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An assessment of the state of firearm sales on the Dark Web

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ABSTRACT

Western law enforcement agencies have made multiple arrests targeting individuals purchasing firearms on Dark Web platforms in recent years, as these transactions may violate national laws and facilitate offline violence. Despite its market presence and growth, research exploring these online illicit markets has been scant, especially as it relates to how firearms are priced on the Dark Web, and the factors that influence their price point. Given this gap in the literature, the current study utilized a sample of 287 firearm products across 20 Dark Web vendors operating in both crypto markets and shops to identify the range and pricing model of illicit weapons. Analyses revealed that long guns offered on the Dark Web had lower average listed prices than their manufacturer's suggested retail price (MSRP), while handguns had higher advertised prices than their recommended retail value. Further, products' MSRP was a significant predictor of firearms' price point for both handguns and long guns, whereas offering a customer service line was only significant for handguns' price point. The implications of this analysis for our understanding of illicit online market operations are discussed in detail.

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Introduction

Research exploring online illicit markets have increased substantially over the last two decades (see Copeland, Wallin, and Holt 2020; Décary-Hétu and Dupont 2013; Holt and Lampke 2010; Holt and Lee 2022a; Holt, Smirnova, and Chua 2016; Roddy and Holt 2022), with particular emphasis on cybercrime-as-service markets offering hacking tools (Holt 2012; Ollmann 2008), attack services (Hyslip and Holt 2019), and stolen data products (Décary-Hétu and Leppänen 2016; Holt 2012; Holt and Lampke 2010; Holt, Smirnova, and Chua 2016; Hutchings and Holt 2015; Holt 2017; Smirnova and Holt 2017). Recent studies have also focussed on illicit goods markets that sell physical products and offline services hosted on the Dark Web, which is generally defined as the part of the web that can only be accessed by specialized browsers, such as the Onion Router (TOR) protocol (see Aldridge and Décary-Hétu 2014; Martin 2014).

Researchers have placed particular emphasis on the global sale and distribution of illicit narcotics and the ways in which these physical goods are exchanged within virtual spaces (see Aldridge and Décary-Hétu 2014; Barratt 2012; Barratt and Aldridge 2016; Barratt, Ferris, and Winstock 2014; Décary-Hétu, Paquet-Clouston, and Aldridge 2016; Martin 2014). Limited research has also explored other physical goods and service markets operating on the Dark Web, such as those selling contract violence (Roddy and Holt 2022) and counterfeit identity documents (Holt and Lee 2022a).

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Though these products and services are inherently illegal, some vendors offer firearms that have different legal statuses based on one's location and jurisdiction (see Copeland, Wallin, and Holt 2020; Holt and Lee 2022b; Paoli et al. 2017). The presence and growth of the online illicit firearms market is concerning for myriad reasons. For one, though gun ownership is legal in many countries, there are restrictions on the sale and possession of various types of firearms, including variations of sub-machine guns, light machine guns, and assault rifles (Grimmett and Kerr 2012). While various countries enforce strict federal regulations and restrictions to monitor the sale, purchase, and possession of firearms (e.g., Gun Control Act of 1968 in the United States), numerous legal loopholes provide interested parties with an avenue to acquire such weapons (see Cook et al. 2007; Cook, Cukier, and Krause 2009; Hureau and Braga 2018). Illegal access to firearms is also problematic due to its potential to foster organized crime and foment offline violence (Australian Criminal Intelligence Commission 2016; European Monitoring Centre for Drugs and Drug Addiction and Europol 2019). Studies suggest firearms sold in underground markets are often higher in cost, with some reports estimating markups of up to triple the suggested retail price and market value (see Cook, Parker, and Pollack 2015; Copeland, Wallin, and Holt 2020; Hales, Lewis, and Silverstone 2006; Hureau and Braga 2018).

Despite the growth of the online illicit firearms market, research assessing the pricing structure of weapons sold on the Dark Web has been scarce (see Broadhurst et al. 2021; Copeland, Wallin, and Holt 2020; Paoli et al. 2017). In addition, many of these studies are unable to provide insight on the current state of the marketplace since their analyses are based on older product and vendor samples collected in 2016 (see Copeland, Wallin, and Holt 2020; Paoli et al. 2017; Rhumorbarbe et al. 2018). The only recent study to explore the online illicit firearms market was conducted by Broadhurst et al. (2021) where a snapshot of available firearms sold through both single-operator shops (n = 12) and crypto markets (n = 8) was provided. Specifically, the study conducted a series of descriptive analyses to explore the count (i.e., frequency), type (e.g., handgun, rifles, submachine guns, shotguns), and advertised prices of firearms sold on the Dark Web between July and December 2019.

While Broadhurst et al. (2021) provided a more recent illustration of the current online illicit firearms marketplace, it did not explore how firearms' prices are influenced by their product attributes, vendor behaviors, or market dynamics. In addition, though research has demonstrated that firearms sold in underground channels are often more costly than in legal supply chains (see Broadhurst et al. 2021; Copeland, Wallin, and Holt 2020; Hureau and Braga 2018; Paoli et al. 2017), there is limited understanding of what determines this pricing structure on the online illicit marketplace. These factors limit our knowledge of the degree to which market pricing is based on product manufacturers' pricing and perceived value, as with offline illicit firearms markets (see Hureau and Braga 2018). Understanding the factors that influence weapons' price point is crucial as it could cultivate knowledge around the informal social mechanisms and market dynamics that guide firearms market participants (see Hureau and Braga 2018).

To address this gap in the literature, the current study utilized a sample of 20 Dark Web vendors operating on crypto markets and shops to explore the range and pricing model of illicit weapons that may be sold. The research objectives of the current study are two-told: (1) To explore the current state of the illicit firearms marketplace hosted on the Dark Web, including identifying the types of weapons sold, and (2) to identify the product features and vendor characteristics that influence weapons' price point. The implications of this analysis for our understanding of illicit firearms market operations are discussed in detail. Additionally, the utility of online data sources for research will be examined, including the ethical concerns they generate for academics.

Dark web firearms market structures and operations

While considerable research has explored the range of markets that enable the sale of firearms through physical spaces (e.g., Braga et al. 2002; Cook, Parker, and Pollack 2015; Hureau and Braga 2018), few have considered the role of the Internet, especially the Dark Web, in the illicit market for

weapons (see Broadhurst et al. 2021; Copeland, Wallin, and Holt 2020; Holt and Lee 2022b; Paoli et al. 2017). Limited evidence suggests the Dark Web constitutes a similar supply chain for weapons to the black, white, and gray markets that exist in physical space (Markowski et al. 2009; Rothe and Collins 2011). Vendors can operate in two primary advertising platforms on the Dark Web: crypto markets and shops (Copeland, Wallin, and Holt 2020; Holt and Lee 2022b). Crypto markets operate as a multi-vendor platform run by third-party entities, where sellers can post multiple advertisements of their products (Aldridge and Décary-Hétu 2016; Barratt 2012; Cunliffe et al. 2017; Holt and Lee 2022a; Li and Chen 2014; Smirnova and Holt 2017). These product advertisements are listed categorically for prospective customers to view and select whom they want to engage with (Aldridge and Décary-Hétu 2016; Barratt 2012; Cunliffe et al. 2017; Holt and Lee 2022a; Li and Chen 2014; Smirnova and Holt 2017). Crypto markets generally follow a two-way mode of communication where buyers and sellers openly interact with one another using posts and threads.

In contrast, shops are websites that serve as e-commerce platforms created and operated by individual vendors that offer products and services directly to consumers (Aldridge and Décary-Hétu 2016; Holt and Lee 2022a; Martin 2014; Smirnova and Holt 2017). Shops are different from crypto markets in that operations are run directly by the seller without any third-party intervention or oversight. Shops generally follow a one-way mode of communication where sellers post information about their products or services without providing an outlet for open dialogue between buyers and sellers on their shop webpages (Copeland, Wallin, and Holt 2020; Holt and Lee 2022b).

Assessing the potential factors shaping weapon pricing

Regardless of structure and modality, both markets utilize similar processes to facilitate illicit transactions (Copeland, Wallin, and Holt 2020; Holt and Lee 2022b). For instance, vendors provide prospective customers with varying levels of information on the products they have available and their cost. Some sellers also post images of items within their advertisements to give context to the physical products that potential customers cannot otherwise inspect or examine in virtual space (Copeland, Wallin, and Holt 2020). Limited research has found that product images that demonstrate the vendor has the items in their possession often appear more legitimate than those that utilize stock images from websites (see Copeland, Wallin, and Holt 2020).

Vendors also consistently list the prices of weapons, though it is unclear what factors specifically influence this advertised price. Prior research exploring the advertised price for stolen credit card numbers offered via illicit online markets suggests the price is directly impacted by the sales practices of the vendor (e.g., Holt, Chua, and Smirnova 2013; Holt, Smirnova, and Chua 2016). For instance, vendors' use of customer service lines was associated with higher product prices (see Holt 2012, 2013; Holt and Lampke 2010; Holt et al. 2015; Holt, Smirnova, and Hutchings 2016). Customer service lines often illustrate vendors' interest and willingness to satisfy customer requests and orders. In fact, prior research on illicit markets demonstrated buyers were more likely to interact with vendors who provided them with a dedicated customer support line than those who did not (Holt 2013; Holt and Lampke 2010; Holt, Smirnova, and Hutchings 2016). It is possible that the same market dynamics are associated with higher prices in Dark Web firearms markets due to increased perceptions of seller reliability.

Similarly, the presence of product replacement services offered by firearms sellers may be associated with higher prices for weapons. There is evidence that various online illicit product vendors offer free product replacements for defective items as long as the request is filed within a specified timeframe after purchase (Herley and Florêncio 2010; Holt, Chua, and Smirnova 2013). While this customer service mechanism would suggest greater reliability on the part of the vendor, it may negatively impact their profits through the free distribution of product (Herley and Florêncio 2010). Dishonest customers may also claim their purchased product was inoperative and request free product replacements even if their original order was functional. As a result, vendors offering product replacements may be associated with

lower product price points as it may be utilized to attract customers with the intent to defraud them (Herley and Florêncio 2010). In fact, research exploring other online illicit markets found product replacements to be associated with lower price points, suggesting it may be used by unreliable sellers as a tactic to both lure and exploit unsuspecting customers (Herley and Florêncio 2010; Holt, Chua, and Smirnova 2013).

There may also be a direct association between shipping costs and the advertised price for weapons on the Dark Web. For instance, numerous firearm vendors provide information regarding their shipping methods and preferred carriers, as they realize the challenges involved in delivering their items covertly to customers (Copeland, Wallin, and Holt 2020; Paoli et al. 2017). Similar to illicit drugs, firearms markets place a unique burden on buyers in ensuring they receive their purchased products while avoiding detection (Copeland, Wallin, and Holt 2020; Liggett et al. 2020). Unlike drugs, however, firearms encounter greater obstacles when it comes to concealment of product given its larger size, volume, and weight (Copeland, Wallin, and Holt 2020). To hide products during transit, vendors disassemble weapons and place certain parts inside other consumer goods to disguise the weight and shape of the purchased firearm (Copeland, Wallin, and Holt 2020; Holt and Lee 2022b; Liggett et al. 2020). As such, vendors who clearly elaborate on their shipping procedures may advertise their products at a higher price point as part of the overall cost of the item.

Finally, it is important to note that Dark Web firearm vendors offer goods that have an established price on the legitimate consumer market (e.g., manufacturer's suggested retail price or MSRP). The degree to which the suggested market price for weapons corresponds to the price for weapons in illicit markets is unclear, though studies exploring offline underground guns markets have noted that individuals attempting to purchase weapons in cities with stricter gun control laws and regulations paid more for poor quality weapons than their secondary legal market value (e.g., Cook et al. 2007; Cook, Molliconi, and Cole 1995; Hureau and Braga 2018). Specifically, Hureau and Braga (2018) found a direct link between the blue book value of firearms and an increased price for the weapon on illicit offline markets. Furthermore, semi-automatic firearms were associated with significant price premiums in the illicit offline guns market given its capability (i.e., potential to fire more shots without reloading) and convenient design (i.e., more concealable when carrying since it is thinner and lighter than revolvers; see Hureau and Braga 2018). Thus, it is plausible that similar dynamics may be observed in Dark Web markets, such that both the action type and market price for weapons are significantly associated with its advertised price online.

Despite increased scholarly attention on Dark Web firearm products and vendors, it is unclear how the scope of the market for firearms has changed over the last few years given increased law enforcement focus on both illicit sellers and buyers (Pleasance 2015; Sengupta 2016). These recent surges in law enforcement attention and crackdowns involving Dark Web firearm vendors reinforces the need to assess how these actions may have expanded or contracted the marketplace and its products. Further, while research exploring the online illicit marketplace has increased in recent years, few have examined the current state of Dark Web firearms markets and the factors that influence weapons' price point.

To address this gap in the literature, the current study examined various product features and vendor characteristics to determine whether they were associated with the variation in Dark Web firearms price point. Specifically, the analyses examined the extent to which the MSRP of a product influenced its price on the Dark Web, similar to what has been observed in offline illicit guns markets (see Hureau and Braga 2018). Additionally, if the informal social dynamics of Dark Web firearms markets are consistent with other online illicit product markets (e.g., Holt, Chua, and Smirnova 2013), vendors with customer service lines and descriptions of shipping methods are expected to have higher firearm price points, while those offering product replacements are expected to have lower firearm price points. The action type (e.g., semi-automatic) of the gun is also expected to increase the product price point, such that semi-automatic weapons are sold at a premium given its capabilities and affordances.

Data and methods

The current study utilized a sample of 287 firearm products across 20 Dark Web vendors operating on both crypto markets (n = 1) and shops (n = 19) to identify the range and pricing model of illicit weapons that may be sold, including handguns and long guns.[1] Data collection took place from August 2018 to March 2020 to allow for a large sample of product advertisements to be collected. Sites were identified using search protocols through Dark Web browsers using keywords such as 'firearms,' 'glock,' and 'gun.' To augment the limited results of Dark Web search engines, this study included vendors (n = 2) listed in indexes, such as the Hidden Wiki and other crypto market listings to identify product vendors that had been observed in the past (see Copeland, Wallin, and Holt 2020; Flamand and Décary-Hétu 2019). In keeping with prior studies of online illicit market operations, vendors' names and identities were excluded to provide a modicum of anonymity for both their users and operations (see Aldridge and Décary-Hétu 2016; Holt 2013; Holt and Lampke 2010; Holt and Lee 2022a, 2022b; Hutchings and Holt 2015).

Data were compiled by saving all webpages from each vendor's site as Hypertext Markup Language (HTML) files without engaging with site operators in any discussion, including when registering to the site (see Holt 2010; Holt, Chua, and Smirnova 2013; Holt, Smirnova, and Chua 2016; Holt et al. 2015; Holt, Smirnova, and Hutchings 2016). Text and images from each website were manually coded using content analysis techniques to create quantitative variables suitable for analysis (see Aldridge and Askew 2017; Copeland, Wallin, and Holt 2020). Specifically, information related to product details (e.g., type/make/model of gun, advertised product descriptions, product prices), and vendor behaviors (e.g., customer service lines, product replacements, shipping methods) were collected.

The current data set reflects a convenience sample of firearms vendors on the Dark Web. For one, only product advertisements communicated in English were included in the present sample (see Copeland, Wallin, and Holt 2020). Though it is unclear how many English-based illicit firearms vendors are likely active at any given time, studies suggest vendors operating in Cyrillic-based languages (e.g., Russian or Ukrainian) comprise a substantive portion of the overall Dark Web marketplace, which may be derived from a lack of deterrence from governments in those countries (see Ablon, Libicki, and Golay 2014; Holt, Smirnova, and Hutchings 2016; Peretti 2008; Smirnova and Holt 2017). Though the current sample cannot be generalized to sites operating in Cyrillic-based languages, it is still reflective of some aspects of the broader Dark Web firearms marketplace since a considerable proportion of weapons market behaviors occurs via English-language sites (Broadhurst et al. 2021; Copeland, Wallin, and Holt 2020; Paoli et al. 2017).

Dependent Variable

The dependent variable used in this study is the advertised price point for illicit firearms sold on the Dark Web. *Advertised Price Point* was measured as a continuous variable, with an average handgun cost of $742.33, and an average long gun cost of $1,085.06 (see Table 1). It is worth noting that products were advertised on the Dark Web using various currencies (e.g., Euro, Pound Sterling, U.S. Dollar, and Bitcoin). To ensure consistency in value, all advertised prices were converted from their original currency to the equivalent U.S. Dollar (USD) value based on 2019 exchange rate listings found on www.statista.com. The converted price in USD was calculated by multiplying the appropriate exchange rate with the listed price of the product. Given the positive skewness in advertised price point, the log value was used for each product as positive skewness in the dependent variable can produce problems for significance testing (see Holt, Chua, and Smirnova 2013; Olivier and Norberg 2010).

Independent variables

A series of five variables were included to examine both product features and vendor characteristics. First, the manufacturer's suggested retail price (*MSRP*) was measured by identifying products' suggested retail price in USD from gun manufacturers' sites. This task proved to be challenging for

Table 1. Firearms' average advertised price (USD) and average MSRPs (USD) by action type.

Type of firearm	Number of Firearms (%)	Average Advertised Price	Average MSRP (Lower/Higher)
Handguns			
Semi-Automatic	99 (34.49)	$744.61	$660.68/$686.28
Revolver	15 (5.23)	$742.81	$759.50/$760.68
Single/Double Action	4 (1.39)	$684.25	$622.75/$643.50
Handgun (Total)	118 (41.11)	$742.33	$671.95/$694.29
Long Guns			
Semi-Automatic	134 (46.69)	$1,110.51	$1,900.33/$2,563.55
Bolt Action	9 (3.14)	$1,355.40	$3,099.35/$3,099.35
Pump Action	26 (9.06)	$861.27	$380.15/$380.15
Long Gun (Total)	169 (58.89)	$1,085.06	$1,730.31/$2,256.84

Notes: Both higher and lower MSRPs were provided if multiple price points for the weapon were available ($r(386) = 0.845$, $p < 0.001$). Relatedly, if a weapon's price was advertised using a value range (e.g., $100-200), a conservative estimate was calculated by using the lower price point. Based on Wald Chi-Square test of equality between different action types, assuming heteroscedasticity, there were significant differences between average advertised price and average MSRP across the different long gun action types (Wald Chi (4) = 111.3, $p < .05$), but not across the different handgun action types (Wald Chi (4) = 2.55, p = n.s.).

certain products, as some advertisements did not provide enough product detail within their item description to identify the precise item and its specifications to a reliable MSRP value (e.g., 'AK-47 with Black Laminate' or 'Armalite AR-10 W/ Scope, Bipod, Mags, and Ammo'). Furthermore, numerous advertisements offered discontinued or collectible items that were no longer observable on the manufacturer's directory. As a result, only firearm products that could be traced back to an identifiable commercial retail price were included in the current study. Given the positive skewness in firearms' MSRP, the log value was used.

Additionally, four binary variables were created to measure both product features and vendor characteristics. First, a measure was constructed to reflect the action type of the weapon (*semi-automatic*: 0 = no; 1 = yes), with non-semi-automatic weapons (i.e., all other action types) being used as the reference category. Semi-automatic action type was selected due to these firearms being the most prevalent across both handguns and long guns. In fact, research has demonstrated that most illicit firearms on the underground market are semi-automatic handguns (see Broadhurst et al. 2021; Copeland, Wallin, and Holt 2020; Hureau and Braga 2018).

A variable for *customer service* was used to indicate whether vendors operated a dedicated customer service line on their web pages, including the listing of email addresses, chat IDs, or phone numbers (0 = no; 1 = yes). A measure was also included to indicate whether vendors offered free replacements for defective items (*product replacement*: 0 = no; 1 = yes; see Herley and Florêncio 2010; Holt, Chua, and Smirnova 2013; Wehinger 2011). Finally, a measure was created to assess whether vendors provided a clear explanation of the delivery processes involved in shipping their items (*shipping method*: 0 = no; 1 = yes).

Analysis plan

The current study followed a multi-step analysis procedure. First, a count/frequency of firearm products separated by action type was generated, including the mean advertised price and MSRP in USD (see Table 1). Then, descriptive statistics for the study variables were assessed, including bivariate associations between the independent variables of interest and the dependent variable, separated by gun type (i.e., handgun v. long gun; see Table 2).

Finally, three linear stepwise regression analyses (i.e., adding different factors sequentially) with simple robust standard errors were estimated, one for each gun type (e.g., handgun v. long gun). Variables were entered in three blocks, with the first model (e.g., Basic 1 and Basic 2) including only the MSRP variable to identify whether the suggested retail price of the gun significantly predicted its

Table 2. Descriptive statistics of key variables with bivariate correlations.

	Handguns							
				Correlations				
Variables	N	Mean	SD	1	2	3	4	5
1. Advertised Price Point (log)	118	6.45	0.66					
2. MSRP (log)	118	6.30	0.78	0.525***(r)				
3. Semi-Automatic	118	0.84	0.37	0.032(p)	−0.099(p)			
4. Product Replacements	118	0.03	0.18	0.156(p)	0.174(p)	−0.681*(t)		
5. Customer Service	118	0.40	0.49	−0.027(p)	−0.289**(p)	0.548**(t)	−1.00(t1)	
6. Shipping Method	118	0.50	0.50	−0.028(p)	0.013(p)	0.392*(t)	−1.00(t1)	0.722***(t)
Variables	Long Guns							
	N	Mean	SD	Correlations				
				1	2	3	4	5
1. Advertised Price Point (log)	169	6.88	0.46					
2. MSRP (log)	169	7.03	0.95	0.307***(r)				
3. Semi-Automatic	169	0.79	0.41	0.070 (p)	0.363***(p)			
4. Product Replacements	169	0.11	0.32	0.164*(p)	0.155*(p)	−0.110(t)		
5. Customer Service	169	0.14	0.34	−0.070(p)	0.049(p)	−0.022(t)	0.618***(t)	
6. Shipping Method	169	0.69	0.47	−0.218**(p)	−0.174*(p)	0.001(t)	−1.00***(t1)	−0.840***(t)

Notes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; (r) stands for Pearson's correlation coefficient between two continuous variables; (p) stands for point-biserial correlations for binary and continuous variables; (t) stands for tetrachoric correlations between binary variables; (t1) product replacement and shipping methods provisions never appear in the same ads.

advertised price point on the Dark Web. The second model (e.g., Extended 1 and Extended 2) included only the product (e.g., semi-automatic) and vendor characteristics (e.g., customer service, product replacement, shipping method) to assess whether significant relationships emerged among these factors. Finally, the third model (e.g., Full 1 and Full 2) combined the former two models (e.g., MSRP, product features, vendor characteristics) to assess whether significant relationships emerged while controlling for the other key variables.

The stepwise approach was employed to test for significant differences between the two models (i.e., Basic and Extended) relative to the full model. Specifically, the analysis enables a calculation of the additional impact of the added variables on the adjusted r2. Simple robust standard errors were also estimated to account for heteroscedasticity. Prior to estimating the regression models, multicollinearity was assessed via tolerance and variance inflation factors (VIF). Multicollinearity was not an issue in the current study as no VIF score was above 1.7 across all the models.

Findings

Table 1 provides the frequency/counts of all Dark Web firearm products (i.e., handguns and long guns) included in the current study, including their mean advertised prices and average MSRPs by action type. The findings revealed a higher frequency of long guns advertised on the Dark Web (long guns = 169; handguns = 118), as well as higher average price points for long guns than handguns (see Table 1). While long guns had higher mean advertised prices, they were advertised at lower prices than their respective MSRPs. This contrasts with the pricing of handguns, as they were sold at a premium on Dark Web firearms markets in comparison to their suggested retail prices. In terms of action type, semi-automatic guns were the most common type for both handguns (n = 99) and long guns (n = 134). Though semi-automatic handguns were the most expensive types of handguns on the Dark Web markets (average advertised price = $744.61), bolt action weapons were the most expensive among long guns (average advertised price = $1,355.40).

Table 2 illustrates the descriptive statistics for the study variables, including the bivariate associations (i.e., Pearson's, point-biserial, and tetrachoric correlations) between the independent variables of interest and the dependent variable, separated by gun type (i.e., handgun v. long gun). Descriptive

statistics revealed that most Dark Web firearms vendors did not employ customer service mechanisms within their sites and advertisements. Specifically, product replacements and customer service lines were not offered by most Dark Web firearms vendors, regardless of whether they were selling handguns or long guns (see Table 2 for details). On the other hand, detailed shipping methods were listed in half of all handgun advertisements, and over two-thirds of all long gun advertisements (69%). This corroborates previous research findings that suggest the importance of elaborate and tactful shipping methods to avoid law enforcement detection and item interception while in transit (Copeland, Wallin, and Holt 2020; Liggett et al. 2020).

The results of the estimated bivariate correlations indicated that the logged MSRPs of both handguns ($r(116) = 0.525$, $p < .001$) and long guns ($r(167) = 0.307$, $p < .001$) were significant and positively correlated to their logged advertised price points. This finding supports previous research that found guns' MSRP to be associated with their price point in offline illicit markets (see Hureau and Braga 2018).

In addition, product replacement was significant and positively correlated with long guns' logged advertised price point (point biserial corr. = 0.164, $p < .05$). Lastly, indicating shipping methods was significant and negatively correlated with long guns' logged advertised price point (point-biserial corr. = – 0.218, $p < .01$). It is worth noting that shipping methods were only significantly correlated with long guns and not handguns (see Table 2 for details). Thus, it may be that market dynamics differentially impact the pricing for firearms based on the distinct weapon type.

The linear stepwise regression analyses demonstrated several significant findings (see Table 3 for details). For one, firearms' logged MSRP was a significant predictor of both handguns' (B = 0.449, SE = 0.158, $p < .01$), and long guns' (B = 0.149, SE = 0.042, $p < .001$) logged advertised price point when included in a model containing just the MSRP variable (see Table 3, Basic 1 and Basic 2). Thus, weapons with a higher MSRP were significantly likely to have higher advertised price points on the Dark Web. While firearms' logged MSRP accounted for approximately 27% of the variance in Dark Web handguns' advertised price point ($R^2_{adjusted} = 0.270$), this only accounted for 8.9% of long guns' advertised prices ($R^2_{adjusted} = 0.089$).

When only product features and vendor characteristics were examined (see Table 3, Extended 1 and Extended 2), product replacements emerged as a significant predictor of handguns' logged advertised price point (B = 0.658, SE = 0.148, $p < 0.001$), while customer service (B = – 0.348, SE = 0.174, $p < 0.05$) and shipping method (B = – 0.297, SE = 0.146, $p < 0.05$) significantly predicted long guns' logged advertised price points. Specifically, handgun vendors offering product replacements were likely to have higher product price points, while long gun vendors operating customer service lines and detailed shipping methods were likely to have lower price points (see Table 3, Extended 1 and Extended 2).

When all the independent variables were included in the same model (see Table 3, Full 1 and Full 2), firearms' logged MSRP remained a significant predictor of the logged advertised price point for both handguns (B = 0.495, SE. 0.152, $p < .01$) and long guns (B = 0.133, SE = 0.040, $p < 0.001$). This finding corroborates previous research that suggests the retail value of a weapon significantly impacts how it is priced on the illicit underground marketplace (see Hureau and Braga 2018).

Further, only customer service lines significantly predicted the logged advertised price point for weapons. Product replacements, shipping methods, and action type did not have a significant impact on both handgun and long gun price point across all models when controlling for the other variables. While Dark Web vendors operating customer service lines were significantly likely to have higher advertised prices for handguns (B = 0.269, SE = 0.076, $p < .001$), this was not the case for long guns. This reinforces the notion that there may be different market dynamics and pricing structures based on gun type within Dark Web markets.

The addition of MSRP, product features, and vendor characteristics increased the amount of variance accounted for in the models (i.e., Handguns' Full Model $R^2_{adjusted} = 0.289$; Long Guns' Full Model $R^2_{adjusted} = 0.141$). At the same time, the changes in $R^2_{adjusted}$ between the Basic, Extended, and

Table 3. Stepwise linear regression models separated by gun type.

Variables	Handguns			Long guns		
	Basic 1 B (SE B)	Extended 1 B (SE B)	Full 1 B (SE B)	Basic 2 B (SE B)	Extended 2 B (SE B)	Full 2 B (SE B)
MSRP	0.449 (0.158)**	–	0.495 (0.152)**	0.149 (0.042)***	–	0.133 (0.040)***
Semi-Automatic	–	0.166 (0.165)	0.165 (0.142)	–	0.083 (0.074)	−0.032 (0.087)
Product Replacements	–	0.658 (0.148)***	0.320 (0.175)	–	0.149 (0.200)	0.101 (0.193)
Customer Service	–	−0.031 (0.112)	0.269 (0.076)***	–	−0.348 (0.174)*	−0.325 (0.167)
Shipping Method	–	−0.003 (0.094)	−0.183 (0.111)	–	−0.297 (0.146)*	−0.257 (0.138)
Intercept	3.614 (1.028)***	6.297 (0.171)***	3.160 (0.978)**	5.830 (0.280)***	7.047 (0.154)	6.180 (0.259)***
Model Fit	N = 118 F(1,116) = 8.12** Adj. R^2 = 0.270	N = 118 F(4,113) = 12.52*** Adj. R^2 = − 0.002	N = 118 F(5,112) = 11.84*** Adj. R^2 = 0.289	N = 169 F(1,167) = 12.45*** Adj. R^2 = 0.089	N = 169 F(4,164) = 1.91 Adj. R^2 = 0.083	N = 169 F(5,163) = 3.60** Adj. R^2 = 0.141

Notes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Full models were only statistically significant for handguns. These findings demonstrate that MSRP was the driving force in handguns' advertised price point, whereas the amount of variance covered between long guns' logged MSRP and its product/vendor traits were relatively similar (Basic Model 2 $R^2_{adjusted}$= 0.089; Extended Model 2 $R^2_{adjusted}$= 0.083).

Discussion and conclusions

The ability to acquire an array of firearms over the Internet demonstrates the evolution of offending behavior pertaining to the illegal acquisition of weapons, as well as the need to develop a more comprehensive understanding of criminal access to guns (Copeland, Wallin, and Holt 2020; Hureau and Braga 2018). Limited knowledge regarding offline gun prices suggests noteworthy markups for guns purchased in underground markets, with higher prices in cities located in jurisdictions with tighter gun laws and regulations (Cook et al. 2007; Cook, Molliconi, and Cole 1995; Hureau and Braga 2018). While previous firearms research has found that guns purchased in illicit underground markets are sold at inflated prices from their formal legal market price structures (see Hureau and Braga 2018), studies exploring the factors that influence online illicit firearms' price point using empirical data has been scant (e.g., Copeland, Wallin, and Holt 2020; Paoli et al. 2017).

There is limited empirical knowledge on whether firearm features and vendor behaviors influence the price point of weapons sold on the Dark Web, highlighting the need for further investigations of price determinants on illegal markets. Descriptive studies have revealed that illicit firearms are higher in cost than those observed in legal supply chains (Hureau and Braga 2018). However, no empirical study to date has examined the product traits and vendor characteristics that predict firearm pricing structures on the Dark Web.

The current analysis revealed that products' MSRP was a significant predictor of both Dark Web handguns and long guns' advertised price point, mirroring studies on gun pricing in illicit offline markets (see Hureau and Braga 2018). This finding also reflects similar analyses of Dark Web drug market pricing, which found that products' cost in offline markets were significantly associated with its value on the Dark Web (see Cunliffe et al. 2017). The price for illicit firearms was closer to its offline market value, which is distinct from other online product markets, such as those selling stolen credit cards and hacking tools (e.g., Holt, Chua, and Smirnova 2013; Smirnova and Holt 2017). It may be the case that social and structural factors of the online illicit firearms market differentially shape how products are priced relative to other products sold on the Dark Web.

In addition, though gun research has found that more handguns were for sale in underground markets (see Broadhurst et al. 2021; Copeland, Wallin, and Holt 2020; Hureau and Braga 2018; Paoli et al. 2017), our findings demonstrated that more long guns were advertised on the Dark Web. The differences observed in the distribution of products may be a function of the more contemporary vendor samples included in this analysis. Additional research is needed to assess the composition of weapons for sale at any given time on the Dark Web. Semi-automatic weapons were also the most frequently advertised among both types (see also Broadhurst et al. 2021; Copeland, Wallin, and Holt 2020; Hureau and Braga 2018). This may be due to its shooting capability and value as a thinner and lighter weapon to carry and conceal (Hureau and Braga 2018).

Further, product replacements, shipping methods, and action type did not appear to bear statistically significant relationships for both Dark Web handguns and long guns when controlling for the other variables. The only significant vendor specification that appeared relevant to price point was customer service, and only for handguns. This suggests customer service lines may have different value and meaning based on the distinct weapon type. For instance, offering customer service lines may potentially illustrate handgun vendors' increased interest and willingness to satisfy customer requests and orders. Additional research is needed to disentangle this relationship, and the broader dynamics shaping the role of traditional business models, such as customer service and product discounts, in online illicit markets generally (see also Holt et al. 2016).

Relatedly, the study also revealed that these product and vendor traits only accounted for a small amount of variation in Dark Web firearms' price point. Future studies would benefit from exploring other product characteristics and vendor behaviors as potential factors affecting Dark Web firearms' price point, including products' country of origin, vendors' preferred method of payment, presence, and quality of product images, and type of customer feedback (Broadhurst et al. 2021; Copeland, Wallin, and Holt 2020). Continuing this line of research would cultivate further knowledge around the informal social mechanisms and market dynamics that guide firearms market participants and their illicit operations.

Future research would also benefit from exploring the degree to which miscellaneous products associated with kinetic weapons are available in online markets, including gun cartridges, explosives, blueprints for homemade weaponry, and other equipment. Though these items are not firearms and may not be available to consumers, such as explosives, they have the potential to incite harm and offline violence when paired with other weapons. Research exploring both the size of these ancillary weapons markets and their product/vendor characteristics would provide a more comprehensive understanding of the online underground weapons market.

Additionally, this study demonstrates the inherent value of online data for criminological analyses. Researchers have used text and visual information posted by individuals in websites, social media feeds, and computer-mediated communications platforms (see Holt 2017; Silverman 2013 for reviews). The observable content on these platforms provides the thoughts of individuals in their own words, often revealing their motivations, methods, and target preferences (Anahita 2006; Baumgarten 2017; Figea, Kaati, and Scrivens 2016; Wong, Frank, and Allsup 2015). In fact, manual collection and coding of HTML content has been used by criminologists to examine various online illicit market economies, including those selling stolen credit card data, counterfeit identity documents, and contract violence/hitmen services (see Holt and Lee 2022a; Roddy and Holt 2022; Holt, Smirnova, and Chua 2016).

Similar strategies using web crawler programs have also been employed to extract data from online illicit markets operating on both the Open and Dark Web (see Broadhurst et al. 2021; Demant et al. 2018). This method of web-based data collection is arguably more accurate, efficient, and useful than conventional self-report or interview methods given traditional methods' susceptibility to various reporting and selection biases (see Barratt and Aldridge 2016; Cunliffe et al. 2017; Latour, Jensen, Venturini, Grauwin, and Boullier 2012; Franklin et al. 2007; Thelwall 2009).

By capturing these detailed data points, researchers are able to conduct various analyses to increase our understanding of the market dynamics that guide illicit market participants and their economic operations at a specific point in time. Researchers can also use online data to conduct longitudinal analyses that track and monitor economic operations to determine whether these market economies, pricing structures, and interactions (i.e., between buyers and sellers) evolve over time. In fact, recent law enforcement actions targeting the online illicit marketplace may have reduced the quantity of vendors operating on the Dark Web and affected the mechanisms buyers and sellers use to continue their behavior (Cox 2015; McKay 2018).

Despite its utility and accessibility as a new and novel data source from which to explore criminology and criminal justice inquires, online outlets present unique ethical concerns when used for research (see Holt and Dupont 2019). In particular, there has been considerable debate around whether data generated from online sources should be considered public or private content given its unique characteristics (Aldridge and Décary-Hétu 2014; Kitchin 2003; Wilkinson and Thelwall 2011). Specifically, those who believe online data is public content argue participant consent is unnecessary because data were collected by natural observation (see Aldridge and Décary-Hétu 2014; Kitchin 2003; Wilkinson and Thelwall 2011). The lack of consensus around standards for online data collection only exacerbates these issues (see Holt and Bossler 2016; Silverman 2013). As a result, there is a clear need for increased discussions around the ethics constraints required to protect people, and greater awareness of the need for human subjects'

protections across all academic disciplines (see Holt and Lee 2022a 2021). Progressing in this way will not only enhance the field of data science but also improve the quality of findings in research and decision-making moving forward.

Though this study benefits our understanding of the pricing for weapons in the online illicit market, there are limitations affecting its generalizability. For one, the price points noted in the current study may not be representative of the definitive pricing of these products as the marketplace evolves. While our sample provides a more recent illustration of the online underground firearms marketplace, which may be a reflection of recent law enforcement crackdowns against Dark Web platforms operating to sell illicit products online, the findings can only function as a snapshot of the product listing and pricing structure of this time (i.e., between 2018 and 2020). Both the list of products and their pricing could change due to any number of factors moving forward (see Demant et al. 2018; Munksgaard, Demant, and Branwen 2016). Additionally, this study focused only on Dark Web firearms vendors, with a particular emphasis on shops (i.e., only one crypto market). As a result, the current findings may not be extensible to other crypto market vendors, or to those operating on the Open Web.

Finally, this study was unable to determine whether product advertisements were generated by actual sellers or other interested parties, such as law enforcement (see Holt, Smirnova, and Hutchings 2016). Such an information is often difficult to obtain through traditional observational methods of online spaces, thus corroborating these data with self-report surveys of online market participants may prove more effective to assess product pricing and market dynamics (see Aldridge and Décary-Hétu 2016; Copeland, Wallin, and Holt 2020). Relatedly, though the current study provided insight into the economic model of online illicit firearms markets, it was unable to determine how many products were actually bought and sold since official transactions occur outside of public sight and observation (e.g., Franklin et al. 2007; Holt 2013; Holt, Chua, and Smirnova 2013; Holt and Lampke 2010; Wehinger 2011).

Despite the study's limitations, the current findings provide knowledge around an under-examined area in both cybercrime and criminal justice research writ large. This study demonstrated a need for more robust datasets and multidisciplinary approaches to improve our understanding of illicit firearm vendors' behaviors relative to their product price points. Future research would benefit from extending this line of inquiry using more comprehensive samples and methodological techniques to better understand the behaviors influencing illicit online market operations.

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