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# Criminal Ecosystems: Autopoiesis, Adaptation, and Resilience in Organized Crime

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**Definition**

Criminal ecosystems are durable social systems in which differentiated criminal functions become recurrently interdependent across organizations, networks, illicit markets, institutional actors, financial facilitators, territorial brokers, and social environments. The concept applies when coercion, illicit accumulation, political protection, territorial regulation, and other specialized capacities depend on one another over time and become structurally coupled with institutional, sociocultural, spatial, or technological conditions. A criminal ecosystem is therefore not defined by the presence of a particular organization, market, or territory, nor by resilience itself. It is identified by functional differentiation, recurrent interdependence, structural coupling, and temporal reproduction. Complex adaptive systems theory explains how decentralized interactions can generate adaptation, substitution, and emergent order, while autopoietic social systems theory explains how recurring communications stabilize expectations and reproduce boundaries. Digital infrastructure can mediate financial and transnational functions without constituting a separate operational dimension in the present framework. This distinction allows resilience, reconfiguration, displacement, and decline to be examined as empirical outcomes rather than assumed properties of the ecosystem.

**Keywords:** criminal ecosystems; organized crime; autopoiesis; complex adaptive systems; criminal governance; illicit markets; state weakness; systemic resilience

## 1. Introduction

The expression criminal ecosystem emerged from a long dissatisfaction with narrow descriptions of organized crime as a collection of isolated groups, bosses, cartels, gangs, or mafia type organizations. Early organizational approaches clarified how criminal groups use violence, secrecy, reputation, and protection to regulate illegal transactions, but they often treated criminal actors as discrete entities whose boundaries could be identified through membership, hierarchy, leadership, or market specialization. Varese placed mafia organizations at the center of this tradition by showing how protection, money, loyalty, and coercion can structure everyday criminal life [1]. Campana and Varese [2] later broadened this view by showing that organized crime may govern markets and communities rather than merely participate in illegal exchange.

A first conceptual breakthrough occurred when scholars began to replace static organizational images with network based explanations. Kenney [3] showed that the Colombian cocaine trade did not operate only through rigid hierarchies, but through adaptive trafficking networks that learned from enforcement pressure, reorganized relations, and preserved

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Academic Editors: Kum Fai Yuen, Xueqin Wang and Xue Li

Received: 10 July 2026
Revised: 20 August 2026
Accepted: 27 August 2026
Published: 1 September 2026

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functions after disruption. Raab and Milward [4] then described dark networks as concealed and resilient structures whose survival depends on relational flexibility, secrecy, redundancy, and the ability to operate across formal institutional boundaries. These works shifted attention from criminal organizations as objects to criminal relations as architectures. They made visible a crucial problem: removing one actor does not necessarily destroy the wider relational system that made the actor useful.

A second breakthrough came from the study of criminal governance. Arias [5] demonstrated that criminal groups in Rio de Janeiro did not simply prey on communities, but participated in the production of order through mediation, violence management, political connections, and local authority. In his later comparative work on Latin America and the Caribbean, Arias [6] showed that criminal enterprises may become part of broader governance arrangements in which state actors, residents, political brokers, and armed organizations coexist within unstable orders. Lessing and Willis [7] extended this debate by showing how the Primeiro Comando da Capital could manage a criminal empire from prison through rules, discipline, legitimacy, and internal normative procedures. This literature made the concept of criminal order central to the study of organized crime.

A third breakthrough involved the recognition that legality and illegality often interact rather than remain separate. Schultze Kraft [8] used the notion of crimilegality to explain how criminal and legal orders may overlap in social fields where illegal practices become embedded in institutional routines, political protection, and everyday governance. Garay, Salcedo, de León, and Guerrero [9] had already documented how criminal interests in Colombia could penetrate state institutions through capture and coopted reconfiguration, transforming public authority from within rather than merely corrupting it from outside. This line of work undermined the simple opposition between state and crime. It showed that criminal power often grows through partial institutional functionality, selective state weakness, and the instrumental use of legal procedures.

A fourth breakthrough came from research on illicit economies and criminal finance. Felbab Brown [10] argued that illegal economies can shape political order because they provide income, protection, employment, and social leverage in territories where the state fails to guarantee security and opportunity. Bergman [11] showed that criminal wealth increases organizational capacity, expands corruption, and connects illicit extraction with formal economic circulation. Levi and Soudijn [12] later insisted that money laundering should be understood as a central mechanism in organized crime because it transforms illicit revenue into usable power, institutional access, and apparently legitimate capital. These contributions revealed that organized crime cannot be reduced to violence or trafficking. It also depends on accumulation, reinvestment, concealment, and economic normalization.

The term criminal ecosystem is analytically useful only if it answers a question that organizations, networks, markets, governance, and resilience cannot answer separately. Organizations explain collective agency, networks explain relational structure, markets explain exchange, governance explains authority, and territorial approaches explain spatial embedding. The ecosystem framework instead asks how heterogeneous criminal functions become interdependent across these units and how those relations are reproduced through time. Its distinctive object is therefore neither the actor nor the tie, but the recurrent architecture of functional dependence that connects coercion, accumulation, protection, brokerage, territorial regulation, and enabling conditions. This shift provides analytical leverage for explaining why changes in one component may produce substitution, reconfiguration, or decline elsewhere in the system rather than a uniform organizational outcome.

The immediate origin of the term is also linked to the language of convergence and deviant globalization. Calderón and Rodríguez Beltrán [13] explicitly described criminal ecosystems as habitats in which illicit actors, illegal economies, territorial opportunities, and

global criminal flows converge. Their use of the term was important because it moved the discussion from the isolated criminal group toward the environment that sustains criminal activity. In this sense, an ecosystem is not a metaphor for disorder. It is a conceptual model for describing interdependence. It invites scholars to ask how actors, markets, institutions, territories, technologies, financial circuits, and social expectations interact until they generate a criminal order that no single component controls completely.

The current status of the field shows that this conceptual move has become increasingly necessary. Recent debates on criminal governance in Latin America describe how violent non state actors regulate territories, influence elections, provide protection, administer punishment, and negotiate with state agents in contexts of institutional fragmentation [14]. Relational approaches to organized crime now emphasize events, connections, brokers, flows, and changing ties rather than fixed organizational labels [15]. Research on criminal fragmentation has also shown that state pressure can sometimes multiply organizations, redistribute violence, and generate new forms of coordination instead of producing the disappearance of illicit markets [16]. These findings support the need for a systemic vocabulary.

The concept of a criminal ecosystem is most useful when it identifies a historically formed and functionally connected system rather than serving as a synonym for criminal environment. It is an environment contains conditions that may facilitate crime, such as weak oversight, social dependence, infrastructure, or market opportunity. This ecosystem exists only when differentiated criminal functions establish recurrent dependencies, become coupled with those conditions, and reproduce those relations over time. This threshold allows researchers to distinguish a setting with extensive criminal activity from a system in which multiple functions depend on one another. The methodological basis for the conceptual reconstruction, including the PRISMA informed review and thematic analysis, is reported in the Supplementary Material.

A mature use of the concept therefore requires disciplined terminology and independent diagnostic criteria. System refers here to the general relational whole, environment to the contextual conditions surrounding its operations, and criminal ecosystem to the specific configuration in which differentiated functions become recurrently interdependent and temporally reproduced. Criminal organization, criminal network, illicit market, criminal governance, crimilegal order, and territory remain analytically distinct categories that may participate in, but are not synonymous with, the ecosystem. This vocabulary also prevents circularity because resilience is not used to identify the ecosystem in advance. Researchers can first establish ecosystemicity and then test whether disturbance produces robustness, substitution, reconfiguration, displacement, resilience, or systemic decline.

## 2. Conceptual Boundaries: Organizations, Networks, Markets and Criminal Ecosystems

A criminal organization is an actor centered concept. It refers to a collective entity that can be identified through membership, leadership, internal discipline, secrecy, reputation, and the capacity to coordinate illegal activity over time. Paoli warned that the expression organized crime often produces conceptual ambiguity because it may refer to organizations, activities, markets, or social worlds without clearly distinguishing among them [17]. Varese treated mafia type organizations as groups that sell protection, regulate illegal transactions, and use violence to sustain authority [1]. Gambetta's classic interpretation of the Sicilian Mafia as a business of private protection further clarified that some criminal organizations do not merely commit crimes, but specialize in producing and selling trust under conditions of insecurity [18]. This concept remains indispensable, but it captures only the actor as a unit of action.

A criminal network is a relation centered concept. It shifts attention from the bounded group to the ties that connect offenders, brokers, suppliers, transporters, financiers, corrupt officials, buyers, and facilitators. Morselli showed that criminal networks operate through social capital, brokerage, and strategic positioning rather than only through hierarchy [19]. Kenney's analysis of Colombian cocaine trafficking demonstrated that flexible network forms can preserve criminal activity under enforcement pressure because knowledge, contacts, and functions are distributed across multiple actors [3]. Raab and Milward described dark networks as concealed relational structures that survive through secrecy, redundancy, and adaptive connection [4]. Bichler, Malm, and Cooper later showed that drug supply networks vary by market function, role specialization, and relational structure [20]. A network explains how actors connect, but not necessarily how those connections become territorially embedded, politically protected, socially tolerated, and financially reproduced.

An illegal market is an exchange centered concept. It refers to the production, distribution, sale, protection, and consumption of prohibited goods or services under conditions of legal risk. Reuter's work on illegal markets challenged exaggerated images of monopoly and hierarchy by showing that many illicit economies operate through competition, fragmentation, and weak centralized control [21]. Beckert and Wehinger later argued that illegal markets require social order because actors must solve problems of valuation, competition, cooperation, and protection despite the absence of legal enforcement [22]. Felbab Brown showed that illicit economies may also provide livelihoods, protection, and political leverage in areas marked by exclusion and insecurity [10]. Bergman connected criminal wealth with increased capacity for corruption and violence [11], while Levi and Soudijn showed that laundering converts illicit revenue into usable power [12]. A market explains how value circulates, but it does not fully explain how violence, legitimacy, institutional capture, and territorial rule become attached to that circulation.

Criminal governance is an authority centered concept. It describes the capacity of criminal actors to impose rules, settle disputes, punish disobedience, collect rents, provide protection, and shape social expectations. Arias showed that criminal groups in Rio de Janeiro participated in local order through relations with residents, state agents, and political intermediaries [5]. His later comparative work demonstrated that criminal enterprises in Latin America and the Caribbean often operate within plural governance arrangements, where state and non state authority coexist [6]. Lessing and Willis showed that the Primeiro Comando da Capital produced legitimacy and discipline through internal rules and prison based authority [7]. Skarbek's political economy of criminal governance further explained why criminal actors may create institutions when illegal exchange requires predictability, discipline, and enforcement [23]. Criminal governance explains rule making, but it does not by itself capture the full system of coercion, finance, logistics, social embedding, and institutional coupling that sustains organized crime across scales.

A criminal ecosystem is a system centered concept whose unit of analysis is functional interdependence across otherwise distinct criminal and social domains. It may include organizations, networks, markets, and governance arrangements, but its analytical contribution begins only when these elements become mutually dependent for the performance of specialized functions. An organization may command coercion, a network may connect brokers, a market may circulate value, and governance may regulate territory, yet none of these features alone demonstrates ecosystemicity. The ecosystem concept explains how those functions become connected across actors and scales, how external conditions are incorporated through structural coupling, and how the resulting configuration can persist or transform independently of the fate of one component. Calderón and Rodríguez Beltrán [13], Schultze Kraft [8], and Sergi and Storti [24] provide complementary foundations for this relational and territorial interpretation.

Four diagnostic conditions identify a criminal ecosystem before resilience or adaptation is assessed. First, functional differentiation requires at least two specialized criminal functions that are not reducible to one organization or transaction. Second, recurrent interdependence requires that the operation of one function regularly depends on resources, decisions, access, or protection generated by another. Third, structural coupling requires repeated connections with institutional, sociocultural, spatial, market, or technological conditions that shape how criminal functions operate. Fourth, temporal reproduction requires these relations to recur beyond an isolated event or temporary association. The four operational dimensions proposed in this entry are therefore analytical domains rather than a mandatory checklist. A locally embedded ecosystem may have limited transnational reach, while a digitally mediated ecosystem may exhibit weak armed capacity, provided that the diagnostic conditions of ecosystemicity are met.

Table 1 summarizes the analytical differences among the principal concepts used in this entry. The comparison makes explicit that the ecosystem framework does not replace established approaches. It connects their distinct units of analysis through a mechanism that they do not individually capture: recurrent functional interdependence across heterogeneous domains. This synthesis also establishes the conceptual vocabulary used throughout the remainder of the entry and reduces the risk that criminal order, network, governance, environment, and ecosystem are treated as interchangeable terms.

**Table 1.** Comparative Analytical Scope of Criminal Ecosystems and Related Concepts.

| Concept | Unit of Analysis | Central Mechanism | Primary Contribution | What Remains Unexplained Without Ecosystem Analysis |
|---|---|---|---|---|
| Criminal organization | Bounded collective actor | Coordination, hierarchy, discipline | Explains agency and organized capacity | Interdependence with markets, institutions, territories, and external facilitators |
| Criminal network | Relations among actors | Brokerage, connectivity, social capital | Explains relational structure and access | How relations become institutionally, territorially, and financially reproduced |
| Illicit market | Exchange and value circulation | Production, distribution, pricing, protection | Explains illegal economic transactions | How coercion, governance, institutional capture, and legitimacy attach to exchange |
| Criminal governance | Authority and rule making | Regulation, punishment, protection, mediation | Explains production of criminal order | How authority connects with finance, logistics, markets, and broader reproduction |
| Crimilegal order | Boundary between legality and illegality | Operational overlap and institutional coupling | Explains hybrid legal and illegal authority | How multiple specialized criminal functions become mutually dependent |
| Territoriality | Spatial embedding and control | Territorialization, access, spatial opportunity | Explains where power and markets become anchored | How spatial relations connect with other functions across scales |
| Criminal ecosystem | Functional configuration across domains | Recurrent interdependence, structural coupling, temporal reproduction | Explains ecosystemicity and systemic transformation | Empirical degree of robustness, resilience, displacement, or decline |

## 3. Theoretical Framework: Complex Adaptive Systems and Autopoietic Social Systems

Complex adaptive systems theory explains why criminal ecosystems produce outcomes that no single actor designs or controls. Holland [25] argued that complex systems emerge when multiple agents interact locally and generate global patterns through adaptation, selection, and learning. In criminal ecosystems, armed groups, brokers, financiers, corrupt officials, transporters, communities, and market intermediaries respond to local incentives. Their repeated interactions create routes, rules, hierarchies, reputations, alliances, and protection arrangements that exceed the capacity of any isolated organization.

Axelrod and Cohen [26] gave this argument a dynamic form by showing that adaptive systems change through variation, selection, and retention. In criminal settings, individuals and organizations test routes, alliances, technologies, and forms of concealment in response to enforcement pressure, competition, or leadership loss. Successful strategies can then diffuse through networks, markets, and brokerage relations. The resulting pattern should be described as emergent systemic adaptation rather than learning by the ecosystem itself, because cognition and agency remain located in actors and organizations. The system level property lies in the distributed reconfiguration that results from many locally adaptive decisions.

Emergence gives the ecosystem concept its strongest theoretical foundation. Green described emergence as the formation of system level properties from interactions among simpler agents [27]. Organized crime displays this property when local coercion becomes territorial order, repeated payments become taxation, laundering becomes economic normalization, and dispersed relationships become durable market access. These properties do not reside inside one group, one leader, or one transaction. They arise from patterned interaction among components that reinforce one another over time.

Self organization explains why criminal ecosystems can reorganize after disruption. Ye, Zhang, and Vasilakos showed that multiagent systems can generate order without central planning when agents adjust their behavior through repeated interaction [28]. Criminal ecosystems display this logic when new actors occupy abandoned routes, when brokers replace captured intermediaries, or when fragmented groups redistribute functions after state intervention. The system does not require a single command center to survive. It requires enough relational memory, market incentive, and functional redundancy to reassemble criminal activity.

Network theory clarifies the architecture through which adaptation operates. Kenney showed that Colombian cocaine trafficking networks preserved functions under pressure because knowledge, contacts, and logistical roles circulated through flexible arrangements [3]. Raab and Milward explained that dark networks combine secrecy and resilience through concealed ties [4]. Watts added that small world networks can connect dense local clusters through strategic long distance ties [29], while Barabási showed that scale free networks depend on highly connected hubs that organize disproportionate flows [30]. Criminal ecosystems combine both patterns: dense local embeddedness and selective transnational connectivity.

Autopoietic social systems theory addresses a different explanatory problem: how social systems reproduce boundaries and expectations through communication. Maturana and Varela [31] developed autopoiesis for living systems, but this entry does not transfer biological self production directly to organized crime. It adopts Luhmann's reformulation, in which social systems reproduce communications through further communications [32]. Applied cautiously, this perspective directs attention to recurring expectations about payment, protection, obligation, secrecy, sanction, and reciprocity that make later communications intelligible. Autopoiesis therefore complements the structural and adaptive mechanisms

described by complex systems theory rather than functioning as a biological analogy for organizational survival.

This communicative approach also requires a narrower definition of criminal communication. A payment, threat, debt, exchange, or transfer of information is not systemically reproductive merely because it occurs in an illegal setting. It becomes reproductive when participants interpret it through recurring expectations that connect prior communications with future obligations, permissions, sanctions, or protections. A payment can therefore reproduce a protection arrangement when it confirms who must pay, who can demand payment, what protection is expected, and what follows from noncompliance. Silence should be treated with equal caution: it acquires communicative meaning only when a shared expectation allows the absence of denunciation or response to be interpreted as compliance, fear, accommodation, or observance of a known rule.

Luhmann's theory also helps explain boundaries. Criminal ecosystems do not have clear borders like formal organizations. They draw boundaries through recurring communications that distinguish insiders, collaborators, enemies, debtors, informants, protectors, and legitimate targets. King and Thornhill showed that Luhmann's theory of law and politics helps analyze plural normative orders [33]. This insight matters because criminal ecosystems often operate beside legal institutions rather than outside them. They need courts, police, ports, contracts, banks, registries, and public offices, but they use those institutions through crimilegal codes.

Complex adaptive systems theory and autopoietic social systems theory are used here as complementary frameworks operating at different analytical registers. Complexity explains decentralized interaction, nonlinear change, diffusion, self organization, functional substitution, and emergent adaptation. Luhmannian systems theory explains how recurring communications stabilize expectations, reproduce distinctions, and maintain boundaries across changing participants. The connection between the two perspectives lies in recurrent functional relations: actors can alter routes, technologies, alliances, and organizational forms while communications about payment, protection, obligation, secrecy, or sanction preserve recognizable expectations. This combination does not posit a conscious ecosystem or a new unified grand theory. It provides two compatible mechanisms for analyzing structural adaptation and communicative reproduction without reducing one to the other.

This theoretical integration also specifies what intervention can and cannot demonstrate. Removing a leader, blocking a route, or dismantling a cell establishes organizational disruption, but it does not by itself prove systemic resilience or systemic failure. Researchers must first examine whether interdependent functions remain connected, whether substitutes restore lost functions, and whether recurrent communications continue to organize expectations after the disturbance. Esberg [16] and van Elteren, Vasconcelos, and Lees [34] show that fragmentation, robustness, and resilience can follow different trajectories under pressure. The ecosystem framework therefore treats post intervention outcomes as empirical questions rather than assuming that criminal continuity necessarily reflects successful adaptation.

## 4. Systemic Architecture: Components, Feedbacks, and Emergent Resilience

The systemic architecture of a criminal ecosystem rests on an analytical distinction between operational dimensions and structural factors. Operational dimensions refer to specialized capacities that criminal actors actively mobilize, coordinate, or adapt in order to perform functions inside the system. Structural factors refer to contextual conditions that enable, constrain, or stabilize those functions without constituting criminal capacities by themselves. The distinction is functional rather than ontological and is not mutually exclusive at the level of actors. A public institution, community broker, business, or

technological platform may form part of the environment in one relation and become operationally integrated into the ecosystem in another when it repeatedly performs a criminally relevant function.

Armed, political, financial, and transnational dimensions form the operational core proposed in this entry, while sociocultural conditions and state weakness describe two recurrent structural factors. The four dimensions are analytical domains rather than universal requirements, and their relative importance can vary across cases. Territory occupies a different status: it is the spatial substrate and relational arena through which coercion, governance, accumulation, brokerage, infrastructure, and social embedding become anchored or connected across scales [24,35–37]. Digital infrastructure also operates transversally by mediating financial circulation, brokerage, communication, market access, and cross border coordination. The current review does not justify treating digital capacity as a fifth autonomous dimension, but contemporary cybercrime research shows that technological infrastructures can intensify specialization and functional interdependence [38,39].

The armed dimension provides the coercive infrastructure of the ecosystem. It allows criminal actors to control territory, protect illegal economies, punish disobedience, intimidate rivals, regulate populations, and secure rents. Barnes [35] showed that criminal territorial control follows a strategic logic of coercion and regulation, while Magaloni, Franco Vivanco, and Melo [40] demonstrated that criminal order, policing, and violence interact in urban territories under illegal authority. In this sense, violence does not operate only as destruction. It also works as a governing technology that marks boundaries, disciplines conduct, and turns space into an operational platform.

The armed dimension becomes ecosystemic when coercion connects with other functions. Armed control protects crops, laboratories, routes, ports, illegal mining sites, extortion markets, and local taxation schemes. It also sustains political intimidation, community silence, and the enforcement of debt. Berg and Carranza [41] connected organized criminal violence with territorial control, and Nossa, Suarez, and Pimenta [42] described hybrid governance arrangements in which violent non state actors share or dispute authority with state institutions. Violence therefore becomes more than force. It becomes an organizing capacity that links territory, economy, authority, and social order.

The political dimension gives criminal ecosystems access to protection, information, contracts, decisions, and impunity. It includes corruption, state capture, electoral interference, institutional cooptation, shared governance, and the strategic use of public authority. Garay, Salcedo, de León, and Guerrero [9] described coopted state reconfiguration as a process through which criminal and political actors reshape institutions from within. Dávid Barrett [43] later clarified state capture as a broader development problem in which private interests distort public decision making. Criminal ecosystems use this dimension when they convert institutional weakness into operational protection.

This political dimension does not always require total control of the state. It often works through selective access. A police unit that warns about raids, a mayor who tolerates illegal taxation, a port official who opens a logistical window, a contractor who channels resources, or a local politician who negotiates votes can each perform a limited but decisive function. Angulo [44] showed how criminal governance can intersect with public resources and service provision. Kostelnik and Skarbek [45] also showed that drug trafficking organizations may develop governance institutions to solve internal and external problems. These dynamics reveal that political penetration converts illegal power into protected power.

The financial dimension sustains the material reproduction of the ecosystem. Criminal actors need money to pay combatants, brokers, corrupt officials, transporters, lawyers, accountants, informants, and local collaborators. Levi and Soudijn [12] argued that money

laundering transforms criminal proceeds into usable resources, while Bergman [11] showed that criminal wealth increases violence, corruption, and organizational capacity. Financial accumulation therefore does not appear after criminal activity as a secondary phase. It participates in every stage of criminal reproduction because it finances coercion, buys protection, stabilizes alliances, and opens access to formal markets.

Laundering gives the financial dimension its systemic role because it reconnects illicit accumulation with assets, businesses, trade, banking, and political influence. Akartuna, Johnson, and Thornton [46] showed that emerging technologies expand laundering risks, while Fronzetti and Remondi [47] demonstrated how network analysis can identify laundering structures. Digital assets, cryptocurrency transfers, online services, and other cyber enabled mechanisms can accelerate concealment and circulation without creating a separate financial logic. Research on cybercrime as a service similarly shows that specialized digital markets and infrastructures reduce entry barriers and distribute technical capacities among different participants [38,48]. Inside a criminal ecosystem, these mechanisms matter when they become recurrently connected with accumulation, reinvestment, brokerage, and access to formal or transnational channels.

The transnational dimension connects local criminal orders with flows that cross jurisdictions. It includes routes, brokers, ports, maritime platforms, financial channels, foreign partners, and increasingly digital infrastructures that allow actors to coordinate without territorial proximity. Madsen [49] described transnational criminal networks as arrangements that move goods, money, people, and protection across borders, while Cooley and Sharman [50] showed how legal fragmentation and mobility create opportunities for concealed power. Shelley [51] similarly emphasized how global networks, pipelines, and technological change enable transnational connections among crime and corruption. Organized cybercrime extends this logic through service markets, distributed infrastructures, affiliate relations, and digitally mediated brokerage that can connect participants located in different jurisdictions [38,39]. The transnational dimension therefore concerns the scaling and dispersion of functions, whether movement occurs through physical routes, financial circuits, or digital infrastructure.

Transnationalization changes the scale of both opportunity and vulnerability. A local group may lose a route while brokers redirect flows through another port, and a digital service may lose one infrastructure provider while affiliates migrate to alternative platforms or tools. These outcomes should not automatically be labeled resilience because rerouting, displacement, and functional recovery are empirically distinct. Kenney [3] showed how cocaine trafficking networks adapted through flexible architecture, while recent research on cybercrime as a service documents specialization and relational substitution across technological markets [39,48]. Transnational reach can therefore create redundancy, but it can also create dependencies on brokers, platforms, jurisdictions, or infrastructures that become points of disruption.

The sociocultural factor shapes the social conditions that make criminal authority possible. It includes fear, tolerance, dependence, silence, prestige, loyalty, status, moral ambiguity, and the normalization of illegal economies. Felbab Brown [10] showed that illicit economies can provide livelihoods and political leverage in contexts of insecurity. Travaglino, Abrams, and Randsley de Moura [52] connected honor codes with attitudes toward criminal organizations, while van Dijk, Kleemans, and Eichelsheim [53] showed that organized crime can reproduce through family and intergenerational mechanisms. These studies show that criminal ecosystems survive not only through coercion, but also through social embeddedness.

This factor does not romanticize criminal legitimacy. It explains why communities may tolerate, fear, resist, or depend on criminal actors in different combinations. Merton [54]

explained anomie as a strain between culturally valued goals and legitimate means, a logic that helps interpret the appeal of illegal opportunity under exclusion. Calderoni, Comunale, Campedelli, Marchesi, Manzi, and Frualdo [55] reviewed individual risk factors associated with recruitment into organized crime. Blume [56] showed that communities may support illicit economies when criminal actors provide income, protection, or order. Sociocultural conditions therefore reduce resistance, lower recruitment costs, and make criminal communications locally intelligible.

State weakness forms the second structural factor. It does not mean total state absence. It refers to fragmented authority, uneven enforcement, weak internal controls, poor service provision, low territorial capacity, and vulnerability to capture. Schatz and Tobias [57] showed how state ineffectiveness can create a vicious cycle with organized crime style homicide in Mexico. Schwartz [58] analyzed how the idea of the state can become fragile in post conflict reconstruction. Sergi and Storti [24] emphasized that criminal groups shape space through territorial resources and local opportunities. State weakness therefore creates niches where criminal actors can regulate, tax, protect, punish, and mediate.

This factor matters because criminal ecosystems often need some state capacity. Total collapse can damage markets, contracts, logistics, laundering, infrastructure, and political protection. Criminal actors therefore benefit from a selective state: weak enough to be penetrated, but functional enough to provide documents, roads, ports, courts, police, contracts, banks, licenses, and public budgets. Arias [6] showed that criminal governance often emerges through plural arrangements rather than simple absence of authority. State weakness opens opportunities, but state fragments provide tools. The ecosystem grows in the tension between institutional insufficiency and institutional usefulness.

Feedback loops describe causal sequences in which the consequence of one operation changes the conditions of a later operation. The armed financial relationship becomes reinforcing when territorial control protects illicit production, extraction, taxation, or logistics and the resulting revenue finances greater coercive capacity. It can become balancing when violence raises enforcement pressure, operating costs, community resistance, or exposure to the point that additional coercion reduces rather than expands revenue. The analytical task is therefore to identify the direction, strength, and context of the feedback rather than infer reinforcement from the mere presence of reciprocal relations. This causal distinction makes the framework capable of explaining both reproduction and decline.

The political armed relationship becomes reinforcing when intimidation or coercive control facilitates selective institutional protection and that protection in turn lowers the risks attached to coercion. Schultze Kraft [8,59] described crimilegal orders in which legality and illegality become operationally intertwined, while Garay, Salcedo, de León, and Guerrero [9] showed how institutional capture can reconfigure public authority. The same relationship can weaken when oversight, judicial action, institutional rotation, or political competition interrupts access to information, impunity, or public resources. Political penetration should therefore be analyzed as a variable coupling rather than a permanent source of reinforcement.

The financial transnational relationship becomes reinforcing when illicit profits purchase logistical access, brokerage, concealment, or jurisdictional mobility and these capabilities expand the scale of revenue generation. Digital infrastructure can intensify this loop by connecting cryptocurrency based payments, service markets, affiliates, technical providers, and cross jurisdictional intermediaries [38,39]. Yet the same concentration of functions in identifiable brokers, platforms, or financial channels can create points of vulnerability. Coordinated financial tracing, infrastructure seizure, or loss of trusted intermediaries may therefore transform a reinforcing relation into a constraining one. The relevant causal

question concerns whether the connection restores or erodes the capacity to perform the underlying function after disturbance.

The armed sociocultural relationship shows how coercion can reshape expectations and how social conditions can in turn alter the cost of coercive control. Repeated violence may normalize silence, dependence, or accommodation, while local tolerance or fear can reduce the resources required for territorial regulation. Blume [56] and Travaglino, Abrams, and Randsley de Moura [52] show that support, dependence, honor, and resistance vary across communities and cannot be reduced to voluntary endorsement of crime. Excessive violence can also produce flight, denunciation, collective resistance, or stronger state intervention. The loop is therefore context dependent and can reinforce or weaken criminal authority.

Structural couplings connect operational dimensions with contextual conditions and with the territory in which those relations acquire practical meaning. Political operations couple with state weakness when deficient oversight creates opportunities for corruption, but effective institutional capacity can restrict the same pathway. Armed operations couple with sociocultural conditions when recruitment, silence, or mediation depend on local expectations and opportunity structures. Financial and transnational operations can couple with regulatory gaps, infrastructure, ports, digital platforms, or socially accepted forms of unexplained wealth. These couplings are analytically important because they identify the interfaces through which an ecosystem incorporates resources from its environment without treating the environment itself as criminal.

The outcomes generated by these relations must be distinguished conceptually. Persistence refers to continued criminal activity over time, while displacement refers to movement across space, markets, technologies, or targets. Functional substitution occurs when a new actor or mechanism performs a comparable task, and reconfiguration refers to a broader change in the pattern of relations. Robustness describes the maintenance of core functions with limited structural change after disturbance. Resilience is more demanding: it requires evidence that the system absorbed disruption and maintained or recovered central interdependent functions through continuity, substitution, or reorganization. These outcomes can coexist, but none should be inferred solely from the survival of criminal activity.

This typology also separates ecosystem identification from ecosystem performance. Van Elteren, Vasconcelos, and Lees [34] distinguished resilience, robustness, and hysteresis in criminal organizations, while Cavallaro, Ficara, de Meo, Fiumara, Catanese, Bagdasar, Song, and Liotta [60] showed that structural vulnerabilities can shape disruption outcomes. A setting can meet the diagnostic criteria of a criminal ecosystem and still fail to recover after a sufficiently disruptive shock. Conversely, persistence of some criminal activity does not prove that the previous ecosystem recovered its functions or relations. Resilience must therefore be demonstrated through longitudinal evidence of functional continuity or recovery after an identified disturbance.

The policy implication should be treated as a diagnostic proposition rather than a universal causal law. Interventions against a single component may produce organizational damage without systemic disruption when other actors or relations continue to perform the affected function, but concentrated intervention can also succeed when it severs a critical dependency or removes a function for which no substitute is available. Table 2 and Figure 1 therefore direct attention to the connections among coercion, finance, protection, social embedding, territorial access, transnational reach, and institutional vulnerability. The framework suggests that durable disruption becomes more likely when interventions weaken reinforcing relations, reduce functional redundancy, and prevent the recovery of central dependencies. Whether this occurs must be established empirically in each case.

**Table 2.** Components of the criminal ecosystem.

| Ecosystem Component | Conceptual Foundation | Distinctive Characteristics | Functions Within the Criminal Ecosystem | Key References |
| --- | --- | --- | --- | --- |
| Armed dimension | Criminal governance; territorial control; coercive regulation | Specialized violence; territorialization; coercive control; selective punishment; competitive governance; blurred legal and illegal boundaries | Enforcement of threats; territorial control; rent extraction; protection of illegal economies; integration of coercion with political and financial functions | Arias [5,6]; Lessing and Willis [7]; Feldmann and Luna [14]; Berg and Carranza [41]; Barnes [35]; Magaloni, Franco Vivanco, and Melo [40]; Nossa, Suarez, and Pimenta [42] |
| Political dimension | State capture; criminal governance; crimilegal authority; institutional cooptation | Selective capture; corruption; penetration of public agencies; electoral interference; shared governance; protection through public authority | Reduction in repression; production of impunity; access to state resources; legal protection of illegal operations; weakening of state monopoly over coercion | Schultze Kraft [8,59]; Garay, Salcedo, de León, and Guerrero [9]; Skarbek [23]; Angulo [44]; Dávid Barrett [43]; Kostelnik and Skarbek [45] |
| Financial dimension | Economic criminology; illicit finance; laundering; hybrid economies | Modular laundering; reinvestment; integration of legal and illegal capital; sectoral infiltration; concealment of ownership; circulation through formal markets | Material support for operations; payment of armed actors and brokers; financing of corruption; legitimization of illicit capital; expansion into legal economies | Bergman [11]; Levi and Soudijn [12]; Akartuna, Johnson, and Thornton [46]; Faysal and Arifuzzaman [61]; Fronzetti and Remondi [47] |
| Transnational dimension | Global criminal networks; deviant globalization; jurisdictional arbitrage; cross border logistics | Multijurisdictional coordination; specialized brokers; routes; ports; financial channels; technological transfer; geographical dispersion | Access to global markets; connection between production and consumption; dispersal of risk; scaling of operations; resilience through cross border redundancy | Kenney [3]; Bichler, Malm, and Cooper [20]; Madsen [49]; Cooley and Sharman [50]; Staiano [62]; Shehdula and Karamuço [63] |
| Sociocultural factor | Anomie; social legitimacy; criminal embeddedness; transformed social capital | Normalization of illegal economies; pragmatic acceptance; codes of silence; intergenerational transmission; community dependence; moral ambiguity | Reduction in resistance; recruitment; local protection; reproduction of criminal expectations; acceptance of illicit wealth; social embedding of illegal authority | Felbab Brown [10]; Travaglino, Abrams, and Randsley de Moura [52]; van Dijk, Kleemans, and Eichelsheim [53]; Calderoni, Comunale, Campedelli, Marchesi, Manzi, and Frualdo [55]; Merton [54]; Blume [56] |
| State weakness factor | State fragility; institutional fragmentation; incomplete territorial authority; weak coercive capacity | Fragmented presence; low regulatory capacity; weak internal controls; poor service provision; ineffective enforcement; vulnerability to capture | Territorial opportunity; demand for criminal governance; impunity; access to institutions; dependence between criminal actors and state fragments | Arias [6]; Berg and Carranza [41]; Barnes [35]; Sergi and Storti [24]; Schatz and Tobias [57]; Schwartz [58] |

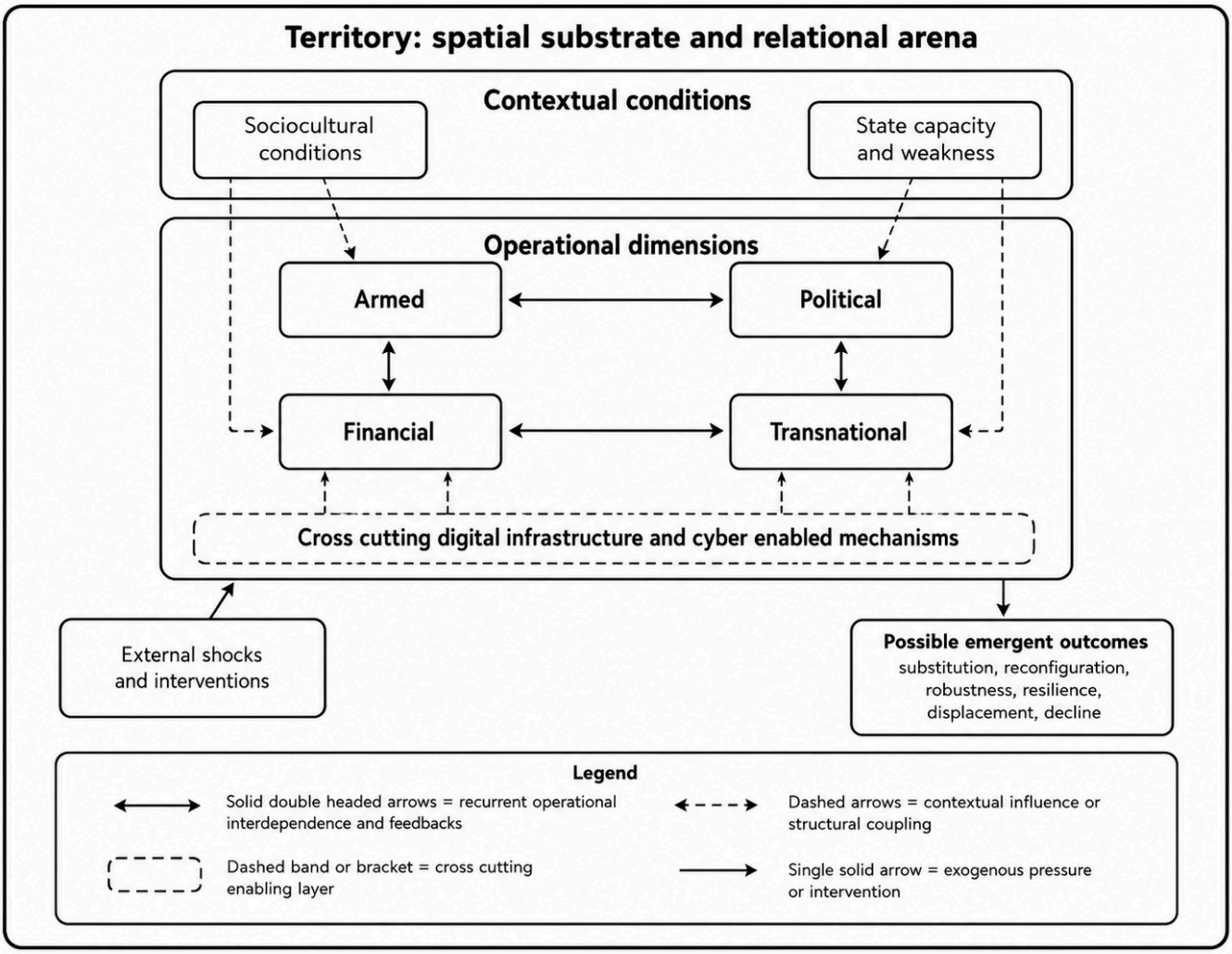


**Figure 1.** Dynamic architecture, contextual couplings, and possible outcomes of a criminal ecosystem.

## 5. Systemic Persistence, Disruption, and Policy Implications

Colombia provides an analytically useful illustration because major criminal organizations have repeatedly changed while cocaine production, trafficking, territorial governance, and illicit finance have also undergone periods of continuity and transformation. The fall of the Medellín and Cali cartels altered leadership, alliances, routes, and organizational forms, but did not by itself eliminate the wider trafficking economy. Kenney [3] showed that Colombian trafficking networks adapted through flexible relations rather than rigid command alone. The case is therefore useful for examining functional continuity across organizational change, but it cannot establish that all criminal ecosystems behave in the same way. Its value lies in tracing mechanisms that can later be tested comparatively.

Luhmannian autopoiesis helps specify one mechanism of continuity without equating reproduction with organizational survival. Criminally relevant communications reproduce the system only when they connect prior expectations with future obligations, permissions, sanctions, or protections. A demand for payment can reproduce a protection relation when it confirms a known obligation and organizes subsequent conduct, while a corruption agreement can reproduce expectations about access, secrecy, and impunity. Individual participants may disappear without ending those expectations if subsequent actors continue to communicate through them. The analytical focus therefore falls on recursive meaning and functional connection rather than on the biological survival of a collective actor.

This argument helps interpret Colombian criminal evolution after major political and security ruptures. The demobilization of armed groups, the fragmentation of post paramilitary structures, and the mutation of trafficking organizations did not erase the ecosystemic conditions that supported illegal accumulation. Arias [6] showed that criminal enterprises in Latin America often operate inside plural governance arrangements, where state actors, residents, armed groups, and political brokers coexist. Schultze Kraft [8,59] explained these arrangements through crimilegal orders, in which legal and illegal practices overlap without fully merging. In Colombia, that overlap helps explain why armed control, institutional protection, illicit finance, and local dependence can survive organizational change.

Colombia also shows that criminal reproduction often depends on territory rather than on organizational labels alone. Ballvé [36] showed how land, decentralization, and everyday state formation became entangled with narco power in Colombia. Gutiérrez Sanín [64] showed that illicit economies opened political opportunities for Colombian paramilitaries between 1982 and 2007. Badillo and Trejos [65] later interpreted the Autodefensas Gaitanistas de Colombia as a politicized armed group that challenges narrow distinctions between organized crime and armed political violence. These works suggest that criminal ecosystems persist because they embed coercion, property, political influence, and illegal markets in territorial orders.

Criminal adaptation also exceeds the intentions of individual leaders, but the ecosystem itself should not be treated as a cognitive actor. Individuals and organizations learn, imitate, and select strategies, while brokers and networks diffuse workable solutions across groups and territories. Holland [25] and Axelrod and Cohen [26] provide a basis for describing the aggregate result as emergent adaptation generated by decentralized decisions. Changes in ports, routes, financial channels, intermediaries, or illicit portfolios can therefore reconfigure the system without any central planner possessing knowledge of the whole. The empirical question is whether these distributed changes restore interdependent functions after disturbance.

Fragmentation has an ambiguous effect and should not be treated as evidence of resilience by itself. Esberg [16] showed that fragmentation in Mexico can redistribute organizations and violence, while van Elteren, Vasconcelos, and Lees [34] and Manzi and Calderoni [66] demonstrated that robustness and adaptation depend on how security, efficiency, and key roles are distributed. Fragmentation can preserve redundancy when multiple actors remain capable of performing the same function, but it can also break brokerage, trust, territorial coordination, or access to finance. Researchers should therefore distinguish organizational multiplication from functional recovery and identify which dependencies were maintained, lost, or reconstructed.

Cybercrime provides a contrasting illustration of the same analytical problem without requiring a fifth operational dimension. Research on ransomware as a service shows functional specialization among developers, affiliates, service providers, brokers, and financial channels, while recent ecosystem research emphasizes technological infrastructure as an enabling layer [38,39,67]. The 2024 international disruption of LockBit targeted servers, public infrastructure, administrators, and affiliates and substantially reduced its operating capacity, while subsequent enforcement continued against developers and affiliates [68]. This case illustrates both possibilities recognized by the framework: distributed functions can facilitate reconstitution, yet coordinated intervention against infrastructure, reputation, and key relationships can also produce measurable decline. The case should therefore be analyzed as evidence about mechanisms of disruption rather than as automatic proof of cyber resilience.

The Colombian case also shows why the state cannot enter the analysis as a simple opposite of crime. Criminal ecosystems do not require total state absence. They often require partial state functionality. Garay, Salcedo, de León, and Guerrero [9] showed how criminal interests can reconfigure public authority from within, while Feldmann and Luna [14] connected criminal governance with the crisis of contemporary Latin American states. A corrupt office, a weak control agency, a permeable port, a captured contract, or a fragmented security response can support criminal reproduction without implying that the state has disappeared. The ecosystem grows in the space between institutional weakness and institutional usefulness.

Policy analysis should therefore begin by identifying the reproductive mechanism and the critical dependencies of each ecosystem. In some territories, the decisive relation may connect armed territorial control with illicit revenue; in others it may connect laundering with political protection, recruitment with social dependence, or transnational logistics with local coercion. Levi and Soudijn [12], Felbab Brown [10], and Lessing [69] show that financial, social, and political mechanisms can alter the effects of coercive intervention. The framework does not establish that simultaneous pressure on every dimension is always necessary. It proposes that analysts identify which dependencies are reinforcing, which functions have substitutes, and which points of intervention can interrupt reproduction without merely displacing activity.

The ecosystem concept therefore offers a diagnostic grammar rather than a generic policy recipe. It distinguishes attacking actors from interrupting functions, reducing visible activity from severing recurrent dependencies, and short term displacement from durable systemic change. Policy should ask not only which group controls a territory, but which relations connect money, coercion, institutional access, logistics, social expectations, and technological infrastructure. It should also examine evidence of failure, including sustained loss of brokerage, declining redundancy, inability to replace critical functions, and weakening structural couplings. These propositions remain hypotheses to be evaluated comparatively rather than causal laws already demonstrated by the present conceptual synthesis.

## 6. Limitations and Future Research

The concept of criminal ecosystem has analytical power, but it also faces limits of scope, evidence, and potential circularity. The diagnostic criteria proposed in Section 2 now identify ecosystemicity independently from resilience, adaptation, or successful reproduction, which must be assessed as outcomes after disturbance. The PRISMA informed review that supports the conceptual reconstruction is reported in the Supplementary Material and documents databases, search domains, screening, eligibility, snowball sampling, and thematic analysis [70,71]. PRISMA was used to structure transparent identification and selection rather than to claim a conventional effect synthesis, and the conceptual integration relied on thematic analysis [72]. The corpus gives substantial weight to Latin American debates, so the framework should be treated as analytically transferable rather than universally validated until comparative research tests it in other regions.

Future research should operationalize ecosystemicity through relational evidence rather than a simple additive index of crime, illicit activity, and state weakness. Measurement should examine functional differentiation, cross domain connectivity, dependence among functions, redundancy or substitutability, temporal recurrence, structural coupling, and responses to identifiable disturbances. Multilayer and longitudinal network analysis can test whether financial, coercive, political, territorial, social, and transnational relations remain connected through time, while system dynamics and agent based models can evaluate how particular feedbacks change under intervention [19,60,73]. The digital

domain deserves specific development because the original review did not treat cyber capacity as an autonomous search domain, even though recent research shows that service markets, technological infrastructure, and distributed cyber relations can reproduce ecosystemic mechanisms [38,39,67]. Future comparative work should therefore test whether digital capacity remains transversal to existing dimensions or, in some forms of organized cybercrime, warrants an additional operational dimension.

## 7. Conclusions

The concept of the criminal ecosystem addresses a definitional and explanatory gap in the study of organized crime. Organizations explain agency, networks explain relations, markets explain exchange, governance explains authority, and territorial approaches explain spatial embedding. The ecosystem concept adds a different object of analysis: recurrent functional interdependence across heterogeneous domains. A criminal setting becomes ecosystemic when differentiated functions depend on one another, become structurally coupled with relevant contextual conditions, and reproduce these relations over time. Resilience is therefore not part of the definition but an outcome that must be tested after disturbance.

This distinction strengthens the explanatory value of the framework because it separates the existence of an ecosystem from the fate of any particular organization. Criminal continuity may result from functional substitution, distributed brokerage, stable communications, territorial embedding, or institutional coupling, but persistence alone does not demonstrate resilience. The framework instead directs research toward the relations that connect coercion, accumulation, protection, authority, logistics, social expectations, territory, and technological infrastructure. It also prevents the ecosystem from being reified as an actor by locating cognition and strategic learning in individuals and organizations while treating adaptation as an emergent systemic pattern.

The framework also creates a clearer comparative agenda. Researchers can examine which operational domains are present, which contextual conditions become structurally coupled, how territory organizes those relations, and whether disturbances produce robustness, substitution, displacement, reconfiguration, resilience, or decline. Such comparison can move across ports, borderlands, prisons, urban peripheries, illicit extraction zones, trafficking corridors, financial nodes, and digitally mediated criminal markets. Future measurement should focus on relational connectivity and functional dependence rather than aggregate indicators of criminal intensity. This approach makes ecosystemicity empirically testable while preserving the conceptual flexibility required for different criminal configurations.

For public policy, the principal utility of the concept lies in diagnosis rather than prescription. Removing visible actors may or may not weaken the wider system depending on whether critical functions remain connected, whether substitutes are available, and whether structural couplings continue to supply resources and protection. The framework therefore encourages analysts to identify reinforcing and constraining relations, points of functional dependency, and conditions under which recovery becomes difficult. Its practical contribution is to shift attention from who appears to control organized crime toward how criminal functions become connected, reproduced, disrupted, and, in some cases, unable to recover.

**Supplementary Materials:** The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/encyclopedia6090189/s1, Figure S1: PRISMA informed literature identification and selection process; Table S1: Search domains and guiding search equations. The supplementary methodological material reports the PRISMA informed identification and selection

procedure [70,71], the thematic and conceptual analysis [72], and the literature on criminal violence and territorial control used in the methodological reconstruction [35,41].

**Funding:** This research received no external funding.

**Institutional Review Board Statement:** Not applicable.

**Informed Consent Statement:** Not applicable.

**Data Availability Statement:** No new data were created or analyzed in this study. Data sharing is not applicable to this article.

**Conflicts of Interest:** The author declares no conflicts of interest.

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