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The Innovation Bank: Blockchain Technology and the Decentralization of the Engineering Professions

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1.0 Abstract
The Innovation Bank is a novel method of business related to the integration and capitalization of knowledge assets. The Innovation Bank is an application of game theory, actuarial math and a simple native "proof-of-stake" blockchain. The system aims to unify the global engineering and scientific disciplines by incentivizing individual practitioners to form knowledge asset networks among each other by producing claims and validations related to physical, measurable, and observable facts. Each claim and associated validation forms a node in a network for which each participant is awarded a cryptographic token memorializing earned stake (equity) in the system. A secure, validated, and decentralized knowledge repository and access management system is secured by a simple native blockchain. Revenue is generated through the liquidation of earned tokens on an external market to third parties seeking access to network metadata for business intelligence. The intrinsic value of the network grows as the number of participants increases. As participation increases, the quantity and quality of the transaction records also increases. Third-party buyers may include banks, insurance companies, and private enterprises.

2.0 Keywords: Asset, bank, blockchain, decentralized, economics, engineer, knowledge, innovation, network, risk, tangible, value.

Nomenclature

κ	capital	\$
B	sensitivity to market volatility	\$
D	data	bits/block
$E(R_i)$	expected rate of return	\$
$E(R_m)$	expected market return	\$
HV	hierarchy value	\$
i	information	bits/block
I	innovation	bits/block
K	knowledge	bits/block
n	number of network nodes	
NV	network value	\$
R_f	risk-free rate of return	\$
V	value	\$
W	wisdom	bits/block
Q	Economic growth	\$

3.0 Introduction
There are currently few methods to directly measure the contribution of the engineering professions on economic growth. To do so would impact everything from individual compensation models to prioritization of what gets engineered and what does not. With trillions of dollars of infrastructure needs, deferred maintenance, and global systemic risks pounding away at legacy economic models, it is largely up to the engineering profession to modernize itself. It is time to reinforce the ideal to uphold the standards and dignity of the engineering profession and to serve humanity by making the best use of Earth's precious wealth [1]. The Innovation Bank further addresses the National Science Foundation program mandate for a systematic application of knowledge towards the production of useful products, processes and outcomes [2].
The Innovation Bank is being designed to enable the formation of a research and development platform where "innovation circuits," i.e., parallel and series iteration, tangential innovation, and comprehensive innovation ecosystems, may be readily modeled and deployed algorithmically at scale. The Innovation Bank once fully implemented, will reveal what combination of "knowledge assets" would have the best probability of executing a specific objective. The Innovation Bank reveals the concentration of knowledge assets, their rate of change and relative impact on communities within a geographical or digital domain [3]. The Innovation Bank excludes irrelevant data such as age, gender, race, or political affiliation. The Innovation Bank augments engineer compensation not unlike royalties on value created [4].

The resulting network curated in The Innovation Bank may be overlaid or combined with other network databases such as Wikipedia, university directories, or disaster relief maps, to precisely allocate the right knowledge assets in a validated and secure manner - rapidly and at scale. The increased visibility of the profession and value-based compensation system will attract a new and diverse younger generation to aspire to STEM professions.

4.0 Background

The practical basis is well documented by this research team across multiple industries. The theoretical basis for value networks is well established in the literature for which a brief overview is provided herein. The current instability in the world appears to have created an opening for new ideas to emerge in the hope of filling the gaps forming across existing organizations and institutions.

4.1 Empirical Background

The current project is a progression of projects by these authors, and many others across several business applications and technology domains. The following is an overview of the live projects and subsequent lessons learned.

1993-1997: Seminal research initially responding to the ratified NAFTA Mutual Recognition Document for professional engineers. In cooperation with CETYS University *(Centro de Enseñanza Técnica y Superior)* this project prepared and sent 250 engineers educated in Mexico to the NCEES EIT exams demonstrating a pass ratio comparable to U.S. engineers [5].

Lesson learned: the relatively lower economic development in Mexico (c.1994) was not due to academic deficiency of the engineers, rather, it was due to gaps in insurability (systemic risk) that constrains public and private investment.

1998-2008: The Boeing Company sought to close the knowledge gap between senior engineers and junior engineers. By expanding the breadth of work, senior engineers were found to have as much to gain working with junior engineers as juniors were to gain working with Seniors [6].

Lesson Learned: The solution was to create an internal "free market" matching supply and demand for knowledge assets within an integrated network community.

2010-2011: Social Flights was a ride-sharing service for private jets. Predating "Uber," the goal was to sell empty seats on private aircraft resulting from dead legs and under-utilization. Given many variables of a heavily regulated industry, a discrete booking solution was not possible [7].

Lesson Learned: A statistical solution was developed where Social Flights was able to predict the likelihood that seats would be filled based on social network connectivity.

2013-present: Community Engineering Services, PLLC (dba CoEngineers) is a loosely associated group of independent engineers that collaborate rather than compete to serve unmet market needs of a diverse range of projects and clients [8].

Lesson Learned: a value network can often solve novel and diverse problems, faster, cheaper, and across a wider geographic area than a centralized engineering company.

2017-2019: The Integrated Engineering Blockchain Consortium was the first blockchain application designed by engineers for engineers. IEBC developed and tested token distribution and blockchain operations specific to goals of this paper [9].

Lesson Learned: Engineers respond favorably to the formation of interdisciplinary networks where interactions are memorialized through the trade and exchange of cryptographic tokens secured by a blockchain.

4.2 Theoretical Background

According to Nobel Laureate Robert Solow, nearly 80% of economic growth may be attributed to technological change rather than classical factors of production [10]. In order to measure this value, Solow introduced the Vintage Capital Growth Model postulating that new capital is more valuable than old (vintage) capital because new capital is produced by more productive technologies. Solow was able to articulate this idea with the introduction of the aggregate production function with factors of labor (L), capital (κ), and time (t).

$$Q = f(\kappa, L, t) \tag{1}$$

Solow used time as a "fudge factor" to represent technological change allowing him to visualize the missing attribution from existing data. This idea is relevant to The Innovation Bank because technological change is the exclusive domain of STEM professionals. What is not obvious, is the ability to directly measure the contribution of engineers and scientists on the economy. As a result, such knowledge assets are often relegated to the "intangible" column of the corporate balance sheet.

Individual attribution and / or class-wise attribution toward economic growth has been the topic of a substantial portfolio of literature from business management to social scientists. Such luminaries include Jane Jacobs, *The Death and Life of Great American Cities;* Peter Senge, *The Fifth Discipline: The Art and Practice of the Learning Organization;* Everest Rodgers, *Diffusion of Innovation*; Richard Florida, *Rise of The Creative Class;* Clayton Christianson, *Innovator's Dilemma;* and Verna Allee, *The Future of Knowledge: Increasing Prosperity through Value Networks* - all of whom have influenced this project in various ways beyond the engineering profession.

4.3 Knowledge Management

The knowledge management discipline arose from the need to understand higher-order thought processes on productive outcomes and the application of academic rigor to such observation. One of the important works cited in the formation of the Innovation Bank was the DIKW theory; data-information-knowledge-wisdom hierarchy, advanced by Jennifer Rowley. DIKW provides a framework for extracting insights and value from all sorts of data: big data, small data, smart data, fast data, slow data, etc. [11] (Figure 1).

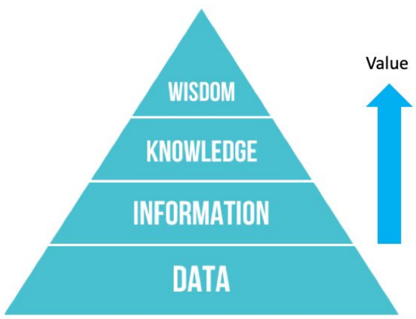

Figure 1: *DIKW model, adapted from Rowley 2006 [11].*

The DIKW model has advantages and limitations. Limitations include the inability to drive actionable strategy. Borrowing from Robert Solow's vintage capital technique, an interpretation of DIKW was developed for The Innovation Bank by adding a time function treating the hierarchy as derivatives, e.g., the value of knowledge is derived from the value of the information which supports it, and so forth.

4.4 The State of the Profession

The engineering professions are segmented in ways that have little relation to the physical laws to which they answer. Engineers are segmented by state laws, national boundaries, insurance pools, academic majors, and the secretive corporate veil, to mention a few. An engineer that works for Boeing cannot easily work for Bechtel even though building systems and aircraft systems have more in common than not. Rather, one would encounter two industries with completely different ontologies that separate them. A mechanical engineer and an electrical engineer often work from different silos even though few examples exist of purely electrical or purely mechanical systems. Software engineers are not considered by some engineers to be "real engineers" despite the fact that all engineers depend on software engineers, and vice versa. The cost of punitive and administrative controls is often borne by the public in the form of licensure boards, a litigious legal system, or corporate IP and associated paywalls.

The problems of the future will require precise and proximate application of diverse combinations of knowledge assets. Solutions must resemble the problems; not unlike a virus, solutions must address systemic risks along the same patterns that such risk occurs. Today, engineers are confined by the necessity for so-called "innovation" to be translated onto a business template for a 3rd-party gatekeeper, who is often not an engineer, to interpret. There is no common ontology that covers all STEM professions and no way to measure the engineer's direct economic interaction with the real physical world. The engineering professions are like an orchestra without a conductor – a staggering omission by any account.

4.4.1 The Invisibility Paradox

By example, a firefighter has little value until there is a fire, then the firefighter is instantly worth millions of dollars per hour preserving life and property. By contrast, fire protection engineers can design buildings that will not burn. But their value is difficult to measure in the absence of the fire. Instead, the value of the engineer becomes commoditized at time-rent wages that increasingly fail to attract sufficient quantities of new and diverse entrants, thereby increasing risk. Dr. Robert Solow goes on to suggest that the value of [engineers] is incorrectly attributed to more visible and easily measured factors of production [such as land, labor, and capital]. This represents a tragic flaw in our economic system which may be easily corrected if engineers were enabled to organize in a different manner.

4.4.2 Risk Management

In reality, engineers and scientists remove risk from complex physical systems such as buildings, airplanes, computer programs, etc. – that is their superpower. In the right form, risk is a relatively simple quantity to measure and manage as a tangible financial instrument founded in actuarial math. The three components of risk management are [12]:

- identify risk exposure
- determine probability peril will manifest
- define the consequences should the peril manifest

Answering these three questions is the stock and trade of the global insurance industry, US military, airplane designers, etc.

More specifically, the SPE model of risk management expresses risk as a function of Severity, Probability, and Exposure [13].

$$\text{Risk} = f(S, P, E) \tag{2}$$

Risk = Severity × Probability × Exposure where specific values for SPE are ranked on a scale of 1-10 as interpreted by an adjudicator.

The Innovation Bank crowdsources such risk assessments to a shared ledger. The ledger curates a comprehensive state of the physical world as seen through the collective opinions of STEM professionals.

By example, the Centers for Disease Control (CDC) curates a comprehensive record of mortality data for humans provided by licensed doctors and accredited hospitals. It is then a relatively simple matter to calculate the net present value (insurance premiums) for any number of ailments – this is largely the basis of the US healthcare system. Yet, no such repository exists for the built environment [14].

4.4.3 The Built Environment

- Buildings, machinery, and infrastructure for which a permanent physical manifestation exists.
- Inter-related, but distinct from the artistic, the financial, or the political environment.
- Trade Off between economic health and public health is largely played out in the built environment.
- The built environment is the domain of STEM professionals and practitioners.

The built environment is itself a product of innovation. We propose that the best way to secure this environment is with The Innovation Bank.

5.0 The Innovation Bank

The Innovation Bank is an application of game theory, actuarial math, and a native "proof-of-stake blockchain". Its purpose is to integrate and capitalize knowledge assets. The Innovation Bank consists of a network of individual engineers and scientists incentivized to form data (*D*), information (*i*), and knowledge (*K*) among themselves from which innovation, (*I*) and wisdom (*W*) may be discerned. This network is expressed upon a ledger composed of claims made by individual practitioners, which become irreversibly paired to corresponding validation of those claims made by other practitioners in the network. Each pairing forms a single node with two branches constituting a knowledge asset – "*K*-asset" – which is memorialized by the creation of an electronic token awarded to each participant in a pair. The aggregate network of *K*-assets forms independently of jurisdictions, corporations, or ontological silos thereby eliminating related brokerage and semantic friction. The intrinsic motivation of the practitioners is to accumulate tokens as they curate their own transaction record. Conceptually, the transaction records may substitute for one's résumé. Unlike a résumé however, the transaction record serves as an electronic key that permits access to sensitive data or external databases. For the non-practitioner, a *K*-asset network of sufficient density would yield extraordinary "business intelligence" for which they would be willing to access by purchasing tokens on an open market. As the "game" progresses with increasing numbers of validated claims, originators of the original claims are awarded proportionally to their "stake" in the game in a manner similar to how royalties, dividends, or annuities are paid.

5.1 What is a blockchain and why is it important?

Despite the solidity that the name implies, a blockchain is purely computer software. Blockchains exist because computers are very good at copying data, and very poor at <u>not</u> copying data. Without a blockchain, things like contracts are difficult to execute electronically since either party can modify the terms and neither can prove which is the valid contract without a 3rd-party intermediary such as a bank, broker, lawyer, escrow service, etc. In other words, a blockchain replaces many types of brokers and intermediaries [15]. The economic implications of this should be obvious.

A second and more interesting vector for blockchain technology can be described as blue sky / green field applications: the discovery of the things that can only be done with blockchain that would never have been viable without blockchain. For example, the blockchain may serve as a timekeeper, metronome, datalogger, etc., to organize an unlimited number of events with respect to time.

Both of these use cases are incorporated to operate, secure, and deploy the Innovation Bank.

For illustrative purposes, a blockchain is to information what a check-valve is to water, or what a diode is to electricity. It allows for the flow of information in only one direction with respect to time and forbids flow in the opposite direction. Just as a world without check valves or diodes is nearly unimaginable today, we reflect on how primitive our present organizational structures will appear once The Innovation Bank permeates the engineering and scientific disciplines.

5.2 Blockchain as a time function

It is not a trivial task to render a computer unable to copy data. In fact, the mathematics are quite daunting. Consider a high-security penitentiary where one must pass a series of steel doors in order to exit. The doors are on timers so that the door behind must be closed before the door in front opens, thus creating a one-way prisoner flow. In spy movies, synchronization of watches is critical to mission success. In navigation, all GPS satellites must agree on the time to within nanoseconds. The same is true of stock market transactions. In engineering calculations, gravity, viscosity, elasticity, pendulum length, diffusion constants and heat transfer coefficients dictate time constants. Blockchains serve the role of the conductor to the orchestra providing consensus to the valid time interval within which decentralized events are coordinated.

5.3 What are tokens and why are they valuable?

Consider the door actuation in the previous example, every time a transaction is completed, the blockchain produces an electronic token analogous to a receipt one gets from the Home Depot to memorialize the purchase of, say, contractor tools. For a certain period of time, a valid receipt can be used to claim a warranty, return the object for cash, exchange for another object, discover accessories, etc. If your shop is robbed, the receipt serves as title to the property and is redeemable by an insurance policy or police investigator. In a very generalized way, the receipt represents value, but is not intrinsically valuable. In a community of economic actors who agree that such receipts represent the productive value of the contractor, they may be exchanged without actually exchanging the tools. Our money today similarly represents the gross domestic product of appliances, machinery, buildings, etc. Herein lies both great promise and great problems.

Modern blockchain technology arose with the advent of Bitcoin and has since been implicated in dubious transactions, epic thievery, and fringe politics [16, 17]. Blockchain has also been rebranded as "Decentralized Ledger Technology" by mainstream firms such as IBM, Amazon, and Microsoft to help companies offload administration workers (along the lines of classical mechanization theory) without invoking "Silk Road" comparisons.

6.0 The Formulation of the *K*-Asset

Corporate leadership frequently claims: "Knowledge is our greatest asset." However, few actually treat knowledge like an asset because it cannot be measured directly. The value of an asset can only be determined if both the quantity and quality are known. An 8-ounce glass of drinking water is a completely different asset than 8-acre-feet of irrigation water, yet each possesses a nearly identical formulation.

For the purposes of The Innovation Bank, a *K*-Asset node and two branches form when two practitioners produce a validated claim (Figure 2). The claim serves as the quantity (definition) and the validation serves as the quality (characteristics) of the node. The blockchain records the asset in time and produces a receipt token(s) issued to each participant. The *K*-Asset is the fundamental unit of value formed by The Innovation Bank. Various combinations of *K*-Assets yield products, services, and solutions for mitigating systemic risk.

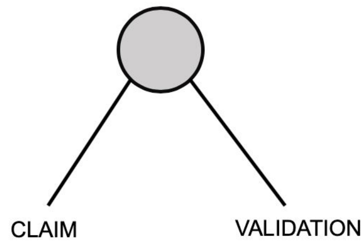

Figure 2. *K-Asset represented by a node and two branches. The K-Asset is the fundamental unit of account for the Innovation Bank.*

6.1 Network Value (NV) vs. Hierarchy Value (HV)

Modern warfare demonstrates that a large command and control military (HV) is more expensive to operate than a collection of semi-autonomous combatant cells (NV). More recently, the COVID-19 pandemic demonstrates that a virus cannot be easily challenged by command-and-control actions. Rather, an equal and opposite "viral" response – such as social distancing and widespread sanitary practices – are most effective. Modern platforms such as Google, Facebook, and AirBnB, take advantage of such network effects enjoying astronomical market valuations despite having few hard assets of their own. Their network serves as a bridge connecting disparate communities and their value is derived from the intrinsic coordination of those combined communities. Many legacy corporations, and even whole industries, struggle against the superior efficacy of some network platforms.

6.1.1 Hierarchy

The value of legacy business structure is expressed in terms of market demand and sensitivity to risk as expressed by the Capital Asset Pricing Model (CAPM) [18],

$$E(R_i) = R_f + B_i\,(E(R_m) - R_f), \qquad (3)$$

where $E(R_i)$ is expected rate of return on capital amount, R_f is risk-free rate of return, B_i is sensitivity to market volatility, and $E(R_m)$ is expected market return. The CAPM valuation model for an organization is dominated by market risk multiplied by a firm's sensitivity to market risk and is largely a linear function except where monopoly or some duopoly conditions exist.

6.1.2 Networks

A network is characterized by a collection of nodes, and branches connecting nodes. The value of networks is a function of the total number of nodes and the total number of possible connections that can be completed between them, multiplied by some coefficient of value for the quality of those connections.

Metcalfe's Law [19] suggests that the theoretical value of a network will be proportional to the square of the number of nodes according to the following relationship.

Theoretical value V(t) is proportional to

$$V(t) \propto n(n - 1) / 2. \tag{4}$$

This value asymptotically approaches n^2 as the square of the number of nodes in the system.

The actual value would be related to: 1. the quality of the nodes or some other empirically derived exponent, 2. the actual number of existing branches, and 3. The net quality for the transactions that transpire over the network.

For example, the value of a network platform such as Facebook, Linkedin, and Instagram, is often estimated with Metcalfe's Law for Networks. Simply stated, the theoretical value will be proportional to the square of the number of nodes in the network by the following relationship.

$$V(t) \propto C\, n^2, \tag{5}$$

where C is a constant of proportionality. For example, the market capitalization value of Facebook in 2015 may be calculated as

$$V(\text{Facebook}) = (5.70 \times 10^{-9}) \times n^2, \tag{6}$$

where n is the total number of users, and 5.70×10^{-9} is the average value assigned to each of their 1.5 billion users [20].

The value of engineers may demonstrate a similar relationship when arranged in a network, except an engineer may yield comparatively high value information as opposed to a Tweet or a Facebook post. When this number is multiplied by the square of the number of colleagues in the network, the valuation of the network may also become very large. The value for the engineer's constant would be proportional to the value of risk removed from complex systems in the built environment.

Social media platforms derive value from creating "digital roads and bridges" that connect large populations of people. We now have the means and methods to assess real roads, bridges, and infrastructure by network valuation and can thus prioritize and capitalize our infrastructure needs as such.

7.0 The Value Game

The initial work for the Value Game arose from the Boeing and Social Flights initiatives where specific behaviors were driven by specific incentives. For the Innovation Bank, game mechanics are used to incentivize efficient and worthwhile interaction of practitioners. The specific branch of study related to the Innovation Bank is cited as Multi-agent Algorithmic Game Theory [21].

For the Innovation Bank, claimants and validators each receive a cryptographic token in return for forming a valid *K*-Asset. Promiscuity on The Innovation Bank platform reflects negatively since the connections are permanent, irreversible, and immutable for all time. If your validator later turns out to be a fraud, this could reflect negatively on one's transaction record. Likewise, making a claim in which nobody else is willing to validate could constitute an act of misinformation which would likewise reflect poorly on the transaction record. In fact, so-called "Fake News," malicious rumors, or conspiracy theories would be readily identified by proximate unvalidated claims. Since a transaction record is cast in time, the consequence for abandoning a poor transaction record becomes greater as time advances because the practitioner would essentially need to start over with a new account at $t = 0$, and the burden to validate every claim anew.

Transaction records are critical to the Value Game. An extensive transaction record would readily serve as a resumé or CV because most employers would likely accept a validated set of professional claims than one which they would need to verify independently. The transaction record may become a public key to open select datasets, work orders, or teaming opportunities. Aggregated transaction records could be used to predict the likelihood that a diverse combination of professionals can execute a certain business objective, etc.

A Value Game creates a condition where the dominant strategy of each player is to preserve the integrity of the Innovation Bank rather than consume the shared asset against the interests of others. Other examples of shared assets include community associations, professional societies, public resources, and affinity groups – so this is not a new idea. In our case, the security of the Innovation Bank is assured by the individual actors in a fault-tolerant network with the ability to isolate aberrations from the central body of data.

7.1 Attack Vectors

Super-villain Max Mallory decides that he wants to obtain access to a nuclear power plant so he can perform nefarious deeds. The problem is that he has no previous experience or education in the area of nuclear engineering. Mallory makes a claim that he is a nuclear engineer on The Innovation Bank but fails to find anyone to validate his claim. Mallory pays his sidekick, Carl to validate the claim and both receive a token that they can sell for a bit of hard cash – so far so good! Mallory then tries to access the nuclear power plant and discovers that he is denied. Mallory's transaction record does not follow the typical sequence of claims and validations compared with other validated nuclear engineers, so his claim is rejected by algorithm. Unfortunately, a blockchain cannot go backwards in time, so Mallory would be unable to assert the proper sequence even if he knew it. For the cost to society of two tokens, the Innovation Bank automatically isolates Mallory and Carl from the network. If either wants to interface with the Innovation Bank at any time in the future, they would have increased difficulty in finding validators for future claims, or they would need to start over at $t = 0$.

The successful attacker would need to be an accomplished professional nuclear engineer with a long transaction record validated by many colleagues, mentors, and institutions in a specific sequence and over a long period of recorded time. The reward from the attack would need to far exceed the attacker's personal loss since they will almost certainly be identified, caught, and prosecuted, if not thwarted.

As this game plays out over millions of claims and validations across the entire value network, the probability that someone is acting fraudulently or incompetently approaches zero, especially at the higher-order claims and functions.

The Value Game played on a blockchain is efficient. Punitive costs and controls are minimized since each participant is incentivized to gain "stake" (i.e., equity) in the system, and disincentivized to exploit the system. Administrative cost and controls are minimized as the blockchain will provide immutable record of time, frequency, and distribution of validated claims. Smart contracts can be programmed to execute logic operations upon adjudication of preprogrammed conditions.

8.0 The WIKiD Tools Algorithm

The WIKiD Tool Algorithm is an interpretation of the DIKW framework with the exception of an added time function treating the hierarchy as a set of derivatives. A derivative is something whose value is derived from the value of something else. As such we can calculate the value of knowledge if we know the value of information, etc. The resulting algorithm provides a means for representing and measuring intangible assets.

8.1 Wisdom, Innovation, Knowledge, information, Data

To date, the current definition for innovation is as follows [22]:

The process of translating an idea or invention into a good or service that creates value or for which customers will pay. To be called an ***innovation****, an idea must be replicable at an economical cost and must satisfy a specific need.*

The problem is that this definition presents a single equation with four unknowns, i.e., *ideation, utility, value, – and the necessity for mass market adoption.* Such a definition cannot be resolved mathematically in advance of the supposed outcome. Further, this definition does not provide units in which an innovation may be measured. Each of the other WIKiD elements are defined in a similar imperfect manner by mainstream sources. The inability to measure these elements precisely and discretely contribute to their classification as intangible, rather than tangible assets. This is largely the same shortcomings found by many academics in the DIKW model presented earlier.

Consider a blockchain that constantly creates blocks within which data is stored, on say, three-second intervals. A unit of measurement can now describe participant activity as a function of time. For example, suppose one practitioner produces one claim or validation every hour. Their productivity can be specified as one token per hour, or one token per 1200 blocks. When queries to the database cite a useful claim, the original claimant receives additional validations, thereby increasing stake. A participant with a higher stake would receive higher awards with respect to time. Each of these events travel up the WIKiD derivative scale of increased value. We can now describe the other WIKiD elements as derivatives (and antiderivatives) of the rate of change of *K*-Assets.

8.2 WIKiD working definitions

- *Data are digital points placed on a ledger. Just noise, nothing more. Without meaning, data is useless.*
- *Information occurs when we apply systems to organize and classify data; who, what, when, would be typical answers at this stage.*
- *Knowledge implicitly requires learning. It means that we can take data, categorize and process it generating Information, then organize all this Information in a way that it can be useful.*
- *Innovation is the physical manifestation of identifying two or more parts to be combined in a novel manner.*
- *Wisdom is the ability to "connect the dots" finding the shortest path between two or more physical states (Figure 3).*

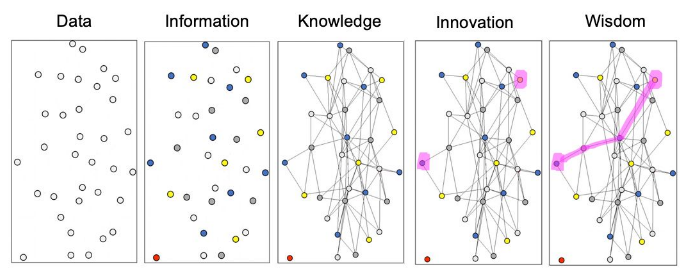

Figure 3: *Mental model of the WIKiD Tools Algorithm across multi- branch nodes. Patterns related to specific outcomes may be discerned, simulated, predicted, tested, repeated, etc.*

The time function provides the ability to form derivatives. For example, one cannot normally identify innovation before it happens, but one could identify high rates of change in knowledge and use that as a proxy for the fact of innovation. If one needs to identify knowledge in a community, one could similarly audit the network for high rates of change of information among persons as a proxy for the presence of knowledge. In that manner, the derivatives of the WIKiD Tools sequence are useful for visualizing previously invisible attributes if given a verified database of information cast in time.

9.0 The Virtuous Circle

A bank will not finance a project unless it is insured. An insurance company will not underwrite a project unless the engineers are qualified. Qualified engineering must be financed in order to cover soft costs. As such, insurance, finance, and engineering are mutually dependent on each other forming a virtuous circle (Figure 4). If there is a break anywhere in this investment cycle, the economics of the project break down. This condition is observed where financial institutions and engineering services are incomplete, segmented, or otherwise corrupted [23].

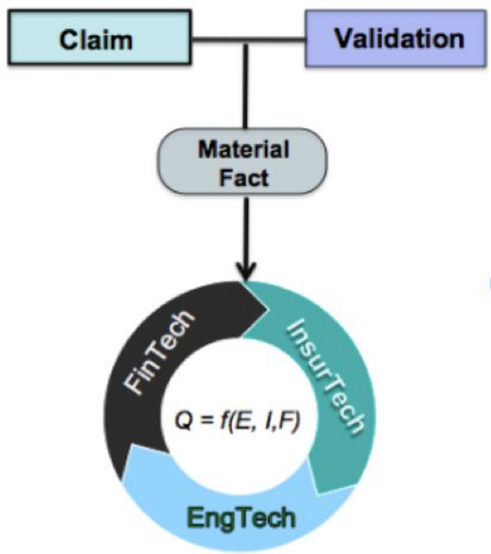

Figure 4: *The Investment Cycle. Economic growth is a function of Engineering (E), Insurance (I), and Financing (F).*

Likewise, any system or method that assures valid and objective information will reinforce the economic activity. Many new technologies such as artificial intelligence, Internet of Things, and Big Data application are being applied to finance, insurance, and increasingly in engineering. These technologies must be "calibrated" to a valid state in order to extrapolate broader conclusions. Poor input may yield, if not amplify, poor output. This is one of the greatest challenges for the engineering profession today – reconciling the "digital twin" with its corresponding physical sibling.

9.1 Reconciliation

Combining the Solow production function (1) with the virtuous circle also suggests factors of production as

$$Q = g(E, I, F). \tag{7}$$

Equating (1) and (7) yields:

$$g(E, I, F) = f(\kappa, L, t). \tag{8}$$

Given that capital, insurance, and finance are all financial instruments and can be represented by a single variable κ_2. we are left with

$$E = f(\kappa_2, L, t) \tag{9}$$

This statement is consistent with the way that money is "created" in a conventional capitalist system. Money is simply a measure of human productivity usually memorialized by promissory notes. It is difficult to "make" sustainable money if you cannot measure that which the money represents. And thus, that is how The Innovation Bank lives up to its name.

Now the debate can become: *"what actually constitutes true productivity?"* Perhaps we should just let the Innovation Bankers decide.

10.0 Conclusion

Technological change precedes economic growth, yet we are going about the process of civilization as if economic growth precedes technological change [24]. Engineering is an apex factor of economic growth, yet the profession struggles for identity, coordination, and interdisciplinary cooperation - and funding. The compensation model for engineers has barely changed in 100 years while many other professions take a percent of value. If engineers were compensated on this basis, the shortage of talent would quickly resolve.

Systemic risks from pandemics to climate change are fundamentally engineering problems, not political or even financial in nature. Many respectable academics and professional published extensively on the challenges facing the STEM professions, but their conclusions are nearly all the same:

"If only the government or big business would change their ways, our problems would be solved ..."

The conclusion to this paper, is:

"Engineers must solve our own organizational problems because nobody else can"

The product of engineers is invisible and it is our responsibility to change that. The Innovation Bank is an act of engineering in itself, intended to make engineering output visible, measurable, and attributable to individual members fairly, securely, and equitably, at scale. Even works that are not part of the Innovation Bank will benefit from the comparable effect of the system on the economic landscape. Ultimately, token valuation would become part of the financial landscape that supports a sustainable economy for the benefit of all.

The process described above, while novel within mainstream engineering culture, is typical of network platforms such as

Google, Facebook, Apple, etc., These platforms realize near-trillion-dollar valuations by simply providing electronic bridges that connect large populations of people. The Innovation Bank enables engineers to measure their own productivity using real bridges, real highways, and real physical infrastructure as the substrate of economic growth [25].

This would not have been possible twenty-five years ago when these researchers started, but over time, we have observed new technologies appear - from email to artificial intelligence. We have considered the implications of social media, several financial crises, pandemics, and terrorism on the utility and implications of a working network of engineers. Most recently, blockchain technology has provided the final ingredient needed to safely and securely implement the decentralized engineering model and finally close the soft-cost funding gap that hinders our visibility. Only now, the basic structure or build-out and stress tests are available.

10.1 Epilogue

This work is based on widespread consensus by social scientists, Nobel laureate economics, major corporations, start-ups and researchers. However, the ideas presented here are incomplete. We have achieved a state where a prototype has been built and underlying theories have been validated. We have published in most major professional societies, we have won national and international innovation contests, and we have made keynote addresses at major conventions, engineering media, and society symposia [26]. We have received our greatest support from the younger generation of engineers who demonstrate the same idealism and "change-the-world" attitude that we ourselves felt at the beginning of our own careers.

The greatest resistance has been from the "Old Guard" or engineering and corporate sponsors who are heavily vested in the command-and-control architecture that worked so well in the 20th century, but may now be faltering in the digital era. Given the events of 2020, we see that minds are opening to new ideas that were once considered radical. The fact that this work is being considered by ASME for publication, is deeply encouraging.

Much work is yet to be done before The Innovation Bank becomes commercially viable. Admittedly, our analysis is imperfect, our evidence is limited, and, ironically, our funding is sparse. But these are problems that we'll save for another day. This paper is offered as a record of the current state of the project and a progress report to the next generation of engineers and scientists who enter this most profound profession.

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