Illegal Firearms Markets

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Abstract

In the United States, the legal status of the 30-40 million annual firearms transactions is defined by state and federal regulations. These regulations primarily aim to reduce criminal misuse while preserving access for the large majority of adults who lack a serious criminal record or are otherwise proscribed from possession. Illicit firearms transactions are embedded in the "formal market"—sales, mostly of new guns, by licensed retail dealers required to screen purchasers and maintain records—and the "informal market," where any of the 80 million gun owners may act as a source. A growing fraction of illicit transactions involve privately made firearms, fabricated from commercial kits or additive manufacturing techniques. The firearms used by proscribed people are diverted from the legal supply chain, in some cases by professional intermediaries (thieves, straw purchasers, scofflaw dealers, home fabricators). Subsequent redistribution may involve professional brokers and traffickers. Most such enterprises are small in scale, with organized criminal groups serving primarily as customers rather than distributors. Compared with the drug trade, the illicit gun market is smaller and more exposed to law enforcement. For illicit buyers, transactions costs may be high and differentiated, varying based on the local prevalence of guns, social networks, and the intensity of regulations and enforcement on dealers. While preventing dangerous people from obtaining guns is intrinsically difficult in a regime designed for broad accessibility to most adults, regulations can substantially affect illicit commerce, and some regulations have the potential to reduce criminal use.

Significance statement

Illicit transactions supply most firearms used in homicide and other violent crime in the United States. Better understanding illicit commerce in firearms is foundational for designing more effective enforcement strategies. This article characterizes the types of transactions that violate current regulations and contribute to deadly misuse of firearms in the U.S., highlighting common points of legal market diversion and diverse actors operating in the subsequent supply chain. Our analysis also contributes to a more general understanding of illegal markets by providing a case study with several distinctive features: illicit transactions are embedded in a large legal market; firearms' durability makes current owners a vast, diffuse potential source; and the legal framework primarily aims to curtail particular uses of the product.

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1. Introduction

Firearms are durable commodities with various valued uses, including hunting, pest control, target shooting, collecting, and defense against personal crimes of theft and violence. Firearms are also misused in ways that produce enormous social costs (1). In the United States, where private firearms outnumber people, they are used in an estimated half million violent crimes each year, resulting in 21,000 deaths and 94,000 injuries from robbery and criminal assault in 2022 (2-4). As in most countries, commerce in firearms in the U.S. is subject to regulations intended to reduce criminal misuse and promote public safety. The force of such regulations is inevitably undercut by various types of noncompliance, including transactions that circumvent the intent of existing regulations and those that are in direct violation and hence illegal. However, firearms regulations can, under some circumstances, profoundly affect commerce and measurably reduce firearms misuse.

As with many other legal goods that can be harmful (e.g., opioid analgesics, TNT), regulations on firearms attempt to limit their misuse while preserving legitimate uses. The United States is exceptional amongst its economic peers in its priority on protecting legitimate uses, and indeed, the U.S. Constitution's Second Amendment creates a right to "keep and bear arms." Most American adults are allowed to acquire any number of handguns, shotguns, and rifles. The exceptions specified by federal law include people who have a serious criminal record, those "adjudicated as a mental defective," illegal aliens, users of federally prohibited drugs, and those under age 18. About 30% of adults and 40% of all households own at least one gun (5), averaging about 5 per gun-owning household (6). With an estimated 350-400 million firearms in civilian hands, the United States' outsized importance for firearms availability and firearms violence has made it the primary context of study for illegal firearm markets, and we focus our subsequent discussion accordingly.

Firearms are regulated more closely than most other readily available weapons because they are deadlier and pose a broader threat than knives or clubs, with fatality rates in shootings far exceeding those of knife attacks under similar circumstances and intents (7). Firearms also provide assailants with the power to kill quickly, at a distance, without the need for skill or strength or sustained determination. These characteristics make firearms an attractive instrument for those intent on inflicting harm or inspiring fear, and they are the predominant weapon employed in presidential assassinations, mass attacks, and gang disputes. While actual victimization is highly concentrated about younger Black males, the costs of gun violence are widely shared. A recent survey found that one-third

of American adults were influenced by the threat of gun violence in deciding where to live, and half thought that gun violence was a serious problem in their community (1).

The market for firearms is large, encompassing 30-40 million transactions annually. Over sixty percent of these transactions take place in the primary (formal) market in which federally licensed retail dealers (FFLs) conduct and record sales to customers who are screened to determine that they satisfy state and federal requirements (8). Most remaining transactions take place in the secondary, informal market, where unlicensed individuals sell or otherwise transfer their firearms without such requirements. A fraction of transactions in both the formal and informal markets are illegal, violating one or more regulations.

The illegal transactions do not necessarily constitute a distinct "market," commonly understood as an institution that facilitates voluntary exchanges, with prices and quantities determined through the interaction of buyers and sellers. For the most part, illegal transactions in firearms are embedded in the much larger formal and informal markets, involving guns that were diverted from the legal supply chain. As one analogy, illegal firearm transactions more closely resemble the market for diverted pharmaceuticals than that for heroin. The supply chain of guns to proscribed users does involve intermediaries dedicated to circumventing legal requirements---corrupt or negligent dealers, straw purchasers, interstate traffickers, international smugglers, brokers. The scarcity of information for matching buyers, sellers, and guns results in a landscape of illegal firearm transactions where prices are far from uniform even for the identical make, model, and condition. More generally, transaction costs differ widely among potential buyers depending on their specific connections and circumstances.

While it continues to be true that most firearms used in crime enter the supply chain as legal commodities, there has been a surge in the use of firearms fabricated by unlicensed individuals. These privately made firearms (PMFs) represent a new potential source for illegal transactions. Beginning in the 2010s, most of the PMFs entering commerce were fabricated from kits that were marketed and distributed by mail-order with no federal requirements for screening, recordkeeping, or registered serial numbers. They provided a direct source for proscribed individuals. Because PMFs without a serial number cannot be traced back to the fabricator or seller, they are referred to as "ghost guns." A change in federal regulation in 2022 effectively outlawed ghost gun kits. Much harder to regulate is the option of home manufacture using 3D printing and other manufacturing innovations, technologies continuing to develop and become more affordable.

From a policy perspective, a crosscutting concern in regulating firearms is "futility" -- whether despite widespread evasion and avoidance, government regulations of firearms can be effective in reducing criminal misuse (9, 10). Since states supplement federal regulations on firearms commerce, the "laboratory of the states" provides some quasi-experimental evidence on the effectiveness of specific regulations. A growing literature supports a conclusion that state laws imposing more stringent processes for keeping

firearms from proscribed individuals can be somewhat effective in reducing criminal misuse of guns, while regulations that attempt to discriminate between entitled and proscribed individuals without systematic enforcement have a mixed record at best.

In sum, illegal commerce in firearms is shaped by two basic facts. First, most firearms, and most firearms transactions, are legal. And second, firearms are highly durable, meaning that used firearms are close substitutes for new, and current owners represent a vast and diffuse potential source of firearms. Both features contribute to the intrinsic difficulty of enforcing regulations designed to exclude felons and others who are banned from possession. But regulation matters both in shaping commerce and misuse.

2. Trends and patterns in firearms transactions

Most illegal transactions in firearms are embedded in the much larger formal and especially the informal firearms markets, with legality distinguished primarily by the identity of the buyer (i.e., proscribed or not) and whether the source observes relevant regulations on screening and documentation. There may exist a distinct illegal market for stolen guns, or for prohibited guns (un-serialized privately manufactured firearms, submachine guns), for which most all transactions are technically illegal. However, diversion from the legal market represents the main source of supply for firearms that serve illegal demand.

Because of the importance of diversion, we provide estimates of the overall volume of retail firearms commerce in the United States, without regard to their legal status. We distinguish between sales by licensed retailers (FFLs), subject to federal recordkeeping and background check requirements, and secondhand transfers by non-licensed individuals, who are prohibited from knowingly transferring to a proscribed individual but are largely unregulated. We then situate illegal transactions and criminal misuse within these broader markets. Details on data sources and calculations are provided in the Online Supplemental Materials.

Sales by FFLs

Retail sales by FFLs (the formal market) include both new and used firearms. The formal supply chain for new sales originates with imports and domestic manufacturing (net of exports) which are conducted and reported by licensees. Figure 1 depicts the flow of these new guns from 1986 to 2022. The peak was in 2021, when nearly 22.7 million new firearms were added to the supply chain, 57% of which were handguns, 20% rifles, and 15% shotguns. New guns are eventually sold at retail by FFLs, although data on when firearms shipped to stores are actually sold are not published and the timing of shipments may not align with the timing of retail sale.

Fig. 1. . New firearms introduced to US retail market and their estimated average wholesale price, 1986-2022. Sum of firearms manufactured in and imported to the United States, net of firearms exported, by year. Average wholesale price in 2023$ calculated as described in the Online Supplement

Based on federal tax collections data, the estimated value of the formal wholesale market for new firearms in 2023 was approximately $5.8 billion, down from its peak of $7.8 billion in 2021. Between 1991 and 2022, the average wholesale price of a handgun in 2023$ was $396 while the average wholesale price of rifles and shotguns was $447. Data on prices for high-selling firearms scraped from online retailers suggest average retail price (in 2023$) of about $700 for pistols and $920 for rifles (11, 12).

Retail FFLs also acquire and sell used guns, employing the same background check and recordkeeping processes as for new sales. Since 1998, it is possible to estimate the total number of sales by retail FFLs by extrapolating from the number of background checks, although with some error (13). During the five pre-COVID years of 2015-2019, the comparison of estimated total sales (71.4 million) with domestic shipments of new guns (65.0 million) suggests that used guns constitute 9% of the total.

Other transactions

About 80 million U.S. residents own at least one firearm, averaging between four and five (5, 6). The estimated stock of approximately 350-400 million firearms in private hands represents a huge potential supply for transactions in secondhand guns (6). Since the market is by definition “off the books,” there are no administrative data on sales volume. An indirect estimate derives from national surveys conducted in 2015 and 2019 that included items on gun acquisitions in the previous two or five years, respectively, and found that 36%-39% acquired their firearm from the informal market (i.e., not a gun store; (8, 14)). If 36-39% of recently acquired guns were from a source other than a retail dealer, the total volume of acquisitions was about 60% larger than the volume of sales by retail dealers. (This calculation in principle understates the true total, since some firearms changed hands multiple times during the two-year or five-year windows in the survey question.) In any event, dividing estimated retail sales by 0.6 suggests a total of 24 million transactions per year during the period 2015-19.

Situating Illegal Transactions and Harms within the Broader Market

During the peak sales volume years of 2020 and 2021 (Figure 1), a period that coincided with a historic surge in firearm violence (15), our estimates suggest more than 32.5 million firearm transactions annually (with over 42 million in 2021). Some fraction of these are illegal, violating regulations on who can possess or purchase a firearm, who can transfer firearms, and processes governing that transfer. Some other partially overlapping fraction will go on to be used for criminal harm, and it is these criminal uses–rather than the illegal transactions themselves–that are responsible for most harms from firearms.

Indeed, typical illegal transactions involving firearms are not directly associated with violence, coercion, or corruption.

Figure 2 offers a schematic representation of retail commerce in firearms in the U.S., with the purpose of providing a qualitative sense of the relative importance of illegal transactions and transactions that arm dangerous individuals within the broader market. As discussed in the next section, the transactions that arm criminals are commonly illegal. However, the durable nature of firearms means efforts to curtail the volume of illegal firearms transactions must also contend with existing local availability (e.g., through theft, gifts) as a potential non-market alternative supply source to criminal misuse.

Fig. 2. Stylized depiction of US retail commerce in firearms. The formal market refers to transfers by federally licensed dealers (FFLs), while the informal market encompasses transfers by unlicensed individuals

3. Structure and Nature of Illegal Transactions, Supply Chains, and Criminal Enterprises

Much of the regulatory structure in the United States is intended to achieve effective discrimination between "entitled" and "proscribed" individuals: the former are allowed to acquire and keep as many firearms as they wish, while the proscribed group is banned from acquiring or possessing any. As with price discrimination by a monopolist, the challenge is to create an effective barrier between the two groups of potential buyers (entitled and proscribed). In practice the barrier is only partially effective, and a large share of firearms violence is committed by proscribed individuals who obtain their firearms illegally (16, 17). Understanding the nature of transactions that ultimately arm criminals, as well as the preceding links in the supply chain, is thus of interest for disrupting illegal markets and preventing violent crime.

Sources of firearms to criminal use

Since 1991, a series of federal surveys have asked a representative sample of state and federal prison inmates who possessed a firearm at the time of their crime about where and how they had obtained it. Based on the most recent 2016 survey, nearly two-thirds (64%) of inmates who possessed a firearm at the time of their offense and had served fewer than two years reported obtaining their firearm by purchase or trade; another 15% said it was a gift or loan. Regardless of the type of transaction, the vast majority reported acquiring their firearm from a friend or family member (31.0%) or "street" sources (39.7%), with just 8% saying they had acquired it from a gun store. Other types of transactions included theft (5%) or obtained at the scene of the crime (8%; see Table S1 for full results). Interviews with local jail inmates and youth at juvenile facilities, as well as data on adolescents involved in shootings at school, suggest heavy reliance on social networks, family, and "street" sources (18-20). Individuals less engaged in serious criminal activity, or those engaged in trafficking, may make greater use of licensed dealers.

While individuals who carry or use firearms illegally seem to rarely rely on the formal market as a direct source, the supply chains to crime almost always begin with a sale by a FFL. One source of data useful in linking crime guns to FFL sales is ATF's National Tracing Center, which traces firearms confiscated or otherwise recovered by law enforcement (hereafter, "crime guns") to their first retail sale. One consistent pattern is that these crime guns have changed hands one or more times since the first sale. Based on crime gun trace data from 2017 through 2021 where purchaser and possessor were known, only 17% of traced crime guns had the same purchaser as possessor (21). (23% are excluded because the police were not able to link the gun to a specific individual.)

Some of those firearms that changed hands were originally purchased by someone who intended to re-sell it (a "straw" purchaser), typically to a proscribed user who would not have cleared the FFL's screening procedure. One indicator that the gun was diverted by a straw purchaser is that it was confiscated within a few months of the original purchase from someone else. Nationwide, the percentage of crime guns recovered within one year

of purchase has typically been between 15%-20%. Relatedly, more than 60% of guns that are recovered after being reported stolen from an FFL are less than one-year old at the time of recovery (22).

Transactions with FFLs

For an entitled buyer, shopping at a gun store (FFL) has obvious advantages in comparison with seeking to obtain one from a private individual. Stores are readily located, offer an array of products of known quality, and likely offer a safe and reliable means of conducting a transaction (23). While proscribed individuals are legally blocked, and there is a remote chance of legal consequences for a proscribed person's attempting to purchase from an FFL, the potential advantages make it attractive for some to access guns from this source if possible.

As summarized above, there is a stark difference in sources of guns to criminal offenders and the general public: an estimated 60% of all firearm transactions are purchases from an FFL retailer, but only 8% of inmates reported acquiring their guns directly from a retail store. That gap suggests that the legal barrier is somewhat effective. However, some proscribed people do find a way to evade the regulations. These evasions include "lie and buy," theft from FFLs, scofflaw dealers, and straw purchasing:

*Lie and buy***.** An obvious possibility is for the proscribed buyer to lie about their status on the required form. That "lie and buy" approach was seemingly common before 1994, when the Brady Act instituted a requirement that FFLs conduct a criminal background check on buyers (24). Nonetheless, the Brady requirement that the buyer show identification leaves open the possibility of using a counterfeit driver's license.[1] Furthermore, gaps in record submission to state and federal background check systems mean that proscribed individuals who falsely claim they are entitled may not always be flagged for denial, and the expected costs associated with being flagged for denial are low. ATF refers about 10% of denials for investigation and prosecutes only one in a thousand of those (e.g., 12 of 12,710 referrals in fiscal year 2017 (25)), relying almost entirely on warning notices in lieu of prosecution. States differ greatly in their enforcement against attempted purchases by proscribed possessors. Some do not investigate or prosecute any firearm denials but may refer information to local authorities for possible arrest if the individual has an active warrant. Other states, those with state-specific statutes penalizing ATF form falsification (e.g., Pennsylvania), investigate a relatively high (e.g., 30%) proportion of denials (26).

Scofflaw dealers. The 70 thousand licensed retail FFLs are required to run background checks on buyers and keep permanent records of any sales, but some are willing to accommodate proscribed individuals and evade the background check and recordkeeping requirements (27-29). Such practices are supposed to be sanctioned through regulatory

[1] Based on the inmate survey, about 10% of those who obtained their firearm from a gun store themselves reported not using their own name.

enforcement conducted by ATF agents, but that enforcement has been lax in practice, due to limited ATF resources and the agency's political exposure. ATF criminal investigations have identified a number of cases in which FFLs have knowingly sold guns to proscribed buyers, and a few cases in which an FFL sold thousands of guns illegally (30). Even if most FFLs are responsible and compliant, a small number of corrupt or negligent FFLs can have an outsized role as a source of legal supply given their access to an unlimited number of firearms that could potentially be diverted.

The obvious incentive for the FFL is to increase sales, and it may also be true in some of these transactions that the FFL charges a premium. There is no evidence that this sort of corrupt activity is organized or anything but a decision by an individual FFL to increase profits by crossing the line.

Straw purchases. Although there are no comprehensive statistics on the subject, the largest source of diversion from retail FFLs is likely through straw purchases, in which an entitled individual buys a gun from an FFL for a proscribed person. Purchasers are required to sign a statement that they are buying the gun for their personal use, and hence they are in violation when they transfer it to another person.

There is a close parallel here to the sale of alcohol to underage youths. Youths may buy it directly from a retailer by use of fake ID or a friendly scofflaw clerk. Or they may prevail on a friend or other adult to serve as a straw purchaser. The potential supply of straw purchasers seems virtually unlimited, since most adults qualify in the case of guns as well as alcohol. But in practice it is common for straw purchases to be conducted by trusted acquaintances and family members.

An important difference between alcohol and guns is the existence of a professional element in straw purchasing of firearms. There are individuals who take advantage of their clean record to make regular purchases from FFLs and resell them to criminal organizations, gang members, and other proscribed individuals (31). Court records (32), media reporting (33), and interviews (34) suggest payments for this activity of about $100 per visit or per firearm are common, although the structure and size of payments may differ for more complex operations. Most notably, the business of smuggling guns to Mexico typically sources guns with purchases from FFLs in the border states, primarily Texas and Arizona (35, 36). The repeat purchasers are presumably individuals who are also involved in smuggling or are known to the brokers or smugglers, but there is little information on whether they are typically freelancing or in some sense part of a criminal organization. We return to this topic in the next section on trafficking.

Little is known about the supply of straw purchasers. Survey evidence, now quite dated, supports their importance as a direct source of firearms for criminally involved youth (37, 38), and ATF trafficking investigations imply straw purchasers or straw purchasing rings are one of the most common trafficking channels (35). There is also indirect evidence from evaluations of some state policies that aim to increase the expected cost of acting as a straw purchaser. For instance, several states have permit-to-purchase laws require that

gun buyers obtain a permit or license issued by a law-enforcement agency at a fee, typically following a background check and fingerprinting by the agency. FFL retailers are required to enforce that requirement, and to the extent they comply, only adults with the appropriate license or permit can serve as a straw purchaser. These requirements appear to have some chilling effect on straw purchasing. Following Missouri's repeal of its permit-to-purchase requirement in 2007, there was a sharp increase in the proportion of crime guns recovered within one year of sale from a dealer, most likely through a straw purchase, as well as an increasing trend in the proportion of crime guns originating from within the state (39, 40). Evaluations of ATF data also suggest crime guns are more likely to flow from states with permit-to-purchase requirements, with laws mandating inspection of dealers, or with laws imposing penalties on straw purchasing to states without such laws (41, 42).

The Role of Informal Markets and Non-Market Alternatives

Would-be buyers in the informal market need to connect with a willing seller of an acceptable gun at an acceptable price. The market is "thin," with relatively few willing sources and buyers at any point in time and location. Unlike other thin markets, there are limits to the extent to which an offer to sell or buy can be advertised or put on eBay (31) because interstate shipments can only be legally received by FFLs, and non-FFLs face additional restrictions. Non-FFLs can use standard mail to ship long guns to residents of their own state but must use common or contract carriers (e.g., FedEx, UPS) to ship handguns within state. In recent years, several common carriers changed company policies and will no longer ship firearms or firearm products from unlicensed individuals. Restrictions on shipping, combined with the relatively large size and weight of a gun, likely contribute to seemingly limited use of conventional online marketplaces or the Dark Web as direct sources for illegal acquisitions (43, 44).

In addition to search costs associated with identifying a seller in the informal market, there is uncertainty about whether a firearm is in good repair, and whether its possession would carry some legal risk; it may have been stolen or used in a criminal shooting, in which case it is possible that law enforcement has a ballistics record. Transactions may also be blocked if the would-be buyer and seller do not have reason to trust each other. One or the other may be an informant, or even a police officer working undercover. The possibility of robbery during the transaction may also be a salient risk. In short, relevant information is not limited to the quality and price of the gun, but includes the identity of the would-be buyer and seller. Such information is scarce and unevenly distributed (31).

Several surveys have asked proscribed individuals whether they would like to have a gun, and if so, how long it would take them to find a connection. The answers suggest considerable heterogeneity. Some claim same-day access, while other respondents report that it would take a week or more. A study of parolees and probationers in Baltimore who had tried to get a gun in the past six months found more than half (53%) were unsuccessful in their most recent attempt (29). Interviews with incarcerated gun offenders

in Los Angeles found more than 25% had purchased their firearm because another individual (i.e., seller) initiated the transaction (i.e., they were not looking to buy a firearm when the opportunity presented) (18). A more consistent finding is that those in social networks where gun ownership is common find it easier than in networks where guns are sparse (17, 19, 45, 46). Criminal gang members may have ready access through the gang's connections, and in fact some individuals may join a gang in order to have easier access to guns (31).

An obvious contrast is with underground retail drug markets, which generally operate with low transactions costs. Drug users often establish regular connections with specific dealers or locations and return as often as necessary to replenish their supply. Indeed, a major difference with the informal gun market is frequency of repeat purchase (31). Drug users may make purchases several times a week, while guns are acquired far less frequently. Information about a reliable connection depreciates over time, so that a successful purchase a year previous may not be replicable. Risk from law enforcement also constrains the establishment of visible or known location-based marketplaces for illegal firearms. While it is often common knowledge that a drug connection can be readily arranged in particular locations, it is difficult to imagine law enforcement tolerating a street-corner gun-selling operation.

A related question is why drug dealers do not routinely offer to sell guns, at least to their regular clients. Sometimes they do–and firearms are sometimes used by consumers and intermediary suppliers as a form of currency to purchase drugs–but that is not the norm. Drug dealers and drug dealing gangs may rightly view guns as a high-risk commodity (due to law enforcement priority on guns over drugs) with relatively little to gain given that there would be relatively few sales. Additionally, to the extent that gangs have an established supply source for their members, they have reason to keep tight control over their armory: selling guns outside of the network may arm potential competitors.

Gun shows and online marketplaces offer two potential mechanisms for reducing transaction costs in the informal market, but these represent a small fraction of the proximate source of firearms in the inmate surveys. Among the plausible explanations: Many of the sellers at gun shows are there as FFLs, prices at gun shows are relatively high, gun shows often have a law enforcement presence, and the socio-demographic and cultural context of gun shows may create their own transaction costs for individuals disconnected from those networks. Online connections do sometimes support illegal transactions, but that does not appear commonplace. That said, ATF criminal investigations and deep reporting by journalists both show that gun shows and online marketplaces are sometimes involved in illegal trafficking and sales to proscribed possessors (35, 47).

In sum, individuals who seek guns in the informal market are highly differentiated with respect to their connections, and hence to the transaction costs – the time, effort, and risks incurred to make an acceptable deal. It is logical that the chance of making a reliable

connection is going to be affected by the overall prevalence of gun possession, as well as the individual's position within that community. With household firearm ownership rates ranging from less than 10% in many Northeastern cities to more than 40% in many Southern and South Central cities (48), we can expect substantial geographic variability in the search and informational costs associated with illegal firearm transactions. Someone with a felony conviction living in a gun-rich environment (New Orleans, Phoenix, Nashville) will likely have family or friends who own guns and may be willing to sell or loan one–far more likely than in Boston or New York.

Prices.

While something is known about non-monetary transaction costs in the informal market, information on money prices is surprisingly scant (see sources in Table S2). Compared to drugs, firearms are relatively expensive on a per-transaction basis. Interviews with 116 non-gang affiliated Chicago youths found they often paid prices between $430-$690 (in 2023$) (31). A 1996-1997 survey of arrestees in samples drawn from 24 cities found somewhat lower prices, with a median price in Chicago of about $290 and average prices for New York of about $500 (both in 2023$) (31, 49). A more recent study (11) using data scraped from Armslist.com, an online retailer than facilitates sales from FFLs and unlicensed sellers, estimated that prices were generally higher for unlicensed versus FFL sales: medians (in 2023$) of about $700 versus $640, respectively for handguns, and $840 versus $590 for rifles. Unfortunately, given the high degree of product differentiation in the firearms market, comparing average prices across market types tells us little about potential price markups for illegal transactions.

One notable contribution to understanding illegal market prices and price markups is the data set painstakingly assembled by David Hureau, who had the trust of a number of gang members in Boston and convinced them to show him their guns and state how much they had paid (17). Comparing these prices with the Bluebook value of the same make, model, age, and condition – a good indication of what the gun would sell for in the formal market -- Hureau and colleagues established three principal findings: 1. Considerable variability in the prices paid by gang members, even after conditioning on the Bluebook price; 2. An average price that represented a large markup (i.e., nearly twofold), with higher markups (fourfold) for the cheaper guns;[2] 3. Average prices increasing with the Bluebook value up to about $750 (in 2023$), but not thereafter. That third finding may provide some indication that the gang did not value the dimensions of quality reflected in the high end of the price range. They also document the use of joint acquisitions, where street gang members pooled resources to purchase a firearm that was shared among the purchasers, an indication that these drug-dealing gang members had low incomes (50).

Based on this meager evidence, we are inclined to conclude that money prices for informal transactions have some relationship to prices in the formal market, but at least in

[2] Estimated markups in non-US countries are comparable, although in some South and Central American countries, legal prices *exceed* illegal prices (see Table S3).

the tightly regulated, low-prevalence environment of Boston, there is considerable "noise." The so-called "law of one price"–market transactions in the same commodity will tend to price uniformity– does not apply, due to limited information and other frictions. Trusted connections are scarce, which engenders isolated opportunities for exchange and one-on-one bargaining.

A related observation is that guns in the informal market are not rationed by money price alone, but also by the costs of finding or developing an acceptable transaction that has acceptable risks. Both money prices and other transactions costs are highly variable even for the same type of gun, depending on the connections of the buyer and other circumstances. Given the wide dispersion of prices, it is logical to suppose that buyers who are willing to spend more time searching or take higher risks can obtain firearms at a lower price–an important tradeoff, given that many proscribed individuals tend to have very limited means. It is reasonable to presume that money price in the formal market matters, and excise taxes or other interventions that tend to increase gun prices in the formal market will influence availability in the informal market.

4. Cross-Border Trafficking

Across states and nations, there are large differences in the stringency of firearms regulation. One way in which the force of these regulations is diminished is the possibility of residents of a more stringent jurisdiction obtaining firearms, either directly or indirectly, from a less stringent jurisdiction. Foreseeing this problem, the Gun Control Act of 1968 included provisions intended to curtail interstate movements of firearms by disallowing interstate shipments to non-FFLs and placing restrictions on in-person sales to buyers from out of state. These regulations aim to ensure the enforceability of more stringent regulations for those states that choose to adopt them.

Jurisdictional differences in the stringency of firearm regulations thus create an arbitrage possibility for traffickers and trafficking rings willing to operate outside the law. The profitability of trafficking is evidenced by trace data for recovered crime guns, which reveals a strong pattern of net flows from less-to-more regulated states (41, 42, 51). Thus, New York City crime guns typically originate in Eastern seaboard states of the South, while crime guns in Chicago originate in less-regulated states along the Mississippi River (35).

A stereotypical case is an individual with a South Carolina driver's license buying a few guns from an FFL there and delivering them to a gang connection in heavily regulated New York City–at a substantial markup. The possibility of small-scale trafficking helps explain why we do not see large enterprises seeking to monopolize this trade (52). The ATF (35) analysis of thousands of illegal trafficking investigations (initiated between 2017 and 2021) found that nearly 90% of cases with identified traffickers involved only one or two traffickers, with 0.3% of cases involving 10 or more. Over half (57%) of investigated cases involved five or fewer guns, while less than 1% involved more than 250 guns. But it is that handful of larger cases that account for most (59%) of the firearms associated with these cases.[3]

Trafficking patterns are sensitive to seemingly small regulatory changes. A case in point is the experience with Virginia's "one gun a month" law, which limited the number of handguns that could be legally purchased by any one buyer. When Virginia implemented this law, New York and other regulated states experienced a sharp drop in the prevalence of crime guns originating in Virginia (53). Similarly, the federal "Brady Law" of 1994 appears to have had a widespread effect on interstate trafficking. That law required all retail FFLs nationwide, including in states that lacked such a regulation of their own, to conduct background checks of customers. One result was to redirect interstate trafficking patterns; as the FFLs in traditional "source" states began conducting background checks on would-be buyers, they became relatively less attractive to traffickers (24). Although

[3] International data on customs seizures show similar patterns: 74% of cases involved a single firearm, but 2% of cases accounted for approximately half of all seized firearms (see Table S4).

the South Central states remained important sources of Chicago crime guns, trace data showed a sharp decline in their relative importance (54). One implication of these results is that traffickers likely source a large share of their guns from dealers, rather than in the informal market.

The illegal flow of guns from the U.S. to Mexico is another example of the flow from more to less regulated jurisdictions. In Mexico, firearms ownership is legal but retail commerce is strictly regulated, with only two retail establishments, controlled by the Army, nationwide. There are an estimated 200,000 guns illegally exported each year from the US to Mexico (55), the sum of a variety of supply chains. The ultimate buyers may be associated with large criminal organizations (the "cartels"), but these supply chains typically originate with individuals purchasing guns from FFLs or gun shows (usually along the Southwest border).

These smuggling operations are highly heterogeneous with respect to the structure and scale of operation. Larger operations require financing and trusted connections that have the capacity to acquire, transport and dispose of a large volume of guns – a capacity that in some cases is created by the far more profitable drug trade. Much of the illegal export of guns to Mexico is the backhaul of illegal drugs from Mexico. For example, in 2010, ATF surveilled several straw purchasers who were selling guns to a broker in Arizona, who in turn was selling to a Mexican cartel affiliate who was distributing drugs around the Southwest. The most active straw purchaser was observed to purchase 723 guns in Phoenix for a total of $575,000, and all together the straws acquired almost 2000 guns (56), apparently acting as freelancer suppliers to intermediaries. But there are also small self-contained operations; in one case described by the reporter Ioan Grillo (56), a Mexican man would occasionally drive across the border to a gun show, buy guns from someone who did not require him to show identification, and then return to his home town where he sold the guns to neighbors, paying a "tax" to the local cartel as the price of doing business.

It is interesting to speculate about the scope of the enterprises involved in smuggling guns to Mexico. There are in effect four possibly separable roles: straw purchaser, broker, transporter (to the border), and smuggler (across the border). These could be incorporated in a single vertically organized enterprise (as in the case of the lone individual who does it all). With larger scale there may be a payoff to specialization in these tasks, which would require coordinating an exchange among the specialists. As explained by Ronald Coase (57) in his theory of the firm, that coordination could be accomplished either hierarchical control arrangements internal to the firm, or through voluntary transactions by independent entities. (In brief, this distinction is referred to as the "make or buy" decision). The choice is influenced by relative cost of transaction vs. coordination. In either case transactions are facilitated if the firearms are acquired from an FFL and hence are of known price and quality. Another concern is with respect to the legal risks created by these transactions, which in turn are affected by whether the parties to each type of transaction trust each other. Trust can be created by a stable arrangement with repeated

exchanges. It is not clear that there is much advantage to a hierarchical arrangement, and contractual arrangements ("buy") have the advantage of greater flexibility.

Overall, trafficked firearms generally flow from less-regulated (typically higher gun prevalence) to more-regulated (typically lower gun prevalence) jurisdictions. The effect of changing regulations on gun availability to criminals is less well documented.

5. Market Developments: The Growing Importance of PMFs in Crime

The general patterns described in the previous sections have remained relatively consistent over time. Substantial developments and disruptions in supply chains and product offerings have most commonly resulted from federal regulations prohibiting classes of weapons (e.g., the National Firearms Act and 1986 amendment) or technological innovations in the legal industry (e.g., 1970s and 1980s manufacturing advances that supported high-volume production of low-cost handguns).

Most recently, manufacturing advances, coupled with innovations by the firearms industry, have made it feasible for individuals to fabricate high-quality firearms in home workshops at a cost that is competitive to retail prices for comparable products. These modern "privately manufactured firearms" (PMFs) are close substitutes for factory-built weapons and have the advantage, from some users' point of view, of being untraceable, since they lack a registered serial number or record of sale. (For that reason, they are sometimes referred to as "ghost guns.") PMFs have become a nontrivial share of crime guns nationwide, especially in states with more stringent regulations on FFLs and private transfers. Regardless of whether proscribed individuals take advantage of PMF developments for "self-supply" (akin to home cultivation of cannabis) or whether enterprising individuals use the new technology to enter the illegal market or restructure existing operations, PMFs compete with weapons diverted from the legal supply chain in arming proscribed individuals. Regulation and technology are both evolving and will shape the trajectory of PMF penetration for criminal use.

It is interesting to compare the PMF phenomenon with the advent of new sources in other illegal markets. Recent history provides a variety of examples in which an illegal market was disrupted by a state-sanctioned alternative: cannabis, on-line sports betting, lottery-style games, and, in some European countries, commercial sex. But the growth in PMFs represents an innovation that facilitates evasion or avoidance of regulations on firearms commerce, and in that sense is perhaps more closely analogous to the effect of cryptocurrency on money laundering.

The scale and organization of the PMF industry are largely unknown, nor are there persuasive research findings on the impact of this industry on gun crime. At this point we can only sketch the history of the relevant innovations and subsequent regulatory responses, and speculate on the nature of the supply chain of PMFs to their customers. While PMFs encompass a range of non-industrially produced firearms, our focus here is on firearms assembled or fabricated by unlicensed individuals using industrially made

components (e.g., kits that can be finished and assembled with non-specialized tools), 3D-printing, or computer-numerical-controlled (CNC) milling technologies.[4]

Improvements in technology and information sharing

The Gun Control Act allows unlicensed individuals to fabricate firearms for their personal use. Historically, the difficulty and cost of creating a functional firearm in a home workshop ensured that only hobbyists attempted to do so. During the 2010s, the development of 3D-printing and related lathe technologies made the necessary tools increasingly affordable, with the help of relevant computer programs distributed on the internet. A second stream of innovations has proven more important in practice, namely the national marketing of kits for assembling high-quality firearms using tools available in a home workshop.

The most prominent and successful firm offering such kits was Polymer80. Their first product was the receiver for an AR-15 rifle, which was sold as a part of a kit (with a disposable jig and drill bits) that was easier to finish than the forged aluminum receivers that had been marketed previously. In 2016, Polymer began marketing a receiver for a Glock-style pistol; before marketing it, they received a ruling from ATF that because the frame was only 80% finished, it did not qualify as a "firearm" under relevant regulations. They also introduced an all-inclusive builder package for rifles (Buy-build-Shoot Rifle kit) retailing for $600. Just three years later, Polymer80 began marketing similarly all-inclusive kits for pistols. Shortly thereafter, ATF decided that such kits were indeed "firearms," and issued a ruling to that effect in 2022. The new regulation requires manufacturers and sellers of readily convertible firearm parts kits to be federally licensed, while the "frame of receiver" component must adhere to marking and serialization requirements. Purchasers are subject to a background check. As of 2025, a dozen states introduced their own regulations (see Table S5).

Note that prior to the 2022 regulation, these kits could be ordered by individuals and direct shipped by mail, with no documentation. The resulting weapon was indeed a "ghost gun" in the sense that without any public record of sale or serial number, law enforcement agencies could not connect it to any one individual in the supply chain. In most states, proscribed individuals could order directly, bypassing the screening and record keeping apparatus implemented by retail FFLs. In that sense it was analogous to mail-order abortion drugs (mifepristone and misoprostol), that can be ordered from on-line pharmacies, effectively bypassing state regulations.

[4] Other categories of PMFs include rudimentary improvised firearms (e.g., the firearm crudely fashioned from metal and wood used in the assassination of the Japanese Prime Minister in 2022), craft-produced semi-automatic or automatic weapons, and convertible firearms.

As of this writing, gun-build kits are regulated as firearms and hence have lost their "ghost"-like quality. A cursory review of information on gun kits being sold online suggests that there is no price advantage. If current regulations are sustained, the market for new gun kits may be limited to hobbyists. But that leaves open the possibility that alternative techniques for fabricating "ghost" PMFs will become increasingly important.

Today, consumer-grade CNC milling machines for firearm production retail for about $2500, are about one square foot in size, and can produce one firearm every 45 to 120 minutes. Tabletop 3D printers capable of printing firearms can be purchased for $200 to $2000 but generally take several hours to a few days to print, and the result is not as reliable as a factory-built gun. Prices and quality concerns will likely diminish given ongoing innovations in milling and 3D printing technologies. For that reason, ghost PMFs are a continuing problem for the foreseeable future, even if kits continue to be restricted.

Growing prevalence of PMFs in crime

There is no publicly available data on sales of PMF kits. ATF does publish the counts of firearms that are identified as PMFs and submitted for tracing–one measure of the extent to which PMFs are being illegally carried or otherwise used in crime. The number of identified PMFs recovered from crime scenes and traced by ATF increased 15-fold between 2016 and 2023 (from 1,758 to 27,490), although growth had leveled off after 2022 (35). Despite the rapid growth, the 2023 figure is just 9% of the number of crime guns traced in that year. It is quite possible that both the growth rate and the prevalence statistics are distorted by the fact that law enforcement agencies may not bother to submit PMFs for tracing or may lack the expertise to record the correct information. (ATF actually conducted trainings on these matters for many departments.) In any event, PMFs also appear to play a relatively small role in trafficking, with 5.6% of ATF trafficking investigations in 2021 involving PMFs (58).

The prevalence of "ghost guns" (un-serialized PMFs) involved in crimes differs greatly across jurisdictions. This geographic pattern suggests that the market for such guns is influenced by the stringency of state regulations on retail sales. From 2017 to 2021, the states with the highest prevalence of PMFs in recoveries were among the handful that require handgun registration (Washington D.C. 6.5%; California 9.0%; Hawaii 10.7%) (22, 58). States with the lowest proportional involvement are all in the largely unregulated South (e.g., 0.2% in Louisiana and Mississippi). Surveys of law enforcement have also indicated greater concerns with ghost guns in California and larger East Coast cities than elsewhere (59). The observation that PMF prevalence has been highest in states that have relatively stringent regulation on firearms commerce, as well as low firearm ownership prevalence, comports with theory that the ability to obtain a PMF kit by mail-order would be especially attractive where it was difficult for a proscribed person to purchase from an FFL (even through a straw).

6. Regulation and Policy Approaches

Our focus has been on supply chains that arm dangerous people in the United States. We have identified three legal sources: 1. Licensed dealers; 2. Private owners; and 3. PMF fabricators. A variety of intermediaries (straw purchasers, brokers, traffickers, fences, unlicensed dealers) play some role in redistributing firearms once diverted from a legal source. All aspects of illegal commerce are defined and shaped by government regulations and enforcement.

Much of the existing regulatory structure aims to block transactions that could arm dangerous people, but the stringency of regulations and their enforcement differ across the three sources. FFLs must run background checks on all buyers, keep records of every sale, and make these records available to ATF. These federal regulations do not apply to transfers made by private owners, although some states impose additional requirements. PMF regulations are too recent to have been thoroughly evaluated, but trends are compatible with a conclusion that the 2022 federal regulation had the desired effect: the rapid growth in PMF crime gun traces leveled out in 2023, and California showed an actual decline (58, 60).

The relative importance of the three sources is affected not only by the stringency of regulation, but also by the prevalence of gun possession. Commercial regulations directly affect sales by FFLs. A state regulation requiring a permit or license issued by law enforcement discourages proscribed individuals and straws from buying from an FFL. In the case of Missouri's repeal of its permit-to-purchase requirement, eliminating that barrier led to a surge in the percentage of crime guns recently purchased from an FFL (39, 40). Local prevalence of gun ownership directly affects availability in the informal market. In high-prevalence areas, proscribed people are more likely to have a connection with someone who is willing to sell, lend, or even give them a gun. In areas with stringent regulations and low prevalence, PMFs and cross-state trafficking are more active.

Some of the effects of regulations on gun commerce are evident in the patterns in the interstate movement of firearms. Crime guns tend to have a different supply chain in states that do not regulate gun commerce beyond the federal regulations, in comparison with those that do. In lax states, crime guns tend to move more quickly from first retail sale to criminal use, than in regulated states. Further, interstate gun trafficking tends to arbitrage differences in regulation, flowing from less to more regulated states (41, 42, 51). But while this pattern undercuts the force of the more stringent regulations to an extent, impact evaluations of several types of regulation suggest many can be effective in reducing criminal use (61).

The effectiveness of regulations depends on enforcement effort, but to differing degrees. Regulations on legitimate commercial enterprises may require little enforcement in practice. As a case in point, Polymer80 went out of business shortly after a new set of federal regulations had the effect of banning its shipments of PMF kits directly to individual customers. Compliance has been more of a problem with regulations that

require FFLs to screen buyers and document sales, although it appears that corrupt dealers are quite rare despite very sparse regulatory enforcement by ATF and a reluctance to impose sanctions on violators. On the other hand, the enforcement "leverage" is lacking when it comes to enforcing regulations on private owners, traffickers, and straw purchasers. Systematic enforcement, both through investigation and willingness of the courts to prosecute, is a necessary element for achieving compliance, but scarce in practice.

Stepping back, a proximate goal of firearms regulation in the United States is to curtail availability to proscribed individuals while preserving availability to everyone else. That goal can be restated as raising the transaction costs to proscribed people with as little impact as possible to transactions costs for others. Transactions costs include both monetary price and other impediments to acquisition, including search time and uncertainty about the quality of the product and the character of the seller. The monetary price of new guns can be raised through an increase in the excise tax, which will also affect prices of used guns (which are close substitutes), but that approach has been unpopular since the price increase is a burden for legitimate buyers as well as proscribed buyers. Another less obvious possibility is to establish a minimum price on used firearms. In effect that is what the New York Police Department has attempted by its long-standing program of offering to buy any gun, no questions asked, for $200. Since teenagers, felons, and other proscribed individuals tend to have limited resources, that approach appears better targeted than an across-the-board excise tax.

A variety of measures can be effective in increasing search time, uncertainty, and legal risk for proscribed buyers. As discussed above, effectively limiting access to FFLs and direct mail-order shipments (for PMF kits, for example) is a place to start. Limiting access in the informal market is a resource-intensive activity, policing fences, traffickers, unlicensed dealers, and other intermediaries. All such measures could effectively discriminate between entitled and proscribed buyers, but enforcement has often been lacking. While some states have enacted laws requiring that unlicensed transfers be conducted through a licensed dealer who is supposed to conduct a background check and maintain a record, compliance with these laws is limited (14, 62).

Another approach, albeit one subject to greater Second Amendment scrutiny, is prohibiting the manufacture and sale of certain weapons. Historically, some laws of this type have had success at limiting access to the banned products, although effects on overall criminal access have often been undermined by regulatory gaps (e.g., failing to prohibit suitable substitutes for the banned weapons) or legal industry innovation. Indeed, one of the most vivid examples of a successful regulation is the National Firearms Act of 1934 (NFA), which imposed a high fee on all transactions involving submachine guns, sawed-off shotguns, and other "gangster-style" weapons. These weapons largely disappeared from criminal use, presumably due to the NFA ban and subsequent (1986) ban on manufacture or import of firearms with the capacity to fire multiple rounds with a

single trigger pull. However, in recent years the market has provided a workaround, a device that converts a semi-automatic weapon into a fully automatic.

7. Conclusions

Most illegally transacted firearms began as legal commodities but were at some point diverted from the legal market. The three primary points of diversion -- licensed retailers, private owners, PMFs -- often represent just one link on a much larger supply chain of intermediaries (brokers and traffickers) that serve as sources to proscribed purchasers.

In comparing illegal commerce in firearms with that for other products that have a large legal market (cannabis, tobacco, prescription painkillers, abortion pills), firearms are unusual in at least two respects. First, they are durable, which means that the 30% of the adult public that owns one or more guns is a potential source. Variation in the existing stock across jurisdictions is key to understanding geographic patterns in illegal transactions. Second, the primary purpose of the regulations that outlaw certain transactions is to curtail criminal misuse of the product, rather than to protect the consumer or collect taxes. One measure of success, then, is the extent to which guns are used in crime.

It has often been argued that gun possession is so widespread in the United States as to make any commercial regulation futile. Yet the guns used in crime are typically acquired shortly before criminal use, so that criminal gun use can be reduced without taking guns away from current owners: it is enough to block the relevant transactions. In practice, transactions are the primary focus of regulations and their enforcement. While not all existing regulations are effective, especially given lax enforcement, many have a profound effect in shaping illegal commerce and some impact on the availability and use of guns in criminal violence.

One challenge with characterizing and intervening in illegal firearm markets is that the transactions that provide most of the firearms used in crime do not constitute a well-organized “market.” Information required to connect willing buyers and sellers is scarce, and social networks play a critical role. This circumstance differs importantly from the retail distribution of illicit drugs. While information about drug sources may be scarce, buyers who are inclined to engage in high-frequency repeated transactions have an incentive to invest in identifying multiple trustworthy sellers to ensure reliable supply with known quality.

The scale and structure of criminal supply chains are highly heterogeneous. Criminal enterprises are often more involved in cross-border trafficking, although they seem to play a more important role as customers than as distributors. In Mexico, drug-trafficking organizations have a well-developed capacity to traffic drugs to the U.S. and arrange distribution. Some of these same connections facilitate the trafficking of guns from the U.S. to Mexico, but primarily for use by the organization’s own members rather than to distribute. Within the U.S., a similar phenomenon appears for drug-dealing gangs. The

groups potentially most well-equipped to monopolize the arms markets do not. This observation perhaps reflects a judgment that gun dealing entails greater legal risk and is less profitable than dealing drugs. In any event, the result is great diversity with respect to scale of traffickers, and little evidence of vertical integration.

The advent of the “PMF era” may prove to be a game changer. Until 2022, PMF prevalence has been driven by the direct distribution of complete easy-to-assemble kits sold by U.S.-based companies. It is an open question whether the decline in the availability of online PMF kits has led to increased use of other methods for ghost gun construction (e.g., 3D-printing; CNC-milled receivers). Since the United States has been the primary source for illegal ghost gun kits and components in other countries, including in the European Union (63) and the Caribbean (64), assessing the implications of changing US regulations for international trafficking and criminal use of PMFs may also improve our understanding of cross-border supply chain dynamics. Finally, looking to the future, it is possible that the federal regulations on PMFs may be relaxed again, or, over the longer run, that it becomes affordable to fabricate a working gun at home from widely available materials. This possibility requires improvements in “additive manufacture” methods. That sort of machinery will no doubt improve over time, although factory-built guns will remain cheaper as long as there continues to exist returns to scale in the production process. In any event, if prices of PMFs and factory-built guns tend to converge due to changing technology, the supply chain of guns to dangerous people may increasingly be initiated with illegal production, rather than diversion.

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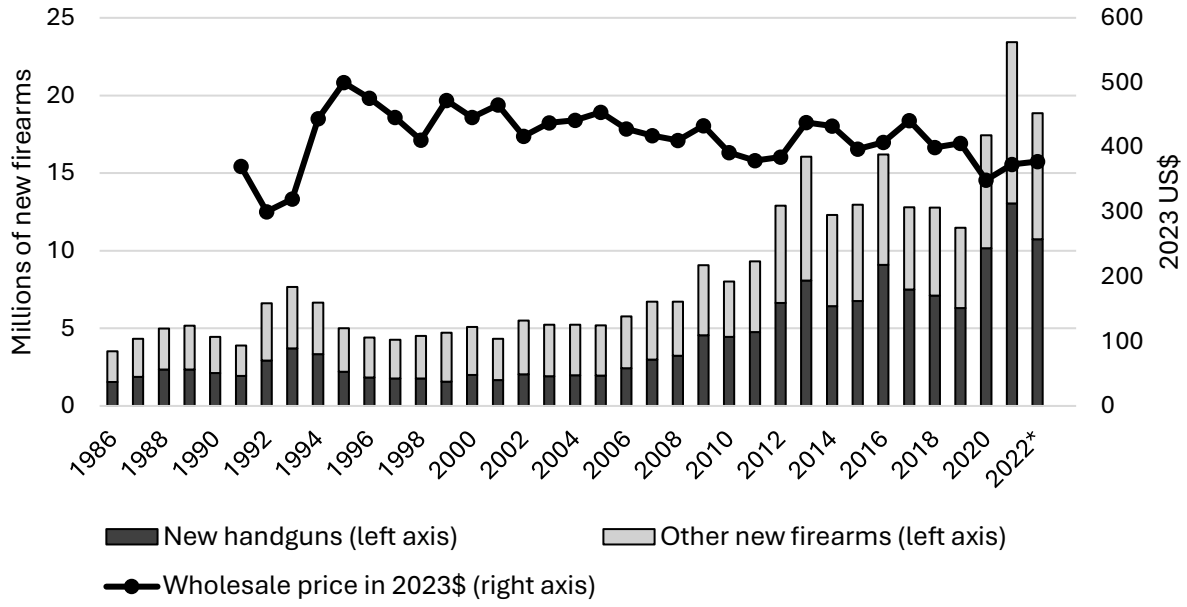
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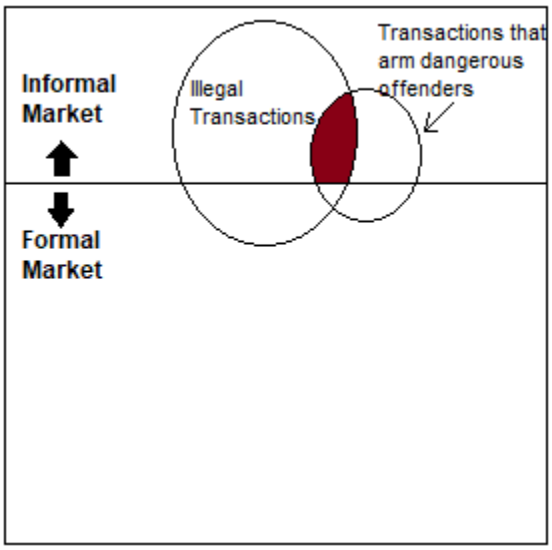
FIGURES

Figure 1. New firearms introduced to US retail market and their estimated average wholesale price, 1986-2022



NOTE: Sum of firearms manufactured in and imported to the United States, net of firearms exported, by year. Average wholesale price in 2023$ calculated as described in the Online Supplement.

Figure 2. Stylized depiction of US retail commerce in firearms



NOTE: The formal market refers to transfers by federally licensed dealers (FFLs), while the informal market encompasses transfers by unlicensed individuals. Source (23)

Supporting Information for
Illegal Firearms Markets

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Supporting text
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Supporting Information Text

Data sources and calculations. Data on new firearm flows (calculated as the sum of firearms manufactured and firearms imported, net of firearms exported) come from various reports produced by the Bureau of Alcohol, Tobacco, Firearms, and Explosives (1, 2).

Data used to estimate total sales by retail FFLs come Ness and Barton (3). Population estimates used to convert survey-based firearm ownership prevalence estimates to the number of U.S. residents who own guns are from the U.S. Census Bureau.

To estimate formal market value and wholesale prices, we used data on the federal firearms and ammunition excise tax (FAET), which is imposed on manufacturers and importers but rebated on exports. FAET revenue from 1991 onward is available from the Alcohol and Tobacco Tax and Trade Bureau, FOIA Electronic Reading Room. We used the tax revenue data to derive estimates for market value by dividing FAET revenue from handguns by 0.1 (the tax rate on pistols and revolvers) and dividing FAET revenue from other firearms by 0.11 (the tax rate on other firearms), then summing. Dividing estimated market value by the number of newly introduced firearms yielded estimates of average wholesale prices. We note that there is some misalignment between the FAET-based revenue estimates and the size of the market for new firearms because gunsmiths can be liable for FAET if their activities sufficiently and materially alter a firearm.

Information on sources of firearms to criminal use come from the Survey of Prison Inmates 2016 (formerly the Survey of Inmates in State and Federal Correctional Facilities), a nationally representative survey of adult prisoners who were incarcerated in state or federally correctional facilities. Full results on sources of firearms based on this survey are provided in Table S1.

Information on retail prices for firearms as compiled across various studies are provided in Table S2. For discussion in the main text, we converted all prices to 2023 U.S. dollars based on the historical consumer price index for all urban consumers (CPI-U) series, published by the Bureau of Labor Statistics.

Information on state legislation related to privately manufactured firearms (PMFs) come from the RAND State Law Database (v 5.0, March 2025). State laws and effective dates as of January 1, 2024 are provided in Table S4. Information on the timeline of technological innovations and criminal use of PMFs in the United States draws on a historical review of media reporting, social media and blog posts, internet articles, and legal documents (4, 5) (6-8).

Table S1. Sources of guns possessed or used in current crime among persons sentenced or awaiting sentencing in state or federal prison, with fewer than two years between their admission and interview date.

	Full sample		Those with non-missing response on source[a]	
	All	Males ages 18-40	All	Males ages 18-40
	N=768	N=553	N=685	N=501
Type of transaction				
Purchased or traded	57.6%	59.6%	64.2%	65.6%
Rented, borrowed, held for other	5.0%	4.7%	5.6%	5.2%
Someone bought it for me	1.8%	2.0%	2.0%	2.2%
Gifted	9.1%	8.6%	10.1%	9.5%
Theft	4.7%	5.1%	5.3%	5.7%
Found it, scene of crime	7.1%	6/9%	7.9%	7.5%
Brought by someone else	2.8%	2.6%	3.1%	2.8%
Other	0.4%	0.1%	0.5%	0.1%
Missing	9.4%	8.8%	0.8%	1.0%
Source of firearm				
Gun store or pawn shop	7.4%	7.2%	8.2%	7.9%
Flea market or gun show	1.5%	1.5%	1.6%	1.7%
Friend or family member	27.9%	27.7%	31.0%	30.5%
Fence, street, drug dealer	35.7%	37.9%	39.7%	41.7%
Theft	4.7%	5.1%	5.3%	5.7%
From victim, found at scene of crime	7.1%	6.8%	7.9%	7.5%
Brought by someone else	2.8%	2.6%	3.1%	2.8%
Other	5.1%	3.9%	5.7%	4.3%
Missing	10.2%	9.2%	0.0%	0.0%

NOTE: Multiple response options are possible, so columns do not necessarily sum to 100%. The sample was restricted to those who used, carried, or possessed a firearm at the time of the controlling offense; who had served fewer than 2 years between their admission (including jail time) and the interview date.

[a]Restricts to those who had at least one non-missing response to the items on source of firearm.

Table S2. Retail price information for firearms transactions

Context	Year collected	Nominal prices (medians unless noted)	Prices in 2023$	Reference
Handguns				
Armslist.com, secondary marketplace	2020	All: $590 FFL: $545 Private: $600	All: $695 FFL: $642 Private: $706	(9)
Gun Digest, fair market values	2016	All: $475 New: $575 Used: $460	All: $603 New: $730 Used: $584	(9)
GalleryofGuns.com, aggregator of prices and retail locations	2020	Pistol: $596[a] Revolver: $819[a]	Pistol: $702[a] Revolver: $964[a]	(10)
Interviews with non-gang affiliated youths (ages 18-21) in Chicago	2001-2002	$250-$400[b]	$427-$683[b]	(11)
Interviews with Boston gang members	2014	$638	$821	(12)
Drug Use Forecasting survey of arrestees, Gun Addendum	1996-1997	Chicago: $150 New York: $259[a] DC: $219[a]	Chicago: $288 New York: $497[a] DC: $420[a]	(11, 13)
Dark Web	2019	$742[a]	$885[a]	(14)
Long guns				
Armslist.com, secondary marketplace	2020	Rifle: $650 Rifle, FFL: $500 Rifle, Private: $715	Rifle: $650 Rifle, FFL: $500 Rifle, Private: $715	(9)
Gun Digest, fair market values	2016	Rifle: $375 Rifle, new: $550 Rifle, used: $375	Rifle: $476 Rifle, new: $698 Rifle, used: $476	(9)
GalleryofGuns.com, aggregator of prices and retail locations	2021	Rifle: $821[a] Shotgun: $875[a]	Rifle: $923[a] Shotgun: $984[a]	(10)

Dark Web	2019	$1,085	$1,293	(14)

NOTE: [a]Average price. [b]Typical range. The sample of included firearms across each study and source may differ greatly, and thus comparisons across different studies will be subject to price dispersion simply related to compositional differences.

Table S3. Type or paste table title here. Paste table below the title.

Country	Type of gun	Markup
Australia	Pistol revolver	~5
	Rifle, shotgun	~2
	Modified blank firing firearm	~5
Brazil	Handgun	<0.4
	Assault rifle or rifle part kits	Between 1-2
Dominican Republic	Pistol	<0.4
El Salvador	Pistol, revolver	<0.4
	Shotgun	<0.2
Lithuania	Pistol	~3
North Macedonia	Pistol	~4
Saint Lucia	Pistol, revolver	Between 1-2
	Rifle, shotgun	Between 1-2
Slovakia	Pistol	~3
Spain	Pistol	~3
	Rifle	Between 1-2
Tunisia	Rifle	<0.9

NOTE: Estimates derived from 2016-2017 information obtained from various countries as published in United Nations Office on Drugs and Crime (15).

Table S4. Composition of firearm seizure cases by number of firearms seized, international information from customs seizures, 2016-2017

Number firearms seized	% of cases	% of firearms seized
1	74%	24%
2-5	20%	17%
6-10	2%	6%
11-17	1%	4%
18 or more	2%	49%

NOTE: Estimates derived from information on customs seizures as provided in United Nations Office on Drugs and Crime (15).

Table S5. Legislation imposing requirements or restrictions on privately manufactured firearms

Jurisdiction	Law	Effective date
California	Serial number requirements	July, 2018
California	Background check and recordkeeping requirements for firearm component parts	July, 2022
Colorado	Serial number requirements	January, 2024
Connecticut	Serial number requirements	October, 2019
District of Columbia	Ban on “undetectable” firearms	March, 2020
Delaware	Serial number requirements	January, 2022
Hawaii	Background check and serial number requirements for firearm component parts, 3d-printed firearms, etc.	September, 2020
Illinois	Serial number requirements	May, 2022
Indiana	Serial number requirements	July, 2020
Maryland	Identifying information and registration requirements	April, 2023
New Jersey	Serial number and background check requirements; ban on 3D-printing of firearms by unlicensed entities	November, 2018
New York	Ban on “undetectable” firearms	January, 2020
Rhode Island	Serial number requirements; ban on “undetectable” firearms; ban on 3D-printing f of firearms by unlicensed entities	July, 2020
Virginia	Ban on “undetectable” firearms	March, 1989
Washington	Ban on “undetectable” firearms	July, 2019
Washington	Serial number requirements	July, 2022

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