-0.011*	-0.011*	-0.011*
			(0.005)	(0.005)	(0.005)
Late Adopters x OT			-0.003	-0.003	-0.003
			(0.004)	(0.004)	(0.004)
Early Adopters x Pre-SMDA			0.002	0.002	0.002
			(0.004)	(0.004)	(0.004)
Late Adopters x Pre-SMDA			-0.005	-0.005	-0.005
			(0.003)	(0.003)	(0.003)
Early Adopters x SMDA			0.005*	0.005*	0.005*
			(0.003)	(0.003)	(0.003)
Late Adopters x SMDA			-0.006***	-0.008***	-0.006***
			(0.002)	(0.002)	(0.002)
Mean Dependent Variable in 2008	0.030	0.030	0.030	0.030	0.030
Period-Specific Time Trends	Yes	Yes	Yes	Yes	Yes
PFA Fixed Effects	Yes	Yes	Yes	Yes	Yes
Month Fixed Effects	Yes	Yes	Yes	Yes	No
Month-Year Fixed Effects	No	No	No	No	Yes
Sample Size	4224	4224	4224	4224	4224
Number of PFAs	44	44	44	44	44

Notes: Early Adopters defined as police force areas (PFAs) of Cleveland, Durham, Northumbria, Humberside, North Yorkshire, South Yorkshire, West Yorkshire, Norfolk, Derbyshire, Leicestershire, Lincolnshire, Northamptonshire, Nottinghamshire, Cheshire, Cumbria, Greater Manchester, Lancashire, Merseyside, Bedfordshire, Cambridgeshire, Essex, Hertfordshire, Suffolk, Hampshire, Kent, Surrey, Sussex, Thames Valley, Avon and Somerset, Devon and Cornwall, Dorset, Gloucestershire, Wiltshire. Late Adopters defined as PFAs of Dyfed-Powys, Gwent, North Wales, South Wales, Staffordshire, Warwickshire, West Mercia, West Midlands, Metropolitan Police Service and City of London. Metal theft defined as total monthly counts of metal thefts per 10,000 population at the PFA level. Regressions weighted by population at the PFA level. Standard errors clustered at the PFA level from Wild Cluster Bootstrap are reported in parentheses. *** Difference-in-Differences statistically significant at the 1 percent level. ** Difference-in-Differences statistically significant at the 5 percent level. * Difference-in-Differences statistically significant at the 10 percent level.

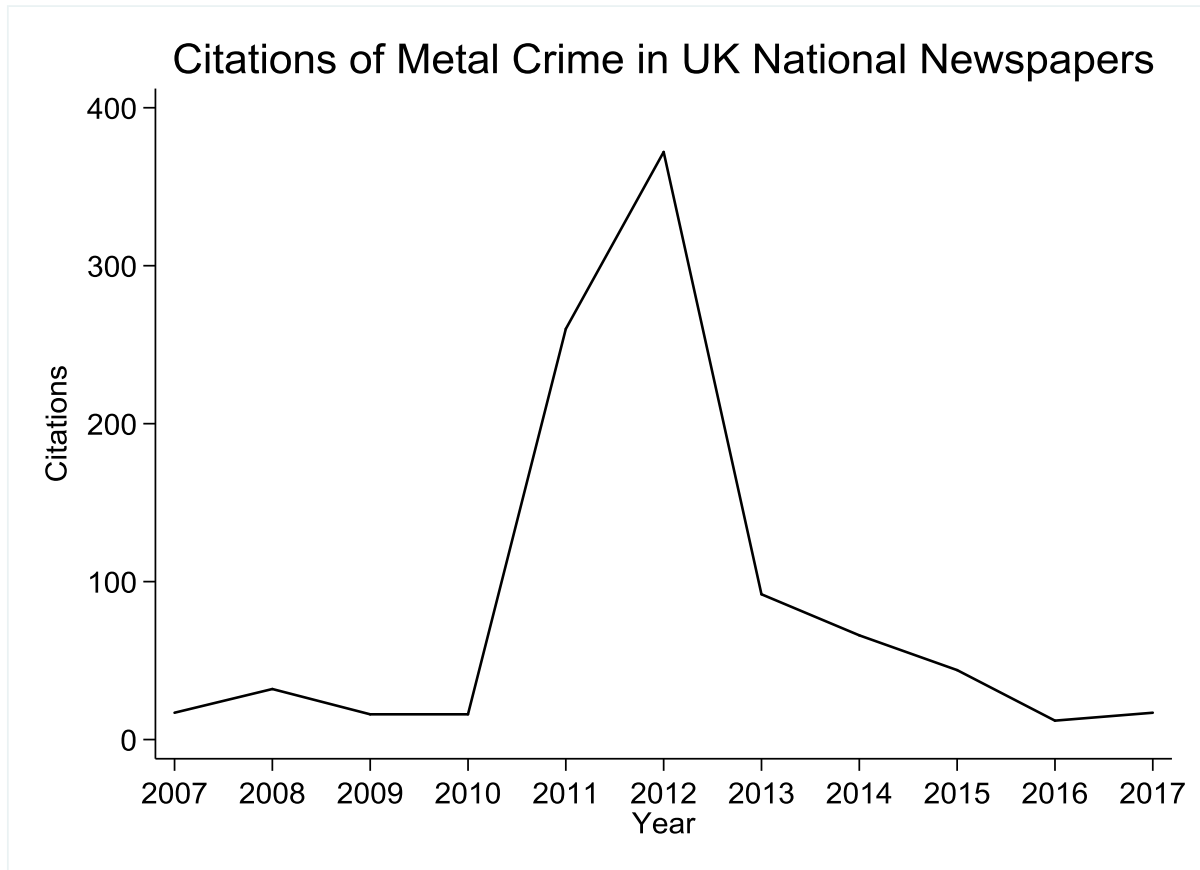**Figure A1. Citations of Metal Theft and Metal Crime in UK National Newspapers from 2007 to 2017.**

Notes: Citations of metal theft and metal crime for every year were calculated using LexisNexis (www.nexis.com) from January 2007 to December 2017.

Figure A2. Event-Study OLS Estimates of Impact of Operation Tornado on Metal Theft, 2008 – Aug 2012. Newey-West Standard Errors with Lag 1 used for inference.
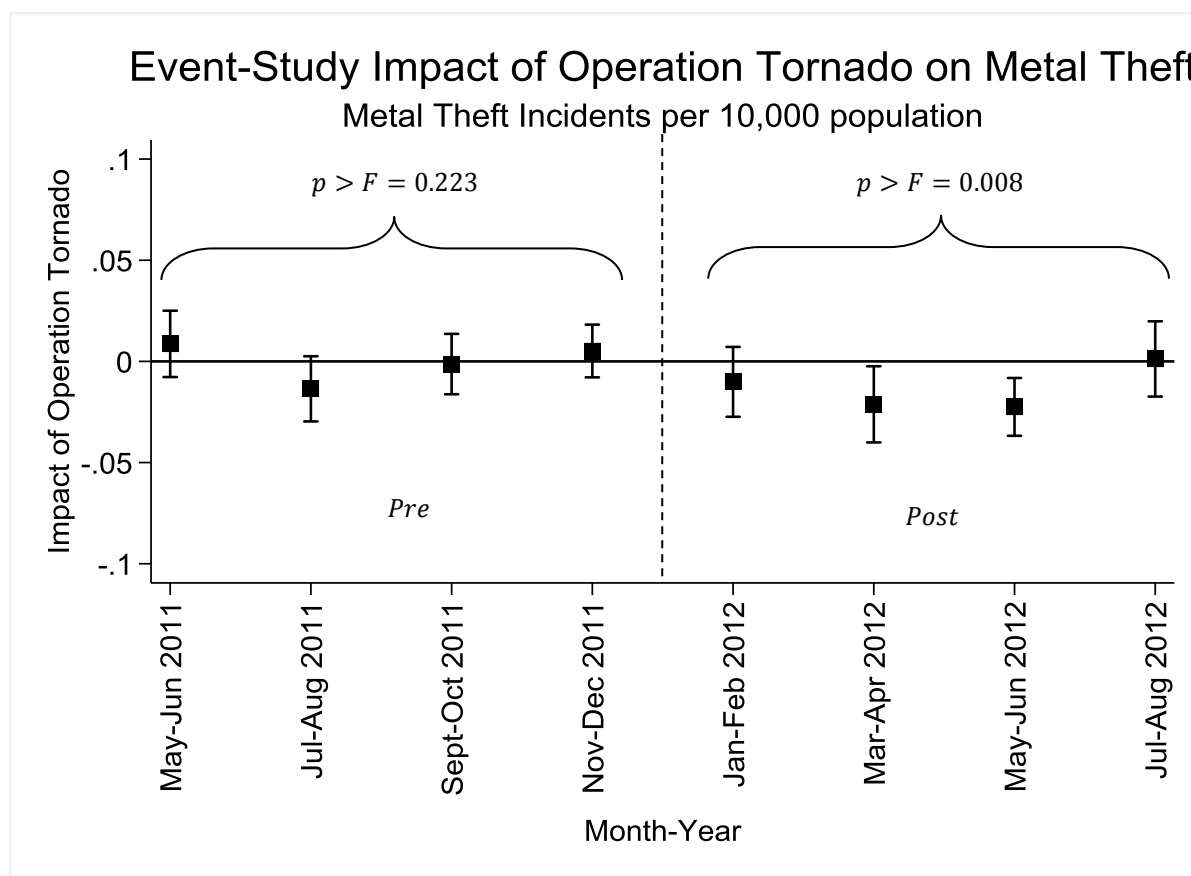
Notes: Post-period defined as starting from January 2012, i.e., the earliest date of adoption of Operation Tornado. Treatment group (T = 1) defined as police force areas (PFAs) Cleveland, Durham, Northumbria, Humberside, North Yorkshire, South Yorkshire, West Yorkshire, Norfolk, Derbyshire, Leicestershire, Lincolnshire, Northamptonshire, Nottinghamshire, Cheshire, Cumbria, Greater Manchester, Lancashire, Merseyside, Bedfordshire, Cambridgeshire, Essex, Hertfordshire, Suffolk, Hampshire, Kent, Surrey, Sussex, Thames Valley, Avon and Somerset, Devon and Cornwall, Dorset, Gloucestershire, Wiltshire. Comparison group (T = 0) defined as PFAs Dyfed-Powys, Gwent, North Wales, South Wales, Staffordshire, Warwickshire, West Mercia, West Midlands, Metropolitan Police Service and City of London. Metal theft defined as total monthly counts of metal thefts per 10,000 population at the PFA level. Regressions weighted by population at the PFA level. Reported dots are point estimates and capped bars are 95 percent confidence intervals.

Figure A3. Event-Study OLS Estimates of Impact of Operation Tornado on Metal Theft, 2008 – Aug 2012. Newey-West Standard Errors with Lag 12 used for inference.

Notes: Post-period defined as starting from January 2012, i.e., the earliest date of adoption of Operation Tornado. Treatment group (T = 1) defined as police force areas (PFAs) of Cleveland, Durham, Northumbria, Humberside, North Yorkshire, South Yorkshire, West Yorkshire, Norfolk, Derbyshire, Leicestershire, Lincolnshire, Northamptonshire, Nottinghamshire, Cheshire, Cumbria, Greater Manchester, Lancashire, Merseyside, Bedfordshire, Cambridgeshire, Essex, Hertfordshire, Suffolk, Hampshire, Kent, Surrey, Sussex, Thames Valley, Avon and Somerset, Devon and Cornwall, Dorset, Gloucestershire, Wiltshire. Comparison group (T = 0) defined as PFAs of Dyfed-Powys, Gwent, North Wales, South Wales, Staffordshire, Warwickshire, West Mercia, West Midlands, Metropolitan Police Service and City of London. Metal theft defined as total monthly counts of metal thefts per 10,000 population at the PFA level. Regressions weighted by population at the PFA level. Reported dots are point estimates and capped bars are 95 percent confidence intervals.

Table A1. Estimates of Metal Crime-Price Elasticities, 2008 to 2015. Newey-West Standard Errors with Lag 12 used for inference.

	Panel A				Panel B			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS Reduced Form	First Stage	IV Structural Form	OLS	OLS Reduced Form	First Stage	IV Structural Form
	Log (Crime)	Log (Crime)	Log (Scrap Price)	Log (Crime)	Log (Crime)	Log (Crime)	Log (Scrap Price)	Log (Crime)
A. BTP Data, England and Wales								
Log(Scrap Price)	1.673***			1.875***	0.900***			1.044***
	(0.291)			(0.318)	(0.131)			(0.203)
Log(World Price)		2.090***	1.115***			1.146***	1.098***	
		(0.174)	(0.123)			(0.133)	(0.155)	
B. BTP Data, London								
Log(Scrap Price)	2.181***			2.524***	1.473***			1.645***
	(0.331)			(0.382)	(0.133)			(0.233)
Log(World Price)		2.813***	1.115***			1.805***	1.098***	
		(0.281)	(0.123)			(0.241)	(0.155)	
C. MPS Data, London								
Log(Scrap Price)	1.849***			2.018***	1.435***			1.449***
	(0.257)			(0.272)	(0.221)			(0.262)
Log(World Price)		2.250***	1.115***			1.591***	1.098***	
		(0.182)	(0.123)			(0.303)	(0.155)	
F-Statistic			44.60				30.40	
Linear Time Trend	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Δ_{12} Differenced	No	No	No	No	Yes	Yes	Yes	Yes
Number of Months	96	96	96	96	96	96	96	96

Notes: Metal theft defined as (Log) total monthly counts of total thefts. Newey-West standard errors are reported in parentheses. *** indicates significance at the 1 percent level. ** indicates significance at the 5 percent level. * indicates significance at the 10 percent level.

Table A2. Estimates of Metal Crime, Price and Labour Market Elasticities, 2008 to 2015. Newey-West Standard Errors with Lag 12 used for inference.

	BTP Data, England and Wales		BTP Data, London		MPS Data, London	
	(1)	(2)	(3)	(4)	(5)	(6)
	IV Structural Form	IV Structural Form	IV Structural Form	IV Structural Form	IV Structural Form	IV Structural Form
	Log(Crime)	Log(Crime)	Log(Crime)	Log(Crime)	Log(Crime)	Log(Crime)
Log(Scrap Price)	0.907***	0.527***	1.299***	0.977***	0.741***	0.449***
	(0.180)	(0.121)	(0.251)	(0.220)	(0.100)	(0.076)
Log (Male Unemployment)	0.495***	-0.037	0.502	0.308	0.272***	0.008
	(0.172)	(0.195)	(0.396)	(0.411)	(0.078)	(0.076)
Log (Lagged Metal Theft)	0.477***	0.580***	0.419***	0.447***	0.623***	0.749***
	(0.107)	(0.057)	(0.114)	(0.126)	(0.046)	(0.050)
Long Run Log(Scrap Price)	1.734***	1.255***	2.235***	1.767***	1.966***	1.786***
	(0.235)	(0.245)	(0.402)	(0.282)	(0.275)	(0.294)
Linear Time Trend	Yes	Yes	Yes	Yes	Yes	Yes
Δ_{12} Differenced	No	Yes	No	Yes	No	Yes
Number of Months	96	96	96	96	96	96
Log (Scrap Price)	0.905***	0.555***	1.788***	1.511***	0.860***	0.351***
	(0.274)	(0.161)	(0.342)	(0.343)	(0.134)	(0.111)
Log (Male Unemployment)	0.566	-0.066	0.363	0.585	0.165	-0.131
	(0.503)	(0.298)	(0.524)	(0.517)	(0.133)	(0.114)
Log (Lagged Metal Theft)	0.388***	0.404***	0.235	0.265**	0.414***	0.768***
	(0.119)	(0.058)	(0.142)	(0.102)	(0.064)	(0.130)
Long Run Log(Scrap Price)	1.479***	0.932***	2.336***	2.054***	1.468***	1.516***
	(0.288)	(0.256)	(0.576)	(0.495)	(0.198)	(0.466)
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Δ_{12} Differenced	No	Yes	No	Yes	No	Yes
Number of Months	96	96	96	96	96	96

Notes: Metal theft defined as (Log) total monthly counts of total thefts. Newey-West standard errors are reported in parentheses. *** indicates significance at the 1 percent level. ** indicates significance at the 5 percent level. * indicates significance at the 10 percent level.

Table A3. Placebo Estimates of Other Theft, Metal Price and Labour Market Elasticities, 2008 to 2015.

	BTP Data, England and Wales					BTP Data, London				MPS Data, London		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	IV Structural Form					IV Structural Form				IV Structural Form		
	Log (Other Theft)					Log (Other Theft)				Log (Other Theft)		
Log(Scrap Price)	0.080	0.024	0.099***	0.032	0.169***	0.041	0.151***	0.019	0.123***	0.017	0.025	0.004
	(0.055)	(0.046)	(0.037)	(0.026)	(0.048)	(0.048)	(0.047)	(0.038)	(0.036)	(0.028)	(0.026)	(0.015)
Log (Male Unemployment)		0.071		0.069		0.081		0.026		0.117***		0.057***
		(0.044)		(0.068)		(0.060)		(0.062)		(0.040)		(0.022)
Log (Lagged Other Theft)		0.600***		0.713***		0.548***		0.754***		0.424***		0.629***
		(0.070)		(0.075)		(0.089)		(0.075)		(0.094)		(0.070)
Long Run Log(Scrap Price)		0.061		0.111		0.091		0.076		0.029		0.010
		(0.113)		(0.084)		(0.100)		(0.144)		(0.048)		(0.040)
Linear Time Trend	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Δ_{12} Differenced	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
Number of Months	96	96	96	96	96	96	96	96	96	96	96	96
Log(Scrap Price)	-0.014	0.045	0.080*	0.041	0.078	0.049	0.196**	0.058	-0.008	-0.012	0.005	-0.005
	(0.097)	(0.083)	(0.048)	(0.030)	(0.084)	(0.084)	(0.080)	(0.057)	(0.036)	(0.033)	(0.024)	(0.019)
Log (Male Unemployment)		0.190		0.122		-0.076		-0.028		-0.007		0.023
		(0.119)		(0.093)		(0.099)		(0.078)		(0.053)		(0.025)
Log (Lagged Other Theft)		0.554***		0.708***		0.397***		0.689***		0.096		0.378***
		(0.085)		(0.083)		(0.097)		(0.088)		(0.120)		(0.125)
Long Run Log(Scrap Price)		0.102		0.140		0.082		0.185		-0.013		-0.009
		(0.188)		(0.115)		(0.137)		(0.173)		(0.037)		(0.031)
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Δ_{12} Differenced	No	No	Yes	Yes	No	No	Yes	Yes	No	No	Yes	Yes
Number of Months	96	96	96	96	96	96	96	96	96	96	96	96

Notes: Other theft defined as (Log) total monthly counts of total thefts. Newey-West standard errors are reported in parentheses. *** indicates significance at the 1 percent level. ** indicates significance at the 5 percent level. * indicates significance at the 10 percent level.

Table A4. OLS Estimates of Impact of SMDA 2013 on the Economic Activity of Scrap Metal Dealers in England and Wales, 2010 – 2015.

	Log(Sales)			Log(Sales Per Employee)			Profit Margin		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
SMD x Post (NW1)	-0.190***	-0.190***	-0.217***	-0.159***	-0.159***	-0.180***	-0.023***	-0.023***	-0.027***
	(0.050)	(0.047)	(0.045)	(0.049)	(0.046)	(0.045)	(0.008)	(0.008)	(0.009)
SMD x Post (NW2)	-0.190***	-0.190***	-0.217***	-0.159***	-0.159***	-0.180***	-0.023***	-0.023***	-0.027***
	(0.051)	(0.048)	(0.045)	(0.048)	(0.046)	(0.045)	(0.008)	(0.008)	(0.009)
SMD x Post (WCB)	-0.190***	-0.190***	-0.217***	-0.159**	-0.159**	-0.180***	-0.023**	-0.023**	-0.027**
	(0.058)	(0.058)	(0.049)	(0.055)	(0.055)	(0.049)	(0.010)	(0.010)	(0.011)
Pre-SMDA Mean of Dependent Variable	9.834	9.834	10.146	6.215	6.215	6.195	0.062	0.062	0.060
Year Fixed Effects	No	Yes	Yes	No	Yes	Yes	No	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sample Size	2028	2028	1506	1686	1686	1506	1728	1728	1506
Number of Firms	338	338	251	281	281	251	288	288	251

Notes: Post-period defined as starting from the fiscal year 2014. Treatment group (T = 1) defined as scrap metal dealers. Comparison group (T = 0) defined as pawnshops and all other businesses involved in the collection of non-hazardous waste, recovery of sorted materials, wholesale of metals and metal ores and wholesale of waste. Only firms that were still active at the time of writing, i.e., early 2018, and for which complete data was available from 2010 to 2015 were included in the analysis. Turnover includes both national and international turnover. Operating Profit (OP) equals Gross Profit - Administration Expenses + Other Operating Income/Costs pre OP + Exceptional Items pre OP. Newey-West standard errors with serial correlation 1 (2) are reported in parentheses in the first (second) row. Standard errors clustered at the firm level from Wild Cluster Bootstrap are reported in parentheses in the third row. *** Difference-in-Differences statistically significant at the 1 percent level. ** Difference-in-Differences statistically significant at the 5 percent level. * Difference-in-Differences statistically significant at the 10 percent level.

Table A5. Event-Study Estimates of Impact of SMDA 2013 on the Economic Activity of Scrap Metal Dealers in England and Wales, 2010 – 2015. Newey-West Standard Errors with Lag 1 (HAC) reported in parentheses

	Log(Sales)		Log(Sales Per Employee)		Profit Margin	
	(1)	(2)	(3)	(4)	(5)	(6)
SMD x Pre 2	0.081	0.081	0.033	0.033	-0.010	-0.010
	(0.054)	(0.054)	(0.062)	(0.062)	(0.009)	(0.009)
SMD x Pre 1	-0.045	-0.045	-0.065	-0.065	-0.015	-0.015
	(0.054)	(0.054)	(0.061)	(0.061)	(0.011)	(0.011)
SMD x Post	-0.181***		-0.167***		-0.030***	
	(0.057)		(0.062)		(0.009)	
SMD x Post 1		-0.106*		-0.111*		-0.024***
		(0.056)		(0.065)		(0.009)
SMD x Post 2		-0.255***		-0.222***		-0.035***
		(0.079)		(0.076)		(0.013)
Pre-SMDA Mean of Dependent Variable	9.779	9.779	6.204	6.204	0.070	0.070
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Sample Size	2028	2028	1686	1686	1728	1728
Number of Firms	338	338	281	281	288	288

Notes: Post-period defined as starting from the fiscal year 2014. Treatment group (T = 1) defined as scrap metal dealers. Comparison group (T = 0) defined as pawnshops and all other businesses involved in the collection of non-hazardous waste, recovery of sorted materials, wholesale of metals and metal ores and wholesale of waste. Only firms that were still active at the time of writing, i.e., early 2018, and for which complete data was available from 2010 to 2015 were included in the analysis. Turnover includes both national and international turnover. Operating Profit (OP) equals Gross Profit - Administration Expenses + Other Operating Income/Costs pre OP + Exceptional Items pre OP. Newey-West standard errors with serial correlation lag one are reported in parentheses. *** Difference-in-Differences statistically significant at the 1 percent level. ** Difference-in-Differences statistically significant at the 5 percent level. * Difference-in-Differences statistically significant at the 10 percent level.

Table A6. Event-Study Estimates of Impact of SMDA 2013 on the Economic Activity of Scrap Metal Dealers in England and Wales, 2010 – 2015. Newey-West Standard Errors with Lag 2 (HAC) reported in parentheses

	Log(Sales)		Log(Sales Per Employee)		Profit Margin	
	(1)	(2)	(3)	(4)	(5)	(6)
SMD x Pre 2	0.081	0.081	0.033	0.033	-0.010	-0.010
	(0.053)	(0.053)	(0.055)	(0.055)	(0.008)	(0.008)
SMD x Pre 1	-0.045	-0.045	-0.065	-0.065	-0.015	-0.015
	(0.055)	(0.055)	(0.057)	(0.057)	(0.011)	(0.011)
SMD x Post	-0.181***		-0.167***		-0.030***	
	(0.059)		(0.059)		(0.009)	
SMD x Post 1		-0.106*		-0.111*		-0.024***
		(0.057)		(0.062)		(0.009)
SMD x Post 2		-0.255***		-0.222***		-0.035***
		(0.080)		(0.073)		(0.013)
Pre-SMDA Mean of Dependent Variable	9.779	9.779	6.204	6.204	0.070	0.070
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Sample Size	2028	2028	1686	1686	1728	1728
Number of Firms	338	338	281	281	288	288

Notes: Post-period defined as starting from the fiscal year 2014. Treatment group (T = 1) defined as scrap metal dealers. Comparison group (T = 0) defined as pawnshops and all other businesses involved in the collection of non-hazardous waste, recovery of sorted materials, wholesale of metals and metal ores and wholesale of waste. Only firms that were still active at the time of writing, i.e., early 2018, and for which complete data was available from 2010 to 2015 were included in the analysis. Turnover includes both national and international turnover. Operating Profit (OP) equals Gross Profit - Administration Expenses + Other Operating Income/Costs pre OP + Exceptional Items pre OP. Newey-West standard errors with serial correlation two are reported in parentheses. *** Difference-in-Differences statistically significant at the 1 percent level. ** Difference-in-Differences statistically significant at the 5 percent level. * Difference-in-Differences statistically significant at the 10 percent level.

Table A7. Event-Study Estimates of Impact of SMDA 2013 on the Economic Activity of Scrap Metal Dealers in England and Wales, 2010 – 2015. Wild Cluster Bootstrap Standard Errors reported in parentheses

	Log(Sales)		Log(Sales Per Employee)		Profit Margin	
	(1)	(2)	(3)	(4)	(5)	(6)
SMD x Pre 2	0.081	0.081	0.033	0.033	-0.010	-0.010
	(0.050)	(0.050)	(0.057)	(0.057)	(0.006)	(0.006)
SMD x Pre 1	-0.045	-0.045	-0.065	-0.065	-0.015	-0.015
	(0.061)	(0.061)	(0.056)	(0.056)	(0.012)	(0.012)
SMD x Post	-0.181**		-0.167**		-0.030**	
	(0.075)		(0.067)		(0.011)	
SMD x Post 1		-0.106		-0.111		-0.024**
		(0.065)		(0.068)		(0.010)
SMD x Post 2		-0.255**		-0.222***		-0.035**
		(0.097)		(0.082)		(0.015)
Pre-SMDA Mean of Dependent Variable	9.779	9.779	6.204	6.204	0.070	0.070
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Sample Size	2028	2028	1686	1686	1728	1728
Number of Firms	338	338	281	281	288	288

Notes: Post-period defined as starting from the fiscal year 2014. Treatment group (T = 1) defined as scrap metal dealers. Comparison group (T = 0) defined as pawnshops and all other businesses involved in the collection of non-hazardous waste, recovery of sorted materials, wholesale of metals and metal ores and wholesale of waste. Only firms that were still active at the time of writing, i.e., early 2018, and for which complete data was available from 2010 to 2015 were included in the analysis. Turnover includes both national and international turnover. Operating Profit (OP) equals Gross Profit - Administration Expenses + Other Operating Income/Costs pre OP + Exceptional Items pre OP. Standard Errors clustered at the firm level from Wild Cluster Bootstrap are reported in parentheses. *** Difference-in-Differences statistically significant at the 1 percent level. ** Difference-in-Differences statistically significant at the 5 percent level. * Difference-in-Differences statistically significant at the 10 percent level.

Table A8. Event-Study Estimates of Impact of SMDA 2013 on the Economic Activity of Scrap Metal Dealers in England and Wales, 2010 – 2015.

	Log(Sales)			Log(Sales Per Employee)			Profit Margin		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
SMD x Pre 2		0.057	0.057		0.046	0.046		-0.009	-0.009
		(0.054)	(0.054)		(0.051)	(0.051)		(0.006)	(0.006)
SMD x Pre 1		-0.075	-0.075		-0.037	-0.037		-0.015	-0.015
		(0.086)	(0.086)		(0.053)	(0.053)		(0.011)	(0.011)
SMD x Post	-0.159***	-0.163**		-0.127**	-0.125*		-0.022**	-0.028***	
	(0.058)	(0.075)		(0.052)	(0.066)		(0.009)	(0.010)	
SMD x Post 1			-0.112*			-0.079			-0.024**
			(0.067)			(0.064)			(0.010)
SMD x Post 2			-0.217**			-0.172**			-0.031**
			(0.097)			(0.080)			(0.014)
Pre-SMDA Mean of Dependent Variable	9.482	9.482	9.482	6.214	6.214	6.214	0.064	0.064	0.064
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sample Size	2442	2442	2442	1973	1973	1973	2073	2073	2073
Number of Firms	429	429	429	343	343	343	363	363	363

Notes: Post-period defined as starting from the fiscal year 2014. Treatment group (T = 1) defined as scrap metal dealers. Comparison group (T = 0) defined as pawnshops and all other businesses involved in the collection of non-hazardous waste, recovery of sorted materials, wholesale of metals and metal ores and wholesale of waste. Only firms for which complete data was available from 2010 to 2013 were included in the analysis. Turnover includes both national and international turnover. Operating Profit (OP) equals Gross Profit - Administration Expenses + Other Operating Income/Costs pre OP + Exceptional Items pre OP. Standard errors clustered at the firm level are reported in parentheses. *** Difference-in-Differences statistically significant at the 1 percent level. ** Difference-in-Differences statistically significant at the 5 percent level. * Difference-in-Differences statistically significant at the 10 percent level.

Table A9. Additional Estimates of Metal Crime-Price Elasticities, 2008 to 2015.

	Panel A				Panel B			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS Reduced Form	First Stage	IV Structural Form	OLS	OLS Reduced Form	First Stage	IV Structural Form
	Log(Crime)	Log(Crime)	Log(Scrap Price)	Log(Crime)	Log(Crime)	Log(Crime)	Log(Scrap Price)	Log(Crime)
A. BTP Data, England and Wales								
Log(Scrap Price)	1.048***			1.087***	0.787***			0.857***
	(0.115)			(0.135)	(0.143)			(0.141)
Log(World Price)		1.313***	1.208***			1.020***	1.189***	
		(0.185)	(0.107)			(0.146)	(0.103)	
B. BTP Data, London								
Log(Scrap Price)	1.374***			1.533***	1.360***			1.457***
	(0.182)			(0.231)	(0.200)			(0.273)
Log(World Price)		1.851***	1.208***			1.733***	1.189***	
		(0.318)	(0.107)			(0.328)	(0.103)	
C. MPS Data, London								
Log(Scrap Price)	1.274***			1.316***	1.278***			1.151***
	(0.147)			(0.149)	(0.183)			(0.153)
Log(World Price)		1.589***	1.208***			1.368***	1.189***	
		(0.223)	(0.107)			(0.224)	(0.103)	
F-Statistic			80.59				44.50	
Linear Time Trend Pre 2012	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Linear Time Trend Post 2012	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Post 2012 Dummy Variable	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Δ_{12} Differenced	No	No	No	No	Yes	Yes	Yes	Yes
Number of Months	96	96	96	96	96	96	96	96

Notes: Metal theft defined as (Log) total monthly counts of total thefts. Newey-West standard errors are reported in parentheses. *** indicates significance at the 1 percent level. ** indicates significance at the 5 percent level. * indicates significance at the 10 percent level.