The Dominium Mundi Game and the Case for Artificial Intelligence in Economics and the Law

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15 December 2018

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December 15, 2018

Abstract

This paper presents two conjectures that are the product of the reconciliation between modern economics and the long-standing jurisprudential tradition originated in Ancient Rome, whose influence is still pervasive in most of the world's legal systems. We show how these conjectures together with the theory that supports them can provide us with a powerful normative mean to solve the world's most challenging problems such as financial crises, poverty, wars, man-made environmental catastrophes and preventable deaths. The core of our theoretical framework is represented by a class of imperfect information game built completely on primitives (self-interest, human fallibility and human sociability) that we have called the *Dominium Mundi* Game (DMG) for reasons that will become obvious. Given the intrinsic difficulties that arise in solving this type of models, we advocate for the use of artificial intelligence as a potentially feasible method to determine the implications of the definitions and assumptions derived from the DMG's framework.

The world is giving signs that things are getting worse and not better. After the global financial crisis of 2008, we have witnessed a series of adverse shocks such as the rise of national populism in the most stable democracies, the fading of former alliances (eg., Brexit and the casted doubts on the reliability of NATO), the annexation of Crimea by Russia in 2014, the pull-out of the United States in both the Paris Climate Agreement and the Iran Nuclear Deal, the threat of a full-blown trade war between China and the USA, mass migration, especially in Europe and the sharp deterioration of the peace process in the Middle East, including Jerusalem almost losing its 1947 international legal status. Even the moral rhetoric of the world is changing. When faced with the murder of the Saudi journalist Jamal Khashoggi, the U.S. President Donald Trump said “Any human rights concerns are outweighed by U.S. national security and economic interests” (Herman, 2018).

Less than a century ago, the world also lived a series of adverse shocks, although with more dramatic intensity and consequences. After the Great Depression, where millions of people lost their jobs, it came the Nazi revolution, then World War II and finally proxy wars that spread out through Latin America, Africa and Asia. But man-made adverse shocks with the unimaginable misery that they inflict to their victims are not a creation of recent history. They have been pervasive through the ages since the very beginning of civilization. Many prosperous cultures have been brought to an end because of adverse shocks and, even as bad as that, history has proved that, under certain conditions, it might take centuries to replace a relative advanced culture and its associated material well-being with another equivalent alternative. That was what happened with the fall of the Western Roman Empire in the year 476 AD and the subsequent arrival of the Middle Age (or Dark Ages).

Given the above facts, a reasonable question to ask is whether or not a pattern for man-made adverse shocks can be elucidated. From the perspective of science, it would be even better to find a causal relationship that will help us to understand not only why these phenomena happen, but also what can be done in order to prevent their emergence. Economics, as the science of scarce means and competing ends (see Boulding, 1966 and cf. Becker, 1976), is particularly suited to deal with the topic of man-made adverse shocks so that we can find scientific answers to the above questions. With this purpose in mind, we pursue the following path. In Section 1, we address the main obstacles that have hindered economics in making significant contributions in this area. In Section 2, we present the primitives of our theoretical framework based on self-interest, human fallibility and human sociability and provide the empirical justification regarding the need of such primitives. In Section 3, we not only cover the main technical aspects of the *Dominium Mundi* Game (DMG) framework (eg., the DMG's Fundamental Inequality and First Conjecture), but also deal with the methodological challenges posed by our game-theoretic approach. We make the case for the use of artificial intelligence as a potentially feasible mean to solve imperfect information games relevant to economics and the Law. In Section 4, we evaluate some empirical evidences to determine the significance of our approach to today's real-world problems and its effectiveness for policy and legal aims. Here we formulate the DMG's Second Conjecture and provide our final considerations.

1. From Adam Smith's Invisible Hand to Francisco de Vitoria's Visible Hand.

The key to solve the puzzle in man-made adverse shocks lies in the conjecture posed by Adam Smith's invisible hand (1759 and 1776). Unfortunately, Adam Smith's conjecture is not easy to understand. As historian Peter Harrison (2011, p. 29) wrote: “Few phrases in the history of ideas have attracted as much attention as Smith’s ‘invisible hand,’ and there is a large body of secondary literature devoted to it. In spite of this there is no consensus on what Smith might have intended when he used this expression, or on what role it played in Smith's thought.” Economists have traditionally interpreted Adam Smith's invisible hand as “In competition, individual ambition serves the common good.” In this context, economists mean by competition, perfect competition or competitive equilibrium, and by common good, Pareto efficient allocation. In this regard, Samuelson (1989, p. 825), a key advocate of the above view stated: "Smith was unable to prove the essence of his invisible-hand doctrine. Indeed, until the 1940s, no one knew how to prove, even to state properly, the kernel of truth in this proposition about perfectly competitive market."

Even critics to mainstream economics like Nobel Prize-winning Joseph Stiglitz asserts that the Invisible Hand leads to Pareto Optimum or welfare maximization (forthcoming). He even affirmed that “Adam Smith's invisible hand may be invisible because, like the Emperor's new clothes, it simply isn't there; or if it is there, it is too palsied to be relied upon” (Stiglitz, 1991, p. 5). The problem with the economists' interpretation of Adam Smith's conjecture is that simply ignores the basic rules of interpretation, which were formulated by Friedrich Savigny in 1840: grammatical (literal), historical, systematic and teleological (purpose) interpretation (see Savigny, 1840). Adam Smith never talked about perfect competition not even suggested the conditions or criteria, which would guarantee the emergence of perfect competition. He only limited himself to the case when an individual, institution or trading company was granted a monopoly or special right by the government. He suggested that in the absence of such privileges enforced by the government, greed would be able to find its way to lead society to the common good. The same Stiglitz proved that this lax conception of a market-based economy is neither a sufficient condition to guarantee competitive equilibrium nor it leads the economy to a Pareto Optimum. Based on his previous work (Greenwald and Stiglitz, 1986, 1988 -as well as other papers: Scitovsky, 1950; Arrow 1958; Stiglitz, 1989; Salop, 1979 and Arnott and Stiglitz, 1988), Stiglitz (1991, p. 16) affirms that “in general, when risk markets are incomplete and information is imperfect, markets are not constrained

Pareto optimal: the Invisible Hand does not work." This statement is consistent with Stiglitz's (forthcoming, p. 1) insightful observation that competitive equilibrium as proved by Arrow (1951) and Debreu (1954), "only held under very restrictive conditions, not satisfied in any real world economy." Stiglitz (1991, p. 17) claims that not only "imperfect information is pervasive in the economy" but also "risk markets are far from complete". He states that "many of the important risks which we face are uninsurable."

The irony of the history of economic thought is that what economists mean by invisible hand is nothing else that the visible hand of the Law. Economists claim that the proof of their particular interpretation of Adam Smith's invisible hand, which was done by Arrow (1951) and Debreu (1954), is one of the greatest intellectual achievement of economics because not only establishes a link between optimality and decentralized equilibria, but also shows that competitive equilibrium allocations maximize the aggregate welfare of society. Therefore, according to this logic, Adam Smith, one of the key figures of the 18th century Scottish Enlightenment, must be considered the father of modern economics. But as we saw earlier, Adam Smith's invisible hand cannot be interpreted as competitive equilibrium. In fact, the very concept of competitive equilibrium was brought to life at least two centuries before Adam Smith by Francisco de Vitoria, a Spanish jurist and Chair of theology at the University of Salamanca, who is considered the father of International Law given his reasoning regarding the legal status and corresponding rights of the native people who, according to Vitoria, form part of a *communitas totius orbis* (an international community), which seeks an universal common good (see Vitoria, 1539 and Cendejas, 2018).

Contrary to Adam Smith's almost unrestricted competition concept, Francisco de Vitoria was very clear and specific in what constitutes a competitive equilibrium. Cendejas (2018, p. 9) summarized the essence of Vitoria's thought in the following terms: "For Vitoria, fairness in exchanges does not result from mere consent, but conditions that allow us to speak of a fully voluntary act must be verified; absence of fraud and deceit, which cause ignorance, and that the seller or the buyer do not take advantage of the situation of need on the other side of the market. These are the fundamental prerequisites of a lawful purchase and the basis of the just price formed from the common estimate...The profit is lawful if it results from buying and selling at just prices." What Vitoria means for common estimate is nothing else than the estimation determined by the market. Excluding the cases of fraud and malice, Vitoria stated (1536a, q. LXXVII, art. 1.) that in order to buy and sell according to justice, we should consider only the price that a product is sold commonly in the market, and not its costs and labor. Thus, Vitoria's economic view formulated in the 16th century is equivalent to the economists' understanding of competitive equilibrium. Due to this fact, Francisco de Vitoria should be considered the true father of modern economics. But Vitoria (1536a, q. LXXVII, art. 1.) went even further in his analysis, suggesting that when there are few buyers and sellers in the market, for example, when wheat during times of hunger is in the hands of one or so few, the fair price is not equal to the market price and, therefore, Conrado's (1500) reasonable conditions and considerations should be applied -expenses, labor, risk and scarcity must be taken into account to determine the fair price.

In Francisco de Vitoria we can see the enormous influence that the Roman jurisprudence had in his economic thought, especially in the topic of voluntary agreement and unfair enrichment, which is summarized by the Latin maxim "*nemo locupletari debet cum aliena iactura*", meaning no one should be benefited at another's expense (see Pomponius, Digest 12.6.14). For Vitoria, a fair market price was not the necessary byproduct of an invisible hand or the natural and unavoidable consequence of market forces. Vitoria understood that markets don't work in a vacuum. As a Catholic theologist and jurist, he also understood that greed, the ruthless maximization of self-interest, is insatiable and knows no bounds. He understood that for a market to meet its above

jurisprudential criteria; that is to say, that for a market to be really competitive, without fraud, market manipulation and malice, the Law (*ius)* should be already firmly established (Victoria, 1536b, c.58, a.1). Vitoria's judgment comes from a long-standing tradition, traced back to the Roman jurist Ulpian who stated: "*Iustitia est constans et perpetua voluntas ius suum cuique tribuendi.*" (Digest 1.1.10pr), which means "Justice is the constant and perpetual will to render to every man his due" (Wikiquote, 2018). In other words, the Law (*ius)* does not come spontaneously or by chance, it must be consciously and actively sought. It is important to notice that "*ius*" and law are not necessarily the same thing. The Latin genitive "iuris, ius" means right. The word law instead it is the Latin equivalent of the word "lex". The difference between "ius" and "lex" is that the former is built from the reasoning of particular cases and the incisive observation of the natural order as was practiced by the Roman jurists, while the latter are norms established by convention or mandate. The Roman jurist Celsus defined Law (*ius*) as "*ars boni et aequi,"* in other words, the Law is the art of goodness and equity. Its fundamental purpose is to to protect the weak against the abuse by the strong (Ayala, 1789, p.6). It is from the fair solution to a case where the rule arises and not from the authority of the prince, parliament, city council or the supreme court. For the Romans, the work of the jurists were more important than legal norms (Blanch Nougués, 2013). Another way to grasp this subtle difference is through the following Latin maxim, which implicitly recognizes that "ius" and "lex" are not always equivalent: "Lex iniusta non est lex" - an unjust law is not law. In addition, it is worth noting that a jurisprudential approach to economics is not equivalent to "law and economics" or the economic analysis of law. This latter approach, which doesn´t follow any long-standing tradition, was developed mostly by scholars of the Chicago school of economics, which is a private institution, characterized by a libertarian and neoclassical school of economic thought.

For the Roman jurists, justice was not invisible, on the contrary, it was represented by a blindfold, a balance and a sword. Using Adam Smith's allegory, the Law is a visible hand. This is so because competitive equilibrium is, as Vitoria suggested, the result of the proper application of the Law. It belongs to the realm of normative economics – what ought to be – and not to the realm of positive economics -what really is. Unfortunately, mainstream economists go the other way around. They claim that competitive equilibrium is the right model to describe how the economy works (see Stokey and Lucas with Prescott, 1989). In their mind, there is no difference between positive and normative economics, issues of political economy do not arise, all economic agents, including both the government and the central bank, behave in the way they are expected to do, thus if something ever goes wrong, it is nobody's fault (eg., market frictions, external shocks, etc.). As a consequence, their models are implicitly designed to be what it could be called a "politically correct" model. Following Lucas critique (1976) on large-scale macroeconometric models, central banks use now dynamic stochastic general equilibrium (DSGE) models for forecasting and policy analysis. DSGE models combine microeconomic analysis of agents' behavior with an estimation approach using macroeconomic variables. When there is a need of a more detailed financial sector, the European Central Bank (ECB) uses the Christiano, Motto and Rostagno model (Smets, et al., 2010). This model assumes a competitive market in the banking sector (Christiano, Motto and Rostagno, 2010). Similarly, the DSGE model used at the Federal Reserve Bank of New York (FRBNY) shares the same assumption. They impose a zero profit condition to the banking sector (Del Negro, Marco et al., 2013). Following this common trust in the market, both DSGE models enforce another zero profit condition in the final good producers, who assemble intermediate goods. It is worth noting that these final good producers are basically traders or businessmen who buy intermediate goods, aggregate them and sell them as final goods. There is no technological progress or innovation in this sector. Therefore, taking into consideration both the banking sector and final good producers, the central banks with their DSGE model are saying that today's merchants operate in a competitive market and earn zero economic profit. This assumption,

however, is in sharp contrast with what we observe in reality. Just to name one example, Anderson and Creswell (2007) affirmed: “Combined, the top 25 hedge fund managers last year earned $14 billion -enough to pay New York City’s 80,000 public school teachers for nearly three years.”

As we could reasonable anticipate from any idealization of reality or a “political correct” model, DSGE macroeconomics not only failed to predict the 2008 financial crisis, but also did not provide any convincing explanation about the causes and best responses to avoid future crisis. As Gatti, Gaffeo and Gallegate (2010, p. 112) stated: “But those models support the idea that markets—albeit recurrently buffeted by random disturbances—are inherently stable and that all uncertainty is exogenous and additive, two statements which have been treated as principles of faith instead of being rigorously demonstrated.” Clarifying this issue, Stiglitz (2018, p. 78-79 and 76) makes two relevant statements: First, that the financial crisis of 2008 was not caused by an exogenous shock like bad weather, a plague or an epidemic, but rather “by the breaking of the housing bubble -something that markets created, and to which misguided policy may have contributed...see, for example, Bernanke (2009), Demyanyk and Van Hemert (2009), Sowell (2009), and Mian and Sufi (2015).” Second, that DSGE models “effectively said that it [the 2008 financial crisis] couldn't happen. Under the core hypotheses (rational expectation, exogenous shocks), a crisis of that form and magnitude simply couldn't occur.”

From our discussion of Francisco de Vitoria's visible hand, the theoretical findings of Greenwald and Stiglitz (1986, 1988), etc., and the new evidences brought to light by the 2008 financial crisis (Stiglitz, 2018 and forthcoming; FCIC, 2011; Webel, 2013; Mehrling, 2016; Hou and Skeie, 2014 and Nelson, et. al., 2017), it is clear that any reasonable model of the economy can not be built on the simplifying assumption of competitive equilibrium or zero-economic profits. Ironically, Adam Smith's conjecture of the invisible hand, properly formulated, is a good starting point for building an alternative theoretical framework. We need to ask ourselves, where greed will take us when the only condition imposed to the economy is the absence of monopolies or special rights granted to individuals or companies by an independent government. Answering this question is the essence of this work. We claim that Adam Smith's conjecture will lead us to the *Dominium Mundi* Game. Let's see why this is so.

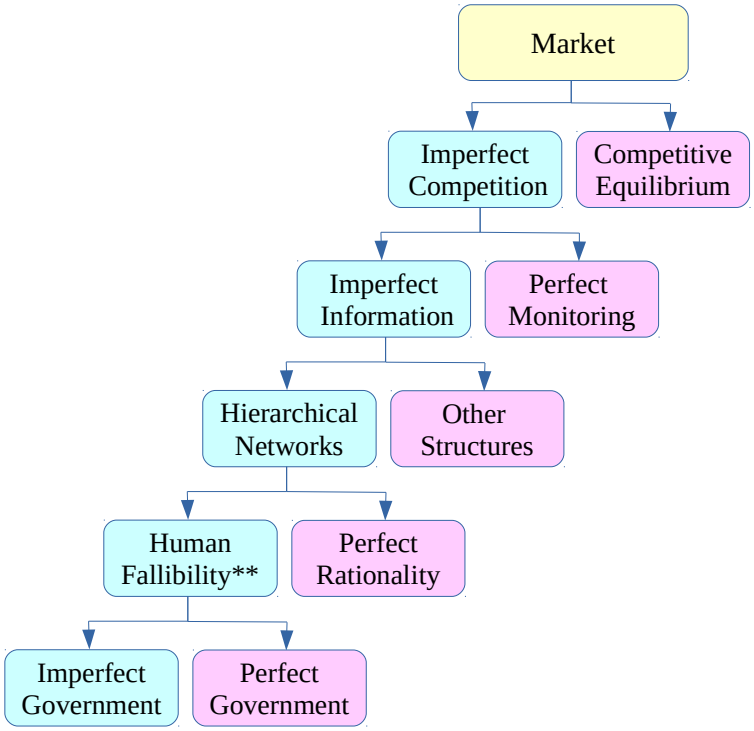
2. The *Dominium Mundi* Game's Primitives and their Empirical Justification

Figure 1 illustrates in a single decision tree the basic structure of the DMG´s theoretical framework. As it can be seen, instead of assuming an idealized form of government, the sanctity of the central bank, zero-economic profits or competitive equilibrium, we propose a new paradigm built entirely on primitives such as self-interest, human fallibility and human sociability. This approach will allow us to develop a theoretical model not only to explain the primary causes of man-made adverse shocks, but also to determine the full implications of Adam Smith's invisible hand as interpreted and formulated in the previous section. In Section 4, we see how the insights provided by this approach can be used for normative purposes.

The first primitive of our model is self-interest. Self-interest is a very powerful driver of human behavior. Even Thomas Aquinas, the medieval Doctor of the Church, recognizes that people are more solicitous on their own affairs than on common things (Aquinas, *Summa Theologiae, Secunda Secundae,* c. 66, a.2, see also Cendejas, 2018). The Fundamental Theorems of Welfare Economics are based on the premise that each individual pursues his or her own self interest. However, the *Dominium Mundi* Game (DMG) approach makes a distinction between self-interest and greed. For us, self-interest is an integral part of human nature, even necessary to ensure survival while greed is, on the other hand, the ruthless maximization of self-interest, and therefore, they are not necessarily

equivalent terms. Greed is rather an innate concept in economics. Economists generally assume that people behave as if they made utility maximization calculations (Friedman, 1953). Regarding its use in economic analysis, Gary Becker (1976, p. 5) wrote: "Everyone recognize that the economic approach assumes maximizing behavior more explicitly and extensively than other approaches do, be it the utility or wealth function of the household, firm, union, or government bureau that is maximized." For the case of a government or a central bank, the concept of greed can pose a challenging problem. What does the government or the central bank exactly maximize? As we pointed out in the previous section, economists prefer to build "politically correct" macroeconomic models where the political authorities are selfless and pursue always the common good. Is not that contradictory? For example, Lucas and Stokey (1983) treated the government as another agent. They stated "...we take the objective of government to be to maximize consumer welfare..." (1983, p. 62). They justified this convenient but dangerous assumption observing "...Ramsey 1927 sought to characterize the excise tax pattern(s) that would maximize the utility of the consumer (or minimize the 'excess burden' or 'welfare cost' of taxation). He thus abstracted from distributional questions and from issues of possible conflict between the objectives of 'government' and those governed, abstractions that will be maintained in this paper, as they were in those cited below" (1983, p. 55-56). But can Ramsey´s approach be generalized to all macroeconomic problems? The DMG framework, in contrast to the neoclassical approach, incorporates both self-interest and greed in modeling the political process.

Figure 1. The *Dominium Mundi* Game Framework*



Note* :The *Dominium Mundi* Game framework follows the aqua color path.
Note** :Human Fallibility includes both bounded rationality and cognitive bias.

The second primitive in the DMG is human fallibility; that is to say, the recognition of the self-evident fact that people do not possess perfect rationality. Human fallibility encompasses two characteristics: "bounded rationality" (Simon, 1955) and cognitive bias (Thaler, 2000)– one popular experiment on this topic is the "invisible gorilla test" carried out by Simons and Chabris

(1999). As a consequence of both impediments to rationality, individuals not only may adopt heuristics or "rules of thumb" when making decisions, but also they may create their own subjective reality when trying to understand certain things from the environment that surrounds them. Given that human fallibility coexists with rationality, the key theoretical question is to determine when to assume rationality and when to assume human fallibility.

In building a DMG model, we need to make assumptions about how agents process information and forecast future events. The easiest way to go would be to assume rational expectations, where all agents share the same model of the world, that is to say, they all share the same probability distribution (Sargent, 2016). The main technical advantage of rational expectation is that allows, as Sargent (2016) pointed out, "a ruthless dimension reduction". For practical reasons, we want to deviate as little as possible from this simplifying assumption. However, because of the nature of our topic and in order to be consistent with the empirical evidence, we are compelled to take a somehow different approach. We assume that agents may hold biased beliefs, especially when faced with conflict of interest (Moore et al., 2010; Ariely, 2012; Moore and Loewenstein, 2004; Murata et. al., 2015; Graber, 1984; Bartlett, 1932; Lord et al., 1979; Zaller, 1992; Rabin and Schrag, 1999 and Klayman, 1995). It is worth mentioning that the assumption of biased belief in the face of conflict of interest is consistent with the jurisprudential principle: "n*emo iudex in causa sua*," which means "no-one should be a judge in his own case" (wikipedia, 2018). In addition, consistent with this behavioral model, we also assume that newspapers (or the provider of information) can slant stories toward these biased beliefs (Mullainathan and Shleifer, 2005; Goldberg, 2002; Coulter 2003; Alterman, 2003; Franken, 2003; Baron, 2004; Besley and Prat, 2006; Djankov et al., 2003; Jensen, 1979, Hamilton, 2003). This assumption is not a surprise because historically newspapers were affiliated with political parties (Hamilton, 2003 and Gentzkow et. al., 2015).

The above two assumptions provide the DMG framework with a powerful mean to introduce irrationality into an otherwise rational economic model. Together with the other two elements of human nature (self-interest and human sociability), human fallibility can give rise not only to hard-to-explain social phenomena such as ideology, religious fanaticism and legal corruption but also to the compulsive nature of greed, which knows no limit. So when an economic agent faces a strong conflict of interest, rationality can not tame greed, cognitive bias comes in and affects the way in which that agent processes information. As John Acton (1887) once wrote: "Power tends to corrupt, and absolute power corrupts absolutely." Ironically, in Aristotle (384-322 BC), the father of logic, we can find a clear example of how rationality can be profoundly distorted by conflict of interest, even in exceptionally gifted minds. In his apology to the institution of slavery, Aristotele affirmed that slavery was even good for the slave. He suggested that natural slaves lack the ability to think properly, so they need to have masters to tell them what to do (Aristotle, Politics). The problem with his logic is that it goes against the Law, against the most fundamental rights of the people. In the Roman law, slavery was never justified by the *ius civile* but taken instead from the *ius gentium* as an international convention. Slavery is considered nowadays a *ius cogens* violation (1926 Slavery Convention and 1969 Vienna Convention).

Given that Adam Smith never meant perfect competition (or competitive equilibrium), a relevant question to ask about his invisible-hand conjecture is if it can also be viewed as an apology but, in this case, for the rich or the merchant elite. As we will see, the answer to this question will provide us with further insights about the nature of the *Dominium Mundi* Game. In the Theory of Moral Sentiment (1759, p. 350), Smith wrote "They [the rich] are led by an invisible hand to make nearly the same distribution of the necessaries of life, which would have made, had the earth been divided into equal proportions among all its inhabitants, and thus without intending it, without knowing it,

advance the interest of the society, and afford means to the multiplication of the species. When Providence divided the earth among a few lordly masters, it neither forgot nor abandoned those who seemed to have been left out in the partition." It seems that with the moral philosopher Adam Smith the merchant elite as a social group could finally reach a moral status similar to the one enjoyed by the nobility and the high clergy, a justification of their privileges by some kind of odd "divine right" or *Dei gratia*. This was an extraordinary accomplishment, which will prove to be very relevant to the DMG framework. It was the culmination of centuries of struggle between the merchant princes and those who opposed them. The power of the rising merchant elite became obvious in the 17th century by a series of events that ended up leading to the Glorious Revolution of 1688, which overthrew King James II of England. Two of these key events were the foundation of the Dutch East India Company in 1602 and the Peace of Westphalia of 1648, which ended the Eighty and Thirty Years' Wars and replaced the medieval European system centered around the figure of the Pope and the Holy Roman Emperor by an international system based on sovereign states and national self-interest. It is worth noting that the rise of a secular world order after the Peace of Westphalia was the consequence of the Thirty Years' "religious" war, which was one of the most deadly armed conflicts that took place before the 20th century, killing, for example, around a quarter of all germans (Wilson, 2010). Paradoxically catholic France, a key player in that war, sided against the catholic coalition. Not surprisingly, France was led by a king whose father was a former Huguenot who fought himself against the Catholic League of France (Wikipedia, 2018). The *Dominium Mundi* Game will make clear why "no one can serve two masters" (Mt. 6:24).

In the Middle Age, there were also clear evidence of power struggles of the kind suggested above. The rivalry between the Guelphs and Ghibellines in Italy, where the Lombard League defended the liberties of their city-states against the centralization of power promoted by the holy Roman emperors. In fact, the name *Dominium Mundi* ("world dominium" or world domination) became popular because of that conflict, which also involved the popes who, paradoxically, sided against the holy Roman emperors, their supposed natural allies. During the 14th century the economic powerhouse of Europe was concentrated in the northern part of Italy (Bairoch et. al., 1988) and their cities were controlled by wealthy mercantile families (see De Long and Shleifer, 1993). The spectacular and mysterious rise of the Medici, the family who founded the Medici Bank, is a canonical example. Among their members were the rulers of the Grand Duchy of Tuscany, two queens regent of France and three popes. However, It its worth mentioning that the dominion of some city-states by merchant oligarchies in Medieval Europe was not a new phenomenon. The Prophet Isaiah, who according to the Jewish Virtual Library, lived between c. 740 and 681 BC and probably belonged to the Jerusalem aristocracy, stated: "Who hath taken this counsel against Tyre, the crowning city, whose merchants are princes, whose traffickers are the *honourable of the earth?"* (Isaiah, 23:8). Isaiah's words are consistent with the historical and archaeological records found in ancient Levant and the Mediterranean region (Nigro, 2018; Röllig, 1983; Glenn, 2000; Katz, 2008; Ordóñez Fernández, 2011; Izquierdo-Egea, 2014; Crawley Quinn and Vella, 2014).

In spite of the above facts, many things still remain unclear, especially the question of how merchants became so rich and powerful. What is the underlying cause of their fabulous wealth throughout the history of civilization? The granting of monopolies or special rights as the most important driver of excess returns, as suggested by Adam Smith for the 18th century, seems to be a consequence rather than a cause. That is to say, the merchant elite obtained those privileges because they were already powerful. Which king or parliament in the 17th and 18th centuries would grant an enviable monopoly to a nobody? In reality, of course, it could also be more like an interactive process or a positive feedback loop, where a rise in economic wealth is translated into a rise in political power, which in turn creates more economic rents (Pagano and Volpin, 2005). In this regards, Stiglitz (2018, p. 76 and 93) provides a good starting point for understanding the

underlying reasons of this mysterious phenomenon. He notices not only that "the presence of imperfect and asymmetric information leads to credit and equity rationing", but also that imperfect capital markets "result in banks playing a central role". But what is really behind the business of banking or, in general, in any large-scale operation of buying and selling? What role plays the merchant elite? The same Stiglitz (forthcoming) stated that financial structure matters but he is rather vague on this topic. Does he means a network structure or merely heterogeneous agents (Stiglitz, 2018)? In spite of his ambiguity, he also mentions something worth of considering. Stiglitz (2017, p. 6) affirmed "the functioning of markets also depends on trust. No economy can rely on the enforcement of contracts through the legal system." So where does this puzzling trust come from? This gap in the current macroeconomic literature provides us with the necessary justification to introduce a third assumption regarding human nature: human sociability, which means, as Aristotle (384-322 BC) brilliantly expressed in his work Politics: "Man is by nature a social animal".

Historically, the two institutions that consistently have provided the strongest bond (or trust) for social life are family and religion. Family is a natural institution. It is an integral part of our humanity and has been present at least since the beginning of human prehistory (Van Arsdale, 2015). Religion, on the other hand, is more elusive regarding its origin. However, the etymology of the word religion can shed some light on its true meaning. It derives from the Latin words "*re"* and "*ligare"* and, therefore, its meaning is related to the word tie or bond (Helena, 2018). So, for our purpose, any system of beliefs that result in a strong tie or bond among people as if they were a family is a religion. Ironically, the followers of Karl Marx (1843), who claimed that "religion is the opium of the people," ended up creating their own religion in the form of Marxism-Leninism and the Stalin's cult of personality. Politics, family, religion and the economy are intimately related. For example, in time of Augustus (27 BC-14 AD), the title of p*ontifex maximus* (the greatest priest or "pope") and the imperial office were subsumed under the same person. In the ancient world, the temples played a central role in the economies of the Mediterranean. In his work on General Economic History (1923), Max Weber tells that at the beginning temples served as deposit boxes, since gods were considered sacred and those who laid their hands on it committed sacrilege. Subsequently, they became lenders for both merchants and princes.

For our purpose, however, the most relevant example of the complex interrelation between markets and religion is offered by the ancient Phoenicians, who developed one of the most enduring culture in human history, which lasted from c. 2,500 BC (see Bentley and Ziegler, 2000 and Nigro, 2007) to 146 BC before the fall of Carthage. What insights can we learn from the greatest merchants of antiquity, the "bestower of crowns" as the Prophet Isaiah called them (Is, 23:8)? The Mediterranean Sea before being named *mare nostrum* (our sea) by the Romans was in fact the sea of the Phoenicians. Among Phoenician cities, Tyre was the one that perfected the art of commerce at levels unprecedented in the history of mankind. Its tentacles reached until the other end of the Mediterranean in the Iberian Peninsula (Ordóñez Fernández, 2011; Izquierdo-Egea, 2014; Aubet, 2001 and Ratzinger, 2012). The Phoenicians founded the city of Carthage, whose general Hannibal Barca left Rome on the verge of destruction. According to Lorenzo Nigro (2018), the Phoenicians didn't have a country. They "belonged to each single harbor city of the Levant." He stated that even though their communities were able to hybridize with other people from the Mediterranean, they wanted to keep something unique about themselves, a cultural identity that would set them apart from everybody else. They achieved that through their own bizarre religion, which seems to have included, among other things, human sacrifices, especially from their own children in what was known as the rite of the Tophet (Nigro, 2018). Another important aspect of the Phoenician religion was the observation and interpretation of stars, useful for navigation (Nigro, 2018). These activities were carried out inside the sacred installations of their temples. As it is to be expected,

these practices were kept secret from outsiders -at least in Motya, Sicily- through high walls that surrounded both the temple and the city (Nigro, 2018).

Given the scale of their trading networks (Puckett, 2012; Nigro, 2018; Katz, 2008; Ordóñez Fernández, 2011; Izquierdo-Egea, 2014 and Crawley Quinn and Vella, 2014), the Phoenician could be considered the father of unfettered market-based economy and, therefore, their legacy could provide us with many useful insights for modeling purpose. As the Phonecians proved, the market is an institution, but rather a very complex one. In essence, for them, markets were hierarchical trading networks where information flowed in an asymmetric way. In other words, a kind of *cosa nostra* ("our thing"). It would be reasonable to assume, without prejudice of any official title, that at the top of the Phoenician hierarchy was the merchant prince from the dominant harbor city (eg., Tyre or Carthage), followed by the merchant princes from other harbor cities (eg., Motya, Sicily or Gadir, Spain) – maybe, as in the case of the nobility, the merchant princes were related by blood or by bonds of marriage,- the next group would come from wealthy merchant families who belonged to the Phoenician inner circle, that is to say, those families who took an active role in the Phoenician rituals. Finally, the last key group of their communities could have been composed of other less affluent Phoenician merchants or even outsiders who had some kind of link or tie (including those by virtue of marriage) with the Phoenician. A market structure dominated by such a powerful network would be very difficult to challenge. When a key Phoenician harbor city fell (eg., The Siege of Tyre by Alexander the Great in 332 BC), another Phoenician harbor city took the lead (eg. Carthage). Adam Smith seems to have missed the possibility that a market-based economy could be organized as a hierarchical trading network.

We shall not underestimate the real power of a hierarchical trading network like the one created by the Phoenicians. History seems to suggest that the only way to bring down a network like that is by taking control of every single harbor city that belongs to that network. The Romans achieved precisely this after defeating the Phoenicians in the Punic wars. But that was not enough. There were also other powers in the Mediterranean (eg. the Hellenistic leagues and kingdoms), which undermined Roma's position. Roma's response was to conquer all of them until it had total control over the whole Mediterranean Basin. This was a truly remarkable achievement in human history known as the *Pax Romana* or *Pax Augusti* in honor to Caesar Augustus. The *Ara Pacis Augusti* ("Altar of Augustan Peace") commissioned by the Roman Senate to honor Augustus is a testimony of the significance of this event. There was a hope of a new world order characterized by Rome's universal peace. According to Joseph Ratzinger (2012, p. 60), "In the inscription at Priene, he [Augustus] is called Saviour, Redeemer (*sōtēr* [a title of gods even ascribed to Zeus])." Ratzinger adds, "Peace, above all, was what the 'Saviour' brought to the world." According to Reiser (2003 p. 458*), Augustus brought "peace, security of law and prosperity for 250 years, which many countries of the former Roman Empire can only dream of today." But as Ratzinger (2012) notices, the *Pax Augusti*, even at the height of the Roman empire, was never completely realized. It did not endure. Why? As we said earlier, the Romans -even after their rise to power- had divided their legal order basically in two main systems: *ius civile*, which was a rational and jurisprudential system applied to Roman citizens, and *ius gentium*, which was a sort of customary rules adopted by convention, reflecting international practices of nations but without having necessarily an *opinio juris sive necessitatis* ("an opinion of law or necessity"). This particular type of Roman *ius gentium* was the legacy of the oppressive systems that prevailed in the ancient Mediterranean, where part of humanity were treated as another tradeable commodity and where elements of law and the apology of power coexisted. The institution of slavery was part of that legacy and the *ius gentium* provided the Romans with the opportunity to profit from their inmense power. In other words, the *Pax Augusti* was not a peace based on justice. As it will become clear, the Romans also played the *Dominum Mundi* Game. The world had to wait until Francisco de Vitoria's (1539) *communitas*

totius orbis and its corresponding universal common good to see the transformation of the old *ius gentium* into a truly international law.

Continuing our discussion on networks, game theory can provide us with some insights regarding issues of identification and affiliation. Rick Riolo (1997) showed that arbitrary tags -in his case random number between zero and one- assigned to artificial agents could become an effective way to organize social interactions. By forming cooperative neighborhoods around common tags, Riolo's agents achieved levels of cooperation that were impossible when contacts were merely random. Given the above facts and arguments, the *Dominium Mundi* Game framework is based on networks as an alternative to some kind of exogenous heterogeneous agents. In contrast to neoclassical economics, which assumes that goods are traded on a centralized Walrasian exchange, where buyers and sellers are anonymous, we assume that markets are decentralized and their participants must share a relationship or link to engage in exchange. The economic literature provides a variety of reasons to explain the emergence of networks as a key component of any market structure. Kranton and Minehart (2001, p. 486) offer two reasons, one economic, the other strategic. “First, networks can allow buyers and sellers collectively to pool uncertainty in demand...When sellers have links to more buyers, they are insulated from the difficulties facing any one buyer. And when buyers purchase from the same set of sellers, there is a saving in overall investment costs. As for the strategic motivation, multiple links can enhance an agent's competitive position. With access to more sources of supply (demand), a buyer (seller) secures better term of trade.” Gale and Kariv (2007) point out that asymmetric information may imply that merchants will trade only with others they know and trust. They also cite transaction costs and increasing returns as motives for network formation. Babus (2016) asserts that a network allows losses to be shared among all counterparties of a failed institution. Gofman (2017) asseverates that the efficiency of trading and liquidity allocation decrease as a banking network faces limits on its interconnectedness because its intermediation chains become longer.

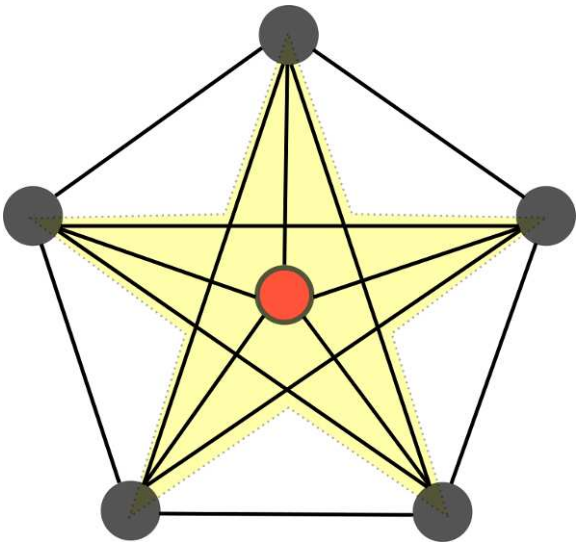
Our assumption of viewing the market as an institution composed of networks, it is supported by the empirical evidence. Soramäki, Bech, Arnold, Glass and Beyeler (2006, p. 1) found a network topology on the interbank payment flows over the Fedwire Funds Service. These authors stated that “At the apex of the U.S. financial system is a network of interconnected financial markets by which domestic and international financial institutions allocate capital and manage their risk exposures.” They found that only a small but tightly connected number of money-center banks to which all other banks connect constitutes the majority of all payment sent over the Fedwire system.

But the network structure of the federal funds market with its Fedwire settlement mechanism is not an exclusive U.S. phenomenon. In fact, this market structure seems to be pervasive in the interbank market from other countries. It has been found in Austria (Boss et. al., 2004), Japan (Inaoka et al., 2004), Belgium (Degryse and Nguyen, 2004), Brazil (Jung Chang et. al., 2008) and Germany (Craig and von Peter, 2014). Additionally, other financial markets also share a network structure. Empirical evidence of these structures were found in the municipal bond market (Schürhoff and Li, 2014), the corporate bond market (Di Maggio, Kermani and Song, 2017), and in the markets of asset-backed securities, collateralized debt obligations, commercial-mortgage-backed securities and collateralized mortgage obligations (Hollifield, Neklyudov and Spatt, 2017).

A decentralized market possesses a flexible architecture and can even accommodate or imply centralized institutions. As Beltran, Bolotnyy and Klee (2015, p. 2) described: “Often, one large bank would buy funds from many smaller banks, and then the larger banks would connect to each other and settle transactions either through a central clearinghouse, or later, through the Federal Reserve.” In fact, Soramäki et. al., characterized the Fedwire as a star network where all banks are

linked to a central hub (the Fed) via a shared telecommunications infrastructure (see Figure 2). One of the most significant implications of viewing the economy as a network of interconnected markets with a core-periphery structure is that the economy possesses a hierarchy and the wholesale money market is the center of the system. Payment system implies a credit system (Mehrling, 2016). Money is the means of final settlement and credit is just a promise to pay money or delaying final settlement (see Mehrling, 2016). This is even more relevant in our world of central bank money where "the price at which this money trades determines monetary policy" (Quinn and Roberds, 2007, p. 262).

Figure 2: Diagram of a Fully Connected Star Network



Regarding the core-periphery structure observed in financial networks, Stigum and Crescenzi (2007) found that in general larger banks were net buyers of federal funds, while smaller ones were net sellers because large customers tended to borrow money from the former but individuals deposited cash at the latter. Mehrling (2016) observes that many banks do not have access to deposit at the Fed so they need to rely on a bank that has that privilege and, thus, a profitable spread emerges as a result of this inequality. Although slowly, the economic literature has begun to acknowledge the possibility that banks are not competitive and, therefore, positive economic profits exist. Farboodi (2015, p. 1), for example, developed a model of the financial sector where "financial institutions have incentives to capture intermediation spreads through strategic borrowing and lending decisions. By doing so, they tilt the division of surplus along an intermediation chain in their favor, while at the same time reducing aggregate surplus." Additionally, empirical evidences in the municipal bond market (Li and Schürhoff, 2014) and the corporate bond market (Di Maggio, Kermani and Song, 2017) suggest the existence of intermediation rents. Di Maggio et. al., (2017) proved that in general dealers provide liquidity in time of crisis to the counterparties with whom they have the strongest tie. In period of distress, the larger dealers exploit their connection and charge higher prices to both the peripheral dealers and those clients who are not in their network. In addition, clients of a failed dealer are forced to redirect their orders through longer intermediation chains, which end up charging them much higher prices.

As we have seen, network structures not only can be applied to a wide range of economic phenomena but also is well suited to a formal treatment thanks to the analytical methodology provided by Graph Theory. For example, following Gale and Kariv's mathematical representation (2007, p. 100), the primitive of a financial network can be expressed as:

A nonempty graph (N, E), where N is the collection of nodes, and $E = \cup_{i=1}^{N}\{(i,j): j \in N_i\} \subset N \times N$ is the set of edges. Therefore, the set $N_i = \{j:(i,j) \in E\}$ represents the neighbors of agent i, that is, the group of agents with whom agent i can trade.

Game theory offers a natural way to model the interactions among organizations or individuals who are linked via a network because the payoffs that an economic agent receives from different choices depend on the behavior of his neighbors (Jackson and Zenou, 2014). In order to keep our model computational tractable, we reduce the number of agents in the *Dominium Mundi* Game framework to only two basic types: the ruling class and the people (household). Given this choice, we implicitly treat both public policies and the legal order as an equilibrium outcome generated by the interaction among our two basic types of agents. In this regard we are assuming that the rights of the people (Law) and the legal norms sanctioned by the public authorities are not necessarily equivalent as it was showed in the previous section. This is in line with the observations of Pagano and Volpin (2005, p. 1005) who wrote: "Laws result from the political process, however, which in turn responds to economic interests. In this sense, legal rules and economic outcomes are jointly determined, politics being the link between them." Explanations for the observed relationship between political power and wealth are not only offered by the economic literature (Rodríguez, 1997; Bénabou, 2000 and Esteban and Ray, 2006), but also can be traced back to Plato's Republic (c. 380 BC) in his discussion of the five types of regimes.

Given that we live now in a secular world order, we restrict our ruling class agent to the merchant elite, in other words, we consider only wealthy traders and rich business people. This assumption implies that both the nobility and the clergy are rather nominal figures in our modern society and do not exercise real control over the world's resources as they used to. Anyhow, a king's property is a public good (Vitoria, 1546 and Ayala, c. 1804), and therefore, the jurisprudential criteria for the qualification of unfair enrichment is more subtle in that case. However, the above assumption does not preclude the possibility of merchant princes like the Phoenician ruling class or the selfish use of religion and ideology. We assume that the merchant elite is organized in hierarchical trading networks as discussed earlier. In our model, they are the only ones who can systematically extract or capture rents or excess returns on their investments. However, they do not create any technological change -this is a simplifying assumption, which will be later relaxed with the introduction of social mobility-. As Donald Trump (2004) suggested, business people grab, fight and win – they are the "overdog" [winners] in our model. This is so because the organization of a market as hierarchical trading networks allows asymmetric information not only within the member of the same network but also between the network's members and the rest of the population. Given this market structure, individuals connected to the merchant elite are more likely to occupy a high public office than agents belonging to the type people -"money is king" or at least matters-. However, it is important to notice that in our model wealthy merchants are not parasites, they do render a useful service to society in the form of intermediation, coordination or aggregation services. They may be charming, educated, smart and hard working individuals who save a lot, spend wisely and take risk. But for our analysis, the fundamental difference between our two types of agents is that the merchant elite is able to grab or receive more than what corresponds to their fair share -Section 4 provides more information on this topic.

On the other hand, the second type of agent in our model, people (household) not only provide labor, service, human capital, consumption, saving and investment, but also are the first and true inventors of any technological progress and have the right to vote in a representative democratic election. Given the above criterion, a merchant, inventor or entrepreneur who receives a fair profit that is just enough to cover all his or her costs, including innovation costs and risk (eg., cost of

capital or cost of equity – see Damodaran, 2012) would be classified as the type people. From an economic point of view, the agent people receive only the necessary incentives to carry out an economic activity. On the contrary, the elite receives true economic profits, disproportionately more of what would be suggested by a competitive equilibrium model or its extension when price-taking competition cannot be supported in equilibrium (Romer, 1990). It is worth noting that an extension to competitive equilibrium may include innovations with zero profit conditions in expectation (Matsuyama et. al., 2012) or some sort of optimal taxation, efficient intellectual property rights, restitution, reasonable regulation, etc., -more about this in Section 4.- The key point is that only the merchant elite possesses real negotiation power.

As sociology reminds us, the division of a society in two agent types or classes will bring inexorably the problem of social mobility. That is to say, how an agent that belongs to one social category can move to another social category. Even in the ancient *régime*, with its relative close social order, there were numerous examples of common people who moved to the rank of the nobility by virtue of royal privilege. The Rothschild family, whose most influential members were granted noble titles in both the Holy Roman Empire and the United Kingdom, is a canonical example. In today's secular world things are somehow different but the basic principle remains the same. The American Dream's ethos could help us to understand the concept of social mobility within the *Dominium Mundi* Game context. First of all, we must distinguish between an "American Dream" that is consistent with the Law and an "American Dream" that goes against the Law. As we saw earlier, the Law (*ius*) and legal rules are not necessarily equivalent and when the difference between them is significant we are in the presence of legal corruption -more about this in Section 4-. For example, if the daughter of a very poor migrant establishes a successful business, trough hard work, innovation, and risk-taking activities, and as a result of that she is fairly compensated for her endeavour and can afford to live a very comfortable life, then she has achieved an "American Dream" consistent with the Law. According to the DMG framework, this hard-working woman still belongs to the agent type people because she just got her fair share. However, in order to be consistent with reality, which also includes social mobility, the DMG allows a variable fraction of agents of the type people to become part of the ruling class or merchant elite. There are many reasons that can justify this assumption. In addition to bonds of marriage or religious affiliation -as defined earlier-, an outsider can be accepted as a member of a powerful hierarchical network because of a mutually-beneficial relationship. Outsiders can bring assets that are valuable to a network such as political leverage, social connections or status, intellectual leadership, access to resources, intellectual property rights, scarce talents, private information, etc. The possibility of social mobility from the common people, who can enjoy at most fair market returns, to the elite, who by definition possesses above-market returns, brings perverse incentives to the political process given the cognitive biases introduced by conflicts of interest. Now, the DMG's agent type people are endogenously divided by different expectations regarding social mobility of the class that is not consistent with the Law but that the legal system allows it. In Section 3, we examine the technical details of why expectations in an economic model matter and how the incentive structure of a repeated game is altered by them.

The above assumptions are without prejudice of any liberal democracy. It only excludes the possibility of a Lincoln's ideal government of the people, by the people and for the people because wealth concentration really matters and, therefore, unfair enrichment is obviously feasible. As justice Louis D. Brandeis once said, "We must make our choice. We may have democracy, or we may have wealth concentrated in the hands of a few, but we can't have both" (Brandeis University, 2007). Democracy is based on the principle: "one person, one vote," which implies that politicians' behavior must be driven by the needs and aspirations of their electorate. But when money enters into the equation as in campaign finance, the above premise may not hold. For

example, in two landmark cases, the U.S. Supreme Court held that the First Amendment provision on freedom of speech severely impairs the government's ability to regulate federal campaign contributions and spending (Buckley v. Valeo, 1976 and Citizens United v. FEC, 2010). As a consequence of these rulings, special interest groups have the doors open for unlimited political spending, which they can channel through devices such as super PACs in order to advance their own agenda. As a Congressional Research Service's report (Garrett, 2016, p. 5) stated: "super PACs can substantially affect the political environment in which Members of Congress and other federal candidates compete." Additionally, super PACs are not transparent. "The original source of some contributions to super PACs can be concealed (either intentionally or coincidentally) by routing the funds through an intermediary" (Garrett, 2016, p. 10). However, the judicial interpretation of the U.S. Supreme Court regarding the freedom of speech in the context of campaign finance is just too severe. The Roman jurist Modestinus (Digest 1. 3. 25) stated: *"Nulla iuris ratio aut aequitatis benignitas patitur, ut quae salubriter pro utilitate hominum introducuntur, ea nos duriore interpretatione contra ipsorum commodum producamus ad severitatem."* This means that no reason of law, nor the benignity of equity allows, that the things that are introduced healthily for the benefit of the people, we take them to severity with a harder interpretation against the welfare of the people. Additionally, the judicial interpretation of the U.S. Supreme Court regarding the freedom of speech and its implications in campaign finance goes against the most basic principle of the Law (understood as *ius*), which is to protect the weak against the abuse by the strong (Ayala, 1789, p.6). Finally, the problems of transparency and secrecy in the political process are exacerbate not only by the offshore interests and activities of many politicians and world leaders as it was revealed in the Panama and Paradise Papers scandals, but also by new opportunities created by technology as it was discovered in the Facebook–Cambridge Analytica data scandal.

3. Technical Details and the Case for Artificial Intelligence

After the discussion of the last two sections, we are ready to introduce the mathematical backbone of the *Dominium Mundi* Game framework, which is nothing else than a recursive structure called "Dynamic Programming Squared" (see Ljungqvist and Sargent, 2012). This is a method to encode history dependence through promised values where value functions are placed inside value functions (Ljungqvist and Sargent, 2012). That is to say, a mathematical structure characterized for having a Bellman equation inside a Bellman equation where the inner Bellman equation describes responses of an agent who incentives are affected by another one -eg., the policymaker- (Sargent, 2016). In this context, the DMG's framework is consistent with the ancient Chinese proverb, quoted and popularized by Sargent (2016): "the government has strategies. The people have counter-strategies"; but with the difference that we replace government by ruling class, which in our case is the merchant elite. Thanks to the "Dynamic Programming Squared" (DP^2) technique, we can formalize the DMG's Fundamental Inequality.

Taking the initial conditions as given, the fundamental problem of the agent type ruling class or elite is to choose an infinite sequence of control variables $\{\varepsilon_t, c_t, v(x_{t+1})\}_{t=0}^{\infty}$ to maximize the present value of their expected future rewards subject to some constraints. For our greedy elite agent, wealth is not only a mean to achieve an end but also an end for its own sake. Therefore, we can consider wealth accumulation like a proxy for the objective of the elite's optimization problem. Under this formulation, x is the state variable, which summarizes the state of the world at the beginning of each period. The state x could be a high-dimensional object $x \in \mathbb{R}^n$ and $\widetilde{x}$ represents the state x in the next period (eg., from x_t to x_{t+1}), which is governed by a controlled Markov Process. $c \in \mathbb{R}^k$ is the typical control or action variable, taken by agents each period after observing the state s, $\varepsilon \in \mathbb{R}^l$ is the elite's exclusive decision variable and $v : X \to \mathbb{R}$ is the people´s objective function to be maximized, where $x, \widetilde{x} \in X$. The Bellman equation $v(x)$ denotes the

optimal value of the people's problem starting from state x, which is to maximize their expected discounted utilities over time subject to their own set of constraints. The DP[2] framework allows the agent type elite to manipulate people's continuation value function $v(\tilde{x})$ given their knowledge of people's value function today $v(x)$. As Sargent (2016) observed, this is a very powerful method because it allows us to solve a maximization problem containing equilibrium constraints. If we make use of the Bellman's Principle of Optimality (see Stokey and Lucas with Prescott, 1989), we can reformulate the elite's sequence problem into an equivalent problem characterized by functional equations. Following Sargent (2016) -with some slight modification-and without being bogging down with cumbersome details, we can express the key basic mathematical relations of the DMG framework as follows:

$$W(v(x),x) = \max_{\varepsilon, c, v(x^*)} \{R(x,\varepsilon) + \beta \int W(v(\tilde{x}),\tilde{x})\, d\Psi(\tilde{x}|x,c,\varepsilon)\}$$

subject to

$$v(x) = \max_{c} \{u(x,c) + \beta \int v(\tilde{x})\, d\Omega(\tilde{x}|x,c,\varepsilon)\}, \qquad \Psi, \Omega \neq F \ \wedge \ \Psi \neq \Omega$$

, the corresponding feasibility constraints and the incentive-compatibility constraints, which characterize the best response of the agent type people to the terms and conditions offered by the agent type elite.

$W(v(x),x)$ represents the optimal value of the elite's problem starting from state x, $\beta \in (0,1)$ is a discount factor, R is the elite's one-period reward function, u is the people's one-period utility function, Ψ and Ω are conditional probability distributions of the elite and the people respectively, which are partly determined by the agents' actions. F is the conditional probability distribution corresponding to the true model of the world. It is worth noting that in a rational expectation model Ψ, Ω and F would be all equal. The term $\int v(\tilde{x})\, d\Omega(\cdots)$ can be interpreted as the people's expected next period value. The same logic applies to the elite's expected next period value. Without affecting the internal consistency of the DMG framework, we also maintain all the other analytical and measure-theoretic results, properties, assumptions and definitions necessaries to render this formulation tractable (see Stokey and Lucas with Prescott, 1989; Ljungqvist and Sargent, 2012; Stachurski, 2009 and Sargent 2016).

Let $\mathring{W}(v(x),x)$ be the optimal value of a Benevolent Social Planner´s problem starting from the state x who only cares about maximizing the welfare of the people, that is to say, in the Bellman equation $W(\cdots)$ we replace our greedy agent elite with a honest, prudent ruler or a *bonus pater familias* ('good family father') to obtain $\mathring{W}(\cdots)$

Given that $W(\cdots), \mathring{W}(\cdots) \in \mathbb{R}$

$$\Delta(v(x),x) = W(v(x),x) - \mathring{W}(v(x),x) > 0, \qquad \forall x$$

is the Fundamental Inequality that triggers the *Dominium Mundi* Game.

$\Delta(v(x),x)>0$ can be interpreted as a metric for unfair enrichment when the state is x and the Benevolent Social Planner or the *bonus pater familias* can be interpreted as the personification of the Law (understood as *ius*).

$$W(v(x),x) = \mathring{W}(v(x),x) \quad \Leftrightarrow \quad \lim_{t\to\infty}\{\Psi_t(\cdots),\Omega_t(\cdots)\} = F(\cdots)$$

The above logical equivalence means that if and only if the Bellman equation $W(\cdots)$ is equal to $\mathring{W}(\cdots)$, because we have replaced the greedy agent elite with the Benevolent Social Planner, then the conditional probability distributions $\Psi(\cdots),\Omega(\cdots)$ converge to $F(\cdots)$, which is the true conditional probability distribution of the world. That is to say, when the Law is firmly established, the *Dominium Mundi* Game becomes a rational expectation model.

With a dynamic programming formulation, we can ruthless apply the self-evident premise of self-interest. We have no need of assuming an idealized form of government or the sanctity of the central bank. Additionally, we can incorporate Graph Theory to the DP^2 framework so that we can introduce hierarchical trading networks into the DMG model. In fact, a more realistic formulation for the *Dominium Mundi* Game would be Dynamic Programming Cubed (DP^3). This would allow us to divide the agent type elite into two hierarchical categories: a senior elite (eg., merchant princes) and a junior elite (eg., connected wealthy merchants). A DP^4 formulation would be even better for our modeling purpose but, unfortunately, as the number of nested Bellman equations increases, the complexity of the problem also grows.

In summary, we have formulated above what it might be called a "nasty" optimization problem. We have consciously deposed of all the beautiful simplifying assumptions that make our lives as modelers relatively easy. In the DMG framework, we don´t have competitive equilibrium or zero profit conditions for the elite. There is no rational expectation, perfect information or even perfect government. Now greed becomes a real headache as it seems to be in the real world. Positive incentives alone (eg., the carrot) will not work because greed is, by definition, boundless and insatiable and, given the hierarchical structure of our model where the greedy elite is at the very top, it will always find its way out of such restrictions. We are forced to bring punishments -a sort of negative incentives (eg., the stick)- into our model, but, unfortunately, as we will see later, punishments don´t work either. So we have a very serious problem. Greed cannot be tamed, it reigns supreme. As a result of that, the *Dominium Mundi* Game is in essence a self-destructive game.

Given our above discussion, we must reformulate our dynamic optimization framework into a full game-theoretic approach. Punishment can be introduced as a price that needs to be paid in order to discipline "bad" behavior or deviation from cooperation or common interest with the aim that all the "players" hold the necessary incentives to remain in the "game" (see Stigler, 1964; Osborne, 1976; Spence, 1978a and 1978b; Friedman, 1971). In the most general sense, the equilibrium strategies must embrace a mechanism that deters agents from cheating (for example, in the case of colluding firms, a defective behavior would be increasing output or cutting prices). If these punishments (eg., reverting from collusion to competitive equilibrium, expelling the defecting agent from a well-positioned network, voting against a corrupt government, etc.) are large enough to outweigh the benefits from bad behavior, then collusion, cooperation, policy agreement or any expected behavior is sustainable (Rotemberg and Saloner, 1986).

As Green and Porter (1984) brilliantly observed, in a certainty world, punishment would not be a problem because incentives are so perfect aligned that the deterrent mechanisms are never observed in equilibrium. Therefore, given that our approach assumes that punishments do happen, the DMG framework must be based on imperfect information. However, our model includes a third feature, which has not been studied in the literature of recursive games. This is the possibility of transferring punishment from one agent to another one, so that the dynamics of the game with its

implied allocation of benefits could be preserved for a longer period. This particular characteristic of the *Dominium Mundi* Game is consistent with the sacrificial nature of the ancient Phoenician religion described earlier. Wrongful acts bring always negative consequences and if the culprits are not held accountable, somebody else will have to suffer the consequences. This is consistent with the natural principle that something can not be obtained out of nothing. Two recent examples of transferability of punishments can be found in the 2008 global financial crisis and in the U.S. withdrawal from the Paris Climate agreement of 2015. The latter is, as we will see later, in detriment of the planet and all future generations. But regarding the former, Stigliz (forthcoming, p. 7 and 4) wrote "our legal system, which has failed to hold accountable almost any of those culpable for the crisis. It is this failure, combined with the fact that so many bankers managed to walk away with mega-bonuses, which has led to disillusionment in our economic and political system, with widely held beliefs that it is "rigged" and unfair." Stiglitz added "they keep the profits in good times, while the public bears the losses in bad [eg., through bailout, etc.]." What Stiglitz affirms is exactly what we mean by a transfer of punishment. In his example, the transfer goes from those who were responsible for the financial crisis, profited from it and walked away with blatant impunity to the taxpayers and other economic agents who suffered its negative consequences (eg., unemployment, poverty, bankruptcy, credit rationing, reduction of social security benefits, social unrest etc.)

The conclusions drawn by two experts cited by the Financial Crisis Inquiry Commission (FCIC)'s report (2011) can shed more lights on the above issue. The first expert is William K. Black, a professor with expertise on white-collar crime and a former bank regulator. He affirmed that "The claim that no one could have foreseen the crisis is false" (FCIC, 2011, p. 15). Again, this powerful statement suggests that the financial crisis was not an unanticipated event. If that were the case, the reasonable presumption would be that somebody should have known what was going on. This would be a problem of asymmetric information. Black even wrote a book with the title: The Best Way to Rob a Bank is to Own One: How Corporate Executives and Politicians Looted the S&L Industry. The second expert who gave testimony to the FCIC is Henry N. Pontell, a professor emeritus of criminology at the University of California, Irvine. He stated: "Lax or practically non-existent government oversight created what criminologists have labeled 'crime-facilitative environments,' where crime could thrive" (FCIC, 2011, p. 161). U.S. senator Elizabeth Warren went even further calling this situation "too big to fail has become too big for trial" (Warren, 2013). Again, the framework provided by the *Dominium Mundi* Game is capable of dealing with situations where "unethical" behavior or wrongful acts are an integral part of the economic activity. Here is where a network as a formal arrangement to describe a market structure shines above all else. Criminal activities are a group phenomenon and have been depicted in the literature as networks (Sutherland, 1947; Haynie, 2001; Sarnecki, 2001; Warr, 2002; Calvó-Armengol and Zenou, 2004; Jackson and Zenou, 2014). It is important that we do not underestimate the true impact of a financial crisis. It is indeed a very dangerous game. It is like playing with fire. For example, the Great Depression, lasting from 1929 to 1939, was not only limited to severe economic hardship. In his 1999 Nobel prize's lecture, Robert Mundell made one of the boldest statement in the history of economics when he affirmed that "had the price of gold been raised in the late 1920's, or, alternatively, had the major central banks pursued policies of price stability instead of adhering to the gold standard, there would have been no Great Depression, no Nazi revolution and no World War II" (Mundell, 2000, p. 331).

Because our model is based on imperfect monitoring, punishments will occur on the equilibrium path. Therefore, under certain conditions, players could prefer the minimum punishment necessary to create the appropriate intertemporal incentives (Obara, 2003). But if instead of receiving the minimum punishment, agents could transfer it with impunity to somebody else, they might do so depending on the their beliefs and preferences. Given that we assume both profit maximization

(greed) and biased belief in the face of conflicts of interest, this transfer of punishment or sacrifice is much more likely to occur in our model than in a model of pure rational expectations. The inclusion of this feature provides the DMG framework not only with more realistic and powerful dynamics, but also with the means to make endogenous otherwise external shocks such as financial crises, deep economic downturns, political upheavals, and social unrest. As a modeling device, we could add to a DMG model an external sector in order to take into account the interactions of our agents with foreign nations and the environment, which are both easy targets for transferring punishments given their intrinsic vulnerabilities or the marginal role that both play in the democratic process of our agents' own political institutions. Neither an unborn child nor a foreigner can vote. For them, it is like receiving "taxation without representation." In this way, more complex and destructive adverse shocks such as war and man-made environmental catastrophes can arise endogenously in equilibrium. Once we take into account all facts, interpretations, concepts and assumptions discussed until now, we are ready to formulate the first conjecture derived from the *Dominium Mundi* Game framework.

First Conjecture: Adam Smith's invisible hand -properly interpreted- doesn't lead society to the maximum good, but on the contrary, it triggers the *Dominium Mundi* Game, $\Delta(v(x),x)>0 \quad \forall x$, leading society through a series of man-made adverse shocks to the maximum evil. Greed is welfare minimizer not welfare maximizer.

Adam Smith's classical case of "free" market in absence of monopolies or privileges granted to companies by an independent government is not sufficient to guarantee competitive equilibrium. Greed will find its way out of the restrictions imposed by Smith´s form of competition and will make society to end up in the worst possible equilibrium. Tempted by the illusion of boundless power and wealth, greed degenerates in a self-destructive behavior like some in the Antiquity could wisely foresee (Plato, c. 380 BC; Ezekiel 28). The basic intuition behind this powerful statement comes from the following two arguments. First, as we saw in Section 1, Adam Smith's invisible hand is not equivalent to perfect competition, competitive equilibrium or zero profit conditions as many economists have wrongly believed. Second, when greed is mixed up with the other two elements of human nature (human fallibility and human sociability), as it was described in Section 2, transferability of punishments not only becomes feasible -given the presence of powerful hierarchical trading networks- but also generates man-made adverse shocks, which might be amplified over time until the worst equilibrium is finally reached. We could think about the consequences of transferability of punishment as if it were a debt with a very high compounding interest rate, which is rolled over until a point in time where further extensions are not longer possible and the whole debt with all its accumulated interests have to be settled. It is a sort of a natural law, a judgment day executed by "nature" where bad actions will always bring bad reactions. Because "there is no such a thing as a free lunch," sooner o later punishment will take place.

The seminal paper of Green and Porter (1984), which deal with problems that arise in noncooperative collusion under uncertainty, is our starting point to the journey of understanding the DMG's First Conjecture. These authors stated that given imperfect price information, firms cannot form a sustainable self-policing cartel to maximize their joint profits, but rather a cyclical pattern emerges, where the economy alternates between collusion (monopolistic conduct) and Cournot behavior (a punishment phase from the perspective of firms). What Green and Porter (1984) mean is that in a world of imperfect monitoring, it is not feasible the type of James Friedman's (1971) colluding oligopolies that exhibit permanent monopolistic profits by virtue of threats of reverting to more competitive behaviors whenever a single firm defects from a cartel. In their own words, "Each firm faces a stationary two-state (normal and reversionary) T-stage Markov dynamic

programming problem. Its optimal policy is to produce z_i in reversionary periods, and to produce some fixed quantity r in normal periods."

What is really interesting in Green and Porter (1984) is the fact that even though firms know that low prices may reflect demand conditions and not actual cheating, it is still optimal for them to break the cartel temporarily and compete among each other. According to the authors (p. 94), the answer to this puzzle is "that everyone understands the incentives properties of equilibrium. If firms did not revert to Cournot behavior in response to low prices, equation (5) would not hold the rest of the time, so monopolistic behavior would cease to be individually optimal for firms." This is a remarkable finding that unfortunately has been overshadowed in the economic literature by the Abreu, Pearce and Stacchetti (APS)'s (1990, p.1054) powerful bang-bang principle, which states that "efficient incentive schemes must necessarily have a bang-bang structure." In other words, "efficiency demands that nonextremal points of the payoff set are never used" (p. 1044). APS (1990, p. 1058) eloquently built a case against Green and Porter (1984) in the following terms: "In a finite action Green-Porter model, for example, losses will result from restricting attention to punishments no worse than 'Cournot-Nash reversion.' Even if this restriction is imposed…, it is best to use punishments involving permanent reversion, rather than temporary reversion followed by resumed cooperation..." In spite of APS's critic, we can bring two arguments in favor of Green and Porter (1984). First, the complexity of reality may impose restrictions or additional constraints on agents' strategy space. Second, as we saw in the previous section, no all relevant models need to be based exclusively on perfect rationality. In fact, the *Dominium Mundi* Game offers a theoretical reason to justify Green and Porter's (1984) approach. Given the cognitive bias caused by conflicts of interest, greedy agents of the type ruling class or merchant elite underestimate systematically the worst equilibrium until it is too late -climate change deniers and "business-as-usual" mentality are examples of that. Therefore, the moderate punishment value introduced in Green and Porter (1984) and Porter (1983) may be constrained optimal as even APS (1990, p. 1058) recognized. However, in the DMG framework, the key difference with respect to Green and Porter (1984) is that moderate punishment might be an illusion and not a real equilibrium outcome. In other words, the moderate punishment is based on the agents' biased expectations and not on the true model of the world. Sooner or later, reality will turn out to be much worse.

Green and Porter (1984) offer two properties that could be generalized in the framework of the *Dominium Mundi* Game. First, their trigger-strategy equilibrium is able to establish endogenous cycles based exclusively on the behavior of profit-maximizing agents who interact in an environment with uncertainty. It is not necessary a technological shock or a change in fundamentals to provoke such a dynamics. Second, firms voluntarily and deliberately accept a moderate bad equilibrium (reversionary period) as a necessary evil that ironically serves their best interests. It is important to understand than in dynamic games, at any history, the concept of Nash equilibrium is too permissive because it doesn't enforce any optimality conditions in the remaining game (Yeltekin, Cai and Judd, 2017). Therefore, equilibrium solutions for recursive games must obey sequential rationality (Green, 1980; Kreps and Wilson, 1982 and APS 1986 and 1990). Green and Porter (1984, p. 93) summarized the result of their equilibrium analysis in the following terms: "the marginal return to a firm from increasing its production in normal period [cheating] must be offset exactly by the marginal increase in risk of suffering a loss in returns [punishment] by triggering a reversionary episode."

Unfortunately, the *Dominium Mundi* Game (DMG) is much more complex than Green and Porter (1984) at least in three fundamental ways. First, in Green and Porter (1984), the trigger variable used for monitoring, the price of the undifferentiated product, is not only imperfectly correlated with firms' conduct, but also observed publicly, so the game has a nice recursive structure and even

a Folk Theorem can be derived (Fudenberg, Levine and Maskin, 1994). In contrast, in the DMG framework, the key trigger variable is $\Delta\ (v(x),x)$, whose observability is subject not only to problems associated with human fallibility and hidden information but also to problems of disinformation (deception). The DMG is based on asymmetric information due to its hierarchical network topology. Agents at the very bottom of the hierarchy (the people) do not have access to the information that agents at the very top (merchant princes) possess. Even worse, agents at the periphery of the same trading network don't know what agents at the core know. There is clearly private information, which is exploited ruthlessly with the aim to maximize profit. Human fallibility also affects to the type of agents at the bottom, the people. The problem of the people is that they not only don't have access to all information, but also they are victims of disinformation campaigns, which are generated endogenously in the model as part of the profit-maximization strategies of the key beneficiaries of the trading networks. This create a big problem because people like the other agents are bounded rational, so the presence of both private information and disinformation impair severely their beliefs about their environment. This, in turn, affects human sociability through religion affiliation and participation. In the previous section, we defined religion in a very broad and general sense as a system of beliefs (including ideology) that create strong bonds or ties among people like if they were a family. So, as a consequence of the above, divisions within religions and conflicts among them emerge endogenously in a DMG model. Expectations regarding social mobility make things even worse. Thus, ideology, religious fanaticism and legal corruption (eg., loopholes, legal tricks and the legitimization of unfair enrichment) arise in equilibrium. This powerful implication means that when the Law is not firmly established, people can be fooled all the time.

Second, as discussed earlier, the DMG introduces the possibility of transferability of punishments, which basically means that the stronger party, instead of being himself punished for his wrongful act, transfers to the weaker party the negative consequences of such action. This is consistent with the natural principle that something can not be obtained out of nothing: actions have consequences. Human fallibility also affects our agents at the very top of the hierarchical trading network (the merchant princes). Given the model design, they have access to more information than anybody else. They are the agents who get the closest to the idealized concept of rational expectations. However, given their exorbitant wealth, power and influence, they suffer from cognitive biases due to conflicts of interest. The moderate punishment might be an illusion based on biased expectation. The real punishment may be in fact much worst but because the elite is in some sort of constant denial, as if they were unconscious individuals, they continue acting in a business-as-usual fashion until it is too late.

Third, we cannot reduce our problem, as in Green and Porter (1984), to a stationary two-state (normal v. reversionary) T-stage problem or as APS's (1986 and 1990) stationary best and worst symmetric sequential equilibrium. The empirical evidence seems to suggest that man-made adverse shocks are not constant over time, but rather nonstationary. In the DMG, adverse shocks come in a discontinuous fashion with different intensities and durations until the game is finally over, which means from societal collapse to total annihilation. This illustration reflects the self-destructive nature of greed as opposed to Adam Smith's benevolent apology. In the DMG, the ruling class or elite type of agents underestimates systematically this perverse dynamics because they suffer from cognitive bias due to conflicts of interest -they only see what they want to see. Irrationality is an intrinsic part of the *Dominium Mundi* Game.

As we move from a dynamic optimization framework to a game-theoretic approach, it would be convenient to take advantage of the powerful tools offered by the theory of recursive games. Abreu, Pearce, and Stacchetti (APS) (1986) showed that optimal symmetric equilibria in the Green-

Porter model exist with a simple intertemporal structure. The technique employed by them was to reduce the repeated game to a family of static games. They introduced novel concepts such as factorization and self-generation. Regarding factorization, the key insight is that in a symmetric sequential equilibrium, the total game payoffs can be factored or decomposed, in a dynamic programming manner, into today's payoffs (eg., first-period reward) and continuation payoffs (a kind of promise of some discounted expected value of the reward function for the remainder of the game). It is worth mentioning that these continuation payoffs could be used to incorporate what we meant by "expectations" in our discussion on social mobility introduced in the previous section. Every decision or action that belongs to an equilibrium strategy, it should induce an optimal strategy for the remainder of the game (Kreps and Wilson, 1982). APS (1986, 1990) developed set-valued dynamic programming techniques for solving recursive games, showing that the set of equilibrium payoffs is a fixed point of a monotone operator, which resembles the Bellman operator (see Judd et. al., 2003). As Sargent (2012) observed, APS (1986, 1990) found it is more efficient to deal with the set of continuation values tied with equilibrium strategies than it is to work directly with the set of equilibrium strategies. The APS's approach is well-suited with the Dynamic Programming Squared formulation presented earlier because we need to map two continuation values into one, as opposed to traditional dynamic programming, which maps one continuation value tomorrow into one value equation today (Sargent, 2012).

According to Yeltekin, Cai, and Judd (YCJ) (2017), one can find a recursive operator that not only maps tomorrow subgame perfect equilibrium (SPE) payoffs into today SPE payoffs, but also maps compact correspondences to compact correspondences and, in addition, is monotone. The advantage of their approach is that allow the application of numerical methods for computing all SPE of recursive games with discrete states. Otherwise, as YCJ (2017) point out, one will be confined to consider only special cases given that dynamic games admit a multiplicity of equilibria. However, the problem for us with the YCJ's (2017) approach is that although they found an efficient method to compute equilibria in dynamic games, it appears that their method is applicable only to cases of perfect monitoring. For the case of repeated or dynamic games with imperfect monitoring, Burkov and Chaib-draa (2015, p. 884) state that "to the best of our knowledge, there are no algorithmic computational methods capable of finding such equilibria." These authors (2013, p. 23) also provide an intuitive description of the main challenges that arise in this class of games. They said that "when monitoring is imperfect, not every deviation can be immediately and with certainty detected, as well as the identity of deviator cannot always be precisely determined. Therefore, an important part of the analysis in games of imperfect monitoring is devoted to specifying conditions, under which the deviations are detectable and the deviators are identifiable." This compelling statement might lead us to the temptation of simplifying and reducing the *Dominium Mundi* Game (DMG) into a game with public monitoring like the one studied by Green and Porter (1984) and APS (1986, 1990). But, unfortunately, this approach would change the nature of the DMG into something else, which may be irrelevant or even misleading for our purpose.

As we discussed earlier, the ancient Phoenician showed us the power of secrecy, starting with their own bizarre religion, as a key factor for the consolidation of their all-powerful hierarchical trading network. The private information that results from this fact could be considered as a very subtle form of a trade secret. Even in modern times, we can find many concrete examples of private or hidden information. Pope Clement XII issued in 1738 a papal bull *In eminenti apostolatus specula* banning Catholics from joining Freemasons, which was even confirmed in 1983 by the Congregation of the Doctrine of the Faith (Ratzinger and Hamer, 1983). Recent scandals as Panama and Paradise papers, Facebook-Cambridge Analytica and many other related to the financial industry (Mallaby, 2010; Litterick, 2002; Neate, 2016; Kolhatkar, 2016; Wilmarth, 2014; Whalen and Tan Bhala, 2011; Freifeld, 2016; Balzli, 2010; Nelson, et. al., 2017; Parikh, 2017;

Jayachandran and Kremer, 2006; Stiglitz, 2018 and forthcoming; FCIC, 2011; Webel, 2013; Mehrling, 2016; Hou and Skeie, 2014) support the asseveration that private or hidden information is a key feature of today´s world as it was in the past. In fact, Michael Bowling et al., (2017), when comparing the realism of imperfect vs perfect information games, quoted John von Neumann, the founder of game theory, in a conversation recounted by Bronowski, when he said: "Real life is not like that [referring to perfect information games]. Real life consists of bluffing, or little tactics of deception, of asking yourself what is the other man going to think I mean to do. And that is what games are about in my theory."

The technical challenges for solving a *Dominium Mundi* Game come mainly from two sources. First, as showed earlier, the DMG's basic functional equations follow a recursive structure called Dynamic Programming Squared. Additionally, the APS's (1986, 1990) powerful methodology (eg., factorization, self-generation, bang-gang theorem) is based on recursive game theory. For high-dimensional problems, this method runs into a technical difficulty known as the "curse of dimensionality" (Bellman, 1957), where the complexity of the algorithm grows exponentially. Second, repeated games with private or hidden information still remain an open research challenge. Little is known about the characterization of the optimality properties of these games, let alone the computation of their equilibria (Levin, 2006; Kandori, 2002; Burkov and Chaib-draa, 2014). There are uncertainties in both the game dynamics and the opponents' strategies. For example, in the card game Poker, Southey et. al. (2012, p. 1) stated that, "Uncertainty in the game stems from partial information, unknown opponents, and game dynamics dictated by a shuffled deck. Add to this the large space of possible game situations in real poker games such as Texas hold'em, and the problem becomes very difficult indeed." So what can we do? We propose that we should start to think out of the box and go beyond operator-theoretic techniques.

Given the above situation, our problem would be how to solve the *Dominium Mundi* Game so that we can accept or reject our first conjecture based on some sort of approximate solution to the DMG model. As suggested by John Nash's 1950 Phd thesis, a formal proof might not be feasible. In other words, the realistic goal might be not to find a direct mathematical proof to the DMG's conjectures, but rather to determine the model implications with respects to its theoretical definitions and assumptions. This will bring us inexorably to the discussion of what constitutes a proof of a conjecture in social science. How can we proof Adam Smith's invisible hand, especially when we know from our previous discussion that his conjecture is not equivalent to Arrow's (1951) and Debreu's (1959) competitive equilibrium? If Adam Smith were right with his invisible hand properly interpreted, then the *Dominium Mundi* Game's First Conjecture would be false and vice versa because they are exactly the opposite. Before we proceed into this analysis it would be useful to remember the words of Kenneth Judd (1998, p. 8-9 and 12) who stated: "One example is not a proof of a proposition; neither do a million examples constitute a proof of any proposition. While the latter is far more convincing than one example, a theorem about a continuum of special tractable cases does not prove anything general... A computational approach will have to focus on computationally tractable cases, but those cases will be far more general than cases that are analytically tractable and amenable to theorem-proving."

In order to gain further intuition on how to solve our model, we could make an analogy between the *Dominium Mundi* Game and the Nazi Enigma Machine, which was a cryptographic device with nearly 159 quintillion (10^{18}) different setting (Wikipedia, 2018). So cracking the Enigma code would be like finding an approximate solution to the DMG. Under this framing of the problem, the insights of Marian Rejewski and Alan Turing could be useful for our purpose. One of their key contributions was to devise an electro-mechanical machine to accomplish the task of deciphering the encrypted messages generated by Enigma. According to Gordon Welchman (1982, p. 120),

another inventor of this type of code-breaking machines, "... the task of the bombe [the machine that cracked Enigma] was simply to reduce the assumptions of wheel order and scrambler positions that required 'further analysis' to a manageable number". So the central message of the Enigma experience was to use a machine to reduce an information problem that seemed intractable into a problem that was manageable within the available resources. But this is precisely what intelligence is all about. The word intelligence comes from the Latin word *intellegere,* whose term is composed of the Latin prefix *inter*, which means "between" and the Latin verb *legere,* which means "choose, read" (Helena, 2018). So intelligence is the ability to choose between two alternatives or among alternatives, the right one or the best one. So in essence, intelligence depends on the nature of the problem to be solved, and therefore, it encompasses from special-purpose intelligence like the cryptologic machines that cracked the Enigma code to general-purpose intelligence like the human mind. It is not a surprise that the same Alan Turing was also very passionate about the theoretical problems posed with the generalization of machine intelligence. He not only introduced the idea of a universal Turing machine (UTM), but also many other ideas, for which he has been credited as the father of artificial intelligence (wikipedia, 2018). For solving the *Dominium Mundi* Game, we need definitely machine intelligence but rather a more general one than the traditional operator-theoretic techniques found in dynamic programming and recursive game theory.

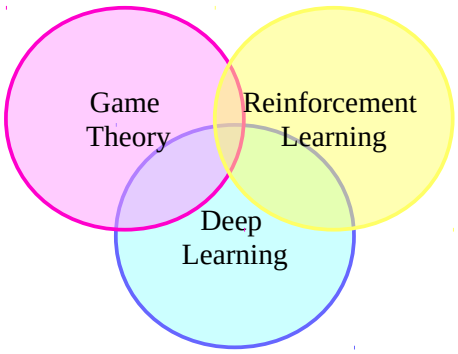
In his paper Computing Machinery and Intelligence (1950, p. 456), Alan Turing wrote: "Instead of trying to produce a programme to simulate the adult mind, why not rather try to produce one which simulates the child's? If this were then subjected to an appropriate course of education one would obtain the adult brain... We have thus divided our problem into two parts. The child-programme and the education process. These two remain very closely connected." Turing (1950) stated that the above method is faster than an evolutionary approach based on natural selection with random mutations because the programmer through careful observations and logical reasoning could speed that process up. He also provided some of the basic insights used in many of today's most powerful machine learning algorithms. Turing indicated (1950, p. 457): "We normally associate punishments and rewards with the teaching process. Some simple child-machines can be constructed or programmed on this sort of principle. The machine has to be so constructed that events which shortly preceded the occurrence of a punishment-signal are unlikely to be repeated, whereas a reward-signal increased the probability of repetition of the events which led up to it."

Turing's insightful observations are truly remarkable, especially because they were published in 1950 when computer science was still an emerging discipline. We will call Turing's approach to machine intelligence, artificial intelligence, which, as he pointed out, is divided into two parts. The "child-programme" and the "education process". The latter is what now is known as machine learning and the former is what needs to be defined. However, it is worth noting that we are not interested in simulating the child's mind as if it were a *Homo economicus*, the unnatural agent of neoclassical economics who can be both perfectly rational and perfectly greedy. Instead, we are interested in simulating the child's mind as a synthetic *Homo sapiens*, characterized by the three elements of human nature -self-interest, human fallibility and human sociability- as described earlier (see also Thaler, 2000 and Stiglitz, 1991). So our child-metaprogramme is more consistent with human intelligence than the one based on the fictitious *Homo economicus* (cf. Parkes and Wellman, 2015).

The economic literature is incorporating, albeit rather slowly, more heterodox approaches for solving economic models. For example, Judd, Maliar and Maliar (2010) introduced a cluster-grid projection method to solve model with high dimensionality. They identified clusters on simulated series and took advantage of clusters' centers as a grid for projections. They stated (p. 1) that: "Making the grid endogenous to the model allows us to avoid costs associated with finding a

solution in areas of state space that are never visited in equilibrium." Richard Evans et. al., (2016) applied big data techniques in a rather novel way: to solve theoretical models "that are otherwise too complex" with large dimensions of heterogeneity, nonconvex optimization problems, multi-objective programming problems, rich policy structure and uncertainties in both model and policy objective. They (2016, p. 1) "sample the parameter space of a parametric model and use the large sample to address a research question." Hart and Mas-Colell (2000) introduced in the journal *Econometrica* an adaptive algorithm called "regret-matching", which computes the correlated equilibria of a game. Neller and Lanctot (2013, p. 1) observed that Hart and Mas-Colell's simple procedure "has sparked a revolution in computer game play of some of the most difficult bluffing games, including clear domination of annual computer poker competitions." In words of their own inventors (Hart and Mas-Colell, 2000, p.1128), their procedure can be summarized as follow: "...At each period, a player may either continue playing the same strategy as in the previous period, or switch to other strategies, with probabilities that are proportional to how much higher his accumulated payoff would have been had he always made that change in the past." Neller and Lanctot (2013) have showed not only how a computer can use the regret-matching algorithm through self-simulated plays, but also how this approach can be extended to sequential games through an algorithm called counterfactual regret minimization (CRM). In 2015, Michael Bowling et. al. (2017, p. 81) presented an improved version of CRM, which was "capable of solving extensive-form games three orders of magnitude larger than previously possible." They claimed that "the smallest variant of poker in-play, heads-up limit Texas hold'em, is now essentially weakly solved." This is an extraordinary accomplishment because, as we saw earlier, Poker is an imperfect information game where players have private information. However, it seems that while game theory has reached a plateau in economics, other disciplines, mainly computer science, are taking game-theoretic approaches to a new high. As Figure 3 shows, three sub-fields of study are converging into a powerful and consistent approach that could give rise to a truly artificial intelligence. In addition to game theory, the other two sub-fields are deep learning and multi-agent reinforcement learning.

Figure 3: The Emergence of Artificial Intelligence



First of all, we shall say that Dynamic Programming, which is a very popular problem-solving technique among economists, and reinforcement learning (RL) are closely related to each other (Bertsekas and Tsitsiklis, 1996; Busoniu et al., 2010 and Bertsekas, 2012). However, as Sutton and Barto (1998) and Busoniu et al. (2010) pointed out, there is a fundamental difference between both approaches; RL not only doesn't require a formal model or a complete understanding of the system, but also can work in the absence of relevant data collected beforehand. This extremely flexible algorithm can learn control policies by interacting with an unknown system. That is to say, a RL algorithm can generate its own data and learn from them. Thus, RL not only belongs to the class of machine learning algorithms, but also could be well suited to deal with many of the problems of

imperfect information games. In this regards, Burkov and Chaib-draa (2014, p. 23) observe: "Imperfect private monitoring can be compared with the notion of partial observability well known in the computer science... Indeed, the imperfect monitoring setting is closely related to general MAS [Multiagent Systems], because the model of artificial agent assumes an uncertain observability of the environment by the agent due to its noised sensors..."

Secondly, for large state-action spaces both Dynamic Programming and RL require function approximation and, in this regard, deep learning, given the right conditions, shines above everything else. In addition to its empirical success in computer vision (Voulodimos, et al., 2018 and Krizhevsky et al., 2012), natural language processing (Young et al., 2018 and Hinton et al., 2012), time series analysis (Thinsungnoen et al., 2017 and Goodfellow et al., 2016), stochastic control problems (Han and E Weinan, 2016), high dimensional partial differential equations (E Weinan, et al., 2017) and game playing (Silver et al., 2017 and Justesen, et al., 2017), another reason to support the above claim is due to the fact that neural networks are universal approximators (Hornik et al. 1989; Hornik 1991 and Poggio et al. 2015). However, not all neural networks are the same and there is a fundamental difference between a deep and a shallow network. Liang and Srikant (2017, p.1) have proved that "for a large class of piecewise smooth functions, the number of neurons needed by a shallow network to approximate a function is exponentially larger than the corresponding number of neurons needed by a deep network for a given degree of function approximation."

Finally, we can combine the above techniques to produce even more powerful algorithms. For example, Mnih et al., (2015) announced an algorithm called deep Q-network that used both deep learning and reinforcement learning, which achieved human-level performance in classic Atari 2600 games. Similarly, deep reinforcement learning has been integrated with game theory to solve imperfect-information games. In 2016, Heinrich and Silver (p. 1) introduced a deep reinforcement learning from self-play, which according to them, it was "the first scalable end-to-end approach to learning approximate Nash equilibrium without prior domain knowledge." They tested their algorithm successfully in both two-player zero-sum computer poker games and Limit Texas Hold'em. Using deep neural networks together with *tabula rasa* reinforcement learning, Silver et al., (2017) generalized the popular AlphaGo Zero program in order to achieve superhuman performance in other games. They (2017, p. 1) claim that "Starting from random play, and given no domain knowledge except the game rules, AlphaZero achieved within 24 hours a superhuman level of play in the games of chess and shogi (Japanese chess) as well as Go, and convincingly defeated a world-champion program in each case."

However, for our modeling purpose, one of the most relevant breakthrough regarding the consistent application of different approaches came in 2018 when a team of Google-DeepMind scientists (Tuyls, et. al., 2018) introduced what they called "A Generalized Method for Empirical Game Theoretic Analysis". A meta game is the key concept of what is known as an empirical game-theoretic analysis. This meta game is understood as a simplified version of a more complex game, so that the analysis of a game is based exclusively on the meta-strategies that are normally played (eg., passive/aggressive or tight/loose in the case of poker) and not in all possible strategies that the full game may possess (Tuyls, et. al., 2018). This approach is justified when it is not computational feasible to enumerate all the game's strategies. Among the main contributions of Tuyls, et. al., 2018 were not only to prove that a Nash equilibrium for the empirical game, which is based on empirical estimates, is a 2ε-Nash equilibrium for the true underlying game, but also to determine how many data samples are needed to reach a reasonable approximation of the full game. The authors applied their generalized game-theoretic method even to asymmetric games such as Leduc Poker using multiagent reinforcement learning.

The central message of this section is that with artificial intelligence we can make even Enrico Fermi's agent-based techniques, which is also popular among economists, Lucas-critique (1976) proof by having agents respond to events according to the fundamental forces of human nature such as self-interest (see Turrell, 2016), human fallibility and human sociability. Hopefully, this would allow us to find an approximate solution to the DMG. In any case, there is no need to assume arbitrary, unrealistic, unreasonable or "politically correct" assumptions or behavioral rules. We can build models completely on primitives, finding causal relationship and "treating the cause rather than the symptom".

4. Empirical Relevance and Policy Implications

The conventional wisdom in economics based on competitive equilibria, zero economic profits, rational expectations and perfect government/central bank looks at odds with the real world. This is particularly striking given the pervasive use of econometrics and statistics in applied economic analysis. But we must remember that in economics like other social sciences, data are nonexperimental. Observations in economics are not repeatable in a controlled environment like in physics, chemistry or biology. So evidence per se are not conclusive. As Stachurski (2016, p. 3) states "our ability to generalize requires more than just data. Ideally, data are combined with a theoretical model that encapsulates our knowledge of the system we are studying. Data can be used to pin down parameter values for the model. If our model is good, then combining the model with data allows us to gain an understanding of how the system works." We don't know the joint distribution of our variables, we just have a sample, that is, we have partial information. If we represent a joint density as: $g_t(x_t, x_{t-1}, x_{t-2}, \ldots, x_0|\theta)$, where the xs are outcomes indexed by time and θ is a vector of deep parameters (eg., preferences, technology, etc.), then we either fix the parameters θ and simulate the corresponding joint densities or observe the data (eg. one realization of the xs) and infer the parameters (Sargent, 2016). Therefore, for a stochastic process $\{g_t\}_{t=1}^{\infty}$ we are forced either to have a theoretical model or to make assumptions if we want to make any meaningful generalization (Stachurski, 2016).

The above fact poses a serious problem for economics as a science because a model based on unreasonable or even false assumptions can be validated empirically. The situation gets even worse when the object of study is a sensitive issue like tax policies, wealth concentration or debt restructuring, where different parties may have opposite interests. Additionally, the problem with the selection of the sample opens the possibility of playing "cherry picking" to support a particular policy position. For example, thanks to analytical tools such as the dynamic stochastic general equilibrium (DSGE) models that we discussed earlier, Alan Greenspan, the Federal Reserve Chairman from 1987 to 2006 who opposed fiercely regulation of derivative markets, felt confident in saying: "Regulation of derivatives transactions that are privately negotiated by professionals is unnecessary. Regulation that serves no useful purpose hinders the efficiency of markets to enlarge standards of living" (The Washington Post, 2008). As the financial crisis of 2008 showed, Greenspan's free-market policy in the derivative market was a big mistake (Greenberger, 2010; FCIC, 2011; Grima, 2012; Wilmarth, 2014; Whalen and Tan Bhala, 2011; Mehrling, 2016 and Webel, 2013). Ironically, the parameters of the DSGE models were estimated or calibrated empirically, that is to say, with real world data. So, thanks to this fact, the unreasonable assumptions of the model such as zero-economic profits and competitive markets in the financial industry were validated with the supposed evidence – like a good scientific model is expected to do.- This was done in spite of all the signs perceived by the common people (including journalists), which pointed exactly to the opposite direction (eg. Litterick, 2002; Anderson and Creswell, 2007 and Associated Press, 2006). The little trick was to take into account only data from relatively "normal" periods. As Korinek (2017) observed: "Financial crisis are tail events that introduce a lot

of skewness and fat tails into time series. As a result, a good model of financial crises may well distinguish itself by not matching the traditional second moments used to evaluate regular business cycle models, which are driven by a different set of shocks." So the DSGE model, which was supposed to be Lucas-critique (1976) consistent, it turned out to be like the old adage says "the cure is worse than the disease".

Another problem with statistics and the supposed empirical evidence in economics is the omission of relevant facts and causal oversimplification. Relevant to the *Dominium Mundi* Game, it is the study conducted by De Long and Shleifer (1993). They presented demographic and urbanistic data of city growth encompassing the eight centuries prior to the Industrial Revolution. As it was to be expected, both the collection of the data *per se* and the statistical analysis were rigorously conducted. However, the problem lies with the interpretation of the results. The authors seem to suggest that merchant-controlled governments lead to high economic growth and prosperity while prince or noble-controlled governments lead to low economic growth, stagnation and even the ruin of a nation. If the first part of that statement were true, then the DMG's First Conjecture would be false. Therefore, a clarification of this issue is absolutely necessary.

Given our earlier discussion, we can say that De Long and Shleifer's (1993) bold claim is even stronger than Adam Smith's invisible hand. Adam Smith (1776) seemed to dislike the concentration of political power in the hand of merchants. He criticized the grant of monopolies, privileges and special rights to merchants or trading companies (Smith, 1776). So in order to support De Long and Shleifer's (1993) claim, it would be necessary to collect far more information. First, we can not exclude from the analysis issues like unfair enrichment, which encompasses a wide variety of wrongful activities from deception, market manipulation, tax evasion, legal corruption, unjustified profit, odious debt and treason to opium trade, piracy, land grabbing, apartheid, slavery, environmental crime, war of aggression and profit-motivated genocide of native population. With unfair enrichment, it is perfectly possible to have islands of prosperity within a sea of misery. And of course, if we just sample the islands, the world will look like a paradise. It is worth noting that empirical evidences regarding unfair enrichment and other criminal activities -including clear *ius cogens* violations- were pervasive before and even during the industrial revolution, especially from the cities that the authors seem to favor (Brion Davis, 2008; Kolchin, 1993; Hanes et al., 2004; Shown Harjo et al., 2014; Mares, 2015; Greenberg, 2013; Dalrymple, 2015; Mann, 2009; Sakolski, 1932; Madley, 2017; Clark and Worger, 2011 and Jalata, 2013). And as the Roman jurisprudence has showed (Digest 50, 17, 29): *Quod initio vitiosum est non potest tractu temporis convalescere*, which translates: "That which is void from the beginning cannot become valid by lapse of time" (Black, 1910).

Second, De Long and Shleifer (1993) give the impression that because of all the implications that arise when a merchant elite effectively control the government, a merchant oligarchy or plutocracy could be a receipt for economic success. However, here again we need more information. Regarding the true causes of innovation in Europe, Epstein's (2004, p. 382) observations are quite revealing. He stated that: "the view that premodern societies experienced low labor productivity and stagnant living standards, and that technological change before ca. 1800 was close to zero due to pervasive guild rent-seeking and poorly specified property rights to knowledge (Douglas c. North, 1981; Joel Mokyr, 2002), is hard to square with the fact that the surge of technological innovation in the 18th century occurred within institutional frameworks not too dissimilar to those of 1300." Khan and Sokoloff (2004, p. 399) confirm this statement when they affirmed that "a key feature of the story [about the great inventors in the United Sates], however, is that much of the population possessed some familiarity with the basic elements of technology during this era. Moreover, apprenticeship or the widespread practice of leaving home during adolescence to pick up

skills in a trade… was both widely accessible and capable of adapting to many of the new developments and to the general quickening of the pace of advance over the 19th century." In today's world, Paul Romer's human capital (1990) as a key driver of endogenous technological change is even more important than before. However, even De Long and Shleifer (1993) noted that the merchant elite not only has "a very strong interest in rapid economic growth," (p. 681) but also seems to see taxation from the princes as a "monopoly on theft" (p. 679). We assume that for the greedy merchant elite, all princes are "absolutists" because greed by definition is boundless. So it doesn't seem reasonable to believe that a merchant oligarchy would invest enough resources on human capital and on the well-being of the people. In contrast, as we saw earlier, the DMG claims that only the Law (or the fictitious Benevolent Social Planner) would allocate resources in a Pareto consistent manner.

Third, in their arguments, De Long and Shleifer (1993) put a lot of emphasis on the security of private property rights, which according to them is better protected with a merchant oligarchy than with a prince. However, they ignore a fundamental fact, the inexorable relationship between property right and sovereignty. The canonical example is La Reconquista ("the reconquest"), where the people from the Iberian Peninsula took almost 800 years to recover their lands and properties. We cannot take peace and security for granted. It is not reasonable to believe that without the popes and the princes that support them the Western civilization could have survived (eg., the meeting between Pope Leo and Attila in 452, the Battle of Poitiers in 732, the Battle of Cerami in 1063, the Battle of Las Navas de Tolosa in 1212, the Battle of Lepanto in 1571, the Battle of Vienna in 1683, etc.). It is also worth mentioning that who bears the burden of a costly war is usually at a disadvantage. In fact, many revolutions and civil wars have been triggered or at least have been strongly influenced by the heavy taxes and other burdens that are imposed in the aftermath of a war (eg., the Dutch Revolt after Philip II of Spain´s wars, the American and French Revolution after the Seven Years' War, the Bolsheviks and Nazi Revolution after World War I). Additionally, De Long and Shleifer (1993) didn't provide any concrete evidence that could give rise to the claim that the "rule of law" in general and that the protection of property rights acquired trough lawful activities in particular were stronger in merchant-controlled governments than in the European states with long-standing jurisprudential tradition such as Spain before the industrial revolution and the former Pontifical states.

The take-home message here is that to draw conclusions from "some" statistical evidence about a very complex social problem could be misleading. In this work, we will not try to validate the *Dominium Mundi* Game (DMG) empirically as if it were the best representation of the world. The problem with the DMG is that it is a greedy-based theory whose applicability depends on whether society is organized by greed or not. Before the rise of Constantine I in 324 AD, it would have been reasonable to assume that greed was the guiding principle for organizing civilization. But in the 4th century AD, after the Diocletianic persecution, it seems that the world experienced a profound moral revolution, which was able not only to defeat some of the world's most powerful men, but also to lay the foundations of a relatively moral civilization without precedent in human history -although far from perfect.- The origin of such a sustainable moral force can be traced back to the highlands of Southern Levant with the figure of the Prophet Elias (Elijah), who lived in the 9th century BC (wikipedia, 2018). He seems to be the first to establish in a very clear way the irreconcilable nature between greed and a truly moral religion (eg. 1 Kings 18:21). It seems that before him it was a common practice to embrace and even to mix two opposite systems of beliefs; in other words, religion corruption was widely tolerated.

Today's world is much more complex. Greed coexists and interacts with moral forces in such a way that it is beyond the scope of this work to try to figure out its dynamics, let alone to predict its

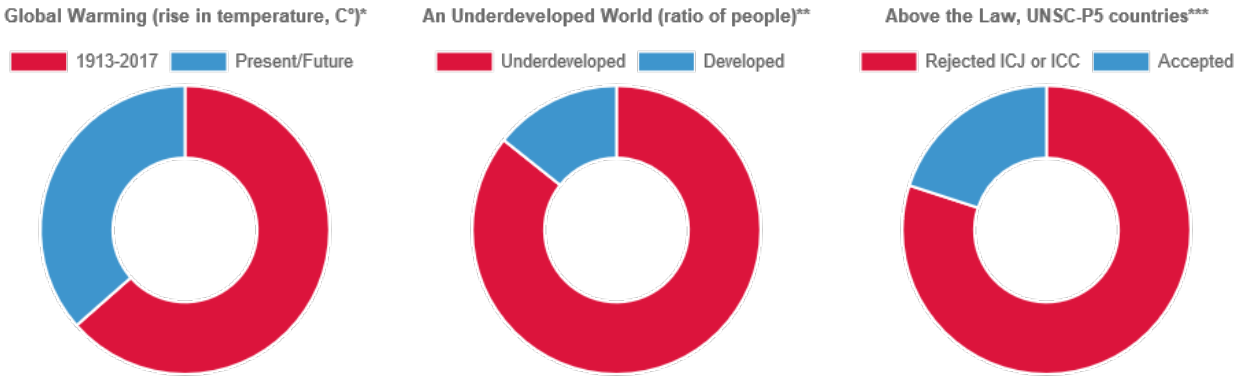
outcomes. Additionally, we recognize the theoretical limitations of the DMG framework to explain endogenously -withing the model- the emergence of a sustainable moral force. That probably would belong to the realm of theology. Instead, we take a pragmatic approach and assume that today's world lies somewhere between two extremes. On one extreme we have Victoria's visible hand (a competitive equilibrium or its extensions consistent with the rule of Law as we saw earlier) and on the other extreme we have the *Dominium Mundi* Game (which also includes Adam Smith's invisible hand). Thus, the key question to ask would be if the DMG framework is still relevant given the state of today´s world. In other words, we would like to know if greed still has an influence in the affairs of the world. If greed were a key or dominant force in today's world, then the *Dominium Mundi* Game could be considered a very crude approximation of how we organize society and, therefore, its normative implications, as suggested by the DMG´s conjectures, should be taken seriously.

Given the DMG's Fundamental Inequality, the most obvious indicator to assess the relevance of our framework would be the world's wealth distribution. Extreme wealth concentration would be consistent with the DMG. According to the Credit Suisse's Global Wealth Report of 2018 (see Shorrocks, et al., 2018), while 64% of the world adult population owns just 1,9% of the global wealth, the 0.8% of the world adult population possesses 45% of the world's wealth. In addition, the Credit Suisse's report states that there are not only 5.1 million adults with wealth above USD 5 million, but also 4,390 individuals with net worth above USD 500 million. Forbes (2017) goes even further, documenting the existence of 1,810 individuals, whose average net worth is around USD 3.6 billions. Together, these billionaires possess an incredible wealth of USD 6.5 trillion (Forbes, 2017), which might be around the total wealth of two third of the world population (see Shorrocks, et al., 2017). In fact, Oxfam (2017) asseverates that only 8 men own as much wealth as half of humanity. According to the World Inequality Report of 2018 (see Alvaredo et al., 2018), the wealth inequality in the United Stated has risen sharply. The report observes: "...where the top 1% wealth share rose from 22% in 1980 to 39% in 2014. Most of that increase in inequality was due to the rise of the top 0.1% wealth owners." Regarding the world's rising global inequality, this report forecast that: "The continuation of past wealth-inequality trends will see the wealth share of the top 0.1% global wealth owners (in a world represented by China, the EU, and the United States) catch up with the share of the global wealth middle class by 2050." The evidence presented above, which may underestimate the true global inequality as the Panama and Paradise papers suggest, is fully consistent with the *Dominium Mundi* Game and it is against the claim of a global economy characterized by competitive equilibrium, zero-economic profit conditions and perfect governments.

Given a world with extreme wealth concentration, the next question to be asked is how is the "state" of the world regarding the lives of people, the environment and the international legal order. The predictions of the *Dominium Mundi* Game, as suggested by its First Conjecture, is that greed has a very negative impact on global welfare. According to Nasa (2018), the evidence of rapid climate change is compelling from global temperature rise, warming oceans, shrinking ice sheets, glacial retreat to decreased snow cover, sea level rise, declining Arctic sea ice, extreme events and ocean acidification. The Intergovernmental Panel on Climate Change (IPCC, 2018) states that a rise of temperature above 2°C relative to pre-industrial levels will cause an irreversible damage on the planet. Figure 4a already shows a rise of temperature of 1.27° during the 1913-2007 period. That means that the rapid economic growth from the last century has been unsustainable, that is to say, at the expense of the environment and future generations. Our global economy needs urgently to make a transition to become a low-carbon economy. A report released in October 2018 by the IPCC reveals (p. 2) that "limiting global warming to 1.5°C would require "rapid and far-reaching" transitions in land, energy, industry, buildings, transport, and cities. Global net human-caused

emissions of carbon dioxide (CO2) would need to fall by about 45 percent from 2010 levels by 2030, reaching 'net zero' around 2050. This means that any remaining emissions would need to be balanced by removing CO2 from the air." But regarding the reliance on techniques that remove CO2 from the air, this report also makes clear that "The effectiveness of such techniques are unproven at large scale and some may carry significant risks for sustainable development." In spite of the overwhelming evidence on climate change and its catastrophic economic impact, the United States decided to withdraw from the Paris Agreement of 2015 on climate change mitigation. This fact is another confirmation of the empirical relevance of the *Dominium Mundi* Game, especially when compared with conventional models found in the economic literature based on rational expectation or even bounded rationality (man-made climate change is a well-known fact even confirmed by a major US government report released on November 23, 2018).

Figure 4. The State of the World's KPIs



Note* :The red slice of the Global Warming chart, which covers the period 1913-2017, illustrates the total absolute change in the earth's surface temperature relative to 1951-1980 average temperatures using NASA's lowess smoothing estimates. On the other hand, the blue slice shows the difference between the 2 degrees Celsius criterion established by the Paris Agreement and the above rise in temperature since 1913.

Note** :This figure means that six out of seven people in the world live in an underdeveloped country.

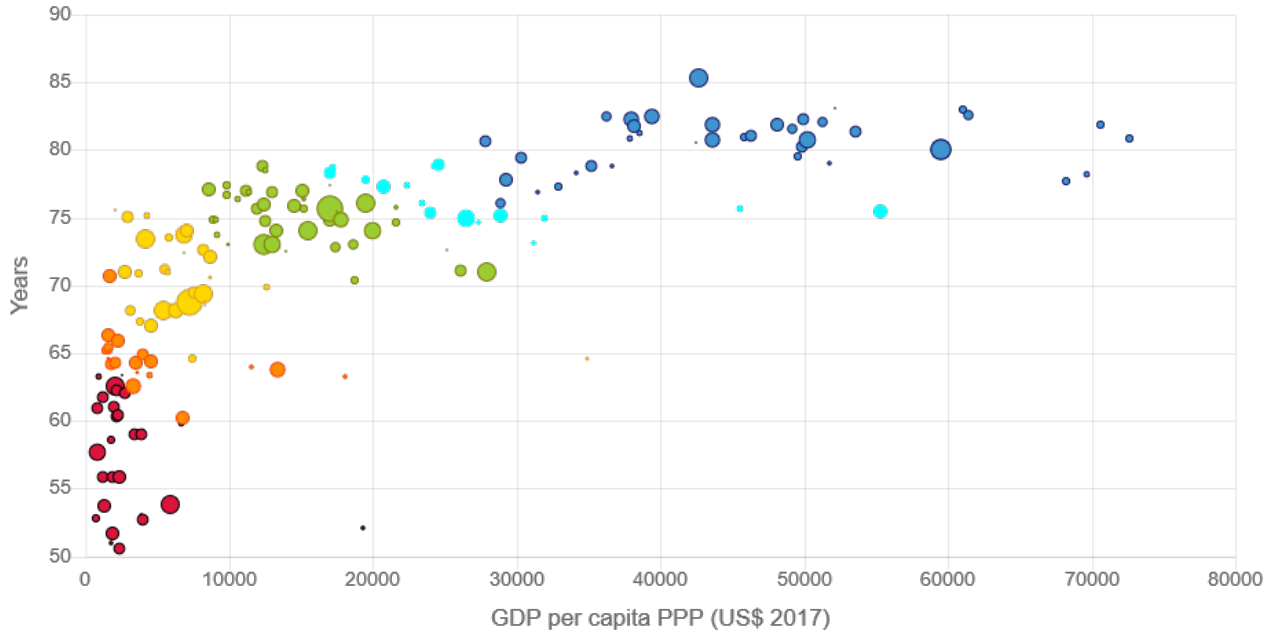
Note*** :ICJ and ICC are the abbreviations for the International Court of Justice and the International Criminal Court respectively. P5-UNSC is the abbreviation for the five permanent members of the United Nations' Security Council.

Data source: NASA's Goddard Institute for Space Studies, The CIA World Factbook (2018), International Criminal Court, United Nations Treaty Collections.

Figure 4b reveals that economic development has been only the privilege of 1/7 (or 14.3%) of the world population. In other words, 6 out 7 people in the world live in an underdeveloped country. Economic development is in today's world a very exclusive club, whose impact goes beyond material well-being to affect significantly vital statistics such as health and life expectancy as Figure 5 implies. Finally, Figure 4c shows that the overwhelming majority of the most powerful nations of the world are not interested in the rule of law. As the Roman Jurist Celsus stated: "The Law is a coherent system and presupposes its order is complete" (Digest, Book IX). That means that no one can be above or outside the Law because otherwise there is no Law -the primary aim of the Law is to protect the weak against the abuse by the strong (Ayala, 1789, p.6). These powerful nations pursue their own self interests as it was accepted in the Peace of Westphalia of 1648. This unfortunate situation opens the doors not only to more subtle forms of unfair enrichment as exposed by the Panama and Paradise papers but also to wars of aggression (eg., the annexation of Crimea by Russia in 2014) and proxy wars (eg., Nicaragua v. United States, see ICJ, 1986) Again, all these

facts mentioned above are fully consistent with the DMG. Thus, according to Figure 4, the world seems to be upside down.

Figure 5. Countries by Life Expectancy at Birth v. GDP per Capita (PPP)



Note :The size of the bubble is scaled in different categories in order to represent the size of the country's population. The bigger the size of the bubble, the bigger the population of the respective country. On one extreme, blue bubbles represent developed countries and, on the other extreme, red bubbles represent the least developed nations. All the country classifications presented here are based exclusively on the displayed two variables. This chart doesn't include the following two group of countries: 1) Qatar, Macau, Luxembourg, Singapore, Brunei, Montenegro, South Sudan, Kosovo, Somalia, Swaziland and Gaza Strip 2) all other countries or territories with a population less than 285,000. PPP means purchasing power parity.

Data source: The CIA World Factbook (2018).

So what can we do to change this situation? Here is where the *Dominium Mundi* Game framework shines above everything else. Given that the DMG is built on primitives such as self-interest, human fallibility and human sociability, "the solution lies within the problem." With some didactic exaggeration from our side, the simple, straightforward solution to the word´s problems would be to get rid of greed and the world would work like a Swiss watch in a very predictable fashion as the old-generation dynamic stochastic general equilibrium (DSGE) models would have suggested. This was showed in the previous section when we replaced $W(\cdots)$ with $\mathring{W}(\cdots)$ to obtain a rational expectation model. But this is not a new idea. In fact, to consider greed as the root of all kinds of evils (1 Tim. 6:10) was the traditional wisdom expressed by jurists and religious leaders until the apology of Adam Smith's invisible hand took off. The Roman jurist Ulpian suggested what a social order without greed could imply when he stated: "*Iuris praecepta sunt haec: honeste vivere, alterum non laedere, suum cuique tribuere*," (Digest 1.1.10.1), which translates as "The basic principles of law are: to live honestly, not to harm anyone, to give each his due." When we apply the DMG framework to normative aims, the little trick is not to assume competitive equilibrium and zero-economic profits as the DSGE did for the trading sector, but instead we must impose these conditions to the market through a rational application of the Law, taking into account the market's powerful incentive structures (see Holmstrom and Milgrom, 1994; Hart, 1983; Stiglitz, 1983; Wang and Williamson, 1996 and Ljungqvist and Sargent, 2012). In other words, we need to go from

Adam Smith's invisible hand to Francisco de Vitoria's visible hand as discussed in Section 1. The Second Conjecture of the DMG expresses the above statement.

Second Conjecture: Given the DMG' Fundamental Inequality $\Delta(v(x),x)>0$, $\forall x$ and its First Conjecture, it is sufficient to ban irrevocably unfair enrichment in all its manifestations and subtle forms in order to prevent the development of man-made adverse shocks.

Unfair enrichment is such a powerful legal concept, which brings to life Celsus' words, "*scire leges non hoc est verba earum tenere, sed vim and potestatem* (Digest. 1.3.17)", which means understanding the laws does not mean simply knowing the words, but their force and scope. Unfair enrichment is the jurisprudential way to deal with the problem of greed. Its formation as a principle of Law can be traced back to the Roman civil law (*ius civile*) and its essence can be summarized in the following maxim "*nemo locupletari debet cum aliena iactura*," which translates "no one should be benefited at another's expense". The above maxim, derived from the work of Roman jurist Sextus Pomponius (Pomponius, Digest 12.6.14), is equivalent to the economic concept of Pareto optimality, which can be summarized as: "an allocation in which no one can be made better-off without someone else becoming worse-off" (Simon and Blume, 1994. p. 565). However, unlike competitive equilibria, whose benefits depend on the well-functioning of the market or the absence of externalities, increasing returns, distorting taxes, etc., unfair enrichment is beyond any market arrangement or failure. Its full power comes from a proper understanding of the Law. The key jurisprudential criterion for unfair enrichment is the absence of basis or lack of explanatory basis (*causa iuris*).

In order to grasp the full meaning of unfair enrichment and its implications in economics, we must make first some clarifications given Andrei Shleifer's (2004) opinions articulated in his paper: Does Competition Destroy Ethical Behavior? He brings a notion of competitive equilibrium that it has nothing to do with Pareto optimality, and therefore, it poses a challenge to the jurisprudential concept of unfair enrichment, which should be equivalent to Pareto Optimum. Shleifer (2004, p. 415 and p. 417) stated the following remarks: "When a firm's competitor can reduce his taxes through corruption, or can import by paying lower bribes rather than higher tariffs, he can pass on his savings to consumers. In a competitive market, then, every firm must itself pay bribes or go out of business." He continues saying: "Corruption may enable small business to get around unreasonable regulations, and actually encourage economic development. Child labor may improve the economic circumstances of both children and their families in places where the feasible alternative are hunger and malnutrition." It seems that Shleifer's cases refer to the phenomenon of competition with externalities -where private and social estimations are not the same. In that situation, the classical connection between Pareto optima and competitive equilibria is broken down (Stokey and Lucas with Prescott, 1989). They are no longer equivalent terms. No one can be made better-off without someone else becoming worse-off. Can we justify a wrongful or criminal act like slavery or child sexual exploitation on the basis that the supposed feasible alternatives are worse or that it will promote economic growth? The jurisprudential answer would be an absolute no. As we already mentioned, the Law is a coherent system and presupposes its order is complete. For the case of corruption and child labor brought by Shleifer, we can not simply analyze both wrongful behavior in isolation and conclude that they are justified without taking into consideration the full impact of each of these wrongful acts in the entire legal order. Additionally, With child labor there can be no Romer's (1990) human capital? Even it may be the case that corruption and child labor are related as common sense would suggest. Maybe there is a vicious circle in which corruption causes poverty and poverty generates child labor, which in turn, produces more corruption and poverty and so on. Additionally, as we saw in Section 1, Francisco de Vitoria, following the reasoning of the Roman jurists, would not even consider Shleifer's cases of wrongful

behavior as competitive equilibrium because they are simply not lawful; that is to say, those cases can not be part of any lawful transaction between two parties. In case of unreasonable regulations or anticipated human misery, the Law shall provide the necessary adjustments and remedies and not leave the solution to traffickers of human dignity.

Intangible assets also pose some challenges to the concept of unfair enrichment. As we saw above, the Law is a coherent system and presupposes its order is complete. Intellectual property law can not contradict the law of unfair enrichment because both seek the common good. In fact, the primary purpose of the Law has always been to protect the weak against the abuse by the strong (Ayala, 1789, p.6). One of the reason for the extraordinary success of US patent law was, according to Khan and Sokoloff (2004, p. 395), to "break from Old World precedent in reserving the right to a patent to "the first and true" inventor anywhere in the world, as opposed to his employer or to the first to import the technology into the respective country...". Intellectual property (IP) laws were enacted to provide incentives for the creation of technological progress, not to enrich the inventor or his/her assignee, or to privatize public domain knowledge (see Mazzucato, 2013). Because of this reason, an IP right has a term, a maximum period for its validity, where it is to be expected that the holder of that right can recover all of his costs and be fairly compensated for the risk taken. This means that intellectual property laws, in principle, must be consistent with Pareto Optima, and therefore, with unfair enrichment. So the key take-home message here is that the market shall provide only the necessary incentives for a productive economic activity (eg., work, investment, innovation, etc.) to take place in a timely and efficient manner. That means that all enrichment processes need to be justified; they must have a cause, an explanatory basis consistent with both economics and the Law (*ius*); they must be for the common good. The Law with all its powerful legal remedies at its disposal must ensure that this will be the case.

The problem with the extreme wealth concentration observed in today's world is that the share of the wealth captured by those individuals at the very top are unreasonable and far disproportionate with respect to their own contributions or the necessary incentives that the market should have provided. How much can claim somebody who worked 66 hours per week, or invested their relative limited savings in a business venture? What is the fair rate of return given a determined risk profile (see Damodaran, 2012)? Can a tiny group of people be entitled to own half of the world because of some kind of "divine right" as the moral philosopher Adam Smith suggested (1759)? Those fabulous wealth are unfair enrichment beyond any reasonable doubt. There are no reasons or causes neither in economics nor the Law that can justify such a high level of wealth concentration. As the words attributed to the Roman jurist Papinian suggest (Nasmith, 1890, p. 99), "It is easier to commit than to justify a parricide." Paradoxically, the world's legal orders have not only tolerated but also protected extreme wealth concentration that clearly goes against the Law. This fact is also consistent with the *Dominium Mundi* Game. Economics, as a social science concerned with the study of the production, distribution and consumption of goods and service, is not only well positioned to provide a rigorous analysis on that issue, but also to take advantage of the legal remedies brought by the jurisprudence of unfair enrichment in order to correct the main dysfunctionalities observed in the market. This is especially important in a world where "financial accumulation implies ever-increasing wealth inequality" (Biondi and Olla, 2018, p. 1. See also Piketty, 2013).

The current economic literature seems to offer neither a theoretical nor a practical solution. Mainstream economics suggests that the optimal tax for capital must be zero (Ordover and Phelps, 1979; Chamley, 1986; Judd, 2002 and Mankiw, et. al., 2009). In a very clear way, Mankiw et. al., (2009, p. 21) provides the justification for the above statement: "the logic for low capital taxes is powerful: the supply of capital is highly elastic, capital taxes yield large distortions to intertemporal

consumption plans and discourage saving, and capital accumulation is central to the aggregate output of the economy." Additionally, given the prevalence of offshore banking, tax havens, lax international tax laws and recent tax cuts to the rich (eg. Trump tax cuts), it seems that in matters of taxation the world is heading to a race to the bottom. Nevertheless, as Nicholas Kaldor (1963) suggested, the world needs resources in order to solve its problems -something cannot come out of nothing-. Restitution, the legal remedy devised by the Roman jurists to treat the problem of unfair enrichment, can indeed accomplish the task that taxation seems unable or unwilling to do. Given the DMG's Fundamental Inequality and the statistics provided earlier on extreme wealth concentration, humanity can apply restitution to recover trillions of dollars of unfair enrichment (including unjustified wealth). This massive amount of resources can be used in the most expeditious way not only to solve the world's most urgent problems such as poverty and climate change but also to invest in the future of mankind, educating humanity and providing funds to finance all the necessary research and development (R&D) that the market will never offer in equilibrium (Romer, 1990). Only then, we can really talk about the rule of law, that is to say, about a world ruled by the Law. Francisco de Vitoria's (1539) *communitas totius orbis* (international community) and its corresponding universal common good would be finally meaningful. Otherwise, the disgraceful alternative to humanity will be the self-destructive *Dominium Mundi* Game.

In a world where greed plays a key role as a way to organize society, an obvious question would be how to bring about the Second Conjecture of the *Dominium Mundi* Game. As we saw earlier, greed has proved throughout history to be such a resilient and even unbeatable force, able to penetrate even religious and legal institutions and to corrupt them from the inside out. Greed, the ruthless maximization of self-interest, is basically a merciless and amoral force. It lacks any moral consideration with the rightness or wrongness of something. So it is reasonable to assume that any serious opposition to greed will be fiercely resisted as the most influential sacred texts have showed with innumerable examples. The triumph of the Law will only come as a result of a deliberate and decisive endeavor (Ulpian, Digest 1.1.10pr); thus, the problem of defeating greed is in essence a moral choice. Humanity, who has free will, must consciously decide and the forces of nature -including human nature- will act accordingly.

5. References

1. **Abreu, Dilip, David Pearce and Ennio Stacchetti.** (1986). "Optimal Cartel Equilibria with Imperfect Monitoring." *Journal of Economic Theory,* 39 (1), pp. 251–269.
2. **Abreu, Dilip, David Pearce and Ennio Stacchetti.** (1990). "Toward a Theory of Discounted Repeated Games with Imperfect Monitoring." *Econometrica*, 58(5), pp. 1041–1063.
3. **Acton Dalberg, John E.** (1887, April 5). Letter to Bishop Mandell Creighton. In *Historical Essays and Studies*, edited by J. N. Figgis and R. V. Laurence, London: Macmillan, 1907.
4. **Alterman, Eric.** (2003). *What Liberal Media? The Truth about Bias and the News.* New York: Basic Books.
5. **Alvaredo, Facundo; Chancel, Lucas; Piketty, Thomas; Saez, Emmanuel and Zucman, Gabriel.** (2018). *World Inequality Report*. World Inequality Lab.
6. **Anderson, Jenny and Creswell, Julie.** (2007, April 24). "Top Hedge Fund Managers Earn Over $240 Million." *The New York Times.* http://www.nytimes.com
7. **Aquinas, Thomas.** (1267-1273 [2001]). *Suma de Teología*. Madrid: Biblioteca de Autores Cristianos.

8. **Ariely, Dan.** (2012). *The (Honest) Truth about Dishonesty.* New York: HarperCollins Publishers LLC.
9. **Aristotle.** *Politics*. Reprint, Oxford: Oxford University Press, 2*009.*
10. **Arnott, Richard J. and Stiglitz, Joseph E.** (1988). "The Basic Analytics of Moral Hazard." NBER Working Paper No. 2484.
11. **Arrow, Kenneth J.** (1951). "An Extension of the Basic Theorems of Classical Welfare Economics." In *Proceedings of the Second Berkeley Symposium on Mathematical Statistics and Probability*, ed. J. Neyman. Berkeley: University of California Press, pp. 507-532. Reprinted in Arrow (1983) 2, pp. 13-45.
12. **Arrow, Kenneth J.** (1958). "Toward a Theory of Price Adjustment," in *The Allocation of Economic Resources*, P.A. Baran, T. Scitovsky and E.S. Shaw, Editors, Stanford University Press.
13. **Associated Press.** (2006, September 21). "Billionaires Only on Forbes' 2006 400 Richest Americans List." https://www.foxnews.com/story/billionaires-only-on-forbes-2006-400-richest-americans-list
14. **Ayala, Manuel Joseph de.** (1787). *Recopilación de las Leyes de Indias: Su Origen, Ilustración y Estado Presente.* Madrid: Biblioteca de Palacio, Manuscrito 2564, T. I., (As cited in Manzano Manzano, Juan. (1945). *Notas a la recopilación de Indias. Origen e historia ilustrada de las leyes de Indias por Manuel Josef de Ayala*. Madrid: Ediciones Cultura Hispánica. (As cited in Fábrega P., Jorge. (1990). *Manuel Joseph de Ayala: 'el más distinguido jurista indiano'*. Panamá: Editoria Jurídica Panameña, p. 97))
15. **Ayala, Manuel Joseph de.** (c. 1804). *Notas a la Recopilación de Indias.* (As cited in Manzano Manzano, Juan. (1945). *Notas a la recopilación de Indias. Origen e historia ilustrada de las leyes de Indias por Manuel Josef de Ayala*. Madrid: Ediciones Cultura Hispánica, p. 7. (As cited in Molina Castillo, Mario José. (2008). Veragua: la tierra de Colón y de Urracá. Tomo I, Panamá: Arte Gráfico Impresores, p. 314.))
16. **Babus, A.** (2016). "The formation of financial networks." *The RAND Journal of Economics*, 47, pp. 239–272. doi:10.1111/1756-2171.12126
17. **Bairoch, Paul; Batou, Jean and Chevre, Pierre.** (1988). *La Population des Villes Européenes de 800-1850.* Geneva: Librairie Droz. (As cited in: De Long, Bradford J. and Shleifer, Andrei. (1993). "Princes and Merchants: City Growth Before the Industrial Revolution," *Journal of Law and Economics*, 36 (October), pp. 671-702).
18. **Balzli, Beat.** (2010, February 8). "How Goldman Sachs Helped Greece to Mask its True Debt." *Spiegel Online*. http://www.spiegel.de
19. **Baron, David.** (2004). "Persistent Media Bias." Stanford University, Graduate School of Business Research Papers: No. 1845.
20. **Bartlett, Frederic.** (1932). *Remembering: A Study in Experimental and Social Psychology.* Cambridge: Cambridge University Press.
21. **Becker, Gary S.** (1976). *The Economic Approach to Human Behavior*. Chicago: The University of Chicago Press.
22. **Bellman, Richard E.** (1957). *Dynamic programming*. Reprint, Courier Dover Publications, 2003.
23. **Beltran, Daniel O.; Bolotnyy, Valentin and Klee, Elizabeth C.** (2015). "Un-Networking: The Evolution of Networks in the Federal Funds Market," Finance and Economics Discussion Series 2015-055. Washington: Board of Governors of the Federal Reserve System. http://dx.doi.org/10.17016/FEDS.2015.055.
24. **Jerry H. Bentley and Ziegler, Herbert F.** (2000). *Traditions & Encounters: From the Beginnings to 1500.* McGraw Hill.
25. **Bernanke, Ben S.** (2009). "Four Questions about the Financial Crisis." At the Morehouse College, Atlanta." https://www.federalreserve.gov

26. **Bertsekas, Dimitri P. and Tsitsiklis, John N.** (1996). *Neuro-Dynamic Programming*. Athena Scientific.
27. **Bertsekas, Dimitri P.** (2012). *Dynamic Programming and Optimal Control: Approximate Dynamic Programming.* Athena Scientific.
28. **Besley, Timothy and Prat, Andrea.** (2006). "Handcuffs for the Grabbing Hand? Media Capture and Government Accountability." *American Economic Review*, 96(3), pp. 720-736.
29. **Biondi, Yuri and Olla, Stefano**. (2018). "Financial Accumulation Implies Ever-Increasing Wealth Inequality." arXiv: 1809.08681v1 [q-fin.GN].
30. **Black Campbell, Henry.** (1910). *Black's Law Dictionary*. 2nd ed. (As cited in OpenJurist, https://openjurist.org [accessed on December 6, 2018]).
31. **Blanch Nougués, Juan M.** (2013). "Introducción al Razonamiento Jurídico." Video. CEU Universidad San Pablo. Miríadax, https://www.miriadax.net
32. **Boss, Michael; Elsinger, Helmut; Summer, Martin and Thurner, Stefan.** (2004). "Network Topology of the Interbank Market." *Quantitative Finance*, 4(6), pp. 677-84.
33. **Boulding, Kenneth E.** (1966). *Economic Analysis*. New York: Harper and Row.
34. **Bowling, Michael; Burch, Neil; Johanson, Michael and Tammelin, Oskari.** (2017). "Heads-Up Limit Hold'em Poker is Solved." *Communications of the ACM*, 60(11), pp. 81-88. The original version of this work was published in Science 347, 6218 (Jan. 2015), pp. 145-149.
35. **Brandeis University.** (2017). "Justice Louis D. Brandeis." Louis D. Brandeis Legacy Fund for Social Justice. http://www.brandeis.edu/legacyfund/bio.html
36. **Brion Davis, David.** (2008). *Inhuman Bondage: The Rise and Fall of Slavery in the New World*. New York: Oxford University Press.
37. **Burkov, Andriy and Chaib-draa, Brahim.** (2014). "Repeated Games for Multiagent Systems: a Survey." *The Knowledge Engineering Review*, 29(1), pp. 1-30.
38. **Burkov, Andriy and Chaib-draa, Brahim.** (2015). "Computing Equilibria in Discounted Dynamic Games." *Applied Mathematics and Computation*, 269, pp. 863-884.
39. **Busoniu, Lucian; Babuska, Robert; De Schutter, Bart and Ernst, Damien.** (2010). *Reinforcement Learning and Dynamic Programming Using Function Approximators*. Boca Raton: CRC Press.
40. **Calvó-Armengol, Antoni and Zenou, Yves.** (2004). "Social Networks and Crime Decisions: The Role of Social Structure in Facilitating Delinquent Behavior," *International Economic Review* 45, pp. 935-954.
41. **Cendejas Bueno, José L.** (2018). "Justicia, Mercado y Precio en Francisco de Vitoria." *Revista Empresa y Humanismo*, XXI(1), pp. 9-38.
42. **Chamley, Christophe.** (1986), "Optimal Taxation of Capital Income in General Equilibrium with Infinite Lives." Econometrica, 54(3), pp. 607–622.
43. **Christiano, Lawrence; Rostagno, Massimo and Motto, Roberto.** (2010). "Financial Factors in Economic Fluctuations." Working Paper Series 1192, European Central Bank.
44. **Clark, Nancy L. and Worger, William H.** (2011). *South Africa: The Rise and Fall of Apartheid*. Oxfordshire: Routledge, 2nd Ed.
45. **Conrado de Summenhart.** (1500). "*Opus septipartitum de contractibus.*" (As cited in Cendejas Bueno, José L. (2018). "Justicia, mercado y precio en Francisco de Vitoria." *Revista Empresa y Humanismo*, XXI(1), pp. 9-38).
46. **Corpus Juris Civilis.** Geneva: Dionysius Gottfried, 1583.
47. **Coulter, Ann.** (2003). *Slander: Liberal Lies about the American Right.* New York: Three Rivers Press.
48. **Craig, Ben and von Peter, Goetz.** (2014). "Interbank Tiering and Money Center Banks." *Journal of Financial Intermediation*, 23(3), pp. 322-347.

49. **Crawley Quinn, Josephine and Vella, Nicholas C. (Eds.).** (2014). *The Punic Mediterranean: Identities and Identification from Phoenician Settlement to Roman Rule.* Cambridge: Cambridge University Press.
50. **Damodaran, Aswath.** (2012). *Investment Valuation: Tools and Techniques for Determining the Value of any Asset.* 3rd ed. New Jersey: John Wiley & Sons.
51. **Dalrymple, William.** (2015, March 4). "The East India Company: The Original Corporate Raiders." *The Guardian.* https://www.theguardian.com
52. **De Long, Bradford J. and Shleifer, Andrei.** (1993). "Princes and Merchants: City Growth Before the Industrial Revolution," *Journal of Law and Economics*, 36 (October), pp. 671-702.
53. **Debreu, Gerard. (**1954). "Valuation equilibrium and Pareto Optimum". *Proceedings of the National Academy of Sciences* 40:588-592. Reprinted in Debreu (1983), pp. 98-104.
54. **Degryse, Hans A. and Nguyen, Gregory.** (2004). "Interbank Exposures: An Empirical Examination of Systemic Risk in the Belgian Banking System." Belgian National Bank Working Paper 43.
55. **Del Negro, M., Eusepi, S., Giannoni, M, Sbordone, A., Tambalotti, A., Cocci, M., Hasegawa, R., Linder, M.H.** (2013). "The FRBNY DSGE Model". Federal Reserve Bank of New York Staff Reports No. 647.
56. **Demyanyk, Yuliya and Van Hemert, Otto.** (2009). "Understanding the Subprime Mortgage Crisis." Reprint, *The Review of Financial Studies*, 24(6), 2011, pp. 1848–1880.
57. **Di Maggio, Marco; Kermani, Amir and Song, Zhaogang.** (2017). "The Value of Trading Relationships in Turbulent Times" *Journal of Financial Economics*, 124(2), pp. 266-284.
58. **Djankov, Simeon; McLiesh, Carlee; Nenova, Tatiana and Shleifer, Andrei.** (2003). "Who Owns the Media?" *Journal of Law and Economics*, 46(2), pp. 341-81.
59. **E Weinan; Han, Jiequn and Jentzen, Arnulf.** (2017). "Deep Learning-Based Numerical Methods for High-Dimensional Parabolic Partial Differential Equations and Backward Stochastic Differential Equations." *Communications in Mathematics and Statistics*, 5(4), pp 349–380
60. **Epstein, Stephan.** (2004). "Property Rights to Technical Knowledge in Premodern Europe, 1300-1800" *American Economic Review*, (Papers and Proceedings), 94(2), pp. 382-387.
61. **Evans, Richard W.; Judd, Kenneth L. and Quist, Kramer.** (2016). "Big Data Techniques as a Solution to Theory Problems." In: Arora R. (eds) *Conquering Big Data with High Performance Computing*. Springer, Cham, pp. 219-231. Quote taken from version 16.02.a.
62. **Farboodi, Maryam.** (2015) "Intermediation and Voluntary Exposure to Counterparty Risk." Unpublished Paper.
63. **Financial Crisis Inquiry Commission (FCIC).** (2011). *The Financial Crisis Inquiry Report*. Official Government Edition, Washington, DC: U.S. Government Printing Office. https://www.gpo.gov/fdsys/pkg/GPO-FCIC/pdf/GPO-FCIC.pdf
64. **Fiske, Susan.** (1995). "Social Cognition," in Abraham Tesser, ed., *Advanced social psychology*. New York: McGraw-Hill.
65. **Forbes.** (2017). "The World's Billionaires." https://www.forbes.com
66. **Franken, Al.** (2003). *Lies and the Lying Liars Who Tell Them: A Fair and Balanced Look at the Right.* New York: E.P. Dutton & Company.
67. **Freifeld, Karen.** (2016, November 3). "Goldman Sachs, Paulson Settle Fraud Lawsuit over Abacus." *Reuters*. http://www.reuters.com
68. **Friedman, James W.** (1971). "A Non-cooperative Equilibrium for Supergames." *Review of Economic Studies*, 38(1), pp. 1-12.

69. **Friedman, Milton. (1953).** "The Methodology of Positive Economics." In *Essays in Positive Economics*. Chicago: University of Chicago Press, pp. 3-43.
70. **Fudenberg, Drew; Levine, David and Maskin, Eric.** (1994). "The Folk Theorem with Imperfect Public Information," *Econometrica*, 62, pp. 997–1039.
71. **Gale, Douglas M. and Kariv, Shachar.** (2007). "Financial Networks" *American Economic Review*, (Papers and Proceedings), 97(2), pp. 99-103.
72. **Garrett, R. Sam.** (2016). "Super PACs in Federal Elections: Overview and Issues for Congress." Congressional Research Service, Report No. R42042.
73. **Gatti, Domenico D., Gaffeo, Edoardo and Gallegati, Mauro.** "Complex Agent-based Macroeconomics: a Manifesto for a New Paradigm." *Journal of Economic Interaction and Coordination*, 5(2), pp. 11-135.
74. **Gentzkow, Matthew; Petek, Nathan; Shapiro, Jesse M.; Sinkinson, Michael.** (2015). "Do Newspapers Serve the State? Incumbent Party Influence on the Us Press, 1869–1928." *Journal of the European Economic Association*, 13(1), pp. 29–61.
75. **Gofman, Michael.** (2017). "Efficiency and Stability of a Financial Architecture with Too-interconnected-to-fail institutions." *Journal of Financial Economics*, 124(1), pp. 113-146.
76. **Goldberg, Bernard.** (2002). *Bias: A CBS insider exposes how the media distort the news.* Washington, DC: Regency Publishing, Inc.
77. **Goodfellow, Ian; Bengio, Yoshua, and Courville, Aaron.** (2016). *Deep Learning*. MIT Press. http://www.deeplearningbook.org
78. **Graber, Doris.** (1984). *Processing the news: How people tame the information tide.* New York: Longman Press.
79. **Green, Edward J. and Porter, Robert H.** (1984). "Noncooperative Collusion under Imperfect Price Information." *Econometrica* 52(1), pp. 87-100.
80. **Greenberg, Amy S.** (2013). *A Wicked War: Polk, Clay, Lincoln, and the 1846 U.S. Invasion of Mexico*. Reprint, Vintage.
81. **Greenberger, Michael.** (2010, June 30). "The Role of Derivatives in the Financial Crisis: Testimony of Michael Greenberger, Law School Professor, University of Maryland School of Law" Financial Crisis Inquiry Commission Hearing, Washington DC.
82. **Greenwald, Bruce C. and Stiglitz, Joseph E.** (1986). "Externalities in Economics with Imperfect Information and Incomplete Markets." *The Quarterly Journal of Economics*, 101(2), pp. 229-264.
83. **Greenwald, Bruce C. and Stiglitz, Joseph E.** (1986). "Pareto Inefficiency of Market Economies: Search and Efficiency Wage Models." *American Economic Review Papers and Proceedings*, 78(2), pp. 351-355.
84. **Grima, Simon.** (2012). "The Current Financial Crisis and Derivative Misuse." *Online Journal of Social Sciences Research*, 1(8), pp. 265-276.
85. **Haynie, D.L.** (2001), "Delinquent Peers Revisited: Does Network Structure Matter?" *American Journal of Sociology,* 106, pp. 1013-1057.
86. **Hamilton, James T**. (2003). *All the news that's fit to sell: How the market transforms information into news.* Princenton: Princenton University Press.
87. **Han, Jiequn and Weinan E.** (2016). "Deep Learning Approximation for Stochastic Control Problems." arXiv:1611.07422v1 [cs.LG].
88. **Hanes, William Travis and Sanello, Frank.** (2004). *The Opium Wars: The Addiction of One Empire and the Corruption of Another*. Naperville: Sourcebooks.
89. **Harrison, Peter. (2011).** "Adam Smith and the History of the Invisible Hand." *Journal of the History of Ideas*, 72(1), pp. 29-49.
90. **Hart, Sergiu and Mas-Colell, Andreu.** (2000). "A Simple Adaptive Procedure Leading to Correlated Equilibrium." *Econometrica*, 68(5), pp. 1127-1150.

91. **Heinrich, Johannes and Silver, David.** (2016). "Deep Reinforcement Learning from Self-Play in Imperfect-Information Games." arXiv:submit/1599862.
92. **Helena.** (2018). Contributor, Diccionario Etimológico Español en Línea, http://etimologias.dechile.net, [accessed on November 24, 2018].
93. **Herman, Steve.** (2018, November 21). "Trump: US Interests Outweigh Harshly Punishing Saudis for Killing Journalist." *Voice of America*. https://www.voanews.com
94. **Hinton, Geoffrey. E.; Deng, Li; Yu, Dong; Dahl, George: Mohamed, Abdel-Rahman; Jaitly, Navdeep; Senior, Andrew; Vanhoucke, Vincent; Nguyen, Patrick; Sainath, Tara and Kingsbury, Brian.** (2012). "Deep Neural Networks for Acoustic Modeling in Speech Recognition." *Signal Processing Magazine* 29, pp. 82–97.
95. **Hollifield, Burton; Neklyudov, Artem and Spatt, Chester.** (2017). "Bid-Ask Spreads, Trading Networks and the Pricing of Securitizations." *Review of Financial Studies*, hhx027, https://doi.org/10.1093/rfs/hhx027.
96. **Holmstrom, Bengt and Milgrom, Paul.** (1994). "The Firm as an Incentive System." *The American Economic Review*. 84(4), pp. pp. 972-991.
97. **Hornik, Kurt; Stinchcombe, Maxwell and White, Halbert.** (1989). "Multilayer Feedforward Networks are Universal Approximators." *Neural Networks*, 2(5), pp. 359-366.
98. **Hornik, Kurt.** (1991). "Approximation Capabilities of Multilayer Feedforward Networks." *Neural Networks*, 4(2), pp. 251-257.
99. **Hou, David and Skeie, David.** (2014). "LIBOR: Origins, Economics, Crisis, Scandal, and Reform." Federal Reserve Bank of New York Staff Reports, No. 667.
100. **Inaoka, Hajime; Ninomiya, Takuto; Taniguchi, Ken; Shimizu, Tokiko and Takayasu, Hideki.** (2004). "Fractal Network Derived from Banking Transaction - An Analysis of Network Structures Formed by Financial Institutions. -" Bank of Japan Working Paper Serie, No.04-E-04.
101. **Intergovernmental Panel on Climate Change (IPCC).** (2018, October 8). "Summary for Policymakers of IPCC Special Report on Global Warming of 1.5ºC approved by governments." IPCC Press Release, 2018/24/PR.
102. **International Court of Justice (IJC).** (1986). "Case Concerning the Military and Paramilitary Activities in and against Nicaragua (Nicaragua v. the United States of America). Reports of Judgments, Advisory Opinions and Orders, Judgment of 27 June 1986.
103. **Izquierdo-Egea, Pascual.** (2014). "Tyre and the Fluctuations of Phoenician Economy during the 8th Century BC." *Arqueología Iberoamericana*, 24, pp. 5–20.
104. **Jackson, Matthew O. and Zenou, Yves.** (2014). "Games on Networks." Handbook of Game Theory, Vol. 4, Peyton Young and Shmuel Zamir, eds., Elsevier Science.
105. **Jalata, Asafa.** (2013). "The Impacts of English Colonial Terrorism and Genocide on Indigenous/ Black Australians." *Sage Open*. DOI: 10.1177/2158244013499143.
106. **Jensen, Michael.** (1979). "Toward a Theory of the Press." in Karl Brunner, ed., *Economics and social institutions: Insights from the conferences on analysis and ideology.* Boston: Martinus Nijhoff Publishing.
107. **Jewish Virtual Library.** "Isaiah (c. 740-681 BCE)." https://www.jewishvirtuallibrary.org
108. **Judd, Kenneth L.** (1998). *Numerical Methods in Economics*. Cambridge: The MIT Press.
109. **Judd, Kenneth L.** (2002). "Capital-Income Taxation with Imperfect Competition." *The American Economic Review,* 92(2), Papers and Proceedings of the One Hundred Fourteenth Annual Meeting of the American Economic Association, pp. 417-421.
110. **Judd, Kenneth L.; Yeltekin, Sevin and Conklin, James.** (2003). "Computing Supergame Equilibria." *Econometrica* 71 (4), pp. 1239–1254.
111. **Judd, Kenneth L.; Maliar, Lilia and Maliar, Serguei.** (2010). "A Cluster-Grid Projection Method: Solving Problems with High Dimensionality." NBER Working Paper No. w15965.

112. **Jung Chang, Eui; Araújo Lima, Eduardo J.; Guerra, Solange M. and Tabak, Benjamin M. (2008).** "Measures of Interbank Market Structure: An Application to Brazil." *Brazilian Review of Econometrics*, 28(2), pp. 163-189.
113. **Justesen, Niewls; Bontrager, Philip; Togelius, Julian and Risi, Sebastian.** (2017). "Deep Learning for Video Game Playing." arXiv:1708.07902v2 [cs.AI].
114. **Kaldor, Nicholas.** (1963). "Taxation for Economic Development." *Journal of Modern African Studies*, 1(1). pp. 7-23.
115. **Kandori, Michihiro.** (2002). "Introduction to Repeated Games with Private Monitoring." *Journal of Economic Theory*, 102(1), pp. 1-15.
116. **Katz, Hayah.** (2008). "The Ship from Uluburun and the Ship from Tyre: An International Trade Network in the Ancient Near East." *Zeitschrift des Deutschen Palästina-Vereins* (1953-), Bd. 124, H. 2, pp. 128-142.
117. **Khan, Zorina and Sokoloff, Kenneth L.** (2004). "Institutions and Democratic Invention in 19th-Century America: Evidence from "Great Inventors," 1790-1930." *American Economic Review*, (Papers and Proceedings), 94(2), pp. 395-401.
118. **Klayman, Josh.** (1995). "Varieties of Confirmation Bias," in Jerome Busemeyer, Reud Hastie and Douglas Medin, eds., *Decision making from a cognitive perspective. The psychology of learning and motivation.* Vol. 32. San Diego: Academic Press, pp. 365-418.
119. **Kolchin, Peter**. (1995). *American Slavery: 1619-1877*. London: Penguin Books.
120. **Kolhatkar, Sheelah.** (2016, October 4). "Wells Fargo and a New Age of Banking Scandals." *The New Yorker.* http://www.newyorker.com
121. **Kranton, Rachel E. and Minehart, Deborah F.** (2001). "A Theory of Buyer-Seller Networks." *American Economic Review*, 91(3), pp. 485-508.
122. **Kreps, David M. and Wilson, Robert.** (1982). "Sequential Equilibria." *Econometrica*, 50(4), pp. 863-894.
123. **Krizhevsky, Alex, Sutskever, Ilya, and Hinton, Geoffrey E.** (2012). "Imagenet Classification with Deep Convolutional Neural Networks." Advances in Neural Information Processing Systems 25, pp. 1097–1105.
124. **La Biblia: Latinoamérica.** Madrid: Editorial Verbo Divino. Edición revisada 1995.
125. **Lancot, Marc; Zambaldi, Vinicius; Gruslys, Audrünas; Lazaridou, Angeliki; Tuyls, Karl; Pérolat, Julien; Silver, David and Graepel, Thore.** (2017). "A Unified Game-Theoretic Approach to Multiagent Reinforcement Learning." arXiv:1711.00832v2 [cs.AI].
126. **League of Nations.** (1926). *Convention to Suppress the Slave Trade and Slavery*, 60 LNTS 253, Registered No. 1414. http://www.refworld.org/docid/3ae6b36fb.html
127. **Levin, Jonathan.** (2006). "Repeated Games III: Imperfect Private Monitoring." Unpublished Paper. https://pdfs.semanticscholar.org/dc01/e4595007e83e27ffa528bceecd2c89c3137d.pdf
128. **Li, Dan and Schürhoff, Norman.** (2014). "Dealer Networks." Swiss Finance Institute Research Paper No. 14-50. http://dx.doi.org/10.2139/ssrn.2023201
129. **Liang, Shiyu and Srikant, R.** (2017). "Why Deep Neural Networks for Function Approximation?" arXiv:1610.04161v2 [cs.LG].
130. **Litterick, David** (2002, September 13). "Billionaire Who Broke the Bank of England." *The Telegraph*. http://www.telegraph.co.uk
131. **Ljungqvist, Lars and Sargent, Thomas J.** (2012). *Recursive Macroeconomic Theory*, Cambridge, Massachusetts: The MIT Press, 3rd edition.
132. **Lord, Charles G.; Ross, Lee and Lepper, Mark R.** (1979). "Biased Assimilation and Attitude Polarization: The Effect of Theories on Subsequently Considered Evidence." *Journal of Personality and Social Psychology*, 37(11), pp. 2098-109.

133. **Lucas, Robert E.** (1976). "Econometric Policy Evaluation: A Critique". In *Brunner, K.; Meltzer, A. The Phillips Curve and Labor Markets.* Carnegie-Rochester Conference Series on Public Policy. 1. New York: American Elsevier. pp.19–46.
134. **Lucas, Robert E. and Stokey, Nancy L.** (1983). "Optimal Fiscal and Monetary Policy in an Economy without Capital." *Journal of Monetary Economics,* 12, pp. 55-93.
135. **Madley, Benjamin.** (2017). *An American Genocide: The United States and the California Indian Catastrophe, 1846-1873.* The Lamar Series in Western History, Reprint, Yale University Press.
136. **Mallaby, Sebastian.** (2010). *More Money Than God: Hedge Funds and the Making of a New Elite.* London: Penguin Press.
137. **Mankiw, N. Gregory; Weinzierl, Matthew and Yagan, Danny.** (2009). "Optimal Taxation in Theory and Practice." NBER Working Paper No. 15071.
138. **Mann, Barbara Alice.** (2009). *George Washington's War on Native America*. Native America: Yesterday and Today, University of Nebraska Press.
139. **Mares, Martin.** (2015). "The British Contribution to the Development of Piracy in the Golden Age of Piracy." Thesis. ResearchGate, DO-10.13140/RG.2.2.18533.19682.
140. **Marx, Karl.** (1843). *Zur Kritik der Hegelschen Rechtsphilosophie.* (As cited in (1976). *Introduction to A Contribution to the Critique of Hegel's Philosophy of Right*. v. 3. New York: Collected Works.
141. ***Markoe, Glenn E.*** *(2000). Peoples of the Past: Phoenicians.* Berkeley: University of California Press.
142. **Mazzucato, Mariana.** (2013), *The Entrepreneurial State – Debunking Public vs. Private Sector Myths*, London: Anthem Press.
143. **Mehrling, Perry.** (2016). Economics of Money and Banking. Columbia University: Coursera, http://www.coursera.com
144. **Mian, Atif and Sufi, Amir.** (2015). *House of Debt: How They (and You) Caused the Great Recession, and How We Can Prevent It from Happening Again.* Chicago: University of Chicago Press.
145. **Mnih, V., Kavukcuoglu, K., Silver, D., Rusu, A. A., Veness, J., Bellemare, M. G., Graves, A., Riedmiller, M., Fidjeland, A. K., Ostrovski, G., Petersen, S., Beattie, C., Sadik, A., Antonoglou, I., King, H., Kumaran, D., Wierstra, D., Legg, S. & Hassabis, D.** (2015). "Human-level Control through Deep Reinforcement Learning." *Nature* 518, pp. 529-533.
146. **Mokyr, Joel.** (2002). *The Gifts of Athena. Historical Origins of the Knowledge Economy.* Princeton, NJ: Princeton University Press.
147. **Moore, Don A. and Loewenstein, George.** (2004). "Self-Interest, Automaticity, and the Psychology of Conflict of Interest." *Social Justice Research*, 17(2), pp. 189-202.
148. **Moore, Don A.; Tanlu, Lloyd and Bazerman, Max H.** (2010). "Conflict of Interest and the Intrusion of Bias." *Judgment and Decision Making*, 5(1), pp. 37–53.
149. **Mullainathan, Sendhil.** (2002). "Thinking through Categories." Unpublished Paper.
150. **Mullainathan, Sendhil and Shleifer, Andrei.** (2005). "The Market for News." *American Economic Review*, 95(4), pp. 1031-1053.
151. **Mundell, Robert A.** (2000). "A Reconsideration of the Twentieth Century." *American Economic Review*, 90(3), pp. 327-340.
152. **Murata, Atsuo; Nakamura, Tomoko and Karwowski, Waldemar.** (2015). "Influence of Cognitive Biases in Distorting Decision Making and Leading to Critical Unfavorable Incidents." *Safety*, 1, pp. 44-58.
153. **Nash Forbes, John Jr.** (1950). "Non-Cooperative Games." Doctoral Dissertation. Princeton University. https://rbsc.princeton.edu/sites/default/files/Non-Cooperative_Games_Nash.pdf

154. **Nasmith, David. (1890).** *Outline of Roman History From Romulus to Justinian.* (As cited in: The Lawbook Exchange, LTD, Clark, New Jersey, 2006).
155. **NASA.** (2018). "Climate Change: How do we know?" Nasa Global Climate Change. https://climate.nasa.gov/evidence [accessed on December 4, 2018].
156. **Neate, Rupert. V** (2016, July 11). "HSBC Escaped US Money-laundering Charges after Osborne's Intervention." *The Guardian.* https://www.theguardian.com
157. **Neller, Todd W. and Lonctot, Marc.** (2013). "An Introduction to Counterfactual Regret Minimization." *Proceedings of the National Conference on Artificial Intelligence*, 3, pp. 1602-1604. (As cited in version of July 9, 2013).
158. **Nelson, Rebecca M.; Belkin, Paul and Jackson, James K.** (2017). "The Greek Debt Crisis: Overview and Implications for the United States." Congressional Research Service, Report No. R44155.
159. **Nigro, Lorenzo.** (2007). "Aside the spring: Byblos and Jericho from village to town in the second half of the 4th milenium BC." In Nigro, Lorenzo, ed., *Byblos and Jericho in the early bronze I: social dynamics and cultural interactions.* Proceedings of the international workshop held in Rome on March 6th 2007 by Università di Roma "La Sapienza."
160. **Nigro, Lorenzo.** (2018). "At the Origins of the Mediterranean Civilization: Archaeology of the City from the Levant to the West, 3rd-1st millennium BC." Sapienza University of Rome: Coursera, http://www.coursera.com
161. **North, Douglass C.** (1981). *Structure and Change in Economic History*. New York: Norton.
162. **Obara, Ichiro.** (2003). "Repeated Games with Imperfect Public Monitoring." Unpublished Paper.
163. **Ordóñez Fernández, Rocío.** (2011). La Crisis del Siglo VI A.C. en las Colonias Fenicias del Occidente Mediterráneo: Contracción Económica, Concentración Poblacional y Cambio Cultural. Unpublished Doctoral Thesis. Universidad de Oviedo.
164. **Ordover, J. A. and Phelps, E. S.** (1979). 'The Concept of Optimal Taxation in the Overlapping-generations Model of Capital and Wealth.' *Journal of Public Economics*, 12(1), pp. 1–26.
165. **Osborne, Dale K.** (1976). "Cartel Problems." *American Economic Review*, 66(5), pp. 835-844.
166. **Oxfam.** (2017). "An economy for the 99%." Oxfam Briefing Paper. https://www.oxfam.org
167. **Pagano, Marco and Volpin, Paolo F.** (2005). "The Political Economy of Corporate Governance." *The American Economic Review*, 95(4), pp. 1005-1030.
168. **Parikh, Tej.** (2017, June 12). "Is Goldman Sachs Supporting Hunger And Oppression In Venezuela? *Huffpost.* http://www.huffingtonpost.com
169. **Parkes, David C. and Wellman, Michael P.** (2015) "Economic Reasoning and Artificial Intelligence." *Science*, 349(6245), pp. 267-272.
170. **Piketty, Thomas.** (2013). *Le Capital au XXIe siècle.* Translated by Arthur Goldhammer. (2014). *Capital in the Twenty-First Century.* Cambridge: Harvard University Press.
171. **Plato.** (c. 380 BC). *The Republic*. Translated by Jowett, Benjamin. (2008). Digireads.com Publishing.
172. **Poggio, Tomaso; Rosasco, Lorenzo; Shashua, Amnon; Cohen, Nadav and Anselmi, Fabio.** (2015). "Notes on Hierarchical Splines, DCLNs and i-Theory." Center for Brains, Minds and Machines (CBMM), Memo No. 037.
173. **Porter, Robert H.** (1983). "Optimal Cartel Trigger Price Strategies." *Journal of Economic Theory*, 29(2), pp. 313-338.

174. **Quinn, Stephen and Roberds, William.** (2007). "The Bank of Amsterdam and the Leap to Central Bank Money." *American Economic Review*, (Papers and Proceedings), 97(2), pp. 262-265.
175. **Rabin, Matthew and Schrag, Joel L.** (1999). "First Impressions Matter: A Model of Confirmatory Bias." *Quarterly Journal of Economics*, 114(1), pp. 37-82.
176. **Ramsey, F.P. (1927).** "A Contribution to the Theory of Taxation." *Economic Journal*, 37, pp. 47-61.
177. **Ratzinger, Joseph and Hamer, Jerome.** (1983, November 26). "Declaration on Masonic Associations." Office of the Sacred Congregation for the Doctrine of the Faith, Rome http://www.vatican.va
178. **Ratzinger, Joseph** (Pope Benedict XVI). (2012). *The Infancy Narratives: Jesus of Nazareth*. New York: Image.
179. ***Riolo, R. L.*** (1997). "The Effects and Evolution of Tag-Meditated Selection of Partners in Evolving Populations Playing the Iterated Prisioner's Dilemma," in Thomas Back, ed., *Proceedings of the International Conference on Genetic Algorithms (ICGA-97)*. San Francisco: Morgan Kaufmann, pp. 378-385.
180. **Romer, Paul M.** (1990). "Endogenous Technological Change." *Journal of Political Economy*, 98(5), pp. 71–102.
181. **Rotemberg, Julio J. and Saloner, Garth.** (1986). "A Supergame-Theoretic Model of Price Wars during Booms." *The American Economic Review*, 76(3), pp. 390-407.
182. **Röllig, Wolfang** (1983) On the Origin of the Phoenicians. Berytus 31: 79–93.
183. **Sakolski, Aaron M.** (1932). *The Great American Land Bubble: The Amazing Story of Land-Grabbing, Speculations, and Booms from Colonial Days to the Present Time*. Reprint, Martino Fine Books, 2011.
184. **Salop, Steven C.** (1979). "Strategic Entry Deterrence." *American Economic Review*, 69(2), Papers and Proceedings of the Ninety-First Annual Meeting of the American Economic Association, pp. 335-338.
185. **Samuelson, Paul A. and Nordhaus, William D.** (1989). *Economics*. 13th edition, New York: McGraw-Hill.
186. **Sargent, Thomas J.** (2016). "Quantitative Macroeconomics." Video. The 3rd Annual Julia Conference, MIT. https://www.youtube.com
187. **Sarnecki, Jerzy.** (2001). *Delinquent Networks: Youth Co-Offending in Stockholm.* Cambridge: Cambridge University Press.
188. **Savigny, Friedrich Carl.** (1840). *System des heutigen Römischen Rechts*. Vol. I. Berlin. Reprint, Classic Reprint Series, London: Forgotten Books, 2018.
189. **Scitovsky, Tibor.** (1950). "Ignorance as a Source of Oligopoly Power." *The American Economic Review*, 40(2), Papers and Proceedings of the Sixty-second Annual Meeting of the American Economic Asociation, pp. 48-53.
190. **Severin, Werner J. and Tankard, Jawes W., Jr.** (1992). *Communication Theories: Origins, Methods and Uses in the Mass Media*, 3rd ed. New York: Longman Group, Ltd.
191. **Shleifer, Andrei.** (2004). "Does Competition Destroy Ethical Behavior?" *American Economic Review*, (Papers and Proceedings), 94(2), pp. 414-418.
192. **Shorrocks, Anthony; Davies, James and Lluberasis, Rodrigo.** (2018). *Global Wealth Report 2018*. Zurich: Credit Suisse AG, Research Institute.
193. **Shorrocks, Anthony; Davies, James and Lluberasis, Rodrigo.** (2017). *Global Wealth Report 2017*. Zurich: Credit Suisse AG, Research Institute.
194. **Shown Harjo, Suzan; Gover, Kevin; Deloria, Philip J.; Adams, Hank and Momaday Scott, N.** (2014). *Nation to Nation: Treaties Between the United States and American Indian Nations*. Smithsonian Books.

195. **Silver, David. (2017).** "Solving Imperfect Information Games." *Communications of the ACM*, 60(11), pp. 80-80.
196. **Silver, David; Hubert, Thomas; Schrittwieser, Julian; Antonoglou, Ioannis; Lai, Matthew, Guez, Arthur; Lanctot, Marc; Sifre, Laurent; Kumaran, Dharshan; Graepel, Thore; Lillicrap, Timothy; Simonyan, Karen and Hassabis, Demis.** (2017). "Mastering Chess and Shogi by Self-Play with a General Reinforcement Learning Algorithm." arXiv:1712.01815v1 [cs.AI].
197. **Simon, Herbert.** (1955). "A Behavioral Model of Rational Choice." *The Quarterly Journal of Economics*, 69(1), pp. 99–118.
198. **Simon, Carl P. and Blume, Lawrence**. (1994). *Mathematics for Economists.* New York: W. W. Norton & Company.
199. **Simons, Daniel J. and Chabris, Christopher F.** (1999). "Gorillas in our Midst: Sustained Inattentional Blindness for Dynamic Events." *Perception*, 28, pp. 1059-1074.
200. **Smets, Frank; Christoffel, Kai; Coenen, Günter; Motto, Roberto and Rostagno, Massimo.** (2010). "DSGE models and their use at the ECB." SERIEs 1: 51. doi:10.1007/s13209-010-0020-9
201. **Smith, Adam.** (1759). *The Theory of Moral Sentiments. Reprint*, Michigan: Eighteenth Century Collections Online, Text Creation Partnership.
202. **Smith, Adam.** (1776). *An Inquiry into the Nature and Causes of the Wealth of Nations.* Reprint, NewYork: Bantam Classics, 2003.
203. **Soramäki, Kimmo; Bech, Morten L.; Arnold, Jeffrey; Glass, Robert J. and Beyeler, Walter E.** (2006). "The Topology of Interbank Payment Flows". Federal Reserve Bank of New York Staff Reports, No. 243.
204. **Southey, Finnegan; Bowling, Michael; Larson, Bryce; Piccione, Carmelo; Burch, Neil; Billings, Darse and Rayner, Chris.** (2012). "Bayes' Bluff: Opponent Modelling in Poker." arXiv:1207.1411v1 [cs.GT].
205. **Sowell, Thomas.** (2009). *The Housing Boom and Bust*. New York: Basic Books.
206. **Spence, Michael.** (1978a). "Tacit Co-ordination and Imperfect Information," *Canadian Journal of Economics*, 11(3), pages 490-505.
207. **Spence, Michael.** (1978b). "Efficient Collusion and Reaction Functions." *Canadian Journal of Economics*, 11(3), pp. 527-533.
208. **Stachurski, John.** (2009). *Economic Dynamics: Theory and Computation.* Cambridge, MA: The MIT Press.
209. **Stachurski, John.** (2016). *A Primer in Econometric Theory.* Cambridge, MA: The MIT Press.
210. **Stigler, George J.** "A Theory of Oligopoly." *Journal of Political Economy*, 1964, 72(1), pp. 44-61.
211. **Stiglitz, Joseph E.** (1983). "Risk, Incentives and Insurance: The Pure Theory of Moral Hazard" *The Geneva Papers on Risk and Insurance*, 8 (No. 26), pp. 4-33.
212. **Stiglitz, Joseph E.** (1989). "Imperfect information in the product market" *Handbook of Industrial Organization*, 1, pp. 769-847.
213. **Stiglitz, Joseph E.** (1991). "The Invisible Hand and Modern Welfare Economics." NBER Working Paper No. 3641.
214. **Stiglitz, Joseph E.** (2017). "Markets, States, and Institutions." Roosevelt Institute Working Paper.
215. **Stiglitz, Joseph E.** (2018). "Where Modern Macroeconomics Went Wrong." *Oxford Review of Economic Policy*, 34(1-2), pp. 70-106.
216. **Stiglitz, Joseph E.** (Forthcoming). "Lessons from the Financial Crisis and their Implications for Global Economic Policy," to be published in *The 10 Years After: The End*

of the Familiar…Reflections on the Great Economic Crisis, Reinventing Bretton Woods Committee (RBWC).
217. **Stigum, Marcia and Crescenzi, Anthony.** (2007). *Stigum's Money Market*. 4th edn. New York: McGraw Hill.
218. **Stokey, Nancy L. and Lucas Jr., Robert E., with Prescott, Edward C.** (1989). *Recursive Methods in Economics Dynamics*. Cambridge: Harvard University Press.
219. **Supreme Court of the United States.** (1976). Buckley v. Valeo. 424 U.S. 1.
220. **Supreme Court of the United States.** (2010). Citizens United v. Federal Election Commission. 558 U.S. 310.
221. **Sutherland, E.H.** (1947). *Principles of Criminology.* Fourth edition. Chicago: J.B. Lippincott.
222. **Sutton, Richard S. and Barto, Andrew G.** (1998). *Reinforcement Learning: An Introduction.* Cambridge: The MIT Press.
223. **United Nations Framework Convention on Climate Change (UNFCCC).** (2015). *Adoption of the Paris Agreement.* 21st Conference of the Parties. Paris: United Nations.
224. **United Nations.** (1969). *Vienna Convention on the Law of Treaties.* Treaty Series, vol. 1155. http://www.refworld.org/docid/3ae6b3a10.html
225. **U.S. Global Change Research Program.** (2018, November, 23). *The Fourth National Climate Assessment (NCA4).* Vol. I and Vol. II. GlobalChange.gov
226. **Thaler, Richard H.** (2000). "From Homo Economicus to Homo Sapiens." *Journal of Economic Perspectives*, 14(1), pp. 133–141.
227. **Thinsungnoen, Tippaya; Kerdprasop, Kittisak and Kerdprasop, Nittaya.** (2017). "A Deep Learning of Time Series for Efficient Analysis." *International Journal of Future Computer and Communication*, 6(3), pp. 123-127.
228. **Trump, Donald J. with Schwartz, Tony.** (2004). *Trump: Think Like a Billionaire: Everything You Need to Know About Success, Real Estate, and Life.* New York: Random House Publishing Group. Reprint. New York: Ballantine Books, 2005. p. viii.
229. **Turing, Alan M.** (1950). "Computing Machinery and Intelligence." *Mind*, New Series, 59(236), pp. 433-460.
230. **Turrell, Arthur.** (2016). "Agent-based Models: Understanding the Economy from the Bottom Up." *Bank of England Quarterly Bulletin*, 56(4), pp. 173-188.
231. **Tuyls, Karl; Perolat, Julien; Lanctot, Marc; Leibo, Joel Z and Graepel, Thore.** (2018). "A Generalised Method for Empirical Game Theoretic Analysis." arXiv:1803.06376v1 [cs.GT].
232. **Van Arsdale, Arsdale.** (2015). "Introduction to Human Evolution." Wellesley College, https://www.edx.org
233. **Vitoria de, Francisco.** (1536a). "Comentarios a la *Secunda secundae* de Santo Tomás." (As cited in D. Iparraguirre. (1957). Francisco de Vitoria. Una teoría social del valor económico. Bilbao: Publicaciones de la Universidad de Deusto, pp. 21-22. (As cited in Paradinas Fuentes, Jesús L. "El pensamiento económico de la escuela de Salamanca." Fundación Canaria Orotova de Historia de la Ciencia)).
234. **Vitoria de, Francisco.** (1536b). "Comentarios a la *Secunda secundae* de Santo Tomás." (As cited in Beltrán de Heredia, Vicente. (1932-1935, 1952). "Comentarios a la *Secunda secundae* de Santo Tomás." Salamanca: Biblioteca de Teólogos Españoles, 6 vols., Madrid: Asociación Francisco de Vitoria. (As cited in Cendejas Bueno, José L. (2018). "Justicia, mercado y precio en Francisco de Vitoria." *Revista Empresa y Humanismo*, XXI(1), pp. 9-38)).
235. **Vitoria de, Francisco.** (1539). "*De Indis recenter inventis*." Relecciones. (As cited in Cendejas Bueno, José L. (2018). "Justicia, mercado y precio en Francisco de Vitoria." *Revista Empresa y Humanismo*, XXI(1), pp. 9-38).

236. **Vitoria de, Francisco.** (1539). "*De iure belli Hispanorum in barbaros*." Relecciones. (As cited in Cendejas Bueno, José L. (2018). "Justicia, mercado y precio en Francisco de Vitoria." *Revista Empresa y Humanismo*, XXI(1), pp. 9-38)).
237. **Vitoria de, Francisco.** (1546, April 28). Letter to Miguel de Arcos. (As cited in Zorroza, M. Idoya (ed.). (2006). Francisco de Vitoria. Contratos y usura. Pamplona: Eunsa. p. 267. (As cited in Cendejas Bueno, José L. (2018). "Justicia, mercado y precio en Francisco de Vitoria." *Revista Empresa y Humanismo*, XXI(1), pp. 9-38)).
238. **Voulodimos, Athanasios; Doulamis, Nikolaos; Doulamis, Anastasios and Protopapadakis, Eftychios.** (2018). "Deep Learning for Computer Vision: A Brief Review." *Computational Intelligence and Neuroscience*, 7068349, pp. 1-13.
239. **Wang, Cheng and Williamson, Stephen.** (1996). "Unemployment Insurance with Moral Hazard in a Dynamic Economy. Carnegie-Rochester Conference Series on Public Policy 44, pp. 1-41.
240. **Warr, Mark.** (2002). *Companions in Crime: The Social Aspects of Criminal Conduct.* Cambridge: Cambridge University Press.
241. **Warren, Elizabeth.** (2013, February 15). "Too Big to Fail has become Too Big for Trial." https://www.youtube.com
242. **Washington Post.** (2008, October 15). "How They Saw It, What They Said." *The Washington Post.* http://www.washingtonpost.com
243. **Washington Post.** (2008). "The Crash: Risk and Regulation. Key Players In the Battle Over Regulating Derivatives." *The Washington Post.* http://www.washingtonpost.com/wp-srv/business/risk/players.html
244. **Webel, Baird.** (2013). "Government Assistance for AIG: Summary and Cost." *Congressional Research Service*, Report No. R42953.
245. **Welchman, Gordon.** (1982). *The Hut Six Story: Breaking the Enigma Codes*. (As cited in "Bombe." Wikipedia, from an edition, which includes corrections published posthumously in 1986, https://en.wikipedia.org/wiki/Bombe [accessed on December 6, 2018]).
246. **Whalen, Philip, and Tan Bhala, Kara.** (2011). "Goldman Sachs and The ABACUS Deal." *Seven Pillars Institute*. http://sevenpillarsinstitute.org/case-studies/goldman-sachs-and-the-abacus-deal.
247. **Wilmarth, Arthur E.** (2014). "Citigroup: A Case Study in Managerial and Regulatory Failures", 47 *Indiana Law Review*. pp. 69-137.
248. **Wilson, Peter H.** (2010). *Europe's Tragedy: A New History of the Thirty Years War.* London: Penguin.
249. **Yeltekin, Sevin; Cai, Yongyangand and Judd, Kenneth L.** (2017). "Computing Equilibria of Dynamic Games" *Operations Research*, 65 (2) pp. 337-356.
250. **Young, Tom; Hazarika, Devamanyu; Poria, Soujanya and Cambria, Erik.** (2018). "Recent Trends in Deep Learning Based Natural Language Processing." arXiv:1708.02709v7 [cs.CL].
251. **Zaller, John R.** (1992). *The Nature and Origins of Mass Opinion.* Cambridge: Cambridge University Press.