Artificial Intelligence and the Revolution in Financial Crimes Compliance
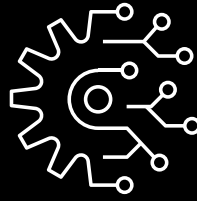
By Gary M. Shiffman, Shelly Liposky and Rick Hamilton

The use of **Artificial Intelligence**
and **Machine Learning**
in anti-fraud programs is expected to

more than
DOUBLE

over the next two years.[1]

We use AI to check the weather; to open our phones with Face ID; to choose our next Netflix show. Doctors use it to collaborate on the reading of X-rays and make decisions on treatment plans. The financial crimes compliance industry has been exploring new Machine Learning/AI technologies for several years, but with little adoption. Is it because of the high consequences of our work? Is it because of the high scrutiny of regulations? Why wouldn't we use AI to prevent financial crimes that enable some of the worst offenses including elder abuse, human trafficking, and terrorism?

Financial institutions can help prevent financial crime with a new way to train AI called Federated Machine Learning, or simply Federated Learning. This innovation has already been applied successfully in highly regulated industries like medicine. Now, it is **available** and **proven** in the banking industry. Not only can Federated Learning reduce costs, it can increase the effectiveness of Anti-Money Laundering programs, all while preserving privacy.

1. Anti-Fraud Technology Benchmarking Report, 2022.

Federated Learning: From tumors to money launderers

Accurately identifying the boundaries of tumors is critical for their removal. In a December 2022 *Nature* article[2], a team of researchers at the University of Pennsylvania's Perelman School of Medicine, in collaboration with Intel Corporation, explained how they used Federated Learning to increase their ability to identify the boundaries of glioblastoma (GBM) tumors – the deadliest human cancer[3] – by an incredible 33%.

In the cancer study, researchers accessed data from 6,314 GBM tumor patients from 71 different hospitals across the globe – the largest data set ever utilized for researching this tumor. How was this rapid improvement possible, considering strict laws protecting the privacy of patient data? Federated Learning allows institutions to collaborate *while preserving privacy*, because the technology shares only AI models – not patient data.

According to the *Nature* article, this collaboration represents "a paradigm shift for multi-site collaborations." No one healthcare institution had enough data on its own to achieve this advancement, and regulations prohibited the sharing of data. But 71 hospitals working together using Federated Learning achieved a breakthrough that will save many lives and help to transform all of medicine. The same Federated Learning approach enabling radical improvements in health outcomes is also benefiting those of us combating financial crimes and fraud.

In banking, we face challenges similar to healthcare. Rarely does one bank have sufficient data to build exquisite models or conduct world-class studies of the patterns of crimes – especially rarely observed but serious events such as human trafficking and terrorism finance. And, like in medicine, we face constraints to collaboration. We must preserve our customers' privacy and comply with significant regulations across jurisdictions.

In particular, the authors of this paper focus on combating financial crime. Stated another way, we seek to prevent criminals from accessing high-quality, safe, and secure global financial systems. We started using Federated Learning a few years ago, and the results are promising.

2. Pati, Sarthak, et. al. "Federated learning enables big data for rare cancer boundary detection." Nature Communications. 05 Dec 2022.
3. Stetka, Bret. "New Strategies Take On the Worst Cancer–Gliobastoma." Scientific American. 27 Mar 2019.

What is Federated Learning?

The best Artificial Intelligence (AI) algorithms are trained on the best data. The more quality data available for training, the more accurate algorithms become. The more patient images, or financial profiles, an algorithm accesses, the better it becomes at identifying patterns across those images.

Artificial Intelligence (AI) is an agent that can perform tasks; AI can appear to perceive and respond to something external to the machine, such as a human. These tasks can include reasoning, problem-solving, understanding natural language, recognizing patterns, and more. Machine Learning (ML) is a specific subset of AI that focuses on developing algorithms and techniques that enable computers to learn from data. Instead of programming a machine, the machine learns patterns and insights from data. Machine Learning models improve their performance over time as they process more data.

Federated Learning is a Machine Learning technique that learns across all available data without the need to move data. Instead of "aggregating" data, which medical, banking, and many others cannot do, Federated Learning keeps the data apart, or "federated." People in regulated institutions are able to simply share what they've learned, in the form of algorithms that reflect patterns. All data remains secure and private.

Essentially, Federated Learning *moves the learning*, not the data. Each institution's data is used to locally train and update an algorithm that is then passed between data sets, getting smarter and more accurate with each use. For learning to occur, no single institution needs a ton of data individually; each only needs what they have available. Like in the brain tumor study, a few research hospitals had many images, but most had only a few. A lot of hospitals with only a few images each added up to the largest training data set in history for this pattern – the GBM tumor.

Federated Learning transforms traditionally siloed environments – regulated or not – into a collective for learning, enabling the *benefits* of collaboration while preserving data privacy. This matters for everyone. AI impacts every industry – but Federated Learning provides the safe path for industries that must prioritize compliance, historically at the cost of accuracy, including health care, government, education, and banking.

Where you find money laundering, you also find horrific crimes

Those of us in the financial industry have a shared belief that the Financial System is not only critical to economic survival but to enabling the most impactful, personal opportunities for individuals the world over – from families achieving home ownership, to the first in a family to go to college, to microfinance of women in impoverished areas. And then there are financial crimes: where you find money laundering, you also find some of the most horrific crimes – like human trafficking, elder abuse, and terrorism. These links have been proven time and again.[4]

The stakes in banking are high – but current efforts are costly, with a low return on investment.

We understand how criminals move and hide money, but we've been limited in the past by our technological capability. Until now, there has been no solution for collaboration in the face of regulatory constraints.

Using Federated Learning in financial crimes compliance, we share knowledge of a pattern without sharing customer data. While medical researchers might share the pattern of a disease as it shows up in an x-ray or other diagnostic (but not a single patient's data), we've shared the pattern of specific financial criminal risk as it shows up in bank data (but not a single customer's data).

The stakes in banking are high – but current efforts are costly, with a low return on investment.

4. "Report to Congress on An Analysis of Anti-Money Laundering Efforts Related to Human Trafficking." US Dept of State. 07 Oct 2020.

Cost without real-world impact

The costs of anti-money laundering (AML) compliance are massively high, and increasing. An estimate published in 2018 in the *Journal of Financial Crime*[5] showed that the direct cost of AML compliance in the United States has reached $80 billion per year. This study found that large financial institutions spend an average of $48 million on AML compliance per year, with costs increasing annually.

Despite the well-documented large and growing financial and societal costs, there is limited evidence that these regulations effectively combat financial crime. The 2017 International Monetary Fund report found that less than 1% of global illicit financial flows are detected and confiscated by authorities.[6] Similarly, a 2019 study titled, "The efficiency of anti-money laundering regulations in detecting criminal money flows," published in the *journal Crime, Law and Social Change*,[7] found that AML regulations were only marginally effective in detecting criminal money flows. And the United Nations Office on Drugs and Crime (UNODC) estimates that 90% of financial flows from drug trafficking remain undetected.[8]

AI and Machine Learning can break the cycle of inefficiency by delivering decreasing costs and increasing effectiveness, all while protecting privacy. Rick Hamilton, in his 2021 article, "The Evolving Nature of Financial and Cyber Crime Behavior Detection," argues that a risk-based approach to regulatory compliance, which incorporates the use of Machine Learning technology, can help improve effectiveness while reducing compliance costs.[9]

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flows are detected
and confiscated by authorities.

5. Roberts, J. J., & Yaeger, M. L. (2018). The rising cost of AML compliance and financial crime prevention. Journal of Financial Crime, 25(2), 263-275.
6. IMF Annual Report 2017. https://www.imf.org
7. Zhang, J. The efficiency of anti-money laundering regulations in detecting criminal money flows. Crime, Law and Social Change, 71(2), 137-155. 2019.
8. United Nations Office on Drugs and Crime. "Estimating Illicit Financial Flows Resulting From Drug Trafficking and Other Transnational Organized Crimes". Oct 2011.
9. Hamilton, R. (May 2021). "The Evolving Nature of Financial and Cyber Crime Behavior Detection." PECB Insights.

Federated Learning reduces costs and breaks down barriers

While AI and Machine Learning offer banks the opportunity to improve their AML program effectiveness and efficiency, their adoption is complex and expensive. The creation of sufficient labeled data, implementing/maintaining robust data stores, acquiring/maintaining a model development environment, and attracting/retaining the requisite staff are challenges that interested banks need to address. Further, AI and Machine Learning do not address structural limitations such as jurisdictional restrictions on information sharing that global financial institutions can face. However, Federated Learning can help reduce these expenses and penetrate restrictive barriers to tackling AML challenges.

1. Smaller institutions struggle to justify the expense associated with funding the infrastructure needed to leverage AI and Machine Learning. A Federated Learning-based solution can deliver a turn-key solution to a smaller bank by training the models on more robust data sets from larger banks. Such a solution would require a much smaller investment in staff and technology while enabling the smaller firm to garner the benefits of these advanced capabilities.

2. Some jurisdictions restrict the ability of international banks to consolidate data for model training which drives the need for them to instantiate redundant modeling frameworks. Federated Learning can overcome this limitation by training a core set of models on all the firm's data sets while at rest in their local jurisdictions. This can permit a re-rationalization of the enterprise AML modeling infrastructure and perhaps drive greater model efficiency through the use of larger data sets. For large banks, even minor efficiency gains garnered from improved data sets (through FL) can lead to material dollar savings.

3. Data science staffing costs are rising at an alarming rate. This prices most small and medium banks out of the market and even puts a strain on the budgets of larger institutions that need to hire data scientists for many different roles. Banks that leverage a Federated Learning model will need a much smaller set of similarly skilled individuals to monitor model results and contribute to feature development.

4. Finally, by leveraging labeled data from many institutions, it is possible to implement models trained on smaller data sets at each institution. This could allow each bank to invest less in data labeling and data curation. Similarly, banks that have extensive labeled data in one typology could, through Federated Learning, 'share' their expertise with banks that lack sufficient labeled data in that typology to build a robust model. This process of sharing expertise between banks, while protecting and not sharing data, will improve the effectiveness of the global anti-money laundering framework and make it harder for criminals to find gaps in the system.

Federated Learning increases effectiveness

We've traveled algorithms across our respective financial institutions, and we've seen increases in efficiency of 75% in the discovery of financial crimes.

What does that mean? What happens after a possible financial crime is discovered and a Suspicious Activity Report (SAR) is filed with the Financial Intelligence Unit (In the United States, the Financial Crimes Enforcement Network (FinCEN); the Financial Transactions and Reports Analysis Centre of Canada (FINTRAC) is Canada's financial intelligence unit)?

In some cases, it can lead to the discovery and shuttering of large-scale trafficking schemes. In 2021, two dozen defendants were indicted for running a labor trafficking operation that illegally imported Mexican and Central American workers into brutal conditions on South Georgia farms. Workers paid the traffickers to help them cross the border into the United States, but when they arrived, their travel and identification documents were withheld, and they were brought at gunpoint to Georgia, where they were kept in fenced areas. Forced to dig onions with their bare hands, they were paid 20 cents for each bucket harvested and slept in cramped, unsanitary rooms with little or no food and limited plumbing. At least two of the workers died as a result of workplace conditions.

A multi-agency investigation led by Homeland Security Investigations uncovered the trafficking scheme, in part due to the more than $200 million laundered through a casino, cashier's checks, and cash purchases of land, homes, vehicles, and businesses. According to the United States Attorney's Office of the Southern District of Georgia, more than 100 individuals were freed from trafficking.[10]

We've traveled algorithms across our respective financial institutions, and we've seen **increases in efficiency of 75%** in the discovery of financial crimes.

10. "Human smuggling, forced labor among allegations in south Georgia federal indictment." United States Attorney's Office, Southern District of Georgia. Nov 22, 2021. https://www.justice.gov/usao-sdga/pr/human-smuggling-forced-labor-among-allegations-south-georgia-federal-indictment

Federated Learning Efficiency Ratio
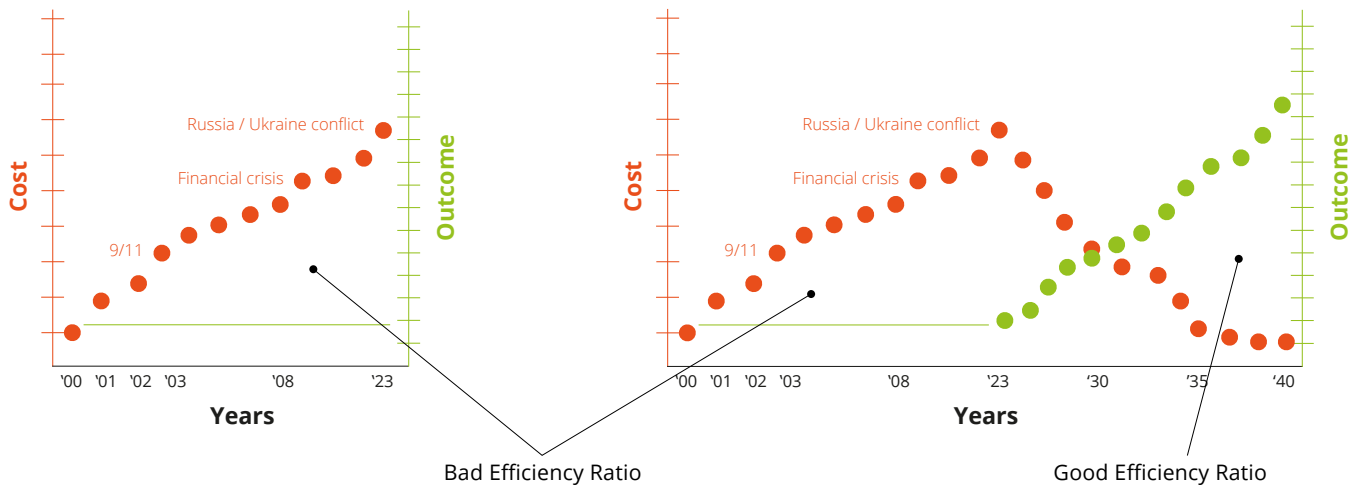
Cost: (people, systems, data, overhead) * (# of FIs)

Outcome: (ML/TF metric)

Federated Learning can invert the Efficiency Ratio

An Efficiency Ratio reflects the cost it takes a company to earn each dollar. The lower the cost to earn each dollar, the more efficient (and profitable) the organization. Applied to this topic, we need the cost to prevent each Money Laundering/Terrorist Financing (ML/TF) transaction to be as low as possible so that we have the capacity to reinvest funds to get ahead of bad actors.

Today, cost continues to increase, yet the outcome remains relatively the same. We don't accept that in our revenue-generating business lines, so why would we accept it in the prevention of ML/TF? If we work as one unit, an industry, implementing Federated ML models in waves, we will generate positive Efficiency Ratios. We can pick a target: measured improvement of x by 2025, improvement of 10x by 2030. And two things happen in year two: realized cost savings and improvement in the quality of suspicious activity data sent from banks to law enforcement.

The market for **AI In RegTech** is forecast to reach **$3.3 billion** by 2026.[11]

11. Artificial Intelligence In Regtech Market Report, 2023. IndustryArc.

Federated Learning helps banks facing edge cases

All banks face "edge cases" – important but not frequent events, like terror financing or human trafficking – where they do not have, and will likely never have, sufficient data to build efficient models. Federated Learning enables banks to build better models for these rare but critical events, in spite of having insufficient data within their own institution.

For example, we built an anti-human trafficking model using Federated Learning and augmented by AI-based adverse media. Using this combined methodology, we screened 15 million customers to generate only 150 alerts which yielded 40 good cases. This entire process took only 2.5 hours of human analyst time.

Even the largest banks in the world will benefit from Federated Learning on rare events. No bank is too large or small to participate in collaboration through Federated Learning.

Federated Learning helps Financial Institutions reach their ESG targets

Our industry has never been more committed to advancing the Social element of ESG. Federated Learning provides an opportunity for banks to reach their ESG goals by prioritizing compliance while also providing access to banking services to underserved populations. The Consultative Group to Assist the Poor (CGAP) has argued that AML compliance measures disproportionately burden low-income individuals.[12] By making AML compliance more effective, Federated Learning technology can increase access to financial services for those in traditionally underserved populations.

In addition, approximately 30% of the adult population globally[13] does not have an account from which they can safely transact, save, or access credit. Federated Learning can increase the availability of banking channels that handle both remittance transfers and foreign direct investment – two key drivers of asset building and economic development in many parts of the world.

Federated Learning leverages expertise

Machine Learning is in large measure successful when well-considered and diverse features are used in modeling. A well-structured Federating Learning community benefits from the creativity of the membership. For example, a 'feature creation' team within one organization or across a small group of collective members might face a similar challenge. This group can test new ideas for effectiveness and promote those that provide the greatest lift in experimentation to the central hub – we call this the Algorithm Factory. Through this type of approach – and this is just one example of creativity in collaboration – the marginal benefit far exceeds any marginal cost.

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12. Abell, Thomas and Vangelis Tsianaxis. "AML/CFT: Balancing Regulation with Innovation." CGAP. 23 Jan 2015.
13. The World Bank. "The Global Findex Database 2021: Financial Inclusion, Digital Payments, and Resilience in the Age of COVID-19." 2021.

Regulator-Encouraged Innovation has begun

Going back to the December 2018 joint statement of the US regulators, the banking industry has been encouraged to experiment with innovation. This was driven by the pressures coming from AI and Machine Learning on all aspects of the global economy. The regulators' only ask was that innovation took place responsibly.

The start of technology adoption in banking compliance is now. According to a 2023 KPMG report, AI is a driver of budget spend for 35% of the compliance sector.[14] And according to a 2020 Gartner report, 40% of privacy compliance technology will rely on AI by the end of 2023.[15] Many regulators are already establishing 'innovation' hubs, focused especially on AI technology. These hubs are eliminating the constraints that in the past have hindered the adoption of new and promising technologies.

- FINRA's Innovation Outreach Initiative encourages financial service providers to rethink their business models, incorporating new technologies and services.[16]

- Canada's Office of the Superintendent of Financial Institutions Digital Innovation Open Door utilizes the evolving digital innovation space to help inform the development of fair and effective guidance, rules, regulations, and supervision endeavors in this rapidly developing space.[17]

- The U.K. Financial Conduct Authority (FCA) Innovation Hub supports tech-based solutions to shared challenges in financial services.[18]

- The U.S. Office of the Comptroller of the Currency (OCC) has established an Office of Innovation and has implemented a framework supporting responsible innovation.[19]

- The U.S. Federal Reserve Bureau is committed to supporting responsible innovation in the financial market and has created Innovation resources on it website.[20]

- The authors of this paper have come together to create the first AML/CFT Federated Learning collective, and we are opening it up to others to join.

Those working in financial institutions, the creators of financial technology, and regulators all share the common goal of innovation. Federated Learning can help us operationalize this goal.

AI is a driver of budget spend for
35%
of the compliance sector.

40%
of privacy compliance technology
will rely on AI
by the end of 2023.

14. 2023 KPMG Chief Ethics & Compliance Officer Survey. https://advisory.kpmg.us/articles

15. "Gartner Says Over 40% of Privacy Compliance Technology Will Rely on Artificial Intelligence in the Next Three Years." Gartner. https://www.gartner.com/en/newsroom/press-releases/2020-02-25-gartner-says-over-40-percent-of-privacy-compliance-technology-will-rely-on-artificial-intelligence-in-the-next-three-years

16. FINRA. "Innovation Outreach Initiative." https://www.finra.org/about/finra-360/progress-report/innovation-outreach-initiative

17. Office of the Superintendent of Financial Institutions. "Digital Innovation Open Door." https://www.osfi-bsif.gc.ca/

18. Financial Conduct Authority Innovation Hub. https://www.fca.org.uk/firms/innovation

19. Office of the Comptroller of the Currency. "Innovation." https://www.occ.treas.gov/topics/supervision-and-examination/responsible-innovation/index-responsible-innovation.html

20. Federal Reserve. "Innovation." https://www.federalreserve.gov/aboutthefed/innovation.htm

Conclusion

What would happen if we worked together to implement Federated Learning within our institutions? What could banking and financial compliance look like by 2030? We challenge our readers and colleagues to join us in transforming our industry's operations and outcomes.

Federated Learning enables collaboration while preserving privacy, which in turn lowers costs, increases ROI, and increases efficiency. This is important in regulated industries – from medicine to banking – that are usually hindered in technology adoption.

In her 2022 article in *American Banker*, "Artificial Intelligence Can Save Banking from Itself," Shelly Liposky argues that "as advancements in safety measures across financial services have evolved, we are more accountable for anticipating what could go wrong and using tools to prevent it." Focusing on inputs such as Suspicious Activity Reports (SARs) rather than real-world impact plays a large part in the ineffectiveness of the existing financial crimes compliance regime.

With the arrival of AI and Federated Learning, banks, regulators, and law enforcement professionals will finally have transparent methods of measurement of policy outcomes, a necessary prerequisite to a better system for fighting crime and expanding financial inclusion.

With the arrival of **AI and Federated Learning**, organizations will finally have a better system for fighting crime and expanding financial inclusion.

Bios

Gary M. Schiffman

Gary M. Shiffman Ph.D.
Co-Founder & CEO

Consilient

Gary M. Shiffman applies economic science to combating illicit violence and coercion. He served in the Gulf War, has served as a National Security professional in the U.S. Senate and at the U.S. Department of Homeland Security, and has led on several DARPA-funded research programs.

He is founder and CEO of Giant Oak, and the inventor of GOST, a machine learning-based screening platform. He teaches at Georgetown University and is the author of "The Economics of Violence" (Cambridge University Press, 2020).
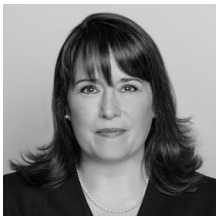
Shelly Liposky

Global Head, Business
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Shelly is a Managing Director at BMO Capital Markets where she leads a global team responsible for the first line of defense including Operational Risk & Resilience, AML, Compliance, Crisis Management, Algorithm & Automation Risk, and ESG Risk. The mandate includes preventing loss due to failure in process, people and systems and ensuring execution of the businesses in compliance with applicable regulations.

She leverages AI to increase the level of sophistication in risk management and drive efficiencies. Previously, Shelly held COO roles at BMO and Barclays and has a blend of experience in M&A, corporate infrastructure, risk and in leading large scale regulatory and business transformations.

Shelly earned an MBA from Columbia Business School, an MS from Johns Hopkins University, and a BS from Penn State University. She holds FINRA Series 7 and 63 licenses and currently sits on the board of BMO Europe PLC and BMO Harris Investment Co.

Rick Hamilton

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PNC Bank, NA

Rick has led PNC's AML modeling program since 2017. In this time, the program has adopted and productionized an array of machine learning capabilities that have improved effectiveness and efficiency. His portfolio includes suspicious behavior detection, sanctions screening, customer verification, simulation modeling, and forecasting. Rick's prior experience includes interest rate risk management, capital management, and credit portfolio analytics.

Rick earned his MS in Management Science and MBA degrees from Case Western Reserve University as his AB in Economics from the University of Michigan. His professional certifications include the Thinkful Data Science Certificate, Certified Anti-Money Laundering Specialist (CAMS), Certified AML and Fraud Practitioner (CAFP), and Fintech Innovation: Future Commerce, Information Technology from MIT.

Recommendations for Further Reading

Alqahtani, Y. (2019). "The impact of anti-money laundering regulations on banks' efficiency: Evidence from Asia." Economic Research-Ekonomska Istraživanja, 32(1), 824-842. This study examines the impact of anti-money laundering regulations on banks' efficiency in Asia, finding that regulations reduce efficiency and increase costs.

ABA Banking Journal. (February 2017). "The Cost of Compliance." This article discusses the rising costs of regulatory compliance for banks in the US and provides insights into the factors driving these costs.

ABA Banking Journal. (October 2017). "Reducing Regulatory Burden: Recommendations from America's Banks." This report provides recommendations for reducing the regulatory burden on banks in the US, including changes to the AML/CFT regime and other financial crimes compliance requirements.

ABA Banking Journal. (2018). "Banking on Efficiency: Streamlining the Regulatory Exam Process." This report provides recommendations for improving the efficiency and effectiveness of the regulatory examination process for banks, with a focus on reducing the burden on institutions.

ABA Banking Journal (May 2021). "Costs of Anti-Money Laundering Compliance for Community Banks." This report examines the costs of AML compliance for community banks in the US, and provides recommendations for reducing the regulatory burden on these institutions.

Bank Policy Institute. (November 2018). "The High Cost of AML Compliance." This article discusses the high costs of AML compliance for financial institutions, and provides recommendations for improving the efficiency and effectiveness of compliance programs.

Bank Policy Institute. (November 2019). "The Time is Now for a Better AML/CFT Regime." This report provides recommendations for improving the efficiency and effectiveness of the AML/CFT regime, including the use of technology and better coordination among regulators.

Bank Policy Institute. (July 2020). "The Promise of AI for Anti-Money Laundering and Fraud Prevention." This article discusses the potential for artificial intelligence (AI) to improve the efficiency and effectiveness of AML and fraud prevention programs.

Bank Policy Institute. (October 2020). "Estimating the Cost of Anti-Money Laundering (AML) and Customer Due Diligence (CDD) Programs." This report examines the costs associated with AML and KYC compliance and provides estimates of the total cost for US banks.

Bobek, V., & Jerman, B. (2020). "A review of anti-money laundering measures in the banking sector." Journal of Money Laundering Control, 23(2), 184-203. This study evaluates the efficiency of anti-money laundering measures in the banking sector, finding that technology can improve efficiency and reduce costs.

Brown, T. (October 2020). "The rising cost of AML compliance." Banking Exchange. This article discusses the rising costs of anti-money laundering (AML) compliance in the US, citing estimates that the total cost of AML compliance for US financial institutions is around $25 billion annually.

Button, M., & Gee, J. (2019). "The cost of anti-money laundering regulation: A cost-benefit analysis." Journal of Money Laundering Control, 22(1), 71-82. This study provides a cost-benefit analysis of anti-money laundering regulation in the UK, finding that the costs of compliance outweigh the benefits.

Cohn, M. (2019). "BSA/AML compliance costs continue to rise." Accounting Today. This article cites a survey of US financial institutions, which found that the average cost of BSA/AML compliance increased by 10% from 2017 to 2018, to reach $5.8 million per year per institution.

Hamilton, R. (2021). "The Evolving Nature of Financial Cyber Crime Behavior Detection." PECB Insights. https://insights.pecb.com/evolving-nature-financial-cyber-crime-behavior-detection/. This article offers insights into how detection methods and strategies have evolved over time to counter emerging threats in the digital realm.

Kelly, M. (November 2018). "The high costs of AML compliance." Compliance Week. This article discusses the high costs of AML compliance for financial institutions, citing estimates that compliance costs can range from 2-10% of a bank's annual revenue.

Korotova, T. (2021). "The impact of AML regulations on the global banking industry: An analysis of SWIFT data." Journal of Financial Crime, 28(2), 406-419. This study analyzes SWIFT data to evaluate the impact of anti-money laundering regulations on the global banking industry, finding that compliance costs have increased significantly since 2015.

Liposky, S. (2018). "Artificial Intelligence can save banking from itself." American Banker. Retrieved from https://www.americanbanker.com/opinion/artificial-intelligence-can-save-banking-from-itself. Liposky contends that AI can significantly enhance the efficiency of banking operations, improve customer experiences, and enhance risk management.

Liposky, S. (2019). "Using creativity to help manage risk for financial institutions." BMO Capital Markets. https://www.americanbanker.com/leaders/how-creativity-can-help-manage-risk-for-financial-institutions. Liposky shares ways in which creativity can solve specific business challenges and design innovative solutions in Operational Loss Intelligence (OLI).

Liposky, S. (May 2022). RMA Voices in Risk Management [Audio podcast episode]. Liposky discusses artificial intelligence-powered platforms and top challenges to managing technology risk.

Roberts, J. J., & Yaeger, M. L. (2018). "The rising cost of AML compliance and financial crime prevention." Journal of Financial Crime, 25(2), 263-275. This article discusses the rising costs of AML compliance and financial crime prevention, citing estimates that the total cost of AML compliance in the US and Europe is around $80 billion annually.

Shiffman, G. M. (2019). The economics of violence: How behavioral science can transform our understanding of crime, insurgency, and terrorism. Cambridge University Press. Shiffman argues that humans are more predictable than we like to believe, and this ability to model human behavior applies equally well to leaders of violent and coercive organizations as it does to everyday people.

Shiffman, G. M. (2019). "An Economist's View on Technology in the Future of BSA/AML." Presented to House Committee on Financial Services. https://www.congress.gov/116/meeting/house/109110/witnesses/HHRG-116-BA10-Wstate-ShiffmanG-20190313.pdf. Shiffman advocates for the integration of technology, particularly Machine Learning (ML) and Artificial Intelligence (AI), along with behavioral science in AML efforts to detect and deter financial crime more effectively.

Shiffman, G. M. (2020). "A step forward in reforming a global banking system that harbors criminals." The Hill. Shiffman argues that innovative technologies can ultimately reducing the economic costs associated with traditional approaches to combatting financial crime.

Shiffman, G. M. (2021). "Five keys to combatting violence: Advice for the Biden administration." The Hill. Shiffman recommends a data-driven approach that utilizes advanced analytics to identify and target high-risk areas and individuals.

Shiffman, G. M. (2021). "Data's Double Edges: How To Use Machine Learning To Solve The Problem Of Unused Data In Risk Management." Forbes. This article explains how AI and ML technologies can sift through vast amounts of financial data to identify suspicious patterns and transactions.

United Nations Office on Drugs and Crime (UNODC). (2011). "Estimating illicit financial flows resulting from drug trafficking and other transnational organized crimes." Vienna, Austria. This report estimates that the annual value of illicit financial flows associated with drug trafficking and other transnational organized crimes ranges from $1.4 trillion to $3.5 trillion, with the majority of the flows (around 90%) remaining undetected.

Zarate, J. (2001). "Terrorism, technology, and petroleum: The new al Qaeda financing puzzle." SAIS Review of International Affairs, 21(1), 123-138.

Zarate, J. (2017). "Treasury's War: The art of sanctions in an age of terror." Foreign Affairs, 96, 94-103. "Treasury's War" underscores the evolution of the Treasury's strategic role in national security, emphasizing its adaptive strategies, cooperation with international bodies, and implementation of regulatory frameworks to safeguard the U.S. and global financial systems against various threats.

Zarate, J. (2017). "The future of financial warfare: A strategy for the United States." Center on Sanctions and Illicit Finance, Foundation for Defense of Democracies. Zarate emphasizes the importance of leveraging economic tools, including sanctions and financial regulations, to counter adversaries and protect national security interests.

Zarate, J. (2019). "Pathways to illicit finance: How U.S. adversaries move money across the globe." Center on Economic and Financial Power, Foundation for Defense of Democracies. Zarate sheds light on the strategies employed by U.S. adversaries to facilitate illicit financial activities on a global scale.

Zarate, J. and Chip Poncy. (2016) "Designing a New AML System." Banking Perspectives. The Clearing House (2016). Zarate and Poncy propose a more risk-based and technology-driven approach that leverages modern data analytics and information sharing among financial institutions and government agencies.