



COLLABORATION: WHY SOME PEOPLE DO AND SOME DON'T?

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Abstract

Collaboration is the mechanism by which some communities of human beings have accomplished extraordinary feats of engineering, science, technology, entrepreneurship and economic growth and development. While intelligence is a required component for success, it is not sufficient. Economic growth is a measure of improved potential for standard of living. Despite evidence that collaboration works, some communities fail to develop a functional level of collaboration and economic development. All this where collaboration, not intelligence is the distinguishing factor. This paper utilizes the prisoner's dilemma to investigate factors that might present obstacles to collaboration and how they might be alleviated.

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INTRODUCTION

The terms collaboration and cooperation are sometimes confused. So are economic growth and economic development. In this research we are interested in collaboration and economic growth based on epistemological, metaphysical, and axiological insights (Randrup et al., 2016), so for clarity of purpose we begin with the following definitions. *Cooperation* is a plan and execution thereof by participants, each with their own personal self-interest and economic gain in mind yet yielding unintended mutual benefits. *Collaboration* is a plan and execution thereof by participants for their intentional mutual benefit of shared goals, objectives, and rewards. *Economic growth* is the improvement in per capita real gross domestic product adjusted for purchasing power parity. *Economic development* is the improvement in infrastructure and social wellbeing. *Player:* A decision maker in a game. *Rational Behavior:* Player actions that tend to optimize payoff. *Payoff:* Gain or loss of a player at the end of a game. *Strategic behavior:* Interrelationship among

the players (or their behaviors) in a game. *Strategy*: Complete description of a player's actions during the game. *Pure strategy*: Player deterministic game plan. *Mixed strategy*: Player game plan that mixes deterministic and random strategies.

Capital comprises exogenous human entrepreneurial ideas of imagination and creativity, and endogenous capital stock of knowledge and machines. Rule of law attracts capital. Democracy deploys capital. This gives rise to the CDR (capitalism, democracy, rule of law) economic model and index (Ridley, 2020a). Capital is converted into wealth, some of which is consumed and some of which is reinvested. Since capital stock depreciates, entrepreneurship must be the true source of wealth. High CDR countries are where ideas go to fly. Low CDR countries are where ideas go to die.

Ridley (2020b) shows that in order for a country to raise its level of economic growth and development it must raise its CDR index. This may simply require education regarding the importance of these three elements. Ridley and deSilva (2019) explained that in cases where the primary obstacle is a corrupt dictatorship, the malevolent dictatorship must first be replaced by a benevolent assembly of nation builders. Examples of such assemblies are the English parliament and the congress of the United States of America. As a cautionary note, Hobbes (1651) advocated those human beings are naturally selfish to the core, such that the only true and correct form of government is the absolute monarch. Absolute monarchy is a form of dictatorship that brings with it a type of efficiency. But absolute monarchy is not necessarily *corrupt* dictatorship, and it can be benevolent. England switched from absolute monarchy to a constitutional monarchy that appears to work well for their good economy. After the benevolent assembly has been elected, the process of developing a culture of collaboration can begin. The purpose of this paper is to identify the remaining intrinsic obstacles to collaboration such that they too may be removed or replaced.

The remainder of the paper includes a review of related literature. This is followed by an illustration of how collaboration works to produce economic growth, conflicts notwithstanding. Then, the prisoner's dilemma is used to explain a common economic decision-making paradox that is a possible obstacle to collaboration. Following a comprehensive discussion, the final section includes conclusions and suggestions for future research.

RELATED LITERATURE

Psychology

Collaboration is one of the human abilities that has been driving the development of humankind (Gilbert, 1990; Tuomela, 2007). The ontogeny of human collaboration as the predictor of the future development of the humankind has recently been reexamined by



developmental psychologists (Brownell et al., 2006; Callaghan et al., 2011; Sterelny, 2011, 2012; Warneken & Tomasello 2007). Although human collaboration was in born at the times of collective foraging (Alvard, 2012; Tomasello et al., 2012), foraging played a role in its development. The next phase of the global economic development of humankind depends on the collaboration within and between countries, global and regional alliances, and organizations in various industries (Ridley & Korovyakovskaya, 2021). Recent research on cooperation and collaboration is based on cooperation theories: The Big Mistake Hypothesis (Burnham & Johnson, 2005), the Cultural Group Selection Hypothesis (Henrich & Henrich, 2007; Richerson & Boyd, 2005), and the Interdependence Hypothesis (Tomasello et al., 2012), to name a few. They examine both individual or small-scale contexts, and larger group higher-level contexts. The collaborative advantage theory (Ansell et al., 2008; Bird et al., 2006; Vangen, & Huxham, 2013) and game theory have been widely used across disciplines and industries to model and explain the nature and the dynamics of collaboration (Skyrms, 2004; Tomasello, 2009).

Although collaboration may bring a host of beneficial outcomes, due to several barriers, it is not always feasible to achieve the full potential of collaborative efforts. These barriers vary in nature and severity depending on the number of participants, industries, organizational internal dynamics, and external environments, to name a few. Common barriers to collaboration include those preventing effective communication: Information filtering as a manipulative tactic (Robbins & Judge, 2015), information overload (Johnson, 2008; Richtel, 2008), negative emotions (Brinol et al., 2007; Giskevicius et al., 2010; Sinclair et al., 2010), lying (Naguin et al., 2010; Serota et al., 2010; Vrij et al., 2010); communication apprehension (Blume et al., 2010; Daly & McCroskey, 1975; Opt & Loffredo, 2000; Rodebaugh, 2004; Schlenker & Leary, 1982; Withers & Vernon, 2006;), employee silence (Bowen & Blackmon, 2003; Morrison & Milliken, 2000; Milliken et al., 2003; Tangirala & Ramunujam, 2008), and other variables.

Individual differences also impede collaboration. Cultural diversity adds to the complexity of intra- and inter-organizational interactions within and among countries around the globe. In the second half of the 20th century, a substantial amount of research on diversity found negative relationships between ethnic diversity and performance as explained by process difficulties in communication, coordination, and collaboration (Tajfel, 1981; Turner, 1982, 1985) that are more pervasive in highly heterogeneous work groups (Korovyakovskaya & Chong, 2015). Bowers, Pharmer and Salas (2000) followed by Webber and Donahue (2001) reported in their meta-analyses, mixed findings on the links between different types of diversity and performance. Culturally diverse work groups and teams have become critically important to the success of organizations in

recent decades (Govindarajan & Gupta, 2001; Nohria & Garcia-Pont, 1991). Their work processes and interactions, including communication and collaboration within culturally diverse frameworks, need further improvement (Aritz & Walker, 2010).

Communication has long been an essential part of human interaction. However, quite often a communicated message is misunderstood (Brewer & Holmes, 2009; Korovyakovskaya et al., 2015), when either the sender or the receiver, or both are at fault. Miscommunication tends to result in relationship, task, and process types of conflict, lack of collaboration, and lower individual and organizational productivity (Amason & Sapienza, 1997; Earley & Mosakoski, 2000; Jehn, 1992, 1997; Jehn & Mannix, 2001; Jehn, Northcraft, & Neale, 1999; Korovyakovskaya & Chong, 2015; Pelled, 1996; Pinkley, 1990; Ravlin, Thomas, & Ilsev, 2000).

Cross-cultural collaboration can be viewed through the prism of the three best known cultural values frameworks developed by Hofstede (1980, 2001), the World Values Survey developed by Inglehart (1997), the GLOBE project (House et al., 2004), and the Schwartz Values Survey (SVS; Schwartz 1992, 1994a, 2006; Ralston et al., 2011) used for individual and societal cultural values instruments for business and research purposes. Cultural values at the societal and individual levels are deeply engrained in the self-concepts of employees and have a strong impact on their behaviors in general (Korovyakovskaya et al., 2015). Cultural distances between members of culturally diverse groups have been reported to have negative effects on collaboration, ranging from cross-cultural negotiations to joint venture performance and failures (Mjoen & Tallman, 1997; Pariche, 1991; Simonin, 1999).

Other barriers to collaboration that transcend culture and geography include the extent of the incongruence of individual-level and societal-level values. The individualism–collectivism dimension of the cultural values frameworks is probably the most intuitive and widely known (Hofstede, 1980, 2001; House et al., 2004; Inglehart, 1997; Schwartz 1992, 1994a, 2006; Ralston et al., 2011). The individualism–collectivism dimension usually refers to distinct and contrasting cultural societal values (Triandis, 1995). However, it is also salient at the personal level (Schwartz 1992, 1994a, 2006; Ralston et al., 2011). Collectivistic values prioritize collective interests and place them above individual interests of the self. Collectivistic values place emphasis on collective goals, shared identities, community, group interests, and relationship building. In collectivism, individuals are expected to work only toward the collective goals of the extended families, communities, organizations, and their country. Individualistic values reward the opposite: prioritizing individual goals ahead of group goals, self-achievement, self-advancements, rewards for individual accomplishments, etc. (Hofstede 1980; Markus and Kitayama 1991; Ralston et al., 2011; Treviño et al., 2020; Triandis 1995). Individuals



have the freedom to place their own goals and those of the immediate family ahead of the collective goals without (a fear of) punishment (Ralston et al., 2011). Thus, in societies and organizations where rewards for individual achievements are higher than those for the group outcomes, the culture, and the environment itself present barriers to collaboration due to better incentives and higher rewards for individual accomplishments.

Economics

The literature on economics addresses the question of cooperation but not collaboration. This paper extends the field of economics to include the impact of collaboration on economic growth. In 1950, the prisoner's dilemma (2021) was designed by Tucker (1905-1995) from a model of cooperation and conflict by Flood (1908-1991) and Dresher (1911-1992). Since then, several applications in social sciences such as economics and politics as well as psychology, biology, and environmental studies, have been devised. Ridley and de Silva (2019) show how corrupt dictatorship is an obstacle to economic growth due to the absence of CDR. Ridley (2020a) shows how CDR is related to economic growth. Ridley et al., (2021) show how collaboration serves to improve university calculus test scores and their distribution. Ridley and Korovyakovskaya (2021) show how collaboration relates to economic growth by way of innovation and capitalism.

Recently, Özekin (2019) criticized the assumptions of orthodox economics theories with the development of new heterodox economics theory using behavioral game theory as a tool, and the prisoner's dilemma game gain matrix for the expression of international trade. Chau et al. (2019) provides an example on how the coordination of the central government of Hong Kong is used as a channel to shift from the prisoner's dilemma to the cooperative game for the development of the Qianhai cooperation zone. Cyxapeb (2021) uses the prisoner's dilemma game to discuss the example of adverse selection through a research methodology based on new institutionalism that was developed by the Ostrom scientific school. See Benhabib and Farmer (1994) and Cooper (1999) for more on coordination. Note however, that coordination is an orchestration of cooperation, but is not necessarily collaboration. An alternative game is the iterated prisoner's dilemma (Chari & Kehoe, 1990, 1993a, 1993b; Mailath & Samuelson, 2006). The iterated prisoner's dilemma, an economic-exchange game used to illustrate how people achieve stable cooperation over repeated interactions, was developed by Thompson et al., (2021). This was the first study to show the neural substrates of the social decision cascade in the context of the iterated prisoner's dilemma game. Engel et al., (2016) explores the motives

in the prisoner's dilemma and how the degree of cooperation depends on several factors (efficiency, fear, greed and conditional cooperation).

Chiaravutthi (2019) tests the effects of ethical considerations in prosocial behavior in the prisoner's dilemma and the dictator economic games. This experiment was conducted in Thailand and results contradict economic predictions based on rationality and self-interest. Arend (2020) proves that cooperation can be a rational choice for players in games defined by a weighted set of payoffs, proposing a new form a game and illustrates its implications based on the prisoner's dilemma. Embrey et al., (2018) reports results of a new experiment on how cooperation varies with the environment, describing forces that affect the formation of cooperation and when cooperation breaks down. The connection between active learning and performance outcomes in an economics 101 course modeled by the prisoner's dilemma, is studied by Byun (2014). Empirical results show a correlation between student's performance on the prisoner's dilemma game and performance on in-class exams and the course overall. The hypothesis of the study was that if students understand the prisoner's dilemma and assumptions of economic theory, the dominant strategy of the game will be chosen. Nicolae et al., (2012) examines the implications of the prisoner's dilemma in economic phenomena via three examples where they show the relevance of the prisoner's dilemma in economy globalization, and free capital and labor migration.

COLLABORATION WORKS

Cooperation occurs when people work together towards their individual goals. Collaboration occurs when people work together towards shared goals. The absence of cooperation rules out collaboration. Human beings are not only capable of cooperation they are capable of collaboration (Tomasello, 2009; Tomasello, et al., 2012). Other members of the animal kingdom cooperate but they do not collaborate.

There are no published data for collaboration by country. The closest available data are the global innovation index (GII) published by the world intellectual property organization (WIPO) (Indicator Rankings & Analysis | Global Innovation Index). The GII comprises an innovation input sub-index and an innovation output sub-index. The innovation input sub-index comprises institutions, human capital and research, infrastructure, market sophistication and business sophistication. The innovation output sub-index comprises knowledge and technology outputs and creative outputs. We choose to use innovation as a proxy for collaboration. Ridley and Korovyakovskaya (2021) gives two examples of how collaboration and innovation are used interchangeably.

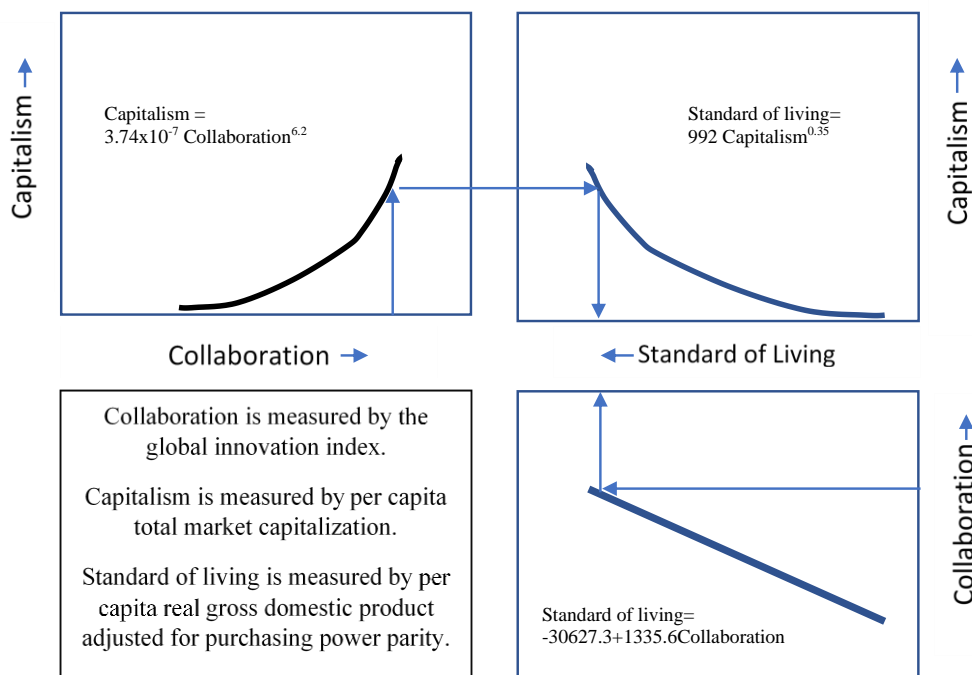


FIGURE 1. TRANSITION FROM COLLABORATION TO STANDARD OF LIVING

Data were collected for the global innovation index to represent collaboration, per capita total market capitalization to represent capitalism (the organization of capital), and per capita real gross domestic product adjusted for purchasing power parity to represent standard of living. They are listed in Table 1 and scatter plotted in Figure 2, Figure 3, and Figure 4 in the appendix. Various functions were fitted to these data by Ridley and Korovyakovskaya (2021). The resulting charts are reoriented and depicted in Figure 1. Standard of living versus capitalism (top right) and standard of living versus collaboration (bottom right) are rotated counterclockwise 90 degrees. These charts represent a wide range of collaboration from unfortunately low to fortunately high. The actual scales in Figure 1 are not important. What matters is that the charts are reoriented so as to align the two capitalism axes and the two standards of living axes, to show how the three charts are connected. As collaboration increases, capitalism increases exponentially. It increases at an increasing rate. As capitalism increases, standard of living increases at a decreasing rate. We observe that these two exponential rates tend to cancel. As it turns out, when estimated directly, collaboration and standard of living form a positive linear relationship. However, despite all this and the observed miracles in engineering and economic growth that have been accomplished as a direct result of

collaboration, some countries fail to accomplish a functional level of collaboration (Ridley & Johnson, 2021).

With regards to mechanisms for collaboration, the Organization for Economic Cooperation and Development (OECD) (2011) report, and Devore and Stai (2019), the three dominant theoretical paradigms used to explain European security cooperation – constructivism, institutionalism and liberalism – each yield distinct predictions. For example, when firms calculate that they would be better served by a national project they will lobby governments to withdraw from collaborative ones. We know from Tucker (1991) that discrepancies in corporations' size and capabilities facilitates collaboration. Firms of an analogous size and with similar core competencies will, within this context, fail to collaborate because of their preoccupation with relative gains, while those that differ will face fewer obstacles to collaboration. Thus complementary, rather than like competitive corporations will collaborate most effectively. These reasons for not collaborating are logical. But some countries fail to collaborate even when there are obvious opportunities available from diversity and complementarity.

COLLABORATION AND CONFLICT

The prisoner's dilemma (2021) in game theory is an example of noncooperation much less collaboration. It demonstrates how rational individuals can be unlikely to cooperate even when it is in their best interests to do so. This is a paradox in decision analysis in which two rational individuals acting in their own self-interests do not produce the optimal outcome. Both parties have outstanding minor offenses, and now they are suspects in the joint commission of a major crime that carries a long sentence. Although there is no evidence to convict them, the situation represents a threat to both. Each prisoner is secretly told that the other will testify that he is the culprit. Each party then agrees to testify against the other (noncooperation) in return for a reduced sentence and to not risk the maximum sentence if the other testifies against him and he is mute. The prisoners are not permitted to talk to each other, and each one chooses independently to protect himself at the expense of the other, resulting in convictions for both. If only they cooperated with each other and kept quiet, they would avoid jail altogether. As it turns out, a logical solution in which the dilemma disappears, is possible when the prisoners are allowed to talk to each other. They would simply reach an agreement with each other to keep quiet. Therefore, the first step in removing obstacles to collaboration is communication and socialization. And collaboration reduces threats from environmental dangers. Rule of law is an aid to cooperation and collaboration in that it produces and enforces contracts that protect each party (not applicable to criminals). This sews the seeds for the attraction of capital and its deployment through democracy. It maximizes the CDR index. We are mindful that criminals are engaged in activities that are extralegal



and are therefore barred from access to court enforceable contracts. So, we acknowledge the caveat that the aforementioned prisoner agreement to keep quiet is not enforceable.

Mixed strategies among two players have been studied by Heuer et al., (2019). They found that pure strategy outperforms mixed strategy in a cooperation game even after controlling for each player's beliefs about the other player's level of cooperation. That was because the level of cooperation varies in the mixed strategy. The decision problems that members of an economic community encounter are very unlikely to contain a saddle point. They are therefore far more likely to involve mixed strategies. The von Neumann (1903-1957) 1928 minimax theorem guarantees a zero-sum outcome with no gain even when the players are rational (Kjeldsen, 2001). Doebeli et al., (2005) studied the possible explanation for cooperation shown in the Snowdrift game and noncooperation in the prisoner's dilemma. But, if cooperation in such games rely on repetition until the players learn each other's intentions (Trivers, 1971), we cannot rely on that in the real-world economy where the specific problems facing a decision maker change constantly. Another real-world problem is that information will always be incomplete. Machine learning models using Bayes' Theorem have been applied to effectively solve an incomplete information game with undisclosed strategies (Xiuqin et al., 2015). Arce (2010) compares four versions of the prisoner's dilemma considering the ethical point of view for economic decision making. The objective there is to reduce the prisoner's dilemma.

APPLICATIONS OF GAME THEORY

In the following examples we consider some intralegal business and economic enterprises and obstacles to cooperation and collaboration.

Communities attracting firms

Ellis and Rogers (2000) used the prisoner's dilemma to improve the business climate in communities by examining the competition among them for attracting a firm to move there, as a simple non-cooperative game. They concluded that this practice has paradoxical results. The competition was based on offering incentives. The competition for firms ends in a bidding war between localities, where communities give away all the benefits of having the firm move to the locality. Cooperation among communities results in a win-win game, but political and economic asymmetries prevent the use of this strategy. This is a local plus-sum game but a nation-wide zero-sum game.

Repeated prisoner's dilemma game

Cho (2011) formulated a model to demonstrate that after a number of repetitions of a prisoner's dilemma game, an equilibrium is reached in which cooperation is sustained.

In this model the players only observe the other's actions while playing the game. This is the situation where firms compete with neighbor firms by setting product prices. The model presents a sequential equilibrium satisfying stability and efficiency. The stability is met because if a defection occurs, player cooperation resumes in the future. Efficiency means that players cooperate along the equilibrium path. With public randomization, players are informed when others resume cooperation. This is not necessarily a zero-sum game and can result in a plus-sum gain.

Central banks and money supply

Central banks have the role of implementing monetary policy by controlling the money supply. Their objective is to guide economic agents (players) on how to set interest rates, thereby promoting savings or investing depending on the message intended by the monetary authorities. Carilli and Dempster (2001) used the prisoner's dilemma to model the profit maximizing behavior of bankers (players) and investors (players) under uncertainty when the market interest rate is below the underlying rate of time preference. The reason for using this framework is to examine the general belief that the monetary policy is enough to stimulate entrepreneurial emphasis in Austrian players. What they observed in the Austrian economy is that expansion in the nominal money supply as opposed to real savings, produces a market interest rate that is below the rate of time preference. In the game, bankers could be fooled into thinking that this is due to real savings. The outcome of their action is certain to be a suboptimal profit or a loss. It would be best if they agreed to cooperate by not acting on nominal money and only acting on real savings. But, under uncertainty, in fear of losing market share to other bankers who defect from the optimal decision, they defect, to capture market share for themselves. Therein lies the prisoner's dilemma. This turns out to be a type of noncooperation among economic agents that leads to an economic boom. However, the ensuing interest rate inevitably returns to its original level followed by a bust that offsets the boom. This boom-and-bust amounts to a national zero-sum game. There is no sustained economic growth beyond what might have occurred absent the interest rate manipulation. And without collaboration, there is no extraordinary economic growth.

DISCUSSION

Accidental cooperation

The above three examples of applications of game theory are few, but they remind us that noncooperation is natural and rational as it is in the prisoner's dilemma. Still, they illustrate the theoretical potential for cooperation in game theory and possibly in the real world of business and economics. As in evolutionary biology, advancement of systems can occur from accidental cooperation in a naturally noncooperative world. And there is



no requirement for the advancement to retract by accident, especially if the advancement is recognized as such. Even, if such advancement due to cooperation were to occur in the economy, the advancements may result in ordinary economic growth. In that scenario, every child may bring its own wealth into the world and ordinary economic growth is pegged to population growth. Ridley (2020a) computed this rate as 1.8%. But per capita real economic growth is approximately constant and average wealth remains constant. Failure to cooperate rules out collaboration. Even if cooperation occurs, that does not mean that collaboration occurs. Collaboration makes it possible for plus sum synergistic human ideas of imagination and creativity, invention, and innovation. Whereas cooperation results in ordinary economic growth, collaboration results in extraordinary economic growth. We have demonstrated that countries with high intra-collaboration attain massive wealth over time. Those that do not remain relatively poor.

Epigenetic transgenerational sequela

The question remains, why do some countries pursue collaboration and others do not? We are resigned to accept that collaboration ranges from being low because of weak democratic leadership all the way down to no collaboration as a result of corrupt dictatorship. At the other end, the unique innate human characteristic of collaboration develops naturally in a high CDR environment. Ridley and deSilva (2019) used game theory to show how to remove dictators. But what happens next? Upon the exit of some dictators and the rise of CDR, some countries have become wealthy. Other countries don't. For example, Haiti remains impoverished decades after the death of its Tonton Macoute aided dictator: François Duvalier (1907-1971), aka, Papa Doc. Even after the overthrow of his successor son: Jean-Claude Duvalier (1951-2014), aka, Baby Doc. This might be due to a devastating epigenetic transgenerational sequela. In that case specialized nationwide psychological treatment is mandatory. Furthermore, just as collaboration is thought to be a training outcome from collective foraging (Alvard, 2012; Tomasello et al., 2012), a nation may have to focus on collaboration training other than foraging, aimed at creating a culture of collaboration.

Collaboration training

Modern day opportunities for training in collaboration are education and the classroom. This can start at the earliest school age. Merely lecturing to young people on the values of collaboration may create a society of academicians and theoreticians about collaboration. But what is needed is the development of practitioners of the art and science of collaboration. Ridley et al., (2021) demonstrated how this can be accomplished by a particular active learning teaching methodology (versus lecture). Their classroom

experiment illustrates how collaboration through active learning tends toward simultaneously higher magnitude and unimodal normally distributed test scores. Moreover, the students see the results of collaboration for themselves through their own involvement as opposed to indoctrination. One can only hope that they place a high value on the results. The widespread occurrence of the normal distribution in observed data suggests that it is natural and beneficial. The lecture method had no impact on distribution. Initial test scores were multimodal nonnormal and remained that way on the final exams. Another example of collaboration building activities is team sports. Cooperation in a team sport can take a team only so far. Collaboration in a shared goal is essential for success. While we recognize that there are numerous cultural and other barriers to collaboration we must play the hand of cards, so to speak, that we have been dealt. There are various corporate management and government systems that can be designed to reduce barriers and mitigate their effects. These systems may be pursued deliberately for purposeful rather than accidental reduction of barriers. At a very minimum, whereas management systems should reward individual achievements, collaborative behavior should receive a bonus reward.

Beyond intelligence

We posit that collaboration is responsible for the incredible successes in science, engineering economic growth and development demonstrated by human beings. These achievements go beyond intelligence. There are many communities presumably with intelligence that are underdeveloped and poor. One deficiency associated with the intelligence apparatus lies wherein everybody thinks that they are intelligent. So called common sense is a means of maintaining one's belief system and one's sanity. Even if it means questioning the intelligence of more intelligent people. Even in team cooperation, everybody assigns best intelligence to him or herself and does with sincerity what others consider to be sabotage. It's not what one doesn't know that gets one into trouble. It's what one knows for sure that just isn't so. Collaboration may help overcome this problem. When the team members collaborate in a shared goal, it is easier to trust each other to intelligently perform his or her duties to the best of their ability.

CONCLUSIONS

Collaboration is correlated with extraordinary economic growth and development. Some countries attain high levels of collaboration. Some attain only modest levels of collaboration. Some attain almost no level of collaboration. The prisoner's dilemma was used to show the counter intuitive phenomenon of how rational people can fail to cooperate much less collaborate even when it is in their best interest to do so. Still, innate collaboration unique to human beings developed, possible from training obtained during the times of collective foraging. Some countries used this capability to develop economic



systems and massive wealth. Some countries had their collaboration training and development destroyed by corrupt dictatorships. To restore collaborative skills and raise the level of CDR (Ridley, 2020a) and economic growth (Ridley & Korovyakovskya, 2021; Ridley & Johnson, 2021) countries should focus on training, not just education by lecture and rote learning. Active learning teaching methodology, team sports and corporate and government institutional design are based on collaboration. By pursuing this type of education and training, beginning in childhood, in a single generation an entire population can acquire the skill of collaboration. Pursuant thereto, a nation can build its level of CDR and economic growth. This paper is confined to a small number of economic applications of CDR theory, game theory, and methods of collaboration training and institutional design. Future research might include other applications of game theory and methods of developing collaboration.

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APPENDIX

Table 1. Per capita real GDP_{PPP} by country (2014), Global innovation index (GII) and Market Capitalization

Country	Per capita real GDP _{PPP}	Global Innovation Index (GII)	Per capita Market Capitalization	Country	Per capita real GDP _{PPP}	Global Innovation Index (GII)	Per capita Market Capitalization
Argentina	22,302	35.1	580	Latvia	23,793	44.8	566
Armenia	8,164	36.1	44	Lebanon	18,052	33.6	1,751
Australia	46,550	55	53584	Lithuania	27,259	41	1,372
Austria	46,640	53.4	12189	Macedonia	13,398	25.5	270
Bangladesh	3,391	24.4	166	Malawi	1,112	27.6	45
Belgium	43,139	51.7	26540	Malaysia	25,145	45.6	15,431
Bolivia	6,224	27.8	405	Mauritius	18,689	40.9	5,686
Botswana	17,050	30.9	2142	Mexico	17,950	36	4,294
Brazil	16,155	36.3	5979	Mongolia	11,919	37.5	421
Bulgaria	17,926	40.7	920	Morocco	7,813	32.2	1,574
Canada	44,967	56.1	56026	Namibia	10,656	28.5	561
Chile	23,057	40.6	17223	Netherlands	47,960	60.6	38,314
China	13,224	46.6	2689	Nigeria	6,054	27.8	302
Colombia	13,480	35.5	5400	Norway	67,166	55.6	48,514
Cote d'Ivoire	3,101	27	357	Oman	43,847	33.9	6,930
Croatia	20,947	40.7	5095	Panama	19,546	38.3	3,288
Denmark	44,625	57.5	39398	Peru	11,860	34.7	3,259
Dominican Republic	14,014	32.3	14	Philippines	6,974	29.9	2,568
Egypt	10,918	30	654	Poland	25,247	40.6	4,618
El Salvador	8,060	29.1	1648	Portugal	27,069	45.6	6,315
Estonia	27,880	51.5	1778	Romania	19,744	38.1	799
Finland	40,661	60.7	28851	Russia	24,449	39.1	5,970
France	40,538	52.2	28263	Saudi Arabia	52,311	41.6	11,578
Germany	46,216	56	18246	Serbia	13,378	35.9	1,047
Ghana	4,137	30.3	114	Singapore	83,066	59.2	74,820
Greece	25,954	38.9	4137	Slovakia	28,279	41.9	850
Hungary	25,019	44.6	2108	Slovenia	29,867	47.2	3,128
India	5,808	33.7	983	South Africa	13,094	38.2	11,142
Indonesia	10,651	31.8	1534	Spain	33,835	49.3	21,435
Iran	17,443	26.1	1782	Sweden	46,219	62.3	56,900
Ireland	51,284	56.7	23518	Switzerland	58,149	64.8	129,905
Israel	33,136	55.5	17538	Thailand	15,579	39.3	5,870
Italy	35,131	45.7	7918	Trinidad and Tobago	32,170	31.6	11,236
Jamaica	8,610	32.4	2347	Turkey	19,698	38.2	3,921
Japan	37,519	52.4	29028	Uganda	1,939	31.1	209
Jordan	11,971	36.2	2829	Ukraine	8,681	36.3	484
Kazakhstan	24,108	32.8	1332	United Kingdom	39,826	62.4	46,384
Kenya	3,099	31.9	313	United States	54,370	60.1	57,812
Korea, South	34,355	55.3	22903	Vietnam	5,656	34.9	355
Kyrgyzstan	3,262	27.8	27				

Per capital real gross domestic product adjusted for purchasing power parity (GDP_{PPP}) - IMF

(<http://www.imf.org/external/data.htm>)

Global innovation index (GII) - World intellectual property organization (WIPO) (Indicator Rankings & Analysis | Global Innovation Index).

Per capita market capitalization - (US\$ mundi)

<http://www.indexmundi.com/facts/indicators/CM.MKT.LCAP.CD/rankings>

The GII comprises an innovation input sub-index and an innovation output sub-index. The innovation input sub-index comprises institutions, human capital and research, infrastructure, market sophistication and business sophistication. The innovation output sub-index comprises knowledge and technology outputs and creative outputs.



These data are for 79 countries for which all data are available. They represent almost all people in the world. The remaining countries have populations less than one million and/or do not provide all data.

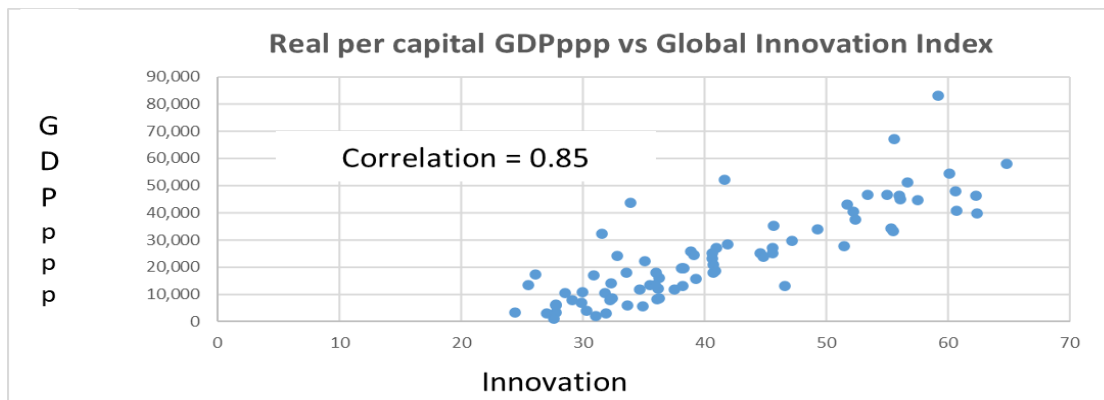


FIGURE 2. PER CAPITA REAL GDP PPP VS GLOBAL INNOVATION INDEX (GII): $(GDP PPP = -30627.3 + 1335.6GII)$

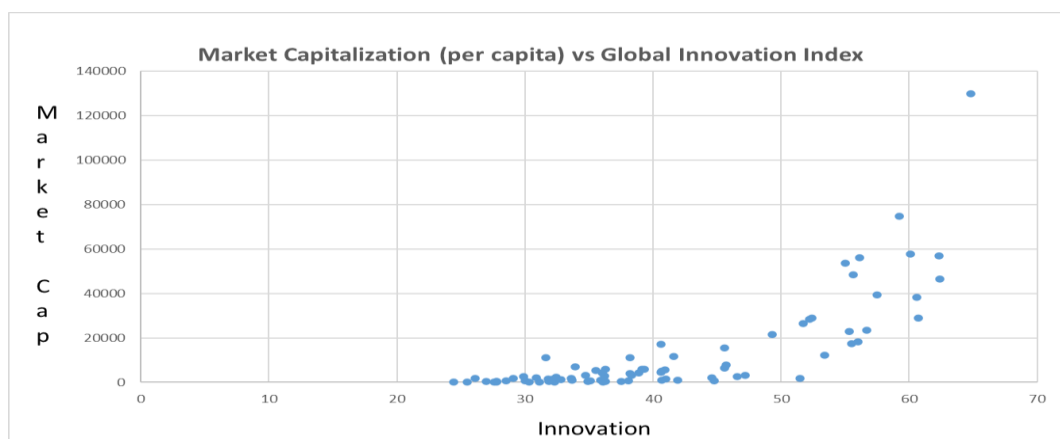


FIGURE 3. MARKET CAPITALIZATION VS. INNOVATION: $(MARKET CAP = 3.74 \times 10^{-7} GII^{6.2})$

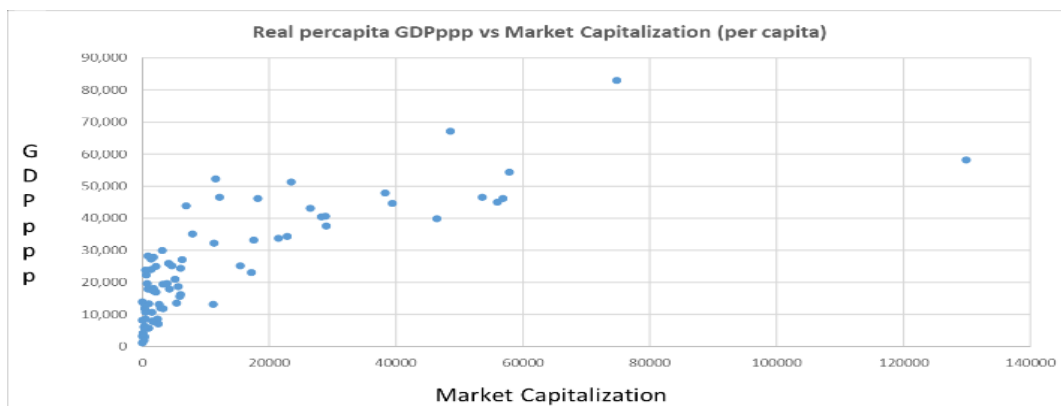


FIGURE 4. MARKET CAPITALIZATION VS. INNOVATION: $(GDP PPP = 992 MARKET CAP^{0.35})$