From Waltz to Chaos: How to Think about Transnational Illicit Flows Using Complex Adaptive Systems

Jorge M. Lasmar
Rashmi Singh

Introduction
....

Transnational illicit flows have become a defining challenge for contemporary international relations (IR). These illegal fluxes shape not only local security conditions but also regional and global governance frameworks. Many of the global illicit flows originate in, transit through or reach South America (SINGH and LASMAR 2024). In this region, these flows exhibit a striking capacity to adapt and persist despite ongoing enforcement efforts. From the tri-border zones—Argentina–Brazil–Paraguay and Bolivia–Peru–Chile—to the Amazon Basin, criminal networks converge around key hotspots and logistical hubs, consistently evading or absorbing crackdowns by state agencies (McDermott et al. 2025). Such resilience exposes critical gaps in our theoretical understanding of how complex, adaptive systems of illicit activity evolve and thrive within international environments.

Illicit flows—encompassing narcotics, illegal services, money laundering, contraband of goods and persons, and more—pose a multifaceted threat to governance, economic stability, and social welfare (Kosmynka, S. 2020). Their negative repercussions range from fueling local corruption and violence to undermining state institutions across borders. Criminal networks in South America have proven highly resilient, regenerating routes and alliances each time an official crackdown occurs. Beyond purely security-focused concerns, these networks also create long-term developmental harms, disincentivizing legal entrepreneurial activities and reinforcing systemic corruption (UNODC & CoE Brazil 2022). Understanding how these trade routes adapt and **why** attempts to dismantle them often fail is therefore central to both practitioners and to this undertheorized IR issue.

Thus, this article builds up on the results of an emprical in-depth research of the illicit flows in South America to address how one can theoretically discuss why these networks remain so robust and how law enforcement or development programs can more effectively intervene. It explores which systemic properties—such as highly connected hubs and convergence — confer unusual resilience and adaptability on illicit trade routes. In doing so, the paper aims to fill a noted gap in International Relations scholarship: although since the works by Kaplan (Kaplan 1957),

Wallerstein (Wallerstein 2004) and specially Waltz (Waltz 1979), structural perspectives in IR have historically acknowledged the systemic character of global politics, much of the discipline has lagged behind in integrating more recent insights from complex adaptive systems (CAS) theory.

Against this backdrop, this article will discuss how key concepts of CAS can be used to examine which properties (i.e., the presence of highly connected hubs or the phenomena of convergence) shape resilience in illicit trade routes and networks, and how law enforcement or development programs can strategically intervene in these systems. To this end, this inquiry delves into the structure and dynamics of criminal illicit flows in South America, examining how their adaptive features— specifically network centrality, multi-commodity overlap, redundancy, and local collusion—enable them to withstand enforcement pressures. It also explores the policy implications for states and intergovernmental agencies committed to curbing transnational crime in the region.

Methodological Outline

Methodologically, the article relies on qualitative and quantitative case studies from the research findings of the Hubs of Illicit Trade project conducted in partnership with the Terrorism Transnational Crime and Corruption Center (TraCCC) at George Mason University (SINGH and LASMAR 2024). The data was drawn from critical hubs of illicit trade in South America (the tri-border zones—Argentina–Brazil–Paraguay and Bolivia–Peru–Chile, and the Amazon Basin) supported by network analyses of trafficking routes. The data sources included official reports (e.g., UNODC, WCO, Transparency International, national police, IRS and border agencies), open-source intelligence from NGOs and think-tanks tracking illicit flows, academic literature on complex networks and supply chain disruptions and key informant interviews with law enforcement officers, development practitioners, and local community leaders (where accessible). By triangulating these various data points, the study illustrated recurrent patterns and emergent properties of illicit networks, culminating in a set of actionable insights for disrupting these flows.

It is important to note that the authors do recognize the shortcomings of data availability, reliability, and secrecy/restricted access to such information and are aware of the potential for information bias. To mitigate these risks, validation techniques were employed when compiling the data used in this study and whenever possible, the data was cross-validated through triangulation and by comparing data and evidence from multiple sources to triangulate information and verify its consistency and accuracy.

From Waltz to Chaos: Complex Adaptive Systems and IR

A crucial dimension of this article is how to situate illicit flows and network resilience within a systemic perspective on international politics. Scholars of International Relations have long recognized that states, non-state actors, and global structures interact in ways that cannot be reduced to individual choices. Kenneth Waltz's

seminal contribution in *Theory of International Politics* (1979) introduced a structure-level analysis of international politics, contending that states' behaviors and outcomes in world politics are influenced by the *structure* of the international system rather than merely by domestic or individual factors. Waltz's structural realism focuses on anarchy and distribution of power as organizing principles, suggesting that system-level forces constrain and shape state behavior (Waltz 1979). Although this was a notable shift away from purely state-centric or individual-level analyses, Waltz's framework remained relatively static in its conceptualization of structure, not fully accounting for adaptive processes within and across borders.

Subsequent developments in complex adaptive systems theory have introduced new ways of thinking about *emergent order, feedback loops, nonlinearity* and *agent-based systems* in global networks (Tranquillo 2019) — precisely the characteristics missing from traditional structural realism. While CAS theory has been widely applied in disciplines such as ecology, computer science, and organizational studies, international relations scholarship has been slower to integrate these dynamic and iterative elements into its systemic analyses. Most IR models, even those that are "neoliberal" or "neorealist," continue to emphasize static structural constraints rather than the fluid interplay of diverse agents capable of self-organization and evolution under changing pressures and structures. These characteristics are exactly what distinguish "complex" from what are merely "complicated" systems (Holland 2014). Complex Adaptive Systems theory views *complexity* as emerging from the multiple, non-linear interactions among individual agents or components within a system. In other words, a system is considered "complex" when the behavior and outcomes that arise cannot be reduced simply to the properties of each component part. Instead, complexity emerges because adaptability, self-organization, and unpredictability drive the collective rather than the individual outcomes (Mitchell 2009).

Illicit trade networks in South America exemplify the *adaptive* and *complex* dimension of global politics. They are not mere byproducts of state preferences but *self-organizing systems* that rewire their routes, memberships, and alliances to survive state interventions. These *emergent* behaviors call for a theoretical lens that sees international politics as *complex and adaptive*—a perspective beyond Waltz's original emphasis on static structure and power balancing. Thus, this study employs CAS concepts—such as *redundancy*, *hysteresis*, and *strange attractors*—to illustrate how illicit flows survive and flourish despite concerted suppression efforts by states and state actors.

While a comprehensive examination of how Complex Adaptive Systems theory might be fully incorporated into International Relations goes beyond this article's central focus, the following eighteen sub-sections expand and engage with essential CAS principles and attempt to illustrate how —given their relatively limited recognition in IR scholarship— they can be used to discuss which transnational illicit flows properties shape resilience and how law enforcement can strategically disrupt high value targets in these systems.

2.1 Equilibrium Points and Velocity Vectors

In CAS, *equilibrium points* describe situations where dynamic forces—such as law enforcement and illicit networks—achieve balance, monetary or not (Tranquillo 2019). Within illicit trade, criminal groups, corrupt networks, and official countermeasures might temporarily stabilize, producing what appears to be a plateau or lull in illegal activities. Equilibrium points can be stable or unstable. In stable equilibria, the stable point acts as an *attractor* and any perturbation will drive system back to the equilibrium point. In unstable equilibrium points, also known as *repellors*, any pertubation will tend to move away from the equilibria. This is important as attractors and repellors can serve as decision boundaries in a system (Tranquillo 2019).

A compelling empirical case of how illicit flows can move towards equilibrium points can be found in Brazil's maritime cocaine trafficking hubs. Cocaine trafficking flows have increasingly used Brazil as a transit corridor. The port of Santos initially emerged as a primary hub, with additional nodes such as Paranaguá and Itajaí subsequently integrating into this adaptive network. The system's non-linear behavior is evident in the evolving trafficking routes within Brazil. In response to intensified security measures at major ports, traffickers have strategically shifted to smaller, less-regulated ports in the northeast and the southern regions, thereby establishing new, albeit less robust, equilibrium points (UNODC 2023). Despite these adjustments, empirical data consistently positions Santos as the dominant export point for cocaine, underscoring its centrality within the global trafficking network.

Another example within the framework of CAS, is the phenomenon of *pax mafiosa*. The pax mafiosa is characterized either by the dominance of a particular organized crime or by a temporary and tacit truce among rival criminal groups (and sometimes even between these groups and state actors) in a region, resulting in a decrease of local violence (UNODC 2024). *Pax mafiosa* reflects a state where violence and overt conflict are momentarily suppressed and thus, it can be understood as an emergent equilibrium point—an indicator that the system has reached a transient balance between competing forces. This stabilization emerges not from the resolution of underlying tensions but from a dynamic negotiation among actors whose adaptive strategies momentarily align, creating a semblance of order within an inherently volatile system.

Much like the shifts observed in illicit trade routes, *pax mafiosa* signals that the system has entered a critical juncture of temporary equilibrium. Here, the forces of criminal ambition, internal rivalry, and state enforcement converge, resulting in a period of relative calm that masks ongoing instability. This calm is inherently ephemeral—small perturbations, such as intensified law enforcement or shifts in criminal alliances, can disrupt this balance, leading to a rapid reconfiguration of power dynamics.

However, because criminal actors continuously seek greater profits and new routes, *velocity vectors* — which capture the direction and rate of system change—often propel the network away from these unstable equilibria (Tranquillo 2019; Fieguth 2017). Thus, an area that seems

to be "under control" or an established route can rapidly shift once traffickers find more attractive corridors or adopt novel smuggling tactics. Examples include how the cocaine flows shifted towards a higher use of airplanes after the pandemic (UNODC & CoE Brazil 2022), the shift in the marijuana and cigarette routes towards Northern Brazil (SINGH and LASMAR 2024) or the establishment of new cocaine routes such as the recent use of Moçambique as a transit point for cocaine shipments (UNODC 2023). Thus, recognizing indicators of points of equilibria such as *pax mafiosa* provides valuable insights into the adaptive behavior of illicit networks and underscores the importance of developing responsive, adaptive policy measures that can anticipate and mitigate abrupt systemic shifts.

2.2 Basins of Attraction

A *basin of attraction* is a set of states towards which the system naturally gravitates in the presence of disruptions (Thurner, Hanel, and Klimek 2018; Tranquillo 2019). In relation to South American illicit flows, any location with strong criminal influence(s) and where several illegal flows converge (i.e. a hub of illicit trade or hotspot) can become a basin of attraction. Once a particular *illicit economy* is entrenched—whether drug trafficking or contraband—small enforcement measures rarely shift it to a wholly licit space. Instead, the illicit system *reinforces* its own conditions, drawing participants back into the same cycle of activities.

In the realm of transnational illicit flows across South America, organized crime dynamics can be seen as gravitating toward distinct basins of attraction—regions of the state space where the system naturally converges into a temporary, stable pattern. One salient example is the phenomenon of crime convergence, wherein polycriminality emerges. This involves criminal actors engaging in multiple illegal activities simultaneously, often exploiting the same networks and infrastructure, thereby reinforcing the system's tendency to settle into particular equilibrium states.

Another compelling attractor is the strategic advantage offered by Brazil's porous land borders and the widespread presence of Free Trade Zones throughout the region. These geographic and regulatory features act as enablers for organized crime. The recent territorial dispute between the PCC and CV over key Brazilian borders, especially in the Amazon region, highlights how physical factors can create basins of attraction that draw criminal networks into intense competition and cooperation alike (FBSP 2024).

A further dynamic attractor lies at the intersection of high-volume legal trade and illicit operations. Major nodes—such as bustling airports, busy ports, and expansive Free Trade Zones—facilitate global connectivity while simultaneously serving as gateways for illicit goods. These hubs allow illegal activities to infiltrate and blend with legitimate commerce, further stabilizing the system's emergent equilibrium. It is interesting to note that these examples demonstrate that basins of attraction are not static endpoints but rather dynamic states that evolve in response to shifting internal strategies and external pressures.

2.3 Hysteresis

Hysteresis implies the system's inability to revert to a previous state after crossing a threshold (Tranquillo 2019; Thurner, Hanel, and Klimek 2018; Miller and Page 2007). In illicit flows, years of smuggling and collusion entrench local communities in illicit livelihoods and create a criminal culture making *them path dependent* on criminal profits and behaviour. Even if authorities heavily invest in crackdowns or alternative development, reversing such dependence may be nonlinear and prolonged, reflecting the deep-rooted inertia behind these illegal economies. The discussions around how heavily corrupted and infiltrated states can become cleptocracies is an example.

2.4 Nullclines and the Separatrix

In mathematical models, *nulclines* represent points or lines where certain variables—like law enforcement budgets or criminal need of certain precursors—remain stable (Tranquillo 2019). A nullcline in illicit trade might reflect the temporary balance between contraband inflows and interdiction capacity.

Separatrix is a boundary that divides distinct basins of attraction (Tranquillo 2019). Crossing it can lead a region from a "manageable" level of smuggling to an uncontrolled spike in violence or corruption—if, for instance, a criminal network suddenly discovers an under-policed corridor. An interesting case is the geographic separatrix that separetes "safe" from "dangerous" places in big cities. Recognizing where that boundary lies is essential for policy timing; pushing the system across a separatrix can radically alter future trajectories.

2.5 Strange Attractors

Strange attractors capture patterns that look random at first glance but, over time, exhibit recognizable structures (Fieguth 2017). In illicit flows, smuggling routes or alliances may appear haphazard, yet traffickers repeatedly gravitate to certain border towns, river crossings, infrastructre facilities or corrupt officials, indicating a hidden order. Understanding these patterns can help law enforcement identify consistent "hot spots" or nodes with disproportionate influence which can become high-value targets for law enforcement actions.

2.6 Trigger Points and Bursting

Trigger points are small catalysts — such as a sudden policy change or a local enforcement raid — that can provoke disproportionately large consequences, referred to as *bursting* (Mitchell 2009). For instance, dismantling a major cartel figure might spark a *burst* of violence as rival gangs fight for control. Alternatively, tight border checks in one region might "burst" illicit flows toward a neighboring corridor, illustrating how small interventions can rapidly redirect entire networks.

A key debate in illicit drug markets centers on whether the growing use of synthetic drugs could act as a *trigger point* in the complex adaptive system that underlies cocaine production and distribution. From this perspective, the surge in synthetics may prompt a *bursting* phase—an abrupt disruption or reconfiguration of established trafficking routes, cultivation patterns, and market dynamics—thereby reshaping the traditional cocaine ecosystem.

2.7 Growth and Differentiation

As adaptive systems, criminal networks *grow* and *differentiate* their operations over time (Tranquillo 2019). Organized crime groups in South America previously dedicated to a single commodity (e.g., cocaine) have been expanding into arms trafficking, illegal mining, or money laundering (OECD 2016). Additionally, as a recent growth and differentiation phenomena in Latin America, various criminal networks no longer control the entire supply chain of illicit trade, such as cocaine. These networks are increasingly fragmenting the supply chain worldwide, depending on a growing number of diverse smaller networks specialised in specific stages or functions. Hence, illicit networks are subcontracting a diverse number of supporting and enabling actors including lawyers, accountants, legal and financial advisors, financiers, transportation, registries, real state agencies, and logistics providers. Frequently, these networks provide services to several organised crime groups, and their specialised knowledge can be critical for the continuity of illicit trade and difficult to substitute. Additionally, increasingly specialised small local networks and service providers are becoming more robust and amassing capabilities to become independent illicit networks (UNODC 2023). This diversification spreads risk and enhances resilience, since a crackdown on one commodity still leaves other revenue streams intact. For policy, it means enforcement must have a systemic response, targeting multi-commodity realities rather than focusing on just one illicit good.

2.8 Phase Transitions and Structural Adaptiveness

A *phase transition* marks a qualitative rather than quantitative shift—where, for example, a smuggling network switches from quiet, small-scale operations to openly defying state forces (Tranquillo 2019). *Structural adaptiveness* emerges when criminal groups reconfigure their own architecture—by forming new alliances or embracing different transport methods—in response to changes such as new border deployments or technological innovations (Fieguth 2017).

A clear illustration of phase transitions and structural adaptiveness within criminal networks emerged during the COVID-19 pandemic. In response to border closures and travel restrictions, these organizations underwent a transformative shift—a phase transition—altering their operational structures and adapting to new environmental constraints. Their key adaptations included:

- **Route and Transportation Shifts**: Traditional trafficking routes were reconfigured as criminals exploited alternative, less-monitored pathways, and innovated new modes of transportation and delivery for illicit goods.
- **Cybercrime Expansion**: With increased reliance on digital platforms during lockdowns, criminal groups rapidly expanded their cyber capabilities, exploiting vulnerabilities in online financial systems and communication networks.
- **Diversification of Commodities and Services**: Faced with disruptions to established supply chains, these networks diversified into new markets—ranging from counterfeit medical supplies to synthetic drugs—thereby creating additional revenue streams.
- **Decentralization of Operations**: To mitigate the risks associated with heightened surveillance and mobility restrictions, criminal organizations decentralized their operations, distributing decision-making and control across smaller, more agile cells (UNODC & CoE Brazil 2022; CdE 2021; Mistler-Ferguson, S. and Dalby, C. 2022).

These adaptations exemplify how criminal groups in response to external perturbations (such as a global pandemic), not only reconfigures its structure but also develops new pathways and strategies that enhance its overall resilience and flexibility. The observed phase transition reflects a reorganization of the system's internal dynamics, where previously dominant structures gave way to novel, emergent patterns of behavior that better suited the altered landscape. Once the structure shifts, returning to the prior status quo can be highly difficult.

2.9 Emergent Functions

One hallmark of CAS is *emergence*—novel functions or behaviors that arise from the collective interactions of agents (Mitchell 2009). In border zones, the integration of local traders, corrupt officials, and logistical specialists can spontaneously yield new forms of smuggling or laundering techniques that no single actor explicitly planned. Recognizing these *emergent functions* underscores how state-centric strategies may miss the *interconnectedness* of grassroots participants. A clear example of emergent function in criminal networks is the rising prominence of technologically-enabled fraud as a key revenue stream (FBSP 2025). As criminal groups adapt to shifting market conditions and exploit digital tools, innovative functions arise that extend beyond their traditional operations. This transformation illustrates how local adaptations and interactions within complex adaptive systems can generate entirely new, profitable activities—demonstrating the emergent capabilities of criminal organizations in the digital age.

2.10 Edge of Chaos

Systems *at the edge of chaos* exhibit a mix of order and fluidity, supporting fast *innovation* and *adaptation* (Holland 2014; Mitchell 2009). Criminal organizations benefit from partial oversight: they exploit

existing infrastructure and financial systems yet remain agile enough to avoid complete suppression. This equilibrium between state control and lawless spaces fosters the innovative smuggling tactics observed in tri-border zones or the Amazon Basin.

2.11 Self-Organized Criticality

Self-organized criticality describes how complex systems evolve into a precarious state where minor events can spark large-scale upheavals (Thurner, Hanel, and Klimek 2018). For instance, a small shift in local policy—like banning a certain precursor chemical—may redirect massive illicit flows across different borders, illustrating a chain reaction that was not readily predictable. This phenomenon informs why partial or piecemeal changes in enforcement can carry unexpected ripple effects.

An intriguing example of self-organized criticality in action is the government initiative in Piauí to combat smartphone theft. By combining measures such as sending alert messages to stolen phones, informing new users that their device was reported stolen, and urging them to return it to the police—while simultaneously disrupting both physical and online marketplaces—the initiative achieved a almost 40% reduction in smartphone theft (Saldanha and Souza 2024). This coordinated intervention illustrates how a minor trigger in a critically poised system can cascade into significant, system-wide change.

Another example can be seen in the criminal underworld's reliance on a single deep web payment tool. When law enforcement managed to neutralize this payment method, multiple websites offering illegal services and goods were taken down simultaneously. This incident highlights the interconnectedness within criminal networks, where the failure of one critical component can precipitate a cascade of disruptions—hallmarks of self-organized criticality in complex adaptive systems.

2.12 Bifurcation Points and Structural Shifts

A *bifurcation point* occurs when subtle changes in system parameters precipitate a qualitative transformation (Tranquillo 2019). In illicit economies, raising penalties on drug dealing for example, have shift criminals' focus toward less risky activities such as fraud and contraband cigarettes, or pushed them to expand routes.

The rising prevalence of synthetic drugs in South America represents a potential bifurcation point—a critical threshold that could catalyze a structural shift in the cocaine trade. In a complex adaptive system, even minor perturbations can lead to significant reconfigurations. As market dynamics evolve in response to the growing influence of synthetics, established networks in cocaine production and distribution may undergo transformative changes. Monitoring these developments closely is essential to understanding how this shift might redefine the illicit drug landscape. Once past such a threshold, the network's underlying **structure** can reorder, rendering old strategies ineffective.

2.13 Panarchy and Nested Adaptive Cycles

Panarchy theory views systems as nested cycles, each scale experiencing growth, conservation, release, and reorganization (Gunderson and Holling 2002). In illicit flows, micro-level communities (e.g., coca growers) feed into mid-level trafficking networks (e.g., regional cartels), which connect to macro-level global markets (UNODC 2023). Changes at one level—say, a crackdown on local production—can reverberate across the entire transnational chain, emphasizing the multi-level nature of criminal ecosystems.

2.14 Scale-Free Networks and Network Centrality

Many smuggling networks exhibit *scale-free* properties, where a few key nodes (logistical hubs, cartel leaders) have disproportionately many connections. Neutralizing these high-centrality hubs—like major ports or influential border officials—can yield system-wide disruptions, at least temporarily. Nonetheless, because these networks maintain back-up nodes, removing one does not guarantee a complete breakdown. This can clearly be seen in the use of several simoutaneous routes in the cocaine trade.

2.15 Resilience and Redundancy

Criminal ecosystems often embed *redundancy*—multiple routes, alternative alliances, decentralized leadership—to enhance *resilience*. When enforcement strikes one corridor, traffickers activate another, illustrating how they absorb shocks without collapsing. Strategies to counter resilience must be similarly coordinated, focusing on both the enablers of the trade as well as in the multiple routes or commodities at once rather than tackling each in isolation.

2.16 Adaptive Co-Management and Feedback Loops

Adaptive co-management emphasizes flexible governance through continuous feedback among stakeholders—communities, authorities, NGOs—allowing quicker policy shifts in response to criminal innovation. For instance, local fisher communities might alert officials to suspicious boat movements. When integrated into official intelligence loops, such bottom-up data can help states adapt as rapidly as criminals.

2.17 Entropy and Information Theory

Criminals thrive under *high entropy* (Tranquillo 2019), generating "noise" that cloaks illicit goods amid legitimate trade, labyrinthine financial transactions, and front businesses. Applying data analytics, cross-database checks, and real-time intelligence can reduce entropy, exposing anomalies and making enforcement more precise. This underscores the importance of information-sharing among regional agencies to cut through the confusion criminals rely on.

2.18 Multi-Level Selection (Evolutionary Perspective)

Drawing on *evolutionary biology, multi-level selection* posits that selection pressures act at individual and group levels simultaneously (Tranquillo 2019). Criminal enterprises balance internal cohesion with external competition—sometimes cooperating with rival factions to outsmart state forces, yet vying for larger market shares. Interdiction efforts may exploit these rivalries, offering deals to select groups to fracture collaborative smuggling rings from within.

3. Institutional Responses and Policy Implications: A CAS-Informed Approach

Transnational criminal networks in South America, exemplified by groups such as the Primeiro Commando da Capital (PCC) and the Commando Vermelho (CV), have demonstrated an extraordinary capacity to adapt and thrive in environments characterized by rapid change and systemic pressure. These organizations employ decentralized, cell-based structures and dynamic alliances that enable them to innovate continuously and out manoeuvre state-led interventions (McDermott et al. 2025). Their resilience and fluidity reveal a deeper reality: they are part of a complex adaptive system in which nonlinearity, multi-scalar interactions, and emergent properties play crucial roles. Rather than being static, these networks evolve through feedback loops, structural shifts, and phase transitions that mirror the dynamics observed in natural and social systems alike.

At the core of CAS theory is the recognition that systems are not fixed but are in constant flux, adapting to both internal and external perturbations (Tranquillo 2019). In the case of illicit transnational flows, criminal networks adjust their strategies in response to changes in market conditions, enforcement practices, and technological innovations (UNODC 2023). Small perturbations—whether in the form of a new regulatory measure or a technological breakthrough—can act as velocity vectors that push these networks toward critical thresholds. Once these thresholds are reached, the networks may experience sudden structural changes or phase transitions, radically altering their operational patterns. The concepts of basins of attraction and hysteresis further illustrate how communities and networks can become locked into particular trajectories, making it challenging to transition from an illicit equilibrium to one dominated by lawful activities.

Understanding these dynamics is essential for designing effective policy interventions. A key starting point is the recognition that many communities in South America have, over time, become enmeshed in the criminal economy, forming what can be described as "friendly networks" (USJFC 2011). In many regions, illicit flows have created an alternative economic order where small-scale criminal activities provide the primary source of income. This situation is reinforced by the phenomenon of hysteresis, whereby communities remain in a state of dependency even when external conditions change. The historical reliance on criminal

revenue, combined with limited access to legitimate economic opportunities, creates a basin of attraction that continuously pulls communities toward illicit activities. To counteract this dynamic, it is imperative that policies focus on building alternative pathways toward legality.

One approach to transforming these communities involves investing in sustainable livelihoods that offer credible alternatives to criminal income. By prioritizing initiatives such as sustainable agriculture, vocational training, and microfinance, policymakers can help create a new basin of attraction oriented toward lawful economic activities. Such investments not only provide immediate economic relief but also lay the groundwork for long-term structural change. In regions where illicit economies have been deeply entrenched, the gradual development of legal economic opportunities can serve as a counterweight to the pervasive influence of criminal networks. Over time, these investments can help shift local cultural norms away from acceptance of contraband and toward a commitment to legality and social integrity.

Another essential element of this transformation is public awareness. Societal norms play a significant role in sustaining illicit networks. When minor criminal activities become normalized, they create a velocity vector that gradually shifts public attitudes in favour of criminal behaviour. However, targeted public awareness campaigns can serve as powerful trigger points that disrupt this momentum. By emphasizing the long-term social, environmental, and economic costs of counterfeit goods and illicit trade, these campaigns can spark bursts of citizen engagement that realign public sentiment. When communities begin to recognize the broader implications of supporting criminal activities, a rapid reorientation of values and behaviours may occur, ultimately shifting the system away from an illicit equilibrium.

In addition to fostering public awareness, it is critical to develop adaptive co-management strategies that integrate the efforts of state agencies, non-governmental organizations (NGOs), and local communities. Continuous dialogue between these stakeholders creates the feedback loops necessary for identifying emergent threats and adjusting policies in real time. For example, community watch initiatives can provide law enforcement with timely intelligence about suspicious activities, while joint training programs between local leaders and regulatory agencies can enhance the detection of corruption and illicit financial flows. Such collaborative efforts not only improve the responsiveness of the system but also help build trust between citizens and the state, thereby strengthening the overall resilience of legal economic structures.

While supporting "friendly networks" is a crucial component of any comprehensive policy response, it is equally important to address the vulnerabilities within "neutral networks" (USJFC 2011) Neutral networks include those sectors of the economy and public administration that are not overtly criminal but are nonetheless susceptible to infiltration by illicit actors. These may include legitimate businesses, financial institutions, and regulatory bodies that operate at the margins between lawful and illicit activities. Often, these entities function near the so-called "edge of chaos," where oversight is partial and the boundaries between legal and

illegal practices become blurred. In such environments, even minor lapses in governance can allow criminal actors to exploit systemic weaknesses, transforming neutral networks into inadvertent facilitators of illicit trade.

To prevent neutral networks from drifting into criminal collusion, policymakers must implement robust regulatory frameworks that enforce enhanced due diligence throughout supply chains. Measures such as mandatory compliance certifications and stringent know-your-supplier protocols can significantly reduce the uncertainty or entropy that criminals exploit to mask their activities. In high-risk sectors, the adoption of digital payment systems and blockchain-based tracking technologies can minimize the reliance on cash transactions, thereby making financial flows more transparent and traceable. These interventions not only strengthen the integrity of neutral networks but also raise the overall cost for criminal actors attempting to infiltrate or co-opt these systems.

Legal and regulatory changes can also function as bifurcation points—critical thresholds that prompt structural shifts within organizations. For example, imposing strict liability on internet marketplaces for the sale of counterfeit goods can force companies to adopt more rigorous vetting procedures. When such regulatory pressures are applied consistently, businesses are compelled to reconfigure their internal processes, shifting from lax oversight to proactive compliance. This structural shift, once initiated, can cascade through entire industries, reducing the channels through which criminals operate. In this way, targeted legal reforms can not only deter individual acts of criminality but also transform the broader operational landscape of neutral networks.

Professional service networks, including those of lawyers, accountants, and logistics experts, also play a pivotal role in sustaining both legal and illicit operations. Many of these networks are characterized by a scale-free structure, in which a few high-centrality nodes exert a disproportionate influence on the system. These hubs often provide the essential services that underpin criminal activities, such as money laundering or the facilitation of international trade in contraband goods. By targeting these critical nodes, regulatory agencies can disrupt the redundancy and resilience that criminal networks rely on. For instance, measures that incentivize whistleblowing or that impose severe penalties on key facilitators can weaken the structural integrity of these service networks, making it more difficult for criminal organizations to maintain their operations.

The ultimate goal, however, is to directly neutralize the criminal networks themselves. This involves a strategic focus on dismantling the high-centrality hubs and choke points that sustain illicit flows. Criminal networks often exhibit a scale-free organization where a few critical nodes—such as major ports, key money-laundering centres, or pivotal communication hubs—anchor the entire system. Targeting these nodes can have a disproportionately large effect on the overall capacity of the network. Coordinated enforcement actions that involve multiple jurisdictions, simultaneous raids, and cross-border intelligence sharing can sever the critical financial and logistical flows that support criminal operations.

An effective strategy to overcome the redundancy inherent in multi-route smuggling networks involves synchronized interventions across

all major corridors. Criminal organizations are known for maintaining multiple, redundant routes to ensure that if one pathway is blocked, another will take its place (UNODC 2023). By launching coordinated actions that target multiple routes simultaneously, law enforcement can overwhelm the network's adaptive capacity, triggering a phase transition that disrupts its internal cohesion. This approach requires not only physical interventions but also the integration of cyber and physical enforcement measures. In an era where criminal networks increasingly rely on digital platforms for coordination, the simultaneous disruption of online communication channels and traditional smuggling routes creates a compounded effect that can significantly hinder the network's operations.

A further challenge arises from the dynamic equilibrium often observed between enforcement spending and criminal revenue. This equilibrium, akin to a nullcline in CAS theory (Tranquillo 2019), can create a stable but undesirable state where illicit activities persist despite continuous intervention. Crossing the separatrix—the boundary between different dynamical regimes—requires calibrated enforcement that avoids triggering unintended consequences such as self-organized criticality, where a minor crackdown might unexpectedly lead to a surge in violence or a rapid reorganization of the network. To navigate this delicate balance, policymakers must engage in continuous, data-driven scenario planning that models the potential outcomes of various enforcement strategies. By simulating different interventions and monitoring their effects on the system's behaviour, authorities can identify the optimal points of intervention that push the network past the critical threshold into a state where its capacity to adapt is severely diminished.

In addition to direct enforcement measures, leveraging the internal dynamics of criminal networks can be a powerful tool for destabilization. Criminal organizations are rarely monolithic; they consist of multiple subgroups that, while cooperating at one level, often compete for resources and influence at another (McDermott et al. 2025). This dynamic of multi-level selection creates internal rivalries that can be exploited by policymakers. By incentivizing defections or offering leniency to mid-level operatives and specialized service providers, authorities can create fissures within the network. When internal rivalries are exposed and exploited, the cohesion of the criminal organization is weakened, making it more vulnerable to targeted interventions. Public exposure of these internal conflicts can also serve as a deterrent, reducing the ability of criminal networks to attract new members or consolidate power.

Effective policy responses to illicit flows in South America must be a whole-of-society approach, that is, multi-scalar and integrated across local, national, and international levels. Given the transnational nature of criminal networks, fragmented approaches are likely to be exploited by criminals who can simply shift their operations to areas with weaker oversight. Enhanced international cooperation, therefore, is a critical component of any comprehensive strategy. This includes formal treaties, intelligence-sharing agreements, and the establishment of secure data platforms that integrate information from multiple jurisdictions. Strengthening subnational capacities is equally important. By equipping

local law enforcement and regulatory agencies with the tools and training necessary to detect and respond to emerging threats, national governments can create a more agile and responsive enforcement apparatus that operates in concert with international partners.

Reducing entropy within illicit economic systems is another crucial objective. Entropy, in this context, refers to the high degree of uncertainty and obscurity that criminal networks exploit to hide their activities. Improving information flow through unified data platforms that cross-reference shipping manifests, financial transactions, and legal records can reveal patterns that might otherwise remain hidden. Legal mandates requiring the disclosure of beneficial ownership for corporations and trade entities further reduce the informational noise that criminals depend on. The adoption of advanced analytics and artificial intelligence enhances these efforts by providing real-time insights into emerging patterns or burst phenomena, enabling authorities to intervene swiftly before criminal networks have a chance to reconfigure.

The importance of adaptive co-management cannot be overstated. In a dynamic environment characterized by constant change, static, one-off interventions are rarely effective in the long term. Instead, an iterative approach that involves continuous monitoring, feedback, and policy adjustment is essential. Regular risk audits that assess the evolving landscape of criminal networks can help determine whether existing interventions are sufficient or if new strategies are required. By embracing an adaptive co-management model, policymakers can remain one step ahead of criminal innovations, adjusting their strategies as needed to maintain a competitive advantage over illicit actors.

In addition to adaptive co-management, phase transitions represent a critical juncture at which meaningful, long-lasting change becomes possible. A phase transition involves a rapid, structural shift from one equilibrium to another (Tranquillo 2019). In the context of illicit flows, the objective is to transition from a system dominated by criminal activities to one characterized by sustainable, legal economic practices. Achieving this transition requires addressing the root economic vulnerabilities that drive communities toward criminality. Investments in education, healthcare, and economic diversification are essential to create an environment where lawful activities can flourish. Cultural change, fostered through public education and social marketing, can help shift societal norms away from tolerance of illicit behaviour. Ultimately, building resilient institutions that are capable of learning and adapting in the face of new threats is key to ensuring that these gains are sustained over time.

When examining the challenges of addressing illicit flows in South America, it becomes clear that a networked, adaptive policy paradigm is required—one that mirrors the complexity of the criminal networks themselves. By applying CAS concepts such as velocity vectors, basins of attraction, hysteresis, trigger points, phase transitions, bifurcation points, and multi-level selection, policymakers can better understand the intricate dynamics at play and design interventions that are both nuanced and effective. This approach calls for a shift away from linear, one-dimensional strategies toward a more holistic model that considers the entire ecosystem of illicit trade.

In practical terms, this means that interventions must be multi--pronged and coordinated across different scales. Local initiatives that support sustainable livelihoods and foster community resilience must be complemented by national policies that regulate neutral networks and disrupt the financial and logistical channels that sustain criminal activities. International cooperation, facilitated by robust data-sharing platforms and harmonized regulatory frameworks, is essential for addressing the transnational dimensions of illicit flows. At every level, the goal is to gradually shift the overall system's basin of attraction—from one that favors criminal activity to one that supports legal, sustainable development.

The integration of advanced technologies plays a pivotal role in this strategy. From blockchain systems that ensure transparency in financial transactions to AI-powered analytics that detect emerging patterns of illicit behaviour, technology provides the tools necessary to reduce entropy and enhance the flow of actionable information. These tools enable authorities to identify critical trigger points, monitor the evolution of criminal networks in real time, and implement targeted interventions that disrupt established patterns. When combined with adaptive co-management and iterative policy feedback, technology becomes a force multiplier that enhances the overall resilience of legal economic structures.

Ultimately, the application of CAS theory to the study of illicit flows in South America reveals a complex interplay of factors that must be addressed in a coordinated and holistic manner. Criminal networks are not static entities but are constantly evolving in response to a multitude of pressures. Their adaptive nature means that interventions must be equally flexible, capable of adjusting to new threats as they emerge. By focusing on building alternative pathways to legality, influencing neutral networks, and directly targeting the high-centrality hubs that underpin criminal operations, policymakers can create a dynamic and responsive framework that not only disrupts illicit flows but also lays the foundation for long-term, sustainable governance.

Conclusion

Addressing the challenge of illicit transnational flows in South America requires a nuanced understanding of the complex adaptive systems that underlie criminal networks. Through the careful application of CAS concepts, from the notion of basins of attraction and hysteresis to phase transitions and bifurcation points, policymakers can design interventions that are both targeted and adaptive. This approach moves beyond traditional, linear strategies and embraces the inherent complexity of the systems involved, offering a pathway toward a future where coordinated, multi-scalar governance transforms the landscape of illicit trade. The task is formidable, but with commitment, collaboration, and the strategic use of technology, it is possible to shift the equilibrium away from criminality and toward a more sustainable, law-abiding economic order.

Using Complex Adaptive Systems to study illicit flows allow IR theory to grasp the multifaceted nature of criminal networks. This is essential because no single intervention is sufficient on its own; rather, it is

the interplay of multiple, adaptive strategies—spanning local economic development, regulatory reform, technological innovation, and international cooperation—that holds the promise of lasting change. In this context, the challenges posed by illicit trade are not merely issues of enforcement or regulation, but are also deeply intertwined with social, economic, and political factors that demand a comprehensive, integrated response.

This CAS-informed policy paradigm, therefore, provides both a conceptual framework and a practical roadmap for disrupting the adaptive mechanisms that sustain illicit flows. By fostering environments where legal economic activities can thrive, ensuring that neutral networks remain free from criminal influence, and strategically dismantling the key hubs and high-value targets that support criminal enterprises, governments, international agencies, the private sector and civil society can collectively push the system toward a new equilibrium. Such an equilibrium is one where sustainable, inclusive development replaces the destabilizing influence of illicit trade—a transformation that, while challenging, is both necessary and achievable in the face of persistent and evolving threats.

In conclusion, the application of CAS theory to the analysis of illicit flows in South America offers profound insights into the nature of criminal networks and the strategies required to counter them. Through continuous adaptation, integrated governance, and the leveraging of technology, it is possible to reshape the very foundations of the illicit economy. By shifting the system's dynamics—from entrenched basins of attraction that favour criminality to vibrant, resilient ecosystems that support lawful economic activity—we can envision a future where coordinated policy responses yield transformative, long-lasting change.

Bibliography

CdE. 2021. "Estudo Estratégico: Covid-19 e Tráfico de Drogas No Brasil: A Adaptação Do Crime Organizado e a Atuação Das Forças Policiais Na Pandemia." Brasilii: Centro de Excelência para a Redução da Oferta de Drogas Ilícitas (CdE).

FBSP. 2024. "Cartographies of Violence in the Amazon." São Paulo: Fórum Brasileiro de Segurança Pública.

———. 2025. "Follow the Products: Rastreamento de Produtos e Enfrentamento Ao Crime Organizado No Brasil." São Paulo: Fórum Brasileiro de Segurança Pública.

Fieguth, Paul. 2017. *An Introduction to Complex Systems: Society, Ecology, and Nonlinear Dynamics.* Cham: Springer.

Gunderson, Lance H., and C. S. Holling. 2002. *Panarchy: Understanding Transformations in Human and Natural Systems.* Washington: Island Press.

Holland, John. 2014. *Complexity: A Very Short Introduction.* Oxford: Oxford University Press.

Kaplan, Morton A. 1957. *System and Process in International Politics.* Colchester: ECPR Press.

Kosmynka, S. 2020. "The Problem of Organized Crime in the South American Tri-Border Area: Paraguay, Brazil and Argentina." *International Studies. Interdisciplinary Political and Cultural Journal* 25 (1). https://doi.org/10.18778/1641-4233.25.02.

McDermott, J., S Dudley, Javier Samper, Marc R Tortosa, and Emilie Breyne. 2025. "Mapping and Profiling the Most Threatening Criminal Networks in Latin America and the Caribean." Paris: Expertise France; Insight Crime; Empact.

Miller, John H., and Scott E. Page. 2007. *Complex Adaptive Systems an Introduction to Computational Models of Social Life.* Pricenton: Princeton University Press.

Mistler-Ferguson, S. and Dalby, C. 2022. "How COVID-19 Reshaped Cocaine and Marijuana Trafficking in Brazil." Think Tank. InSight Crime. August 1, 2022. https://insightcrime.org/news/covid-19-reshaped-cocaine-cannabis-trafficking-brazil/.

Mitchell, Melanie. 2009. *Complexity A Guided Tour*. Oxford: Oxford University Press.

OECD. 2016. "Illicit Trade; Convergiving Criminal Networks, OECD Reviews of Risk Management Policies." Paris: OECD Publishing.

Saldanha, Rafael, and Beto Souza. 2024. "Ministério Da Justiça Vai Incorporar Programa Do Piauí Para Diminuir Roubos de Celulares No Brasil." *CNN*, 2024. https://www.cnnbrasil.com.br/nacional/ministerio-da-justica-vai-incorporar-programa-do-piaui-para-diminuir-roubos-de-celulares-no-brasil/.

SINGH, R., and J.M. LASMAR. 2024. "Regional Hubs of Illicit Trade: The Triborder Area." Washington, D.C.: George Mason University, Terrorism, Transnational Crime & Corruption Center. https://traccc.gmu.edu/wp-content/uploads/2024/11/Final-TBA.pdf.

Thurner, Rudolf Hanel, and Klimek. 2018. *Introduction to the Theory of Complex Systems*. Oxford: Oxford University Press.

Tranquillo, Joe. 2019. *An Introduction to Complex Systems: Making Sense of a Changing World*. Cham: Springer.

UNODC. 2023. "Global Report on Cocaine 2023: Local Dynamics, Global Challenges." United Nations Office on Drugs and Crime. https://www.unodc.org/documents/data-and-analysis/cocaine/Global_cocaine_report_2023.pdf.

———. 2024. "UNODC Global Study on Homicide 2023 Homicide and Organized Crime in Latin America and the Caribbean." Vienna: United Nations Office on Drugs and Crime.

UNODC & CoE Brazil. 2022. "Cocaine Insights 4: Brazil in the Regional and Transatlantic Cocaine Supply Chain: The Impact of COVID-19." 4. Vienna: UNODC.

USJFC. 2011. *United States Joint Forces Commanders Handbook for Attack the Network*. 1st ed. Suffolk, Virginia: Joint Warfighting Center (Joint Doctrine Support Division). https://www.jcs.mil/Portals/36/Documents/Doctrine/pams_hands/atn_hbk.pdf.

Wallerstein, Immanuel. 2004. *World-Systems Analysis: An Introduction*. Durham: Duke University Press.

Waltz K.N. 1979. *Theory of International Politics*. New York: McGraw Hill.