Citation: Berry, M. (2026). “Risk Actants and the Socio-Technical Evolution of Illicit Drug Markets Through Time: From Payphones to Crypto-Spatial Markets and a Nascent Dark Metaverse.” *Drugs, Habits and Social Policy*, 27(3), 161–174. https://doi.org/10.1108/DHS-01-2026-0005

Risk Actants and the Socio-Technical Evolution of Illicit Drug Markets Through Time: From Payphones to Crypto-Spatial Markets and a nascent Dark Metaverse

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Abstract

Purpose
The purpose of this study is to examine how illicit drug markets have evolved alongside information and communications technologies (ICT) in different forms of hybridisation, providing insights into their future organisation, policing, and harms.

Design
The article adopts a literature-based, narrative review, which employs Actor-Network Theory to trace the socio-technical evolution of illicit drug markets across three technological phases: pagers, mobile phones and the internet, whilst the discussion moves to a consideration of extended reality (XR).

Findings
The findings show that illicit drug markets are repeatedly reconfigured through the adoption of emergent ICTs. Each technological wave generates new forms of coordination while simultaneously creating new risk actants through policing and regulation. Dealers respond by displacing or containing these risks, producing shifts between open and closed and differentiated hybrid market forms. With the emergence of XR, these dynamics are argued to be giving rise to crypto-spatial markets and a nascent Dark Metaverse, in which immersive digital environments, encrypted ghost infrastructures, and virtualised 3D marketplaces become integrated with physical drug distribution systems.

Originality/value
The article advances current debates on drug markets, technology, and policing, offering a forward-looking framework for understanding how future forms of drug supply may be organised. Theoretically, the article extends Actor–Network Theory by conceptualising technologies as 'risk actants'. It introduces the concepts of 'crypto-spatial markets' and the 'dark metaverse' to explain particular configurations of drug market hybridity in XR.

Introduction

Despite international enforcement and deterrence strategies, the War on Drugs has failed to provide any meaningful long-term reductions on the ground. The main impact of police crackdowns has been shown to be symbolic and has tended to displace drug markets rather than reduce them, pushing them into new spaces and technological forms (Berry and Berry, 2024). The history of drug control is therefore one of adaptation, where criminals modify their operational strategies to mitigate risks whilst continuing and diversifying supply. In the last few decades, this adaptive capacity has been profoundly shaped by information and communications technologies (ICT) originally designed for everyday consumer usage (Berry, 2018). These technologies allow buyers and sellers to coordinate transactions with unprecedented speed and reach, whilst creating new spaces and platforms to market products. At the same time, they enable drug markets to become more anonymous, mobile and geographically dispersed, reducing reliance on fixed dealing locations and lowering exposure to traditional forms of surveillance (May and Hough, 2004).

Nonetheless, the contemporary concern with 'digital' drug markets should not be understood as marking an entirely novel rupture, but rather as the latest phase in a longer process of socio-technical adaptation. As Berry (2018, p. 1) argues, "rather than replacing traditional drug markets, ICT extends them into virtual domains, creating communication channels and buying platforms that alter power relations between stakeholders". Indeed, successive waves of ICT have reconfigured the ways in which market actors coordinate supply and negotiate risk, but suppliers and the drugs themselves are always grounded in the physical world. What changes over time, therefore, is not whether illicit drug markets are hybrid (offline and online), but the particular form that hybridity assumes. In tracing these historical developments, the article looks to the future to consider how the next phase of ICT (extended reality) will impact the illicit drugs trade. To make sense of these changes, what is required is an approach capable of tracing how these heterogeneous elements, cutting across a physical-digital divide, come together to form the shifting architectures of illicit exchange. Actor-network theory is particularly well suited to achieving this aim.

Theoretical Framework

Actor Network Theory

Actor-Network Theory (ANT) is a theoretical and methodological framework within the field of Science and Technology Studies developed by Bruno Latour, Michel Callon, and John Law in the 1980s (Callon, 1984; Latour, 1987; Law, 1987). According to ANT, our world is constructed of a seamless web of socio-technical networks; social, in that they are comprised of people, and technical in regard to technologies (Latour, 2005). The strength of ANT for understanding technological change in the drugs trade is that it avoids social and technological determinism (Berry and Berry, 2024). It is down to the researcher to trace the associations between actors in determining the effect they have (Law, 2004). In doing so, it encourages us to avoid making unhelpful divides between online and offline aspects of reality.

ANT radically proposes that inert material objects have agency and have the same capacity to affect the network as people. Indeed, all actors within the network are referred to as 'actants' to denote their capacity to act. This is the principle of 'generalised symmetry'; both human and non-human actants can equally produce effects that shape outcomes (Law, 1986). The approach is also anti-dualist as it rejects binary distinctions (subject and object, micro and macro, local vs global, offline vs online); it is a flat ontology. It is important to note, however, in ANT, power is not something that someone/something has; instead, it is distributed throughout the actor-network and is a consequence of the constant work of the actors involved (Latour, 2005).

A central ANT concept in understanding organisation and change is that of 'translation'. This refers to the process through which actors negotiate and redefine roles within networks to achieve specific outcomes. In translation, prime movers persuade others to join or align with their interests, thereby enabling the establishment and sustainability of the network (Callon, 1984). Callon conceptualises this as a four-stage process: problematization (defining a shared problem), interessement (aligning and attracting actors to a proposed solution), enrolment (securing their roles), and mobilisation (coordinating them to act collectively). In this process, ANT also differentiates between mediators and intermediaries; an intermediary simply carries action or meaning unchanged, while a mediator actively transforms and redirects what passes through it (Latour, 2005).

Risk Actants and Drugs Supply

In the illicit drug trade, risk has been shown to be a major driver of market transformation over time (Bakken and Demant, 2019), yet it remains theoretically underdeveloped. A particularly under-utilised ANT-informed framework with strong relevance for criminology is Hilgartner's (1992) concept of 'risk objects', which explains how specific risks become identified and stabilised within socio-technical networks. This approach was first applied to organised crime and drug markets by Berry (2018) and is further developed here.

According to Hilgartner (1992), something becomes an object of risk when it is defined as risky. This definition includes at least three elements: 1) an object deemed to pose a risk, 2) a putative harm, and 3) a linkage of causation between the object and the harm. Illicit drugs are risk objects par excellence. They are risk objects to society due to the harm they cause users. They are risk objects to the dealer because of threats from police and criminal predators (Berry, 2018). A risk object is a significant force. It is important to note that objects in ANT are also networks in themselves that have become stabilised and black boxed to appear as a single entity (Latour, 2005). Hilgartner (1992) recognises that risk does not exist solely within something, nor is it some force that exists out there; it is continuous rather than discrete and is a consequence of relations within the network; however, his approach does slip back into social constructivism. From a true ANT perspective, risk is better seen as a networked effect produced by the causal associations between human and non-human actants that materially enact the very threats that actors interpret as risk.

To avoid the potential harm of risk objects, actors must devise strategies to eliminate and neutralise them. One strategy is to completely displace the object from the network; the other is to contain it, so it remains in place, but the linkage to harm is severed. In both cases, risk is deconstructed. In opposition to this, risk can also be intentionally constructed and emplaced into objects to influence network structure (Hilgartner, 1992). That being said, the term 'risk actant' is a better descriptor here (human or non-human); as stated, even inert objects are not passive and have the capacity to effect network change (Law, 2004). Moreover, in the illicit drugs trade, there may be multiple interconnect assemblages of risk actants being constructed and mobilised at one time.

Although from a different lens, Crime Science offers a further point of connection here through Ekblom's (2017) 'arms race' metaphor, which conceptualises offending vs policing as processes of continual adaptation. This aligns with the idea of risk actants, insofar as innovations are frequently adopted because they alter exposure to surveillance, interception, arrest, violence and so on, while counter-innovations attempt to deconstruct or reimpose those risks upon adversaries. ANT enhances this insight by rejecting a narrow dualism between offenders and police, instead tracing how heterogeneous actants mediate these struggles.

Nonetheless, while the arms race helps explain the adaptive and conflictual dynamics through which drug markets and policing co-adapt, it is also necessary to account for the broader market transformations produced by emergent technologies themselves. It is here that the concept of disruptive innovation becomes useful.

Disruptive Innovation

Disruptive innovation is a concept that explains how technologies transform social and economic life. Bower and Christensen (1995) first conceptualised disruptive technologies before Christensen went on to reframe this process more broadly as disruptive innovation, to account for both the social and technological elements of change (Christensen, 1997). In

disruptive innovation, sustaining technologies make existing products and services better for customers, whereas disrupting technologies initially start off at the fringe before being adopted on mass as they improve. Disruptive technologies significantly reshape market structure, supplanting old technologies and ways of doing things. Schuelke-Leech (2018) distinguishes between, 1) first-order disruptions that produce relatively localised changes within a market or industry and, 2) second-order disruptions that extend beyond a single sector, restructuring multiple industries and producing wider transformations in institutions and everyday social practices (Schuelke-Leech, 2018). Hopster (2021) argues that disruption can be both positive and negative, whilst the impact can be more or less extensive.

Disruptive innovation is used here as a heuristic device that helps explain the scale and direction of market transformation, while ANT traces how that transformation is assembled. "ANT enables the researcher to follow the actants from one to another, to identify actants which may have agency, but which may not be evident at the macro-level analysis of markets and business (Kennan and Cole, 2008, p. 6). According to May and Hough (2004), both risk and technological innovation have been central to the reconfiguration of drug markets through time. These markets are organised along a continuum from open to closed, public or private, offline to different degrees of digital hybridity; each representing a different configuration for managing the visibility of suppliers and exposure of risk (Bakken and Demant, 2019), each being shaped and enabled by the emergence of disruptive information communication technologies.

Methodological Approach

The article adopts a literature-based, theory driven, narrative review drawing together academic, legal, media and historical documents (N=53), added to the theoretical/methodological literature (N=14). It traces the socio-technical evolution of illicit drug markets across three technological phases: pagers, mobile phones and the internet, whilst the discussion considers extended reality. The cases were selected because each represents a historically significant socio-technical phase in the evolution of ICT in society and drug market organisation. Analysis proceeded through cycles of reading, comparison and interpretation (Sukhera, 2022). Google Scholar was the primary search tool. Search terms included: illicit drug markets, pagers, mobile phones, smartphones, online drug markets, cryptomarkets, extended reality, policing and surveillance. From an ANT perspective, the literature is understood as inscriptions that translate socio-technical practices into durable textual form (Latour, 2005). The literature reviewed here, and this article itself, is thus considered as part of the actor-network (Law, 2004). The paper seeks to answer the following questions:

1. How has technological change reshaped illicit drug markets over time?
2. How have technologies altered risk and risk management within illicit drug markets across these historical periods?
3. What do past and present technological changes suggest about the possible development of drug markets in the future?

Having set this out, the following sections outline three case studies demonstrating how emergent technologies significantly disrupted the structure of illicit drug markets through time, with the introduction of the first mobile communications device - the pager.

Case Study 1: From Payphone to Pager

The pager (also known as a beeper) is a telecommunications device invented in the 1920s when radios were first installed in police cars. In 1949, Al Gross officially patented the device, and it became widely used in American hospitals. At the time, pagers could only receive signals and sent an audible alert to physicians (Schroer, 2001). In the 1970s, pagers were adapted to receive brief audio recordings. In the 1980s, numeric displays were introduced, which allowed physicians to receive silent messages (Morton, 2015). Early medical use of the pager represents a first-order disruption that produced relatively localised changes within a sector. The creation of wide-area paging networks, which enabled messages to be transmitted via radio waves across countries, shifted the device to a second-order disruption as it was enrolled into multiple sectors. Indeed, the additional range increased their commercial viability and led to pagers being adopted globally on mass (Vuori, Honkanen and Skytta, 1994; Schuelke-Leech, 2018).

Before the emergence of pagers, retail drug markets in the UK and US relied on fixed locations (street corners, crack houses, bars) where dealers could communicate face-to-face or use fixed phone lines. According to Coomber (2006, p. 139), in the 1980s, crack dealers were on 'virtually every block in inner-city New York City and at some locations in many middle-class and suburban neighbourhoods as well'. The geographically fixed nature of sales patterns made dealers visible, predictable and easy to police. Under Reagan's War on Drugs, law enforcement came down heavily on poor African American areas with police crackdowns and increased penalties for selling crack cocaine, creating heightened risks. By the late 1980s, the pager had become a significant mediator (Latour, 2005), allowing dealers to be more mobile (Gambetta, 2009). The dealer would receive a number from their customer, which they could then call back from a public payphone to organise the sale. In a 1989 hearing in the US Senate, a statement from a former trafficker exemplifies this:

> "That's correct, Senator. I would be called on a regular basis across my pager, and I would not return a phone call across my pager from my home phone. I'd jump in a car, drive a couple of miles to a pay phone, and return that call from a payphone…" (US Department of Justice, 1989, p. 57).

According to Natarajan, Clarke and Johnson (1995), authorities considered a range of strategies to disrupt drug dealing around public payphones. This included removing or relocating phones, licensing and restricting where they could be installed, blocking incoming calls, blocking outgoing pager calls, and recording calls. This process was a combination of containing risk actants (through restricting and blocking) and constructing risk actants (through monitoring communications). In the wake of these risks, the ability to coordinate sales through ICT led the open market street corner sales that were common previously into decline (Gambetta, 2009). By '1994–1997 the hustle and bustle of the Bronx drug world had quieted, almost disappeared' (Contreras, 2012, p. 105). May and Hough (2004) outline similar findings in the UK.

As the pager became popular with youth, a moral panic ensued. The War on Drugs particularly evoked fear of drug dealers targeting children, as epitomised by Nancy Reagan's 'Just Say No to Drugs' campaign. In an interview with the New York Times in 1988, a public school district official stated, "How can we expect students to 'just say no to drugs' when we allow them to wear the most dominant symbol of the drug trade on their belts" (Sims, 1988, p. 22). In response, States and schools enacted regulations prohibiting pagers. New Jersey completely banned beepers for those under 18, with possession potentially leading to a six-month prison sentence (New Jersey Legislature, 1989).

During this time, U.S. courts routinely described pagers as 'a standard part of the drug dealer's equipment' and recognised their 'fundamental importance in today's drug trade' (Decker, 1999, p. 344). The 1986 Electronic Communications Privacy Act amended the Federal Wiretap Act to modernise the legislation in response. Federal courts ruled that the memory of a pager functioned like an address book where officers could lawfully retrieve stored numbers following arrest or under a warrant (Decker, 1999, p. 355). In 1999, the Clone Pager Authorization Act authorised the use of cloned pagers by law enforcement to receive messages being sent to suspects. From an ANT perspective, this 'arms race' (Ekblom, 2017) can be described as counter-translations in which the state tried to reconfigure the network by enrolling telecom regulation, city licensing and surveillance into its own programme of control (Callon, 1984; Hilgartner, 1992). Nonetheless, it is important to note that different drug markets during this time operated through distinct retail forms - not all were on street corners or produced high levels of violence (Coomber, 2006). The pager thus entered a differentiated drug market landscape, but one in which the risks associated with open-air crack selling created especially strong incentives to adopt the pager to frustrate policing.

Case Study 2 - The Mobile Phone

The mobile phone was first demonstrated in 1973 by Motorola in New York City. In 1978, one cellular phone system existed globally: a small experimental network in Chicago. In 1979, Japan's Nippon Telegraph and Telephone launched the first 1G commercial cellular network. This was analogue, voice-only and had limited coverage. The first commercially available mobile phone went on sale to the public in 1983 - the Dynatac 8000X, costing $3995 dollars (equivalent to $13,000 today). The phone was bulky and reserved for the wealthy. By the end of 1988, the global cellular subscriber count exceeded 4 million (Garcia-Swartz and Campbell-Kelly, 2022). Nonetheless, these usage rates are still very low in comparison to today, where it has matured into a significant second-order disruptive technology (Schuelke-Leech, 2018).

The second generation (2G network) mobiles arrived in the 1990s, which enabled SMS text messaging services over GSM (Global System for Mobile Communications). The first SMS text message was sent by a UK software programmer in 1992, although it was a few years before texting became widely available (Dobson *et al.*, 2024). The 1990s also saw the birth of the first internet-enabled 'smartphone' - the IBM Simon 1994, which featured a touch screen display. The phone was expensive at $899 ($1,966 today). Aside from the internet, smartphones also began to integrate other technologies and acquire greater functionality. The inclusion of GPS was a landmark moment that demonstrated satellite positioning on handheld devices (Garcia-Swartz and Campbell-Kelly, 2022).

Due to the cost of mobile phones, pagers were still the primary communication device during the early 90s for drug dealers (Gambetta, 2009). Nonetheless, the heavy price tag for the mobile was not an issue for traffickers higher up the chain. Natarajan, Clarke and Johnson (1995) describe the notorious 'Blue Thunder' heroin case in New York, which heavily relied on wiretapping. Interestingly, they write how the technology enabling law enforcement to intercept mobile phone numbers was accessible to criminals who also used it to clone them, providing low-risk communications. This shows that technological artefacts can have multiple, competing uses depending on how they are translated into different networks (Latour, 2005).

From 1993 onwards, mobile phones became more widespread when regulatory reform and technological shifts accelerated the spread of digital mobile networks, including the release of

new spectrum for Personal Communications Services and AT&T's entry into nationwide wireless service. This made cheap and flexible mobile communication increasingly viable. As Christensen (2003, p. xviii) notes, "products based on disruptive technologies are typically cheaper, simpler, smaller, and, frequently, more convenient to use". Indeed, the introduction of pre-paid mobile phones in 1994, combined with falling handset prices and per-minute charges, allowed mobile phones to become accessible to street-level drug dealers and customers, reducing reliance on payphones, pagers and fixed dealing locations. Accordingly, this contributed to a reduction in gang-related murders in America, as drug dealers no longer had to sell from street corners and protect their turf (Edlund and Machado, 2019).

The 2000s marks the birth of the third-generation mobiles with 3G networks having faster data and video services. The Nokia 5510 was a popular model released in 2002 for $362 dollars, enabling sales on mass, effectively making the pager obsolete as a consumer technology (Linge and Sutton, 2015; Verhoef, 2024). Until the early 2000s, voice and texting dominated communications. The development of mobile data was constantly progressing, facilitated by phones that permitted email access and media sharing. Mobile phones began seeing swift advancements, accommodating several media forms beyond speech (Bergström *et al.*, 2024).

Although the first internet-enabled 'smartphone' emerged in the 1990s, the release of the iPhone in 2007 marked the birth of contemporary smartphones that have a variety of applications that can be downloaded from the internet. This allows phones to take on additional functionality that was not included at release, as directed by the user (Garcia-Swartz and Campbell-Kelly, 2022). Today, smartphones now host a vast ecosystem of apps covering communication, information, media, work apps, banking, entertainment and gaming, and increasingly AI-driven tools, all of which have been used for drug supply.

As the mobile phone became the communication method of choice for drug dealers, the police increasingly used them to collect evidence; this occurred through wiretapping communications as well as forensic analysis of recovered devices (Piskopani *et al.*, 2024). In the UK, the Police and Criminal Evidence Act 1984 gives the authorities power to confiscate devices where there are reasonable grounds to suspect they contain evidence of a crime. In regard to wiretapping, the principal statute governing the interception of communications was the Regulation of Investigatory Powers Act 2000 until it was superseded by the Investigatory Powers Act 2016. Whilst wiretapping typically requires a warrant to gain permission from the operator, the police have also been reported to use IMSI-catchers ("stingray" devices) and covert network emulators (fake mobile towers) to intercept signals and collect identifiers (Privacy International, 2020). End-to-end encryption in apps such as WhatsApp makes monitoring communications more challenging for law enforcement (more on this later). Although in Operation Trojan Shield, criminals became unstuck as the encrypted devices they used had been devised by law enforcement and marketed to them, so they could collect data en masse (Hoppe, 2025). Latour (2005) describes such moments as controversies, periods in which previously taken-for-granted arrangements are unsettled, exposing the actants, relations, and dependencies that can remain hidden beneath stabilised actor-networks. As phone lines become more central to the trade, there are also cases where competing criminals will rob other dealers of these phone lines (Berry, 2018), demonstrating that the 'arms race' (Ekblom, 2017) is not simply a matter of criminals vs the police.

Whilst mobile phones have increased functionality, they also create more data, providing intelligence and evidence. To mitigate this, dealers have reverted to using 'burner phones' with basic functionality, no GPS systems with pay-as-you-go SIM cards registered to fake names

and addresses (Søgaard *et al.*, 2019). Nonetheless, even without GPS monitoring, cell site data can provide evidence on whereabouts (Jones and Brookman, 2024). Aside from SIMs, Mobile phones also have IMEI numbers, which are unique identifiers. These can be changed, although this requires technological competencies (Berry, 2018). The level of risk mitigation that dealers employ is also related to the drugs they sell; for example, anabolic steroids carry low risk to dealers (due to their legal status and police priorities), who use smartphones more brazenly (Berry and Berry, 2024). Nonetheless, the enhanced data that smartphones collect has also been used to provide 'digital alibis' for criminals as they leave these registered phones on at home whilst they go about their business (Berry, 2018). As with the pager, the strategies employed by law enforcement to monitor criminals have also been used against them. Aside from the street, the mobile has particularly facilitated the drugs trade in prison (Gooch and Treadwell, 2025).

Overall, the mobile phone significantly reconfigured the socio-technical network of drug supply by affecting how dealers, customers, police, institutions, and policies related to each other. As mobiles became cheaper and more multifunctional, they displaced older communication forms, demonstrating a disruptive innovation that further shifted drug markets away from more fixed, visible street-based dealing. At the same time, the mobile also became a significant risk actant: while it reduced some dangers for dealers, it simultaneously generated new risks through interception, forensic recovery, cell-site analysis and device identification.

Case Study 3 - The Internet

The internet was established in the US throughout the 1950s Cold War era, characterised by tensions with the Soviet Union. America saw the need for a communications infrastructure impervious to a Soviet nuclear assault. The Soviet Union's deployment of the Sputnik satellite prompted the US Department of Defence to explore methods to distribute information in the event of a nuclear strike. This resulted in the establishment of the ARPANET (Advanced Research Projects Agency Network), which, over time, developed into the internet we recognise today (Kumar and Perakis, 2022). Beyond its military origins, ARPANET quickly became a platform for civilian scientific communication and illicit commerce. One of the earliest documented online drug transactions occurred in the early 1970s, when two Stanford students used ARPANET to arrange the sale of cannabis (Markoff, 2005)

January 1, 1983, is regarded as the official inception date of the Internet. Previously, disparate computer networks lacked a standardised method for intercommunication. A new communications protocol named Transmission Control Protocol/Internet Protocol enabled various types of computers across networks to communicate. The rise of the global internet (Web 1.0) occurred in 1989, when Tim Berners-Lee created the World Wide Web, providing a hypertext system that made the internet usable by the public. By the early 1990s, browsers helped popularise internet access beyond researchers (Kumar and Perakis, 2022), marking the shift from first-order to second-order disruption (Schuelke-Leech, 2018). During these early stages of the internet, online forums and chat rooms were some of the first instances of using the technology to facilitate drug distribution through arranged in-person meetings, or discussions of drug manufacturing methods. Even while these early online drug market activities were not common enough to drastically alter conventional street markets, they nonetheless indicate a first step toward the integration of internet technology (Childs and Bernot, 2025).

Web 2.0 (also known as the participatory web) came to the fore in 2004, resulting in a shift from read-only websites to interactive, participatory platforms where users could create and share content and participate in online communities (Blank and Reisdorf, 2012). This transformed the internet into a social collaborative space with platform-based economies. The internet quickly became an obligatory passage point (Callon, 1984) for social and economic activity. Indeed, surface-web 2.0 marked a significant turning point in the growth of online illegal drug marketplaces. The distribution of lifestyle and grey-market pharmaceuticals (such as performance and image-enhancing drugs, and new psychoactive substances) were found through straightforward website searches and early technologies that enabled electronic payments (Childs and Bernot, 2025).

The Rise of Darknet Drug Markets

The Darknet is a term that originated in the 1970s to refer to networks that were isolated from ARPANET. The term gained wider acceptance in 2002 with the publication of a paper of the same name. The surface web is the publicly accessible part of the internet that is indexed by search engines. Today, the darknet refers to private, encrypted networks requiring special software, such as Tor, to access and is designed to provide anonymity (Adewopo *et al.*, 2019).

Tor is founded upon a system called 'onion routing' which provides encrypted communications. It was developed in the 1990s by US Naval Research Laboratories and American scientists to protect American intelligence. In 2002, the official TOR 'Onion Router' was launched - a free open-source software allowing anonymous communication and browsing online (Kavallieros *et al.*, 2021). A crucial technological development enabling darknet markets was the emergence of cryptocurrencies in 2008, especially Bitcoin. Cryptocurrencies allow peer-to-peer payments without banks or credit-card companies and provide a degree of anonymity, making them attractive for illicit commerce. Escrow services increased trust in the platform in which a neutral third party holds cryptocurrency until both sides of a deal meet the agreed conditions (e.g. the drugs are delivered). Together, Tor and Bitcoin created the technical conditions for large-scale anonymous online drug markets to exist (Martin, 2014).

The first major darknet drug market was Silk Road, launched in 2011. Silk Road functioned as a multi-vendor cryptomarket, allowing sellers to advertise drugs, set prices, upload photographs and build reputations through customer reviews. Buyers could browse listings, compare quality and prices, and have drugs delivered through the post. Meaning buyers could access drugs without having to find and meet dealers in the local community (Décary-Hétu and Giommoni, 2017). Silk Road also increased access to a wide variety of drugs that may not have been accessible otherwise. Importantly, it also reduced interpersonal violence because disputes were handled online rather than face-to-face (Martin, 2014). Nonetheless, even where exchange is coordinated through encrypted platforms, vendors, buyers and the drugs themselves remain physically located, and market activity is shaped by physical infrastructure and transport systems (Korshøj and Søgaard, 2024). Silk Road succeeded because it translated diverse interests into one relatively stable market platform (Callon, 1984). Escrow, customer feedback, PGP keys (encryption), stealth packaging, postal systems and forum moderation all worked as mediators that transformed risk and uncertainty to help stabilise the network. In Latour's (1987) sense, the cryptomarket became black-boxed for ordinary users once these alignments held.

Silk Road was taken down in 2013 after a long FBI investigation where agents were able to penetrate the black box and identify the site's administrator. Following its closure, Silk Road 2.0 and numerous competing platforms emerged, including AlphaBay and Hansa (Kermitsis *et al.*, 2021). Rather than eliminating the market, law enforcement intervention accelerated its security and diversification. Operation Onymous, led by the FBI and Europol in 2014, was the first major international crackdown, resulting in the closure of multiple markets at once (Van Buskirk *et al.*, 2017). In 2017, under Operation Bayonet, law enforcement shut down AlphaBay, then secretly took control of Hansa. For several weeks, Dutch police ran Hansa while collecting usernames, IP addresses, transaction histories, PGP keys and shipping data. When Hansa was finally closed, thousands of users had been exposed, leading to arrests and seizures across Europe and North America (Abdel Samad, 2021). Nonetheless, the impact of these operations on drug supply over time was limited, as vendors quickly set up again on new and alternative darknet platforms (Décary-Hétu and Giommoni, 2017; Van Buskirk *et al.*, 2017), providing further sustaining technologies to the market base (Christensen, 2003). Indeed, cryptomarkets had similar struggles over the construction of risk actants as the pager and mobile phone.

App-Mediated Supply

Contemporary drug markets have also seen a rise in app-mediated supply, using platforms such as Snapchat, Facebook, Instagram, WhatsApp and Telegram (BenBaruch *et al.*, 2025). This may occur in private, direct one-to-one conversations, or sales advertised on chat forums/groups or social media webpages. These apps are typically accessed through smartphones but are available on many internet-enabled devices. According to Moyle et al. (2019), customers using these systems prefer them for their immediacy, convenience and visual dealing practices. Many of these apps provide anonymous, encrypted communications, making them harder for law enforcement to access. Telegram has emerged as a popular platform for drugs, with both private communication among individuals as well as interactions with large groups and channels. It imposes few constraints on content (Blankers *et al.*, 2021). In light of this, the owner of Telegram was arrested in France and indicted on charges of complicity in drug trafficking and the distribution of child exploitation material for failing to properly moderate it (Tidy, 2025).

Most transactions on Telegram result in in-person exchanges, reflecting trends seen in other digital drug marketplaces, whereby online coordination precedes in-person delivery. This further exemplifies how digital markets extend rather than replace the conventional offline dealing practices (Berry 2018) in different configurations of offline-online hybridity (Korshøj and Søgaard, 2024; BenBaruch *et al.*, 2025). At a higher policy level, there have been moves to force providers to remove the encryption protection and provide backdoors. In the UK, the Online Safety Act 2023 and Investigatory Powers (Amendment) Act 2024 included provisions that could force tech companies to weaken or allow access to encrypted messages. Tech companies and civil rights activists have pushed back with arguments that this threatens civil liberties (Judson, Kira and Howard, 2024).

Overall, the internet produced new socio-technical arrangements in which market exchange became more dispersed, less territorially fixed and restructured hybridity across market dimensions in physical and virtual environments. As a second-order disruptive innovation, it restructured the wider ecology of supply, trust, visibility and control and produced multiple waves of disruptive innovations through multiple online drug market platforms. Nonetheless, it also functions as a risk actant: although anonymity tools and encrypted apps can sever some links to harm, they simultaneously create new vulnerabilities through data capture, infiltration,

tracing and platform intervention. What emerges, then, is not a fully virtual drug market but a reassembled actor-network in which risk, opportunity and power are continuously renegotiated through social and digital mediation.

Discussion

The cases demonstrate that illicit drug markets have been significantly reshaped in different hybrid forms through time by emergent technologies and the management of risk. These technologies are not adopted as neutral tools, rather drug markets are reassembled as human and non-human actants produce new forms of coordination (Latour, 2005; Law, 1986). Through a process of translation, dealers enrol and mobilise technologies (Callon, 1984) that were originally designed for legitimate purposes, so they align with their interests of concealment, whilst improving coordination and sales. Regarding risk, dealers translate ICT to contain or displace existing risk actants, but technologies themselves rapidly become new risk actants as policing adapts. Indeed, when law enforcement targets a technology through legislation and interception capabilities, it strengthens the causal linkage between the actant and harm (i.e. arrest, seizure, conviction), which intensifies the actant's riskiness in the network (Hilgartner, 1992).

Regarding disruptive innovation, the case studies suggest a movement from relatively bounded, first-order disruptions toward increasingly systemic, second-order disruptions as ICT becomes embedded in everyday life (Christensen, 1997; Schuelke-Leech, 2018). Historically, each ICT wave generated (1) new coordination affordances, (2) new risk actants, and (3) new policing and regulatory alignments that partially destabilised the network until further containment and displacement occurred. Moreover, disruptive technologies do not operate in isolation, and their effects may be amplified when they intersect, as is the case with the internet-enabled smartphone. In this sense, disruption is not simply produced by standalone technologies, but by their convergence, layering and recombination - including a mixing/blending of older and newer technological forms.

The arms race metaphor (Ekblom, 2017) remains a valuable heuristic in explaining innovation in the drug trade through time; however, this only becomes useful when decoupled from the binary distinction between criminals and the police and expanded to include an actor-networked approach to change. Here, what evolves over time is not just ‘criminal tactics’ and ‘police tactics’, but the whole arrangement of sociotechnical actants that makes these tactics possible. Nonetheless, it is worth noting that not all market actors may seek anonymity to the same extent. In some contexts, visibility, street presence, masculine reputation and social status remain important motivations and resources, even where these increase exposure to policing and violence (McLean and Densley, 2022). The adoption of concealing technologies (Berry and Berry, 2024) is therefore uneven, market-specific and bound up with economic, cultural and social meanings.

Future Horizons: Extended Reality

The histories of the case studies provided are important not only for understanding how drug markets changed in the past, but also for providing insight into the future. The latest development in ICT is extended reality (XR), encompassing virtual reality (VR), augmented reality (AR) and mixed reality (MR) (Vasarainen, Paavola and Vetoshkina, 2021). At present, there is no empirical literature on XR use in illicit drug supply. Existing work focuses on therapeutic uses of VR in addiction treatment (Segawa *et al.*, 2020), while adjacent scholarship

examines cybercrime and terrorism in metaverse and envisioned Web 3.0 environments (i.e. Weimann and Dimant, 2023; Zhang *et al.*, 2023). The broader history traced in this article suggests that immersive and spatially aware technologies are unlikely to remain outside illicit adaptation.

Indeed, drug deals can take place in any XR environment. This could be in a legitimate communal social space in the metaverse through meetings of avatars or a virtual marketplace on the darknet, much like the Silk Road, but in VR (a dark metaverse). Such spaces have the potential to be the successor to today's Tor-hosted darknet marketplaces, but instead of flat web pages, they could be comprised of immersive virtual spaces - VR drug bazaars. MR also provides the potential to create digitally layered operational spaces to coordinate supply. Criminals could attach directions or instructions to real-world places only visible to those wearing the device on encrypted crypto-spatial networks, creating ghost infrastructure and shadow logistics (crypto-spatial markets). With the rise of artificial intelligence and prompt based language models, the technological barriers to building such an overlay are reducing rapidly (Weisheit, 2025). Glasses, such as the Ray-Ban Meta, with AI capacities could also allow criminals to employ their facial recognition systems; a feat demonstrated by students at Harvard University (Hill, 2024). XR could further intensify digital hybridity in drugs supply.

Conclusion

Overall, the historical perspective developed here points to a broader conceptual issue. Much current research treats the online/offline divide, or the question of the 'digital', as though it were a new or separate and distinct problem. Yet if one takes a broader view of ICT, it becomes clear that drug trading has a long history of hybrid physical and technically mediated configurations. Online drug markets are thus best understood as extensions of offline markets with different configurations of offline-online hybridity (from less to more hybrid). What is 'new', then, is not simply a movement of drug markets into digital space, but the different mixing/blending of digital and physical relations, and of past and present technological forms. Seen in this light, current anxieties around app-mediated dealing and cryptomarkets should be located within a longer genealogy of technological adaptation. With the lessons from the past, the key question moving forward is not whether technologies such as XR can be used for illicit exchange, but how socio-technical arrangements, in a context of new forms of policing and regulation, will construct them as risk actants resulting in different forms of adaptions and harms. This is, however, best treated as an agenda for future empirical research.

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