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THE IMPACT OF TECHNOLOGICAL INNOVATIONS ON MONEY AND FINANCIAL MARKETS

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Preface

Changes in financial regulation are usually driven by responses to current failures and often generate additional, if unforeseen, risky behavior. In contrast, Hyman Minsky argued that the creation and maintenance of a robust financial system capable of supporting the capital development of the economy would require dynamic macroprudential regulation that took into account the evolving practices and technologies that continuously alter the financial structure.

Jan Kregel and Paolo Savona suggest such an approach in response to some recent innovations, such as cryptocurrencies and associated instruments based on distributed ledger technology, the deployment of artificial intelligence, and, more generally, the use of data science in financial markets. In this policy brief, they analyze the impacts of these innovations on the present institutional environment and outline an appropriate regulatory framework.

Attempting to maintain the status quo in the face of the introduction of cryptomoney will create risks that increase instability and threaten national financial systems, according to the authors. As with many innovations, they note that this new technology has had an impact beyond its original purpose. While regulators are still mainly focused on potential disruption to traditional deposits as means of payment, Kregel and Savona warn that this underestimates the potential for instruments based on distributed ledger technology to have much wider, systemic effects. The authors observe, for instance, that ICOs (initial coin offerings) represent an alternative mechanism for underwriting investment and allocating financial resources, while the proliferation of cryptocurrencies complicates the exercise of monetary policy as currently designed.

Kregel and Savona warn that a single, unregulated private cryptocurrency platform could come to supplant other cryptocurrencies and even the official payment system. What would effectively be a private monopoly on the payment system would imply loss of control over the money supply and thus debilitate monetary policy. Moreover, the dominance of a single cryptocurrency would disrupt the intermediation process, interfering with the traditional functions of banks and capital markets.

While noting that some monetary authorities seem to be inclined toward regulatory solutions that involve the coexistence of privately issued cryptocurrency alongside traditional money, Kregel and Savona argue that a public monopoly on the issuance of cryptocurrency would be the superior alternative. For instance, with a public platform, the stability of the payment system would be the responsibility of the central bank while the protection of savings would be the domain of securities regulators. Regulation would no longer be forced to serve “two masters,” as Minsky put it—that is, to secure both the stability of credit and purchasing power—which would remove a significant source of instability.

Ultimately, Kregel and Savona envision that these technological innovations, if surrounded by the right institutional framework, could promote financial stability and help repair the disconnection between finance and the real economy. Furthermore, given the proliferation of various proposals at the national level, they argue that the manner in which these technological innovations impact integrated regulatory systems in the context of the globalized digital economy dictates a similarly integrated response, with a degree of uniformity necessary between countries. As such, the authors advocate a process reminiscent of the Bretton Woods model, with an international monetary conference aimed at establishing coordination in order to secure the potential benefits of these new technologies while enabling the formation of a more resilient financial system.

As always, I welcome your comments.

Dimitri B. Papadimitriou, *President*

June 2020

Introduction

In increasingly integrated global financial markets, innovation threatens the stability of national financial institutions and the adequacy of domestic regulation. Quasi-cryptomoney—in the presence of portfolio choices and capital allocation based on algorithms generated by artificial intelligence (AI)—challenges the 20th century interface of central banks and private financial institutions that provides for the creation of the majority of the capital assets and monetary liabilities in financial markets. These innovations create regulatory uncertainty for financial institutions, and the failure to apply suitable regulation increases the potential for instability and recurrent bank and financial crises. This policy brief outlines the current institutional framework and evaluates competing proposals for managing the emergence of technological innovations such as distributed ledger technologies (DLT) and data science methods.

Prior to the era of globalization, domestic socioeconomic conditions, along with policy and regulatory responses, were the major causes of differences in national financial systems. However, globalization has mitigated these country differences, particularly in banking and capital markets—through, for instance, European Commission directives and the promulgation of global standards by the Financial Stability Board and the Bank for International Settlements' Basel Committee on Banking Supervision. As a result, financial innovations in instruments and methodologies and the national responses to them—which have generally been implemented outside formal regulatory regimes—have become the major determinants of differences in national financial systems (Kregel 2016).

Today, DLT and AI—or better, data science more generally—represent the areas of major technological innovation influencing the transparency, security, and credit evaluation that provide protection for private savings. If surrounded by an appropriate institutional framework, these innovations could help establish Hyman Minsky's ideal regulatory structure—one that minimizes both monetary and financial instability as well as periodic bank crises in order to satisfy society's demand for a stable store of value for savings, real growth, and employment.

The impact of technological innovations usually develops in two stages. Initially, they replicate existing activities (e.g., teller machines replace human tellers), but their major impact is to displace existing practices with new activities and institutional structures. Electronic payment systems using digital currencies such as Bitcoin and tokens based on encrypted digital

ledger accounts were initially promoted as more efficient substitutes for bank notes, bank deposits, or bank transfers. Yet these innovations have the potential to displace bank liabilities as the dominant means of payment and threaten revenues for traditional banking institutions. And while the introduction of DLT can guarantee transaction security and transparency, the choice of private or public platforms will have an impact on monetary policy. For example, if the incentive structure for verifying private transaction chains determines the creation and distribution of digital currency (e.g., via mining), this would require reformulation of monetary policy instruments and objectives. Further, the creation of hundreds of private cryptocurrencies already in circulation (Bitcoin, Ethereum, tokens, etc.) creates substantial difficulties for monetary policy designed for a system organized around the control of interest rates for regulated institutions.

Competition in the introduction of digital currencies via initial coin offerings (ICOs) represents an alternative mechanism of underwriting private investment and threatens investment banking activities, as well as providing an alternative mechanism for allocating financial resources. While data science may deliver more effective portfolio allocation of private savings, it may also distort the allocation of funds for productive investment.

These changes have generated and will continue to generate subsequent actions and actors outside the confines of traditional monetary and capital market regulations, and have drawn the attention of government regulators in a number of countries. An array of different responses has been proposed, initially concentrated on the impact of technology on payment systems: e.g., Sweden has proposed the “e-krona,” and China has announced the introduction of a generalized electronic payment system in the presence of an already well-developed private system of digital payments. Other central banks are also considering the choice between public and private management of digital payments. Many supranational organizations have published reports on the subject—such that there is now an excess supply of proposals for practical implementation that are centered on private initiatives.

However, the generalized impact of these technological changes across integrated regulatory systems suggests that a more uniform approach is required—establishing coordination of measures across countries in line with the Bretton Woods model for Western countries. The aim should be to capture the benefits of the new technology and eliminate the instability inherent in the existing institutional structure—instability that was partially sustained by the regulatory responses to the recent

global financial crisis. Indeed, these new technologies suggest the response should go beyond simple domestic regulatory changes and imply the need for changes to the direct role of government in regulating financial markets across countries.

Here we argue that the greatest benefits from the new DLT systems would result from their implementation in a public platform overseen by the monetary authority. This would increase financial stability and enable the design of more effective monetary policy. However, this public platform approach would concentrate credit and funding risks in the private financial institutions that are providing financing for investment in capital markets. In sum, the ability of monetary policy to ensure the stability of the means of payment's purchasing power (inflation) would be enhanced, and the necessity for various national prudential regulations designed to counter risks associated with private payment systems would be reduced or eliminated. At the same time, more effective and extensive capital market supervision and regulation would be necessary for monitoring the increased funding and credit risks of private provision of investment financing and to ensure the stability of assets for savers' private portfolios.

The proposed changes should ensure that:

- Payment systems grounded in DLT guarantee complete transparency for participants and are impregnable.
- Electronic assets and liabilities composing the money payments system are secured by a public agency. In the case of loss or disruption due to cyberattack, the state (or states, as in the EU) would fully compensate any loss of value.
- Application of data science to investment and saving choices improves due diligence and assessment of creditworthiness, reducing subjectivity in valuation and reporting.

Monetary Creation Today and Tomorrow

The majority of the liabilities in the current monetary system are the result of banks' multiplication of the money base created by public authorities, through the grant of bank credit matched by creation of deposit liabilities or deposit transfers credited to enterprises and households. The formulas economists use to study the deposit and credit multiplier are well-known and widely applied by both authorities and market participants to monitor conditions in money markets. Such formulas take into account the multiple avenues by which this credit creation process supports

the payment system, yet they continue to ignore the impact of electronic cryptocurrencies—such as Bitcoin or others used as means of payment.

Application of these innovations is evolving rapidly. Approximately 100 electronic currencies exist today, many of which are considered “crypto” currencies: i.e., they circulate in an encrypted habitat where ownership is represented by predetermined codes and transferred by means of decentralized accounting procedures only accessible to participants in the mechanism. So-called “tokens” have also developed, issued in connection with an ad hoc private funding mechanism (the ICO). In the absence of regulation, tokens have created some problems for the functioning of regulated capital markets and the protection of savings, due to a weak creditworthiness assessment mechanism. The importance of controlling the issue of cryptocurrencies was highlighted by Facebook's intention to create an electronic currency, the Libra, for use by its millions of members worldwide.¹

The case for public provision rests on the undesirable consequences of a purely private platform. Since the acceptability of private means of payment is determined by the generality of its ability to complete purchases and extinguish debts, the most extensive platform will soon come to dominate others—even the traditional official payment system—creating a de facto private monopoly in the payment system.² Given the global dominance of Facebook in social media, it quickly became obvious that the Libra would start as a near monopoly with Facebook users. Since governments are unlikely to accept complete loss of control over the money supply and the evisceration of monetary policy, there will have to be regulations—which are in any case difficult to establish and control in a DLT framework—or a government cryptosystem of payments that is different in nature but functionally equivalent.

In addition, the creation and dominance of a single, widely used cryptocurrency would produce disruption of the linkages between the monetary system and the provision of investment funding traditionally carried out in banks and capital markets. Economists have long debated the advantages and consequences of purely private money creation relative to the current public-private mechanism, but the disruption of intermediation caused by the implementation of a payment system based on DLT requires an assessment of the possible radical institutional and regulatory consequences.

While most national monetary authorities are examining the issue, they have been hesitant to act to influence the outcome.³

They argue the phenomenon has not reached levels significant enough to impinge on the operation of monetary policy, and thus a regulatory response is not needed, while at the same time allowing experimentation with various alternative approaches. This equanimity, however, fails to allow for the possible emergence of a dominant digital payment system that displaces the existing system and is outside formal regulatory control. At present, monetary authorities seem to be solely focused on cryptocurrencies' disruptive effects on deposit banks rather than seeking systemic alternatives.

Some national monetary authorities have reached the conclusion that electronic currency issuance should be a public monopoly, preserving control over the money base. China is expected to implement the decision by 2020; other countries (Russia, Australia, Finland, etc.) announced they are considering following suit.

The technology that lies behind the creation of an electronic means of payment is mature and can be made subject to basic legislation by relevant legal authorities. However, the political motivation for establishing a public monopoly on the issuance of cryptocurrency is still lacking, constrained by the typical objections to technological innovations based on ethical protections (primarily the right to privacy). At this stage, it is possible to lay out an accounting framework to assess the differences between the existing monetary system and a representation of possible digital alternatives (Table 1).

In Case A (public platform), the central bank provides for the stability of the payment system and securities regulators are responsible for the protection of savings. Regulation would no longer have to "serve two masters," in Minsky's terminology (i.e., ensure the stability of credit and the stability of the means of payment), thus eliminating instability produced by linking the value of household and company deposits to the assets that the banks finance. Both functions must respond to requests for a store of value, which, for the former, primarily implies the guarantee of having a stable capital value of invested savings; for the latter, it implies the guarantee of currency purchasing power stability.

In Case B (coexistence of traditional money [M2] and private cryptocurrency, which appears to be the solution preferred by most monetary authorities), market balances are more complex, exacerbating the already difficult management of monetary policy and public financial controls without attaining—and possibly complicating—stability in credit and financial markets. The European Union's sovereign bonds crisis after the 2008 world

financial crisis is a case study of such perverse links. If monetary authorities accept private cryptomoney, the main control tool would be a mandatory reserve composed of the monetary base and financial assets collected in exchange for cryptocurrency issuance, so as to dissociate the power to issue money from the power to use the proceeds thereof. The balance would be restored if this reserve were held by a public body at a reserve ratio of 100 percent.

Table 1 Cryptocurrency under Alternative Accounting Frameworks

Old Accounting			
Central Banks		Banks	
Credits to banks Credits to public Credits to Treasury	Monetary base	Credits to clients Financial assets Monetary base	Deposits Debts to central bank
Enterprises and Families			
Monetary base Deposits	Debts to central bank Debts to banks		

Note: Credits and debts are the two sides of a contract.

New Accounting			
Case A: Cryptocurrency Issuance as a Public Monopoly			
Central Banks		Banks	
Old currency Financial assets	Cryptocurrency	Credits to clients Financial assets Cryptocurrency	Financial liabilities
Enterprises and Families			
Cryptocurrency Financial assets	Debts to banks		

Note: Financial assets and financial liabilities (likewise credits and debts) are the two sides of their related contracts (issuing liabilities and granting loans).

Case B: Issuance of Private Cryptocurrency with 100 Percent Reserve			
Central Banks		Banks	
Credits to banks Credits to public Credits to Treasury Cryptocurrency reserve	Monetary base	Credits to clients Financial assets Monetary assets Cryptocurrency	Debts to central bank
Enterprises and Families			
Monetary base Deposits Cryptocurrency Cryptocurrency reserve	Debts to central bank Debts to banks Cryptocurrency		

Note: Credits and debts, and assets and liabilities, as in Case A; the reserve is equal to the collection of monetary base and financial assets from private subjects in exchange for the creation of cryptocurrency. If reserves are below 100 percent, then accounting becomes more complex.

If a central bank (or public-money-issuing institution) were entrusted to collect reserves, it would be involved in financial management activities that would turn it from a referee or regulator into a principal participant. Conversely, if a bank were designated to hold the reserves, this would strengthen its own function of collecting savings and granting credit with nonmonetary means, neutralizing the main source of banking crises, such that we have recently observed. These banks should resume the traditional banking function of "creditworthiness magistrates"—indispensable for selecting entrepreneurs capable of making good

use of the loans received and repaying them, and thus ensuring proper functioning of the credit market. Such a function is by now almost obsolete, as banks can gain profits from the payment system or from a mere intermediation activity without taking on and evaluating risks.⁴

When the system comprises more than one cryptocurrency, it would be possible to establish differential reserve ratios that further complicate monetary and financial management (as well as accounting). Above all, they would complicate the pursuit for market balances. It would then be difficult, but not impossible, to calculate the credit or deposit multiplier so as to determine the “optimal” amount of money (if any). This is still an unexplored world.

Finance Today and Tomorrow

It has been said that money, under the pressure of technological innovations, will dissociate itself from finance but will remain anchored to the real economy and continue to act as a means of payment. Yet, it is more likely that money will continue to be the handmaiden of finance, as financial innovations (or “fintech”) still prevail over those aimed at financing the real economy. The phenomenon, known as the “financialization” of the economy, has greatly increased the size of financial production compared to real production, accentuating its role as a store of value for savings. This feature is linked to the popular and conventional notion that possessing financial assets, which necessarily have an equal counterpart in financial liabilities, is “equivalent” to possessing real assets. However, this is based on two assumptions not always taken into due consideration by savers: that liabilities are convertible into money and money has legal value (or it cannot be refused) for repaying debts. If currency were deprived of such features, we would be lacking a solid theoretical and practical basis for validating the commonly agreed upon equivalence (money has purchasing power) mentioned above. Both possession of money and financial assets involve risks, respectively linked to inflation and credit risk. Central banks are required to prevent the former; capital market regulatory and control institutions are in charge of preventing the latter.

In the current institutional setup, the inflation risks are added to risks for nonreimbursement of deposits due to banking crises, often the result of the absence or deficiencies of due diligence in the assessment of creditworthiness. In order to provide deposits with a safety shield, voluntary and/or mandatory guarantee systems have been established based on insurance funds (in

the United States) or mutual mechanisms between banks (in the European Union). The use of cryptocurrencies issued by a public authority would remove such risk and eliminate the need for the existing deposit guarantee funds. In contrast, if the means of payment were to be provided by private cryptocurrency platforms, the encrypted electronic money would be exposed to an equivalent risk of insolvency without any protective safety net.

Technological innovations change the nature of risks related to credit securities—both money and finance must be placed in this technological context, if not in its legal framework. The definition of basic innovations in the money and credit markets under the new technological conditions requires special attention, which has so far been highly insufficient.

The case of derivatives is a textbook example. Although introduced with the aim of better risk management, they actually ended up creating new risks, to the extent that in 2008 their dissemination caused the already-quoted worst global financial and real crisis since that of 1929–33.⁵ After generating a pyramid of accounting records based on traditional securities (stocks, bonds, and other more complex financial instruments), bankers and financial market participants have now directed their attention toward the creation of new nonregulated or minimally regulated instruments (such as ICOs, crowdfunding, tokens, etc.)—taking advantage, from the time of their introduction, of the benign neglect by authorities. The prevailing principle among financial market participants has always been that regulatory arbitrage increases profits. As a result, the risks created are shifted onto savers (most often small ones), and profits take the form of commissions paid to intermediaries regardless of the results attained.

Peer-to-peer (P2P) systems, such as Lending Club, represent an advanced form of this process: an electronic intermediary takes on the contractual task of directly linking borrowers and savers in return for fees and commissions. Since there is no financial intermediary between the borrower and lender, due diligence of commercial and investment activities as well as regulation of the borrowers tends to disappear as risks are taken on by the lenders. The dissociation between finance and the real economy is mended by risks being transferred onto savers that participate in direct contact with credit applicants. The oversight and due diligence of borrowers’ credit that used to be entrusted to private rating agencies and public authorities (which, we know, operate in a domain subject to practical difficulties, conflicts of interest, or political influences) disappears.

The Prospective Role of Technological Innovations in Finance

Risk management improves as the quality and quantity of information increases, hence the need to expand the contents of the database (or data lake) that supports the objectives pursued. These stores of information are available in several financial sectors with vertical characteristics, which need to be more fully integrated. The magnitude of the system increases the need to rely on a quick method of access and use. The stock exchange is equipped with such a repository and, not surprisingly, stock exchange negotiations are currently the most dependent on AI methods that generate increasingly sophisticated algorithms. Trading will soon take place on a P2P basis, and market sentiment or market value will no longer result from operators' intuitive evaluations of pricing, but on improving the information-processing algorithm or identifying who will be able to do so.

An important step lies between the database creation and the use thereof, as per data science methods: namely, transparency with respect to the source of the data. As noted above, the DLT technology is not only important for cryptocurrencies, but also for constructing a satisfactory certified data lake. The wider the use of this tool, the more efficient the control of data transparency/truthfulness in valuation and reporting. In corporate governance and public controls, moving from traditional reports to an electronic certification of decisions made has revolutionary effects. For instance, if the credit-granting process is reported with DLT mechanisms, then in the case of default, for instance, there would be an objective verification of the conditions producing the declaration. Internal and external controls on private/public financial operators would be easier and faster, hence more effective—this, much more than simply automating the conditions of written contractual relations, is the essence of so-called “smart contracts.”

Once the decisionmaking process has gone through a DLT database, it is then possible to proceed to applying data science methods to provide decisionmakers with objective bases for their choices. Currently, the most advanced methods mathematically simulate the ways in which human brains work (neural method), express the rules of chaos with logical mathematical tools (swarm analysis), and detect the law governing the evolution of the variable analyzed (genetic or Darwinian approach) (see Domingos 2015, Bostrom 2014, and Brain 2012).

The three phases would reanchor finance to the real economy, as investment choices would also be tied to an array of

variables mirroring the productive universe. A similar decision-making structure would tend to reduce the size of financial transactions “for their own sake,” as they would operate within spaces emerging from the competition between computers/algorithms, generating a more stable market—even potentially eliminating the causes for instability as we know them (thanks to the analyses of financial instability proposed by Kindleberger [1978] and Minsky [2008]).

Conclusions

History is populated with repeated examples of the consequences of a financial expansion that generates real crises with high social costs. Geopolitical balances themselves have been affected. The main responses have consisted of a proliferating series of rules of conduct that failed to solve the issue of financial instability. Money remained involved in the crisis and dragged monetary policy into an improper—albeit inevitable—dimension (i.e., unconventional policies and negative interest rates). Finance has changed, moving toward unregulated instruments—not necessarily more risky, but certainly more exposed to risks—and ending with increased risks for private savers.

If authorities insist on merely improving the rules of the old monetary-financial system, and financial operators keep resisting innovative changes instead of shifting to a DLT-AI based system, conditions of instability and their related crises will persist. A DLT-AI based system would resolve the dissociation between finance and the real economy by reestablishing a direct relationship between, first, credit applicants and savers and, then, between investment and growth. It is a highly challenging task, yet not impossible—if, along with the design of the new system, an ad hoc program is devised to cope with transition risks, mainly for deposit banks.

Attempts to respond to difficulties in managing financial markets and to limit risks for savers will not be effective in the current institutional framework. Maintaining the existing system in the presence of the current wave of innovations will inevitably lead to risks that will challenge the stability and survival of companies and national financial systems. Proposals for the implementation of these innovations should not be postponed and should be the subject of an international monetary conference, since the decisions on these issues must be placed within the context of the globalized digital economy. As in the development of the Bretton Woods system, the conference should consider the possibility of creating a single reference cryptocurrency (a modern Keynesian

bancor) or an international clearing mechanism linked to exchange ratios between cryptocurrencies—which cannot follow the framework of present foreign currency markets.

Notes

1. The proposed name—Libra, or “livre” (lira or pound)—recalls the duodecimal money system (12 denier equal one sous, 20 sous equal one livre) created by Charlemagne and the fact that only the denier was minted, leaving the lira as what economists refer to as “imaginary money.”
2. See Kregel (2016, 29). In support of this belief, Kregel cites Henry Kaufman’s work (2000, 2012).
3. Among the most recent, see Bindseil (2020).
4. This role performed by major international banks is known as P2P (person-to-person or peer-to-peer)—Lending Club being a leading example—which eliminates credit granting expertise and the creditworthiness assessments of traditional commercial banking and substitutes computer algorithms or AI. Kregel (2016) lays out a documented analysis of these practices.
5. An analysis of the need for more detailed assessment of the risks created by derivative contracts and their extended application in the financial system is set out in Savona (2014, 147–54).

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JAN KREGEL is director of research at the Levy Economics Institute of Bard College and head of its Monetary Policy and Financial Structure program. He also holds the position of professor of development finance at Tallinn University of Technology. In 2009, Kregel served as Rapporteur of the President of the UN General Assembly's Commission on Reform of the International Financial System. He previously directed the Policy Analysis and Development Branch of the UN Financing for Development Office and was deputy secretary of the UN Committee of Experts on International Cooperation in Tax Matters. He is a former professor of political economy at the Università degli Studi di Bologna and a past professor of international economics at Johns Hopkins University's Paul Nitze School of Advanced International Studies, where he was also associate director of its Bologna Center from 1987 to 1990. Kregel has published extensively, contributing over 200 articles to edited volumes and scholarly journals, including the *Economic Journal*, *American Economic Review*, *Journal of Economic Literature*, *Journal of Post Keynesian Economics*, *Economie Appliquée*, and *Giornale degli Economisti*. His major works include a series of books on economic theory, among them, *Rate of Profit, Distribution and Growth: Two Views*, 1971; *The Theory of Economic Growth*, 1972; *Theory of Capital*, 1976; and *Origini e sviluppo dei mercati finanziari*, 1996.

In 2011, Kregel was elected to the Accademia Nazionale dei Lincei, also known as the Lincean Academy, the oldest honorific scientific organization in the world. Founded in 1603, the academy counts Galileo Galilei among its original members. It has remained an elite organization of only 540 members, with only 180 of those from outside Italy. Although the academy covers all scientific and literary fields, Kregel is a member of the division for moral, historical, and philological sciences; specifically, the social and political sciences. Robert Solow, Amartya Sen, the late Paul Samuelson, and fellow Levy Senior Scholar James K. Galbraith are among the other American economists who have been elected foreign members of the academy.

Kregel studied under Joan Robinson and Nicholas Kaldor at the University of Cambridge, and received his Ph.D. from Rutgers University under the chairmanship of Paul Davidson. He is a life fellow of the Royal Economic Society (UK) and an elected member of the Società Italiana degli Economisti. In 2010, he was awarded the prestigious Veblen-Commons Award by the Association for Evolutionary Economics for his many contributions to the economics field.

PAOLO SAVONA is chairman of the Italian financial markets' authority, CONSOB (Commissione Nazionale per le Società e la Borsa), and formerly Italy's Minister of European Affairs. An emeritus professor of political economy at the LUISS-Guido Carli University, Rome and a cum laude graduate in economics, he began his career at the Bank of Italy (1963-76), where he became director of the financial market office within the research department. He undertook special studies in monetary economics and econometrics at the Massachusetts Institute of Technology under the tutorship of Charles P. Kindleberger and Franco Modigliani. He also carried out research at the Federal Reserve Board of Governors' special studies section in Washington, D.C.

Savona has served as general manager of the Italian Confederation of Industry (1976-80); secretary general for economic planning, Italian ministry of budget (1980-82); chairman, Sardinian Investment Banks (1980-89); director general, Lavoro Bank (1989-90); president, Fondo Interbancario di Tutela dei Depositi (1990-99; 2010-12); and head of the European policy department, office of the prime minister (2004-5). In 1993-94, he served in the Italian government as minister for industry, with a mandate to privatize state industrial holdings. He is author of the first econometric model of the Italian economy, M1BI, and of many publications on monetary and financial economics, the workings of the eurodollar market, the macroeconomic effects of derivatives contracts, and the impact of structural differences in productivity in the operation of the eurosystem.