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# Content

**Geraldine D. Rodriguez**

Self-Directed Learning Activities and Performance in Basic Economics:  
Basis for Obedized Modules in Basic Economics 5-30

**Dennis Ridley, Inessa Korovyakovskaya, Felipe Llaugel**

Collaboration: Why Some People Do and Some Don't? 31-53

**Len-Kuo Hu, Daniel C. Lee**

Dynamic Economic Process, Animal Spirits, and Chinese Qi 54-69

**Muhammad Nadzif Bin Ramlan**

Econophysics and Econolinguistics: A Conceptual Analysis 70-99

**Siti Istikhoroh, Moeljadi, Made Sudarma, Siti Aisjah**

Social Media as a Communication Means Judging from the Influence of  
Intellectual Capital on the Sustainability of Private Higher Education  
Organizations in the East Java Region 100-109



# SELF-DIRECTED LEARNING ACTIVITIES AND PERFORMANCE IN BASIC ECONOMICS: BASIS FOR OBEDIZED MODULES IN BASIC ECONOMICS

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## **Abstract**

*This experimental study is aimed at determining the use of self-directed learning activities in teaching Basic Economics to freshmen college students of Ramon Magsaysay Memorial Colleges, General Santos City. The researcher made pretest-posttest was used to gather the data of the randomly selected freshmen students coming from 12 sections. The result shows that the mean pre-test scores of the experimental and control group is “good”. There is a significant difference between the pre-test mean scores of the control and experimental group. Compared with the control group, the experimental group got higher post-test scores than their pre-test scores in all the areas. There is a significant difference between the pre-test and post-test mean scores of the control group in the nature of economics, factors of production, demand and supply, price determination, elasticity, cost of production, Philippine financial system and economic development. On the other hand, topics on basic economics such as economic systems, major forms of business organization, and economic nationalism showed no significant difference. There is a significant difference between the mean gain score of the experimental and the control group in all areas. There is no significant difference between the mean gain score of experimental and the control group in economic systems, major forms of business organization, market structure, national income and economic nationalism. The obedized module in basic economics is an introduction to the rudiments of economic concepts, principles and policy. General topics include aspects of the market system, introduction of national income, the financial system, government finances, foreign trade, growth and development.*

**Keywords:** Self-directed Learning Activities; Performance; Basic Economics, Philippines.

## **INTRODUCTION**

Learning is the acquisition of new behavior patterns through either simple or complex conditioning and reinforcement. Under the rubrics of what the teacher does, we must ask what design the teacher should employ in arranging the lesson. She has to check how does learning occur, how is learning related to knowing, and in both, what is the role of intelligence (Brubacher et al., 2014).

Self-directed learning (SDL) is the concept in which the students undertake the responsibility of their own learning process; this also includes acquiring their own material and monitoring their own progress. Self-directed learning came into existence through the education of the adults and is into implementation in elementary and secondary schools. Self-directed learning is a collaborative process between the teachers and the students. The teachers are supposed to provide them the information and sources for learning and the students should never develop this viewpoint that they are learning on their own, they must be interested and have the inventiveness towards learning (Self-Directed Learning, 2009).

As it has been stated that self-directed learning involves that students should learn on their own; it is the responsibility of the teachers to make the students aware of their function in their own learning, encourage the students to show resourcefulness and creativeness in their learning. Teachers have to develop an amiable and an approachable attitude towards the students, provide them enough room for discussion and suggestions and students should not be made to think that they are working independently and there is no support from the teachers. Opportunities should always be available for amelioration and discussion in the learning process (Self-Directed Learning, 2009).

Institutions of higher education are being affected by considerable changes. Student numbers have risen drastically since 1991 and the composition of the student population has also altered considerably. More mature and part-time students are now entering higher education and the proportion of students in non-standard entry qualifications has increased. There is greater pressure on teaching accommodation thus teaching resources are in short supply as a consequence of changes in students-staff ratios. The staff is now being faced with increased assessment loads and the maintenance of quality is becoming a priority in educational institutions and consequently, quality audit and assessment systems are being established (Wade, 2004). One response, which meets the challenge, is the self-directed learning approach to learning and teaching which encourages flexibility at all stages from the design of courses through forms and assessment.

The last decades have been the growth of individualized learning systems on a massive scale of managing the difficulty of mixed-ability learners. The teachers employ techniques and strategies so that the advent of learner's stimuli gives a greater chance of avoiding such habitual reactions and opportunity to re-rationalized the handling of teacher-learner interactions. But these interactions can be best remedied by the actual use of self-directed learning activities, which the teachers from direct instructions to enhance free discussions of what the instructions actually mean.

Self-directed learning activities help place more responsibility for learning on the student's part himself and thus tend towards encouraging more personal



involvement as well as freedom to choose varied learning situations (School Council, 2011). At best, this learning system provides the necessary clues for students to pursue self-productivity with minimum interference from the teacher.

According to Thomas (2010), learning by experience involves the complete person. He further stressed that self-organized learners are better able to control their individual destinies. Self-organized learning provides students with ample opportunities to engage on their learning activities and to satisfy their own individual needs. He emphasized that learning is self-directed when learners can come to a situation with an intention, something they want to solve, do, learn, try-out and accomplish.

In General Santos City, South Cotabato, it has been observed that many freshmen college students from the Ramon Magsaysay Memorial Colleges have no enthusiasm in learning economics subject. They take these subjects as requirements for graduation without thoroughly understanding the significance of these subjects in their lives.

Learning is best enhanced and best facilitated when the learners are given the ample opportunity to participate in the learning activity. Self-organized learning provides students with ample opportunities to engage in their learning activities, to satisfy their own individual needs. Students lack the motivating factor in learning the subject matter meaningfully since many teachers are still using the traditional method or the so-called "Chalk and Talk Method" and not relating the concepts learned to real problem situations.

The aforecited situations prompted the researcher to prepare modular instructions on self-directed learning activities in Basic Economics for freshmen college students so that teachers will meet the challenge in encouraging their students to learn by doing with minimum guidance and directions. In that way, teachers would become effective and efficient in teaching basic economics subject. Through these modular instructions on self-directed learning activities, the methodology of teaching will improve and teachers' competence shall be enhanced.

The study is anchored on Thorndike's principle of learning which states that man learns best by doing. This is supported by Meuller (1995) who said that learning goes hand in hand with autonomy, increased liberty, expansion of choice, and the inclusion of the members or those concerned in the system. However, this does not mean that such system cannot develop in a rigid fashion or take an unwanted direction. In directed learning system, Meuller added that an organizer's role and task are seen in different light. He is expected to support and facilitate, create contexts for reflection, experiments and learnings, and to encourage the expansion of functions and possibilities of self-realization. Lamire (1998) also cited half a dozen

studies of community college students in that a dominant learning style among them was visual followed by what he referred to as haptic or learning by doing. Apparently the use of a variety of instructional methods, particularly those using or visual or hands on approaches to learning are more likely to appeal to the learning styles of students.

This study further theorizes that the use of self-directed learning activities in basic economics among freshmen college students, will upgrade students' achievement. This theory is also supported by Piaget (1992) who stressed that a child must experience and manipulate material objects to develop his intellectual power while Jansen (1989) on the other hand stated that ideas can be internalized best if what is learned can be put into action. Further, he said that learning could only be meaningful and effective if the learner can translate his ideas into action and where student empowerment is given a very high regard.

## **METHODOLOGY**

This study used an experimental method of research. This is because the main focus of the author is to find out how effective is the use of self-directed learning activities in teaching Basic Economics to freshmen college students. This study made use of one of the experimental designs categorized by Campbell and Stanley as cited by Sevilla et al., (1993) as the Non-equivalent Control Group Design. This design is considered as one of the most widely used design in educational research with the following paradigm.

This non-equivalent control group design is commonly used in groups with participants naturally assembled such as those in the classrooms. The assumption is that both groups are equal, but in case there are initial differences of the independent variable identified, the analysis of covariance may be used. In this study, difference in achievement was partialled out. This was done by assigning randomly groups with pretest having insignificant means and standard deviation as experimental and control groups taking into consideration their academic programs or department they were enrolled.

The study was conducted at the Ramon Magsaysay Memorial Colleges, General Santos City within the first semester of School Year 2016-2017 and the subjects of the study were the freshmen college students of the said school.

The main focus of this study was the preparation of self-directed learning activities in Basic Economics and the testing thereto of their effectiveness. The preparation of these modules was based on the CHED'S prescription in teaching Basic Economics with the following proposed major topics: The Nature of Economics, Economics Systems; Factors of Productions; Major forms of Business Organization; Market Structure; Demand and Supply: Price Determination; Elasticity; Cost of Production;



National income; The Philippine Financial System; Economic Development; and Economic Nationalism.

This study as an experimental design involved two groups, the experimental and the control groups. These two groups who were the subjects of the study were Freshmen College students coming from the different departments enrolled during the First Semester of school year 2016-2017. These two groups were randomly selected from twelve sections of basic economic classes from the different departments enrolled in Basic Economics. The groups which were subjected to experimentation had comparable pretest results.

In this experiment, there were two groups considered, one as the experimental and the other, control group. The experimental group received the treatment under investigation (Self-Directed Learning Activities) while the control group received the usual method (Chalk and Talk) of teaching Basic Economics. Before the experiment began, the researcher considered the two groups equal because they were all freshmen college students enrolled for the first time in the subject and had passed the cut-off score required to be enrolled in their respective departments/programs.

In conducting the experiment, the researcher strictly followed the experimental design. In this experiment, the conduct of the study lasted for one semester. To be sure that all the proper steps in carrying out the experiment was followed, the researcher herself handled the two groups in teaching Basic Economics. Since experimental factors may seriously affect the results of an experiment, she saw to it that extraneous factors enumerated by Manuel and Medel as cited by Gonzales (1983) were taken care of:

- 1) History refers to occasions or specific events between the first and second measurement of the dependent variable which inevitably, may cause changes in the dependent variable. These events are not part of the experimental treatment, yet they may cause serious effect on the dependent variable. In this study, the researcher saw to it that none of the members of either experimental or control group had some advanced learning in basic economics as this constitutes history and would probably interfere with the effect of the experimental treatment which is the giving of self-directed learning activities.

- 2) Maturation, biological or psychological processes which operate with the passage of time, regardless of events. To safeguard the experiment from this threat to internal validity, the researcher conducted this experiment within one semester and personally handled the subject. One semester could be long enough to cause any appreciable biological or psychological changes in the students. The researcher who acted as the facilitator of the subject saw to it

that all the topics were covered as contained in the modules to be accomplished for a given period.

3) Testing has some effects on the scores of subjects when they both take the first and second test. In this study, the pre-tests and post-tests for both groups were administered in such a longer time that they may not be able to recall what the pre-test items were all about. The post-tests were also given as final examinations on the scheduled period in order to let them forget their experience in the pre-test.

4) Selection occurs when subjects are chosen by groups which were naturally assembled. Freshmen students were heterogeneously grouped as they enrolled in Basic Economics. These subjects represented the population desired in the experiment since they belonged to the same curriculum year taking the same subject, passed the cut off score of the course and their ages were more or less the same.

5) Experimental mortality, loss of respondents from comparison groups. In this study, the researcher noted no one of the subjects dropped in the course of the experimental duration.

6) Interaction effects which represent effects of the experimental factor and some other variables such as experimental settings, reactive effect of testing and prior treatment interference. In this study, the researcher as the teacher/facilitator of the subjects ensured that all non-experimental variables that would adversely affect the results were kept equal among the groups such as time, conditions of the rooms, the giving of praise keeping absences to all minimum, non-scolding of students as much as possible, the giving of quizzes or tests, and other classroom activities.

## **RESULTS AND DISCUSSION**

### *Sub-problem No. 1: Pre-Test Mean Scores of the Experimental and the Control Group in Basic Economics*

At the start of the experiment, the researcher was able to establish comparability between the two groups, the experimental and control, because the overall mean scores of both groups in Basic Economics were found to be having no significant difference. To have a closer look of the comparability of the level of achievement of the two groups at the start of the experiment, the researcher made an itemized comparison of the mean scores of the two groups and the results are explained in the succeeding discussion.

The pre-test mean scores of the students in the experimental and the control group on the twelve areas of Basic Economics are shown in Table 1.



TABLE 1. PRE-TEST MEAN SCORES OF THE EXPERIMENTAL AND THE CONTROL GROUP IN BASIC ECONOMICS

Area of Basic Economics	Group	Mean Scores	Grade Equivalent	Verbal Description
(a) Nature of Economics	Control	2.49	66	Good
	Experimental	3.18	70	Good
(b) Economic Systems	Control	0.37	69	Good
	Experimental	0.38	69	Good
(c) Factors of Production	Control	1.09	68	Good
	Experimental	1.18	70	Good
(d) Major Forms of Business Organization	Control	0.91	87	Excellent
	Experimental	0.74	96	Excellent
(e) Market Structure	Control	1.80	62	Good
	Experimental	1.21	68	Good
(f) Demand and Supply; Price Determination	Control	3.57	65	Good
	Experimental	3.97	67	Good
(g) Elasticity	Control	3.46	63	Good
	Experimental	4.06	66	Good
(h) Cost of Production	Control	2.60	64	Good
	Experimental	4.65	76	Good
(i) National Income	Control	3.97	64	Good
	Experimental	7.97	78	Good
(j) The Philippine Financial System	Control	6.91	63	Good
	Experimental	12.94	74	Good
(k) Economic Development	Control	1.57	63	Good
	Experimental	3.21	77	Good
(l) Economic Nationalism	Control	0.74	87	Excellent
	Experimental	0.76	88	Excellent
OVERALL	Control	29.51	68	Good
	Experimental	29.53	75	Good

As can be seen from Table 1, both the control and experimental group obtained a “good” mean score in their pretest. However, the experimental group shows an “excellent” mean score in the area of Major Forms of Business Organization and Economic Nationalism over the control group. The “good” mean score of students means that the student gets 61-80% correct answers of the test. This indicates very good learning. A student who gets this score passed in the test. This presupposes that at the start of the experiment, neither of the two groups, experimental or control, had an edge over the other in terms of achievement or performance in the twelve areas of Basic Economics. Thus, comparability of grouping there from is established.

***Sub-problem No. 2: t-test of significant differences between the pre-test mean scores of the control group and experimental group in Basic Economics***

The t-test on the significance of the difference between the pre-test mean scores of the experimental group in the twelve areas of Basic Economics is shown in Table 2.

TABLE 2. T-TEST RESULT ON THE SIGNIFICANT DIFFERENCES BETWEEN THE PRETEST MEAN SCORES OF THE CONTROL GROUP AND EXPERIMENTAL GROUP IN BASIC ECONOMICS

Area of Basic Economics	Group	Mean Scores	Computed t-value
(m) Nature of Economics	Experimental	2.49	<b>1.84<sup>NS</sup></b>
	Control	3.18	
(n) Economic Systems	Experimental	0.37	<b>0.09<sup>NS</sup></b>
	Control	0.38	
(o) Factors of Production	Experimental	1.09	<b>0.43<sup>NS</sup></b>
	Control	1.18	
(p) Major Forms of Business Organization	Experimental	0.91	<b>1.98<sup>S</sup></b>
	Control	0.74	
(q) Market Structure	Experimental	1.80	<b>2.31<sup>S</sup></b>
	Control	1.21	
(r) Demand and Supply; Price Determination	Experimental	3.57	<b>1.03<sup>NS</sup></b>
	Control	3.97	
(s) Elasticity	Experimental	3.46	<b>1.74<sup>NS</sup></b>
	Control	4.06	
(t) Cost of Production	Experimental	2.60	<b>5.31<sup>S</sup></b>
	Control	4.65	
(u) National Income	Experimental	3.97	<b>8.31<sup>S</sup></b>
	Control	7.97	
(v) The Philippine Financial System	Experimental	6.91	<b>7.19<sup>S</sup></b>
	Control	12.94	
(w) Economic Development	Experimental	1.57	<b>5.55<sup>S</sup></b>
	Control	3.21	
(x) Economic Nationalism	Experimental	0.74	<b>0.19<sup>NS</sup></b>
	Control	0.76	
OVERALL	Experimental	29.51	<b>0.01</b>
	Control	29.53	

*Legend:*

Critical t-value at  $\alpha=0.05$  is 1.96

NS Not Significant

In all the twelve areas of Basic Economics, there exists a significant difference between the pre-test mean score and the post-test mean scores of the experimental group in each of the areas evidenced by the computed t-values which are all significant at  $\alpha=0.05$ . This leads to the rejection of all the null hypotheses, which pertain to the significance of the difference between the pre-test and post-test mean scores of the experimental group in all subtests. This means that the students in the experimental group were able to significantly improve their scores from the pre-test to the post-test in all the twelve areas of Basic Economics and the increase in their mean scores from the pre-test to the post-test can be due to the students' use of the instructional modules developed by the researcher which provides simple exercises or activities which they can follow through by themselves. As explained by Dumual (1985), such activities provide students active learning replacing the traditional



passive reading techniques or just simple listening lectures fed by their teachers. The findings of Cadungog (1995) are supportive of the findings of this study that manipulatives are effective devices in enhancing learning among students. She disclosed that exposing students of the experimental group to practical work activities makes a difference between the performance of the experimental and the control group in favor of the experimental.

**Sub-problem No. 3: Post-test mean scores of the control group and experimental group in Basic Economics**

Table 3 shows the post-test mean scores of the control group and experimental group in Basic Economics.

TABLE 3. POSTTEST MEAN SCORES OF THE EXPERIMENTAL AND THE CONTROL GROUP IN BASIC ECONOMICS

Area of Basic Economics	Group	Mean Score	Grade Equivalent	Verbal Description
(a) Nature of Economics	Control	3.18	70	Good
	Experimental	4.76	80	Good
(b) Economic System	Control	0.38	69	Good
	Experimental	0.50	75	Good
(c) Factors of Production	Control	1.18	70	Good
	Experimental	1.76	79	Good
(d) Major Forms of Business Organization	Control	0.74	75	Good
	Experimental	0.50	87	Excellent
(e) Market Structure	Control	1.21	62	Good
	Experimental	2.76	78	Good
(f) Demand and Supply; Price Determination	Control	3.97	67	Good
	Experimental	7.14	80	Good
(g) Elasticity	Control	4.06	66	Good
	Experimental	6.85	76	Good
(h) Cost of Production	Control	4.65	76	Good
	Experimental	2.44	79	Good
(I) National Income	Control	7.97	78	Good
	Experimental	3.68	80	Good
(j) The Philippine Financial System	Control	12.94	61	Good
	Experimental	6.00	74	Good
(k) Economic Development	Control	3.21	65	Good
	Experimental	1.79	77	Good
(l) Economic Nationalism	Control	0.76	84	Excellent
	Experimental	0.68	88	Excellent
OVERALL	Control	29.53	71	Good
	Experimental	53.85	78	Good

Table 3 reveals a “good” mean of the post-test scores of the experimental group and the control group. This implies that the student gets 61-80% correct answers of the test. This indicates very good learning. A student who gets this score passed in the test.

The experimental group shows a higher post-test mean score over the control group in the areas of: Nature of Economics, Economic System, Factors of Production, Market Structure, Demand and Supply, Price Determination, Elasticity, Cost of Production and National Income. While the control group shows a higher post-test mean scores over the experimental in the areas of: Major Forms of Business Organization, The Philippine Financial System, Economic Development and Economic Nationalism.

***Sub-problem No. 4: t-test result on the significant differences between the post-test mean scores of the experimental group and control group***

The t-test of significance of the differences between between the post-test mean scores of the experimental group and control group is presented in Table 4.

TABLE 4. T-TEST RESULT ON THE SIGNIFICANT DIFFERENCES BETWEEN THE POST-TEST MEAN SCORES OF THE EXPERIMENTAL GROUP AND CONTROL GROUP

Area of Basic Economics	Group	Mean Score	Computed t-value
(a) Nature of Economics	Control	3.18	<b>5.62<sup>S</sup></b>
	Experimental	4.76	
(b) Economic System	Control	0.38	<b>1.07<sup>NS</sup></b>
	Experimental	0.50	
(c) Factors of Production	Control	1.18	<b>3.11<sup>S</sup></b>
	Experimental	1.76	
(d) Major Forms of Business Organization	Control	0.74	<b>1.85<sup>NS</sup></b>
	Experimental	0.50	
(e) Market Structure	Control	1.21	<b>6.31<sup>S</sup></b>
	Experimental	2.76	
(f) Demand and Supply; Price Determination	Control	3.97	<b>7.19<sup>S</sup></b>
	Experimental	7.14	
(g) Elasticity	Control	4.06	<b>5.54<sup>S</sup></b>
	Experimental	6.85	
(h) Cost of Production	Control	4.65	<b>5.96<sup>S</sup></b>
	Experimental	2.44	
(I) National Income	Control	7.97	<b>8.43<sup>S</sup></b>
	Experimental	3.68	
(j) The Philippine Financial System	Control	12.94	<b>8.16<sup>S</sup></b>
	Experimental	6.00	
(k) Economic Development	Control	3.21	<b>4.82<sup>S</sup></b>
	Experimental	1.79	
(l) Economic Nationalism	Control	0.76	<b>1.00<sup>NS</sup></b>
	Experimental	0.68	
OVERALL	Control	29.53	<b>11.77<sup>S</sup></b>
	Experimental	53.85	

Legend:

Critical t-value at  $\alpha= 0.05$  is 1.96

NS Not Significant



As can be gleaned from table 4, there is a significant difference between the pre-test and post-test mean scores of the control group in the following topics: (1) Nature of Economics, (2) Factors of Production, (3) Demand and Supply; Price Determination, (4) Elasticity, (5) Cost of Production, (6) Philippine Financial System and (7) Economic Development.

The overall mean scores of the experimental group clearly reveals that there is a difference between the group's pre-test and post-test mean scores in the above mentioned areas of Basic Economics. This means that the experimental group was able to significantly improve its mean scores from pre-test to post-test because the computed t-values in all the topics experimented showed that they were all significant at  $\alpha=0.05$  level of significance. The null hypotheses therefore, which state that there are no significant differences in the pre-test and post-test mean scores of the control group in the seven areas of Basic Economics as enumerated are all rejected. Hence, in each of said areas of Basic Economics, the control group which was not exposed to the instructional modules in Basic Economics which was developed by the researcher in this study was able to significantly improve achievement mean score of the control group from pre-test to post-test.

On the other hand, topics of Basic Economics such as (1) Economic Systems (2) Major forms of Business Organization, and (3) Economic Nationalism showed no significant difference on the performance of the experimental group no significant difference on the performance of the control group from pre-test to post-test. The null hypotheses therefore regarding these subtopics stating that no difference exists in the pre-test and post-test means scores of the control group cannot be rejected. This shows that the control group which was not exposed to the self-directed learning activities did not learn significantly in (1) Economic Systems (2) Major Forms of Business Organization, and (3) Economic Nationalism. This further indicates that the traditional method of teaching using the lecture method is not effective in teaching these three topics of Basic Economics.

***Sub-problem No. 5: t-test on the Significant Differences in the Mean Gain Scores between the Experimental Group and Control Group in Basic Economics***

The t-test on the significance of the difference between the mean gain scores of the experimental and the control group in the twelve areas of Basic Economics is presented in Table 5.

TABLE 5. T-TEST ON THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN THE MEAN GAIN SCORES OF THE EXPERIMENTAL AND THE CONTROL GROUP

Area of Basic Economics	Group	Mean Gain Score	Computed t-value
1. Nature of Economics	Experimental	3.66	4.68 <sup>S</sup>
	Control	1.59	
2. Economic Systems	Experimental	.34	1.52 <sup>NS</sup>
	Control	.12	
3. Factors of Production	Experimental	1.23	2.29 <sup>S</sup>
	Control	.59	
4. Major Forms of Business Organization	Experimental	.11	0.73 <sup>NS</sup>
	Control	.23	
5. Market Structure	Experimental	1.40	.44 <sup>NS</sup>
	Control	1.56	
6. Demand and Supply; Price Determination	Experimental	5.86	4.51 <sup>S</sup>
	Control	3.18	
7. Elasticity	Experimental	5.83	4.77 <sup>S</sup>
	Control	2.79	
8. Cost of Production	Experimental	5.11	5.66 <sup>S</sup>
	Control	2.21	
9. National Income	Experimental	5.11	.20 <sup>NS</sup>
	Control	4.23	
10. The Philippine Financial System	Experimental	12.60	5.22 <sup>S</sup>
	Control	6.94	
11. Economic Development	Experimental	2.74	3.58 <sup>S</sup>
	Control	1.41	
12. Economic Nationalism	Experimental	.11	0.20 <sup>NS</sup>
	Control	.08	
OVERALL	Experimental	42.25	7.4 <sup>S</sup>
	Control	24.32	

*Legend:*

Critical value of  $\alpha=0.05$  is 1.96;

S Significant;

NS Not Significant

It can be seen from the table that the mean gain scores of the experimental group in the following areas of Basic Economics (1) Nature of Economics, (2) Factors of Production, (3) Demand and Supply; Price Determination; (4) Elasticity, (5) Cost of Production, (6) Philippine Financial System, and (7) Economic Development are significantly higher than that of the control group. This rejects all the null hypotheses on the no significance of the difference between the mean gain scores of the experimental and the control group in those areas of Basic Economics.

This means that the experimental group which was exposed to instructional manual developed by the researcher in this study performed better than the control group which was taught without the developed instructional material. It can be said then



that in teaching these seven components of Basic Economics, using the instructional material developed by the researcher is better than teaching without using said materials.

### ***Sub-problem No. 6: Obedized Modules in Basic Economics***

An introduction to the rudiments of economic concepts, principles and policy. General topics include aspects of the market system, introduction of national income, the financial system, government finances, foreign trade, growth and development. Also, this course will introduce the basic principles of taxation, agrarian reform, economic nationalism and other current economic problems that can help students understand and deal with their own economic activities everyday with ease.

### ***General Objective***

This course is primarily aimed to give the students vital understanding regarding the principles and concepts of economics as a tool for survival.

### ***Specific Objectives***

Students should be able to:

- Explain the basic concepts of economics.
- Know the importance of utilizing the four factors of production.
- Identify the different forms of business organization.
- Understand and be aware of the different types of market structure.
- Graph the demand and supply schedules.
- Analyze and interpret the reactions and responses of buyers and sellers as price changes.
- Compute cost of production to achieve profit maximization.
- Discuss Philippine Financial System particularly the types and functions of money and how it takes part in solving Philippine financial problems.
- Discuss Agrarian Reform and Land Reform Programs and know how useful they are in solving agrarian problems.
- Know the different for/s structures of taxation and understand the role of taxation in meeting country's financial needs.
- Explain industrialization and economic development.
- Know the importance of economics nationalism as a vital factor in attaining growth and development.

### ***Course Outline***

#### ***Nature of Economics***

*Objectives:*

1. Explain the nature of economics and how it seeks to improve man's material welfare.
2. Discuss why economics is considered science and social science.

3. Differentiate economics with other social sciences (disciplines); economics being the queen of all social sciences.
4. Identify scientific statement with value judgment in a real life situation specially in meeting their needs and wants.
5. Understand the distinction between positive and normative economics and between microeconomics and macroeconomics.
6. Increase sensitivity on the use of available scarce resources.
7. Acquire functional information of the three basic economics questions and how students answer them.
8. Instill in their minds that each of them must work out for the attainment of the national economics goals for future economic security.
  - a. Economics Defined
  - b. Economics as a Science
  - c. Economics as a Social Science
  - d. History of Economics
  - e. Five Economic Goals
  - f. Scientific Statements versus Value Judgements
  - g. The Economic Problem
  - h. Why Economic Problem Arise
  - i. Scarcity
  - j. Role of Scarcity
  - k. Opportunity Cost
  - l. The Three Basic Economic Questions

### **I. Economics Systems**

#### *Objectives:*

1. Identify the kinds of economic system that can possibly be employed by society.
2. Compare and contrast Philippine economic system. With the other economic system employed in other parts of the world.
3. Internalize the value of creating system in running their own lives for economic stability.
4. Value economic justice and freedom in choosing an economic system as they run their own lives.
  - a. Capitalism
  - b. Communism
  - c. Socialism
  - d. Fascism
  - e. Feudalism

### **II. Factors of Production**

#### *Objectives:*

1. Understand the different factor of production that caused man to survive.



2. Identify the different factors of production and their kinds.
3. Explain the uses of all the factors units in the maximization of production.
4. Identify the kind of labor student should engage in when he is already thought with his college education.
5. Instill in the minds of the students how significant labor is in the survival of man.
6. Take courage in making themselves productive for greater economic security in their future.
  - a. Land
  - b. Labor
  - c. capital
  - d. Entrepreneur

## II. Major Forms of Business Organization

*Objectives:*

1. Value entrepreneurship as a tool in increasing of every society.
2. Identify the kind of business organization they wish to engage in someday.
3. Explain and discuss the different business organizations especially its advantage and disadvantages.
  - a. Sole Proprietorship
  - b. Partnership
  - c. Corporation
  - d. Cooperative

## III. Market Structure

*Objectives:*

1. Explain the different market situations/structures and the significance of their existence in the society.
2. Identify the kinds of market structures that are growing in their own communities.
3. Understand the existing methods of selling of goods in a competitive and monopolistic markets.
4. Appreciate the market as an ongoing process, as opposed to a geographic location or a graph with supply curve drawn on it.
5. Be able to itemize shortcomings of competitive market process.
6. Appreciate the benefits of non price competition as a substitute for price competition.
7. Know the meaning of perfect competition and how such a market structure be distinguished from monopoly, monopolistic competition and oligopoly.
  - a. Pure Competition
  - b. Pure Monopoly

- c. Monopolistic Competition
- d. Imperfect Monopoly or Oligopoly

#### **IV. Demand and Supply: Price Determination**

*Objectives:*

1. Explain how prices are determined.
2. Differentiate between demand and supply, schedules, curves and laws.
3. Plot, analyze and interpret demand and supply curves.
4. Explain how equilibrium in a product market obtained and market shortages and surpluses operate to push buyers and sellers toward equilibrium.
5. Predict the impact of increases and decreases in supply and demand on equilibrium price and quantity.
6. Know how changes in taste, income, price of substitute, and complement goods, and expected future changes in prices of the good in question affect then demand for a product and the equilibrium price and quantity.
7. Know how changes in resources will affect the position of the supply curve.
8. Read, analyze and interpret the shifting of the demand and supply curves whether downward or upward to the right.
  - a. Meaning of Demand
  - b. Demand Schedule
  - c. Demand Curve
  - d. Factors Affecting Demand Curve
  - e. Shifting of the Demand Curve
  - f. The Law of Demand
  - g. Meaning of Supply
  - h. Supply Schedule
  - i. Supply Curve
  - j. Factors Affecting Supply Curve
  - l. The Law of Supply
  - m. The Law of Supply and Demand
  - n. The Equilibrium

#### **V. Elasticity**

*Objectives:*

1. Explain what elasticity is and its relation to the market forces (demand and supply).
2. Compute price, income, cross, demand and supply elasticities.
3. Interpret the results of the computation made on the elasticity of supply, demand, price, income and cross.
4. Compute the percentage changes in quantity demanded and supplied to percentages changes in price and income.



5. Make use of the knowledge in the computation of elasticities in the different real market situations.
  - a. Meaning of Demand Elasticity
  - b. Determinants of Demand Elasticity
  - c. Price Elasticity of Demand
  - d. Income Elasticity of Demand
  - e. Cross Elasticity of Demand
  - f. Meaning of Supply Elasticity
  - g. Determinants of Supply Elasticity
  - h. Price Elasticity of Supply
  - i. Income Elasticity of Demand
  - j. Cross Elasticity of Demand

## VI. Cost of production

*Objective:*

1. Know the difference between explicit and implicit costs.
  1. Understand why profit maximizing firm should produce where price or marginal revenue equals marginal cost.
  2. Understand why some costs are irrelevant to the decisions of individuals and firms.
  3. Know how fixed cost, variable cost, total cost, marginal cost, average variable cost, average fixed cost, and average cost be computed and interpret likewise with average revenue, marginal revenue, total revenue, profit and loss.
  4. Discuss how profit is maximized.
  5. Analyze and interpret  $TR > TC$ ,  $TR < TC$  and  $TR = TC$ .
  6. Identify in the graph individual's profits and losses, the price at which the firm will shut down.
    - a. Economic Cost
    - b. Revenue
    - c. Profit Maximization

## VII. National Income

*Objectives:*

1. Explain the circular flow of income.
2. See how, through the circular flow of income, broad sectors of the economy are interrelated, that is to say, the consumption expenditures of households are dependent on the production decisions of firms, and the production decisions of firms are dependent on the incomes received by consumption decisions of households.
3. Determine differences from among consumption, savings, and investment.

4. Identify consumption, savings, and investment on the allowances they are receiving every month.
5. Explain fiscal policy and its role in solving the financial problem of the Philippine economy.
6. Know where the government gets its funding and how these funds are disbursed.
  - a. Circular Flow of Goods, services, and Money
  - b. Consumption, Investment, and Savings
  - c. Public Finance
    - Role of Fiscal Policy
    - Philippine fiscal Framework
    - Patterns of Philippine Revenue
    - Patterns of Philippine Expenditures
  - d. Taxation
    - Theory and Concept of Taxation
    - Development Requirements and Taxation
    - The Philippine Tax system
  - e. International Trade
    - Absolute and Comparative Advantages
    - Foreign Trade in the Philippine Economy and its Problems
    - Barriers to Free Trade
    - Trade Agreements and Associations

### **VIII. The Philippine Financial Systems**

#### *Objective:*

1. Discuss monetary policy and its role in the Philippine economy.
  1. Differentiate between easy and tight money.
  2. Explain how money, as a medium that facilitates trade, can increase
  3. National income.
  4. Understand the different types and functions of money.
  5. Explain why is there a great need for credit.
  6. Discuss the advantages and disadvantages of credit.
  7. Gain insights on local, national and global banking.
    - a. Monetary Policy
      - Definition of Money
      - Functions of Money
      - Types of Money
      - Easy and Tight Money
      - Money Multiplier
      - BSP and Money Supply
    - b. Credit
      - Bases of Credit



- Advantages and Disadvantages of Credit
- c. Bank
  - Central Banking
  - Universal Banking
  - Global Banking
  - World Bank
  - International Monetary Fund
  - Asian Development Bank

## IX. Economic Development

*Objectives:*

1. Know the distinction between economic growth and development.
  1. Describe and explain the characteristics of a developing economies.
  2. Know the stages of economic development.
  3. Identify the problems of developing countries in search for growth and development.
  4. Aware of giving importance on “self” development.
  5. Understand industrialization and the significance of its existence in every community.
  6. Know and understand the advantages and disadvantages of industrialization.
  7. Have an in-depth knowledge of the implementation of the Agrarian Reform Program and Land Reform Program.
  8. Know some sociocultural factors that block economic development.
    - a. Introduction
    - b. Meaning of Economics Growth and Development
    - c. The State and Development
    - d. Industrialization
    - e. Agrarian reform
    - f. The Environment and Sustainable Economic Development

## X. Economic Nationalism

*Objectives:*

1. Have an in-depth knowledge on how can one exercise nationalism in a silent way.
  1. Understand why economic nationalism will promote the national interest, economic growth, and welfare of a large number of citizens, and most of all, social stability.
  2. Distinguish the true nationalist from the fake.
  3. Understand why it is said that economic nationalism is a strong force affecting national development.

## **SUMMARY, CONCLUSION AND RECOMMENDATION**

### *Summary*

This study aimed to propose modular instruction on self-directed learning activities in basic economics among freshmen college students for teachers.

1. Pre-test mean scores of experimental and control groups in basic economics  
The mean pre-test scores of the experimental and control group in nature economics, economics systems, factors of production, market structure, demand and supply, price structure, elasticity, cost of production, national income, the philippine financial system and economic development are "good". in the topic on major forms of business organizational and economic nationalism the mean scores of the experimental and control group is "excellent".

2. Difference in the pre-test mean scores of the control group and experimental group

There is a significant difference between the pre-test mean scores of the control and experimental group in the areas of nature of economics, factors of production, demand and supply, price determination, elasticity, cost of production, philippine financial system and economic development.

3. Post-test mean scores of the experimental and control group  
Compared with the control group, the experimental group got higher post-test scores than their pre-test scores in the nature of economics, economics systems, factors of production, markets structure, elasticity, cost of production, national income, the philippine financial system, economic development and in overall areas.

4. Difference in the post-test mean score of the experimental and control group  
There is a significant difference between the pre-test and post-test mean scores of the control group in the nature of economics, factors of production, demand and supply, price determination, elasticity, cost of production, philippine financial system and economic development. On the other hand, topics of basic economics such as economic systems, major forms of business organization, and economic nationalism showed no significant difference on the performance of the experimental group and the control group from pre-test to post-test.

5. Difference in the mean gain score of experimental and control group  
There is a significant difference between the mean gain score of the experimental and the control group in the areas of nature of economics, factors of production, markets structure, demand and supply: price determination, elasticity, cost of production, national income, the philippine financial system, economics development and in overall area. There is no significant difference between the mean gain score of experimental and the control group in economic systems, major forms of business organization, market structure, national income and economic nationalism.



#### 6. Obedized modules in basic economics

This module is an introduction to the rudiments of economic concepts, principles and policy. General topics include aspects of the market system, introduction of national income, the financial system, government finances, foreign trade, growth and development. Also, this course will introduce the basic principles of taxation, agrarian reform, economic nationalism and other current economic problems that can help students understand and deal with their own economic activities everyday with ease.

#### *Conclusions*

Based on the findings of the study, the following conclusions are drawn:

1. The pretest performance of the control and experimental groups in basic economics is “good”.
2. The experimental and the control group are comparable in their performance at the start of the experiment.
3. The experimental group have higher post-test performance in basic economics over the control group.
4. The use of self-directed learning activities is effective in the experimental group as revealed by their increase in the post-test mean scores.
5. The experimental group have better performance over the control group in the areas of the nature of economics, factors of production, market supply, demand and supply: price determination, elasticity, cost of production, national income, the Philippine financial system, economic development and in overall area. However, both the experimental and control group have comparable performance in the areas of economic system, major form of business organization, market structure, national income and economic nationalism.
6. The use of obedized modules in basic economics could greatly help the teachers who are teaching Basic Economics.

#### *Recommendations*

In the light of the findings and conclusions of the study, it is highly recommended:

1. The economics teacher could use the raw scores obtained in the pretest in order to plan and design teaching strategies in economics to further enhance instruction. They can utilize the use of graph, charts, pictures and other related instructional materials in teaching.
2. The teacher could contextualized the teaching of economics by identifying the topics that could be localized and indigenized. This would help them make the lesson more relevant to the learners.
3. The use of self-directed learning activities could be sustained by the teachers in teaching basic economics since it was found out that it increased the scores of

students. Other economics teachers from other colleges and universities could also use this strategy.

4. Self-directed learning activities are found to be effective, thus, it is recommended to all economics teachers. They can use this strategy in teaching economics.

5. The self-directed learning activities resulted to a better performance of students in basic economics, thus, this strategy could be replicated for wider utilization.

6. The use of obedized instruction in teaching basic economics is recommended to all economics teachers. The use of this teaching strategy could help increase the basic knowledge of students in economics.

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# 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.*

*JEL: E02, P16.*

*Keywords: Collaboration; Entrepreneurship; Capitalism; Economic growth; Game theory; Prisoner's dilemma.*

## **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, Pharmed 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.

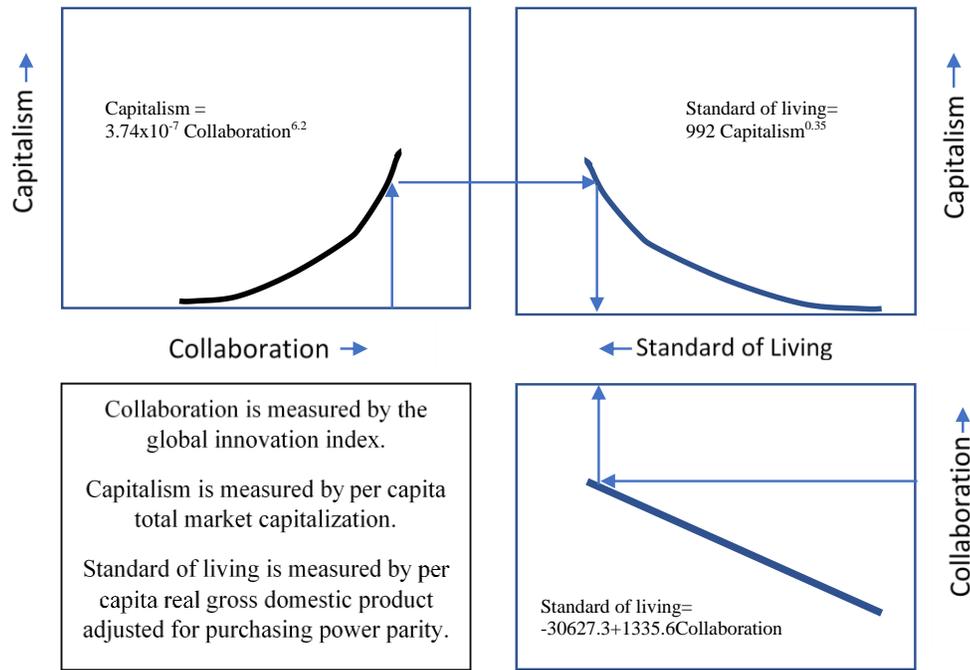


FIGURE 1. TRANSITION FROM COLLABORATION TO STANDARD OF LIVING

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<sub>PPP</sub> by country (2014), Global innovation index (GII) and Market Capitalization

Country	Per capita real GDP <sub>PPP</sub>	Global Innovation Index (GII)	Per capita Market Capitalization	Country	Per capita real GDP <sub>PPP</sub>	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<sub>PPP</sub>) - 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.

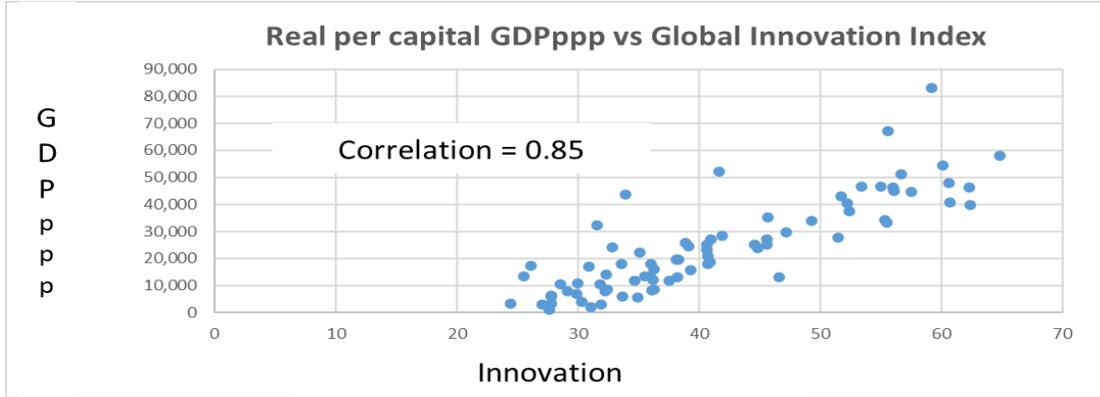


FIGURE 2. PER CAPITA REAL GDP PPP VS GLOBAL INNOVATION INDEX (GII):  $(GDP PPP = -30627.3 + 1335.6GII)$

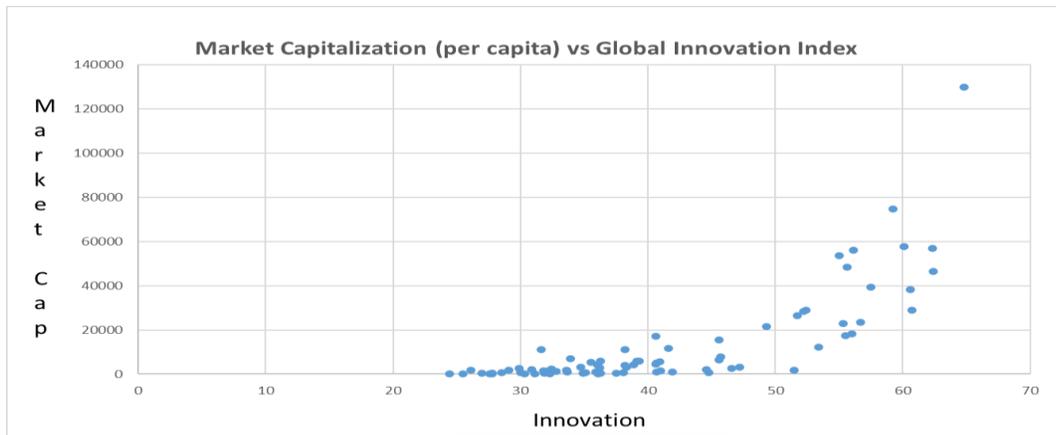


FIGURE 3. MARKET CAPITALIZATION VS. INNOVATION:  $(MARKET CAP = 3.74 \times 10^{-7} GII^{6.2})$

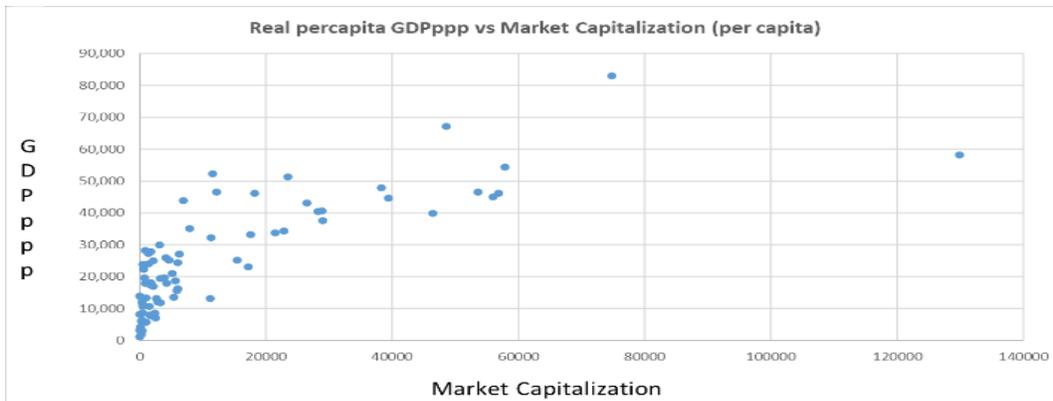


FIGURE 4. MARKET CAPITALIZATION VS. INNOVATION:  $(GDP PPP = 992 MARKET CAP^{0.35})$



# DYNAMIC ECONOMIC PROCESS, ANIMAL SPIRITS, AND CHINESE QI

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## **Abstract**

*This study builds up a theoretical model to quantify the formation of Keynes' animal spirits. It derives the equations demonstrating why and how the herding behavior or the business cycle would conduct. We integrate the Western concept of spirits and the Chinese qi in our model to show that the internal force drives a human's motive to behave and bridges man's brain and action like hidden consciousness. After deriving the dynamic behavior of the qi movement, this study illustrates how one's marginal utility function evolves across time. This non-stationary marginal utility concept is closer to modern behavioral economics and would revolutionize the conventional utilitarianism-related economic models. Our model is applicable in the micro-context to a human being and is expandable in the macro-context to any artificial entity. We hope that the methodology underpinned in this study could open a new window for future research to better cope with the current intractable and turbulent economic environment.*

**Keywords:** Animal spirits; Changing marginal utility; Human decision; Qi dynamics; Quantum mind.

## **INTRODUCTION**

The economic foundation that underlies the forces driving our daily economic activities should not merely be a "constrained optimization" (Samuelson, 1948) but an "incremental improvement." In our mundane human history, evolution rather than revolution is the norm. From waking in the morning till the moment of sleep, we are busy thriving for the betterment of our lives, not just simply for accomplishing our dreams or lives' ultimate goals. The economic equilibrium that is supposed to be achieved from the intersection of demand and supply is too vague and flimsy a term to fathom for our ordinary people. We are all living in an instantaneous dynamic process, not aiming to jump toward our long-term destination in one giant step.

To thoroughly comprehend the recurrence of the global economic crises these days, acclaimed economists Akerlof and Shiller (2009) reassert the necessity of including the idea of animal spirits as the powerful psychological forces that influence the financial and economic performance and wealth of nations. Just as Adam Smith's

invisible hand is the driving force in classical economics, John Maynard Keynes' animal spirits are the keynote to another view of the economy—a view that explains the underlying instability of capitalism. In 1936, when *The General Theory of Employment, Interest, and Money* was published, the political-economic spectrum were those who thought the old economics had gotten it right (Keynes, 1936). According to this classical economics, the private markets of their own accord and with no government interference would, "as if by an invisible hand," assure full employment.

However, in Keynes's view, the economy is not just governed by rational actors, who "as if by an invisible hand" will engage in any transaction to their mutual benefit as the classicists believed. Keynes argued that people with animal spirits have noneconomic motives and are not always rational in pursuing their economic goals. In Keynes' view, these animal spirits are the leading cause for why the economy fluctuates as it does. They would help set in motion an intellectual revolution that will change the way we think about economic depressions, unemployment, poverty, financial crises, and much more.

## **SPIRITS AND HUMAN BEHAVIOR**

To probe into the origin of the animal spirit, we need to delve into the formation of our decision-making via the impulse or response of our neural system toward the outside information input or shock. Numerous neuroscientific studies have all shown that our decision process is nothing but an effective transmission of the information at the molecular level, on a nanoscale, within living cells, and quantum mechanics is needed to explain the procession and storage of the information. In other words, our decision-making is driven by an invisible "quantum mind" to cope with the flow of information (Al-Khalili, 2014).

The idea of information derives originally from the realm of human discourse. It can be a purely abstract concept like a person's value system or moral standard. It also indirectly plays a physical role in the sphere of biology; a change in the information stored in an organism's DNA may produce a mutant offspring and alter the course of evolution. By and large, information itself has a casual power to make a difference in the world. The challenge to physical and social science is figuring out how to couple abstract information into our daily lives.

Dissatisfied with the existing economic doctrine that stresses the Nash equilibrium concept, this study intends to provide specific laws that could animate people's ideas and feelings and govern human decisions. These laws, which should not contradict the basic principles of physics and biology, are briefly phrased in the following:

- The First Law of Human Behavior – all the activities of the human's mind are driven by the quantum mechanics of human's brain cell;



- The Second Law of Human Behavior – the dynamics of human behavior should mimic our nerve impulses toward external stimulus as specified by the cable equation of the Ohmic model.

The internal information movement driven by our quantum mind is quite akin to Chinese qi (氣 or spiritual strength). This qi, meaning volition in Chinese, is the undercurrent of a human's mental power that flows freely within our physical body and plays a pivotal role in forming our preference. The internal force drives our intention or motive to behave, thus bridging our brain and action like our hidden consciousness.

Every time we go through the daily grind, trudging through our everyday activities, we de-energize ourselves. Our spirit is being drained away, and our bodies are inundated with exhausted qi instead. This exhausted and depreciated qi causes us to live poorly and out of balance that we easily get fatigued. If we continue living like this, our qi, hence spirit, will ebb away long before our physical life ended. The world of our experience consists of discrete things that typically interact poorly with one another. The fragile, imperfect relationships among human beings are good examples.

Balancing out different spheres of external distraction (i.e., the thermodynamic noises in the quantum world) helps to support our emotions and strengthen our qi. Many of us seek tranquility and alignment by withdrawing from the world temporarily, avoiding the various entanglements that draw out all sorts of uncomfortable feelings. Aside from taking a break, going on vacation or a retreat, or doing meditation, we can experience balance and alignment (or the so-called coherence in terms of quantum biology) always by modulating our impulsive desires and smoothing the ups and downs that come with too much anger or even too much joy.

After deriving the dynamic behavior of qi movement, this study illustrates how one's marginal utility evolves across time and somehow resolves the long-pending prisoner's dilemma. By converting the qi equation into the wave function in the format of quantum mechanism, this model can further explain the phenomenon of coherence or resonance that is the critical factor to dampen the adverse impact of external shock. It thus justifies the role played by culture to align the conflicting interests among game participants and facilitate more efficient economic development.

### **DYNAMIC EQUATION OF QI**

In the following, we are trying to formulate the movement and characterize the behavior of qi in line with the nature of quantum biology. To begin with, we define

"qi" (abbreviated as C) as something like the concentration of one's volition, which may be caused by the biochemical movement of ions across the membrane of one's nerve system. The interplay of physical and biochemical approaches to life science has borne significant fruits in interpreting how our nerve impulses work. We will not go to the details of this discussion. Instead, we derive an equation of qi's movement in a more general sense.

Suppose we know the number of elements at each point along the x-axis at time t, as  $N(x)$ , where the element can stand for the constituent of "qi" and the distance x is measured along the conduit of our mental body. How many elements will move across the unit area from point x to point  $(x + \varepsilon)$ ?

$$N(x) : N(x + \varepsilon)$$

$$x : x + \varepsilon$$

First, we assume that there is no other external force so that the elements will behave like a random walk. At time  $t + \tau$ , half the element at x will have stepped across the dashed line from left to right, and half the elements at  $x + \varepsilon$  will have stepped across the dashed line from right to left. The net number crossing to the right will be

$$-\frac{1}{2}[N(x + \varepsilon) - N(x)].$$

This study builds up a theoretical model to quantify the formation of Keynes' animal spirits. It derives the equations demonstrating why and how the herding behavior or the business cycle would conduct. We integrate the Western concept of spirits and the Chinese qi in our model to show that the internal force drives a human's motive to behave and bridges man's brain and action like hidden consciousness. After deriving the dynamic behavior of the qi movement, this study illustrates how one's marginal utility function evolves across time. This non-stationary marginal utility concept is closer to modern behavioral economics and would revolutionize the conventional utilitarianism-related economic models. Our model is applicable in the micro-context to a human being and is expandable in the macro-context to any artificial entity. We hope that the methodology underpinned in this study could open a new window for future research to better cope with the current intractable and turbulent economic environment.

If it turns out to be negative, more elements will cross to the left than to the right. To obtain the net flux,  $J_x$ , we divide the net number above by the area normal to the x-axis,  $A^1$ , and by the time interval,  $\tau$ ,

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<sup>1</sup>A is the cross-section area of the "qi" aqueduct. It is considered here for the sake of easy derivation. The final formulation of our "qi" equation will not depend on A.

$$\begin{aligned}
 J_x &= -\frac{1}{2}[N(x + \varepsilon) - N(x)] / A\tau \\
 &= -\frac{\varepsilon^2}{2\tau} \frac{1}{\varepsilon} \left[ \frac{N(x + \varepsilon)}{A\varepsilon} - \frac{N(x)}{A\varepsilon} \right] \\
 &= -D \frac{1}{\varepsilon} [C(x + \varepsilon) - C(x)]
 \end{aligned}$$

Where  $D \equiv \varepsilon^2 / 2\tau$  is the diffusion coefficient, and  $C(x + \varepsilon) = N(x + \varepsilon) / A\varepsilon$  &  $C(x) = N(x) / A\varepsilon$  are the number of elements per unit volume at the points  $x + \varepsilon$  &  $x$  respectively. In the limit  $\varepsilon \rightarrow 0$ , we obtain the net flux,  $J_x$ :

$$J_x = -D \frac{\partial C}{\partial x} \tag{1}$$

Assume that the total number of elements is conserved, as shown in Figure 1 below.

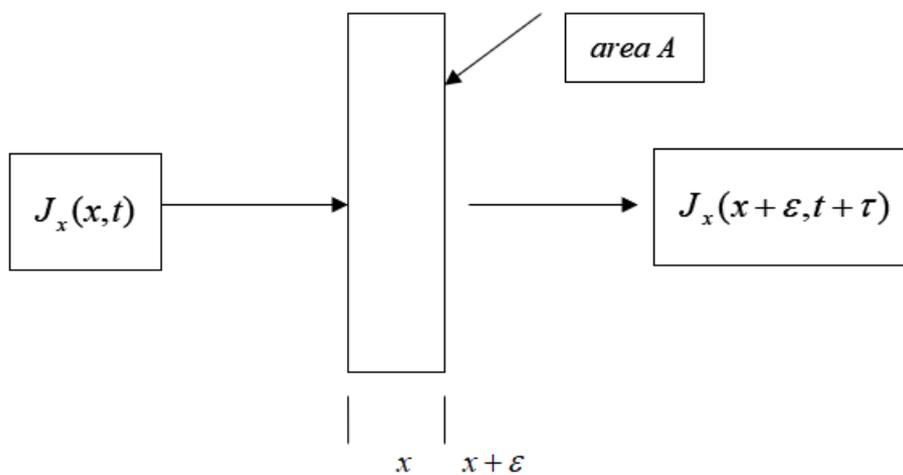


FIG 1. THE ELEMENTS MOVEMENT

Consider the box in Figure 1. In a period of time  $\tau$ ,  $J_x(x)A\tau$  elements will enter from the left, and  $J_x(x + \varepsilon)A\tau$  elements will leave from the right. The volume of the box is  $A\varepsilon$ . If the elements are neither created nor destroyed, the number of elements per unit volume in the box must increase at the rate

$$\begin{aligned}
 \frac{1}{\tau} [C(t + \tau) - C(t)] &= -\frac{1}{\tau} [J_x(x + \varepsilon) - J_x(x)] A\tau / A\varepsilon \\
 &= -\frac{1}{\varepsilon} [J_x(x + \varepsilon) - J_x(x)]
 \end{aligned}$$

In the limit  $\tau \rightarrow 0$  and  $\varepsilon \rightarrow 0$ , this means that

$$\frac{\partial C}{\partial t} = -\frac{\partial J_x}{\partial x} \quad (2)$$

By substituting equation (1) into equation (2), we get the equation of qi's movement as

$$\frac{\partial C}{\partial t} = D \frac{\partial^2 C}{\partial x^2} \quad (3)$$

The equation (3) above is similar to the linear cable equation for nerve impulse that embodies the Ohmic hypothesis, i.e.,

$$(\lambda_{axon})^2 \frac{d^2 v}{dx^2} - \tau \frac{dv}{dt} = v.$$

where  $v$  is the difference between the interior potential of an axon and its quasi-steady value.

Letting  $w(x,t) \equiv e^{t/\tau} v(x,t)$ , the linear cable equation becomes

$$\frac{(\lambda_{axon})^2}{\tau} \frac{d^2 w}{dx^2} = \frac{dw}{dt},$$

which has precisely the same form as our dynamic equation of "qi". The derivation of the linear cable equation for nerve impulses above can be seen in Nelson (2004, chapter 12).

We now turn to the discussion of diffuse with drift. We compute the velocity at which an element drifts through the medium when exposed to an externally applied force. If all the elements in a distribution drift in the +x direction at velocity  $v_d$ , then the flux at point x must increase by an amount  $v_d C(x)$ . Thus equation (1) above becomes

$$J_x = -D \frac{\partial C}{\partial x} + v_d C \quad (4)$$

The derivation of the equation of qi's movement with drift proceeds as before, giving

$$\frac{\partial C}{\partial t} = D \frac{\partial^2 C}{\partial x^2} - v_d \frac{\partial C}{\partial x} \quad (5)$$

One example of  $v_d$  can be derived by imposing an external force  $F_x$  on the element that randomly walks with speed  $v_x = \varepsilon/\tau$  initially. From Newton's second law, we know that  $v_d = \frac{1}{2} \frac{F_x}{m} \tau$ . An element at absolute temperature T with mass m and velocity  $v_x$  on the x-axis has kinetic energy  $mv_x^2/2$ . This quantity fluctuates, but on



average  $mv_x^2/2 = kT/2$ , where  $k$  is Boltzmann's constant. By substituting  $D = \varepsilon^2/2\tau, v_x = \varepsilon/\tau$  &  $mv_x^2/2 = kT/2$  into  $v_d = \frac{1}{2} \frac{F_x}{m} \tau$ , we can get  $v_d = (D/kT)F_x$ . For economic interpretation, the consumption of a specific good or service,  $Y$ , is deemed as the dispensation of  $qi$  and will decrease the concentration of  $qi$  at the present time and bring in an inverse external force, i.e.,  $F_x$ , and a negative  $v_d$  as well. Therefore, we can write the above  $v_d$  as

$$v_d = -\lambda Y \tag{6}$$

as a result of consumption  $Y$ , and  $\lambda$  gauges the characteristics of one's "qi" system and should be positively correlated with  $D/kT$ .

After considering the natural depreciation of our life as tallied by an increase of entropy based on the second law of thermodynamics and the learning effect as addressed by the Hebb rule (see appendix 1), we can obtain the complete equation for the dynamics of  $qi$  as:

$$\frac{\partial C}{\partial t} = D \frac{\partial^2 C}{\partial x^2} + \lambda Y \frac{\partial C}{\partial x} - \frac{1}{Tk(1 + \ln C)} \frac{dE}{dt} - C + \sum_b w_b u_b \tag{7}$$

where  $k$  is Boltzmann's constant,  $E$  and  $T$  are the energy and temperature of the system we are dealing with, respectively. In this study, we adopt and modify the concept of the Hebb rule to include all the relevant inputs in our memory that affect the reaction of our  $qi$  toward the specific activity  $u_b$  with  $w_b$  capturing the strength of that memory impact on  $qi$ . This learning impact from various memory sources provides the theoretical argument for how culture affects one's decision.

### CONVERTING QI EQUATION INTO THE DYNAMICS OF ECONOMIC SATISFACTION

We define one's satisfaction (or happiness)  $\mu$  as the underlying force that consumes (or depreciates) one's  $qi$  and moves against the normal direction of a life force. It can be written as  $\mu \equiv -\partial C / \partial x$ . Let  $v = dx / dt$ , which measures the normal speed of passage for one's life and is an inherent characteristic of one's  $qi$  system. For simplicity, we assume it maintains relatively constant in the process<sup>2</sup>. Then  $\partial C / \partial t = -\mu(t) \cdot v$ , and  $\partial^2 C / \partial x^2 = -d\mu / dt \cdot dt / dx = (-1/v) \cdot d\mu / dt$ . Putting all these together, we can rewrite equation (7) as

<sup>2</sup>It is assumed constant for simplicity. Otherwise, we need to solve a complicated partial differential equation.

$$\mu(t) \cdot v = \frac{D}{v} \cdot \frac{d\mu(t)}{dt} + \lambda Y \mu(t) + \frac{dE/dt}{Tk(1+\ln C)} + C - \sum_b w_b u_b \quad (8)$$

The solution for the above first-order differential equation is

$$\mu(t) = (\mu(0) - A) \cdot \exp\left[\frac{v^2 - \lambda Y v}{D} \cdot t\right] + A$$

where

$$A = -f / (v - \lambda Y) = \left[ \frac{dE/dt}{Tk(1+\ln C)} + C - \sum_b w_b u_b \right] / (v - \lambda Y) \quad (A)$$

and  $\mu(0)$  is determined by the boundary condition at  $t = 0$ . We assume that the consumption of Y good or service happens in the very beginning, i.e., at  $t = 0$ . Hence,  $\mu(0)$  is a function of  $Y$  and can be rewritten as  $\mu(0; Y)$ . As time goes on,  $\mu(t)$  will become

$$\mu(t; Y) = (\mu(0; Y) - A) \cdot \exp\left[\frac{v^2 - \lambda Y v}{D} \cdot t\right] + A \quad (9)$$

And the marginal satisfaction (utility) from the consumption of Y can be shown as follows:

$$\frac{\partial \mu(t; Y)}{\partial Y} = [\mu(0; Y) - A] \cdot \exp\left[\frac{v^2 - \lambda Y v}{D} \cdot t\right] \cdot \left(-\frac{\lambda v t}{D}\right) (> 0) \quad (9')$$

Let  $v$  be the normal speed of qi movement against the direction of depreciation (or consumption). In the case that the net impact of entropy and learning effect on the accumulation of qi is negative (i.e.,  $f < 0$ ),  $v$  must be greater than  $\lambda Y$  in such a way that  $A$  becomes greater than  $\mu(0; Y)$ . Otherwise, we would have a negative marginal utility from consumption of Y as shown in the marginal satisfaction from consumption Y above. In the case that the net impact of entropy and learning effect is positive (i.e.,  $f > 0$ ),  $v$  must be less than  $\lambda Y$  so that  $A > \mu(0; Y)$  (otherwise marginal utility from Y would be negative).

When the consumption of Y is conducted repeatedly (instead of one shock happening at time 0), we can derive the property of declining marginal satisfaction (utility) as shown below:

$$\frac{\partial \mu^2(t; Y)}{\partial Y^2} = [\mu(0; Y) - A] \cdot \exp\left[\frac{v^2 - \lambda Y v}{D} \cdot t\right] \cdot \left(\frac{\lambda v t}{D}\right)^2 \quad (9'')$$

which is less than zero as long as  $\mu(0; Y) - A < 0$  is satisfied. In other words, in order to bring about the property conventionally assumed by our economics textbook, i.e., a positive and declining marginal utility, we need to satisfy the following biological assumption:



Biological Assumption for a Positive and Diminishing Marginal Utility:

- (1) The influx of external input  $Y$  never exceeds the natural speed of  $q_i$  movement  $v$  so that  $v > \lambda Y$ ;
- (2) The net impact of entropy and learning effect on the accumulation of  $q_i$  is sufficiently negative (i.e.,  $f < 0$ ) so that  $A$  is greater than  $\mu(0; Y)$ .

Equation (9) describes the dynamic path of one's satisfaction from the one-time consumption at time 0. It shows that every economic activity has a lingering effect that will eventually sink into the sediment of our memory through the  $u_b$  in the above equation and exert its impact on our future interaction with the same or similar activity. This equation explicates the important role played by wealth, education, experience, culture, enthusiasm, and health condition through the parameters  $dE/dt, D, T, v, w_b, u_b$  &  $\lambda$  in the digestion and consummation of one's satisfaction. Moreover, the entropic force that works by the second law of thermodynamics will boost our satisfaction through its natural dispersion of order and the consumption of our accumulated  $q_i$ .

From equations (9') and (9'') we can readily see that the greater  $A$  is, the greater the marginal utility becomes and the faster the marginal utility diminishes. According to the definition of  $A$  in equation (A) above, we can derive the following proposition:

*Proposition 1: When the biological assumption holds, an increase in the growth of one's wealth (i.e., an increase in  $dE/dt$ ) will result in a decline in one's marginal utility and an accelerating diminution in one's marginal utility from the consumption of  $Y$ .*

*Corollary 1: When the biological assumption holds, a reduction in one's enthusiasm or eagerness about the consumption of  $Y$  (i.e., a reduction in  $T$ ) will result in a decline in one's marginal utility and an accelerating diminution in one's marginal utility from the consumption of  $Y$ .*

*Corollary 2: When the biological assumption holds, a relatively less experience or habit in consuming  $Y$  (i.e., a diminution in one's learning effect  $w_b u_b$ ) will result in a decline in one's marginal utility and an accelerating diminution in one's marginal utility from the consumption of  $Y$ .*

The proposition above provides a theoretical underpinning of how our marginal utility evolves owing to the effect exerted by the second law of thermodynamics (i.e., from the impact of  $dE/dt$  and  $T$ ) and the impact of culture, education, habit, and experience (i.e., through the learning effect  $\sum_b w_b u_b$ ). This property of ever-changing marginal utility paves the way of overcoming the inevitable outcome of

the prisoner's dilemma that beleaguers our conventional economics. When one takes the initiative to cooperate, the experience of this benign intention observed by her opponent will gradually alter her marginal utility to become less diminishing or more treasure the long-term relationship. Therefore, both players are more willing to show the cooperative intention and dampen the incentive to violate the cooperative agreement or atmosphere thus developed.

Moreover, the implication of this evolving marginal utility will open the door of how one's behavior affects her opponents' attitude through the learning effect. The Nash equilibrium that becomes the cornerstone of modern economics will have since been revised. When one player chooses her best strategy in a game, she should no longer assume that her opponent's behavior or strategy be stationary in response to her offer. The consequence of any activity will imbue her opponent with a specific connotation of what it exactly means and bring in a change in the opponent's attitude (or marginal utility).

## **QI AND ECONOMIC SYSTEM**

In modern economics, it has become standard practice to model agents as utility maximizers. Consumption is modeled by assuming that agents maximize utility over their lifetimes, or even over an infinite horizon that includes the lives of their descendants. Demand for money is the result of selecting an optimal portfolio of assets given the need to finance transactions and expectations of the future (King, 2016). This study basically modifies the conventional utilitarianism and challenges the notion of rational behavior upon which the micro-foundations in modern economics are constructed. The framework laid out in this model is closer to that of modern behavioral economics. Economic behavior is based on one's gut feeling, the biological reaction (or intuition) about how sensible people would behave according to his education, experiences, and lessons learned through observing behavior close at hand. As Keynes claimed in his *General Theory*, people's "animal spirit" and optimism or pessimism about unpredictable future is the predominant factor to cause the economic repercussion. This model intends to shed some light on this "animal spirit."

A conscious human being makes numerous economic decisions every day based on how her thinking framework is grated on the interaction of billions' neurons. Although thinking pattern differs dramatically from one another by one's distinct experience, heritage, and cultural background, a common trait would not deviate too much from the dynamic rule of evolution (or qi) as described in equation (7) above. This equation of qi can be interpreted more broadly in the following sense:

$$\frac{\partial C}{\partial t} - \sigma(C, t) \frac{\partial^2 C}{\partial x^2} - \alpha(C, t) \frac{\partial C}{\partial x} - f(C, t) = 0 \quad (10)$$



Where  $\sigma(C,t)$  characterizes the diffusion nature of the system and equals D in this model,  $\alpha(C,t)$  depicts the external driving force upon this system and equals  $\lambda Y$  in this model,  $f(C,t)$  reflects the inherent depreciating force in the absence of any outside disturbance and equals  $-\frac{1}{Tk(1+\ln C)} \frac{dE}{dt} - C + \sum_b w_b u_b$  in this model.

By assuming a constant  $v(t) = \frac{\partial x}{\partial t}$  for the simplification of interpretation, the dynamics of perceived satisfaction,  $\mu = -\frac{\partial C}{\partial x}$ , will then follow the following equation:

$$\mu(t) \cdot v(t) = \frac{\sigma}{v(t)} \cdot \frac{d\mu(t)}{dt} + \alpha\mu(t) - f \tag{11}$$

The solution for the above first-order differential equation is

$$\mu(t) = (\mu(0) - A) \cdot \exp\left[\frac{v(t)^2 - \alpha v(t)}{\sigma} \cdot t\right] + A \tag{12}$$

where  $A \equiv -f / (v(t) - \alpha)$ , and  $\mu(0)$  is determined by the boundary condition at  $t = 0$ .

An economic agent's behavior is driven by her gut feeling about the consequence of her economic decision. This gut feeling can be gauged by the repercussion on qi (equation 10) or satisfaction (equation 11). The impetus of economic activity is summarized in three factors:  $\alpha, \sigma$  &  $f$ .  $\alpha$  measures the average magnitude of external shock (force), which is likened to the government's economic stimulus or the rate of return for a portfolio choice in the example of an investment decision.  $\sigma$  reflects the dispersion or variance of the economic environment faced by a government or the return variance of an investment portfolio for an investor. One's memory, or the impact of culture on the decision object, is captured by the factor  $f$ . In addition,  $f$  manifests the natural depreciation force of one feeling as displayed in the second law of thermodynamics. The latter force leads to such economic phenomena as diminishing marginal utility, fad or herding behavior, and even the inexorable business cycle.

When we ignore the term  $f(C,t)$ , equation (10) reduces to the celebrated Kolmogorov's forward equation, the solution of which is

$$C(t, x) = \frac{1}{\sqrt{4\pi\sigma t}} \exp\left\{-\frac{[x - (x_0 + \alpha t)]^2}{4\sigma t}\right\},$$

where  $x_0$  is the initial value of  $x(t)$  when  $t = 0$ . If we add the term  $f(C, t)$  and simplify it to be  $C \cdot \beta (< 0)$ , then the solution to equation (10) becomes

$$C(t, x) = \exp(-\beta t) \cdot \frac{1}{\sqrt{4\pi\sigma t}} \exp\left\{-\frac{[x - (x_0 + \alpha t)]^2}{4\sigma t}\right\} \quad (13)$$

And the equation (12) above is a special case of equation (13) when we assume  $x = v \cdot t$ .

The equation (13) can be interpreted as the strength and resilience of an entity's growth potential and can be used as an alternative measurement of how the entity will evolve at time  $t$  when the subject maintains its current position  $x_0$  at time  $t = 0$ . The entity can be an individual, financial derivative asset, society, corporation, country, or economic system. For example, if we interpret  $x_0$  as a country's per capita wealth, then the qi (i.e., the degree of concentration or likelihood) that her per capita wealth would achieve the level  $x$  at time  $t$  is equal to  $C(t, x)$  as shown in equation (13).

The expression for  $C(t, x)$  is akin to the normal distribution with a mean equal to  $x_0 + \alpha t$  and variance equal to  $\sigma t$ , and magnified by a magnitude  $\exp(-\beta t)$ . The latter is the primary factor in gauging the degree of assurance for what a specific agent (an individual, a corporation, or a state) can achieve its objective ( $x$ ) at time  $t$  through its effort of exerting  $Y$ . It is noted that

$$\beta = \frac{f}{C} = -\frac{\frac{dE}{dt}}{Tk(1+\ln C)} * \frac{1}{C} - 1 + \frac{\sum_b w_b u_b}{C} < 0.$$

In the case of securing a country's higher standard of per capita wealth through its boosting economic policy ( $Y$ ), we can readily derive the following proposition:

*Proposition 2: The greater escalation of a state's wealth (i.e., an increasing  $dE/dt$ ), the lesser hubbub in striking its specific public policy (i.e., a lesser degree in  $T$ ),*

*Corollary 3: The more willing to learn the lesson from its history (i.e., a larger sum of  $\sum_b w_b u_b$ ), the more likely for the state to secure its economic achievement through its policy inputs ( $Y$ ).*

Another analogy of this model is the implication on the pricing of a derivative asset. It is known that under the arbitrage-free condition, the diffusion differential equation associated with an asset price ( $F$ ) that is derived from the underlying stock price ( $S$ ) can be written as

$$\frac{\partial F}{\partial t} + \frac{1}{2} b^2 S^2 \frac{\partial^2 F}{\partial S^2} + rS \frac{\partial F}{\partial S} - rF = 0$$

when the diffusion process for the stock price is described by a geometric Brownian motion as  $dS = aSdt + bSdW$ . This diffusion differential equation is akin to our



broadly defined dynamic equation of qi (equation 10) above as long as we interpret asset price F moves against the direction of qi (similar to the direction of

consumption),  $\sigma$  to be  $\frac{1}{2}b^2S^2$ ,  $\alpha$  to be  $rS$ , and  $f$  to be  $-rF$ . The solution to this diffusion equation is the well-known *Black-Scholes Formula* (Bjork, 2004).

**CONCLUDING REMARKS**

This paper exemplifies how the Chinese qi, which is transfigured in the form of animal spirits in Keynes' study, can illustrate human behaviors and multifaceted economic phenomena. Economic behavior is nothing but one dimension of qi's manifestation in the macro-environment context. It presides over an economic man's behavior and underscores the market activities of our economic system. On the one hand, it is congruent and resonant with the thermodynamic theory of entropy and the Ohmic hypothesis of our nerve impulse (cable equation). On the other hand, it dictates how our desire evolves, how our inter-temporal investment decision is made, and underpins the Black-Scholes formula of derivative asset pricing.

The qi dynamics can be interpreted as one's indirect utility function that satisfies all the resource constraints confronted in the interconnected economic system. Or, more precisely, our human behavior is conducted in accordance with a partial differential equation with its coefficients determined in a complicated way by economic conditions as well as the natural law of entropy dissipation and an individual's personality and learning characteristics.

These qi dynamics are the same law that governs both our human behavior and the natural phenomenon. It not only echoes an individual's decision but also reins in a group's aggregate behavior with its coefficients adequately adjusted based on the nature of the group's economic system. Human history falls prey to the interaction of the market and morals. Chinese history of economic thought is fraught with moral disciplines while modern Western history emphasizes and treasures more on the market mechanism. Either moral or market has its own strength and weakness and will earmark a distinctive set of coefficients in qi's partial differential equation. How these coefficients are derived or adjusted from different settings of the economic system is worthy of our further study.

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APPENDIX 1: Consideration of Entropy and Learning Effect

According to thermodynamics, a measure of the disorder called the entropy, denoted S, is written as

S = -k sum\_{j=1}^M P\_j ln P\_j

where k is Boltzmann's constant and P\_j is the probability of a particle j that would appear in an isolated container with M particles. This P\_j is like the concentration measure (i.e., C\_j) in our model^3. Assume that we focus on the movement of a specific element j which is caused by an external force like consumption of good or service. Then the remaining M-1 elements can be kept intact. Then taking the differentiation of S yields

dS = -k(1 + ln C\_j)dC\_j

According to the fundamental definition of temperature^4, T, we have the following relationship among entropy (S), energy (E), and temperature (T) as

T = (dS/dE)^-1

If we bring a small system A into thermal contact with a big system B in equilibrium at temperature T, then B will stay in equilibrium at the same temperature (a is too small to affect it), but a will come to a new equilibrium, which minimizes the quantity F = E - TS. The quantity F is called Helmholtz free energy of the subsystem. The minimum is the point where F is stationary when delta F = 0, which implies T \* delta S = delta E as the one for the definition of T. When a subsystem is in a state of greater than minimum free energy, it can do work on an external load. The maximum possible work we can extract is F - F\_min. From the above equations, we can obtain another source of change in qi as

dC/dt = -1/(k(1+ln C)) \* dS/dt = -1/(Tk(1+ln C)) \* dE/dt (A1)

As we accumulate more energy (or economic wealth) E, it will create a self-depreciation force that gradually drains the concentration of our "qi" according to the second law of thermodynamics.

In 1949, Donald Hebb conjectured that if input from neuron A often contributes to the firing of neuron B, then the synapse from A to B should be strengthened. Hebb suggested that such synaptic modification could produce neuronal assemblies that reflect the relationships experienced during training. The Hebb rule forms the basis of much of the research done on the role of synaptic plasticity in learning and memory. For example, consider applying this rule to neurons that fire together during training due to an association between a stimulus and a response. These neurons would develop strong interconnections, and subsequent activation of some of them by the stimulus could produce the synaptic drive needed to activate the remaining neurons and generate the associated response.

Consider a single postsynaptic neuron driven by N\_u presynaptic inputs with activities represented by u\_b for b = 1, 2, ..., N\_u, then the dynamics of postsynaptic activity v can be described according to the Hebb learning rule as

gamma \* dv/dt = -v + sum\_{b=1}^{N\_u} w\_b \* u\_b

where gamma is a time constant that controls the firing-rate response dynamics and w\_b is the synaptic weight that describes the strength of the synapse from presynaptic neuron b to the postsynaptic neuron.

^3 For simplicity we normalized the concentration C to be some value less than one in the discussion below.

^4 The temperature T can be interpreted as the degree of enthusiasm toward the object entering into the qi system.

In this study, we adopt and modify the concept of the Hebb rule to include all the relevant inputs in our memory that affect the reaction of our qi toward the specific activity  $u_b$  with  $w_b$  capturing the strength of that memory impact on qi. This learning impact from various memory sources provides the theoretical argument for how culture affects one's decision. Accordingly, we have an additional source of thrust on the qi movement from this learning effect as

$$\frac{dC}{dt} = -C + \sum_b w_b u_b \tag{A2}$$

Combining equations (5), (6), (A1), and (A2), we can obtain the complete equation for the dynamics of qi as:

$$\frac{\partial C}{\partial t} = D \frac{\partial^2 C}{\partial x^2} + \lambda Y \frac{\partial C}{\partial x} - \frac{1}{Tk(1 + \ln C)} \frac{dE}{dt} - C + \sum_b w_b u_b \tag{A3}$$

## APPENDIX 2: Human Spirit and Chinese Qi

The quantum life described according to the recent development of quantum biology can be reinterpreted by the Chinese "qi." The Righteous Qi poem written by Wen Tien-Shang, the Chinese scholar in Sung dynasty, once described the "righteous (or divine) qi" that permeates everywhere in the world in the following way<sup>5</sup>

*As for the essence of all things, it is this that is life.  
Below it generates the five grains;  
Above it becomes the arrayed stars.  
When it floats between Heaven and Earth, we call it ghosts and spirits;  
When it is stored within a person's chest, we call that person a sage.*

The notion of divine energies was hardly an unusual one in antiquity. It was a pan-Eurasian concept: in India, there was the notion of prana, or "breath," and in Greece, there was pneuma, or "breath of life," "soul," "spirit." All described a sense that some ineffable, unseen life force coursed throughout the cosmos and was responsible for the origins of life itself. Today many people would be skeptical that feelings of vitality come from divine energies. But the Chinese "qi" is a useful metaphor for what it would take to make us feel more alive.

Although qi exists in everything, there are infinite gradations of it. Rocks, mud, earth, and other inanimate parts of the cosmos are composed of a low and coarse qi—what we might call turbid qi. As qi becomes more highly refined, it becomes "vital essence" What sets vital essence apart from all else is that it exists only within things that have life. It is a life-giving force found in plants and animals. And finally, when qi is at its most ethereal and refined, it becomes divine qi. This sort of qi is so highly energized that it actually affects things around it. This qi is spirit itself. Spirit goes beyond a life-giving force; it gives living beings consciousness.

To hold the spirit within and not allow things to disorder our senses, we need to find an underlying Tao (道) in which everything is connected. The more these discrete things of the world interact with one another, resonating with one another, the closer they get to the Tao. These dynamics of qi reflect the interaction of Chinese Yin and Yang (Ritsema, 2005). We get closer to the Tao and increase our feelings of vitality when we cultivate the ability to remain balanced. The more stable we are, the more able we are to refine and hold on to the fresh qi.

We believe that we have created the first quantitative model to demonstrate the power of the Chinese qi. Chinese culture believes that qi is omnipresent and reflected into kaleidoscopic shapes of things and beings in the universe (天地有正氣, 雜然付流形). Equation (13) demonstrates the flexibility of our model, which is applicable not only in the micro-context to a human being but also is expandable in the macro-context to any artificial entity.

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<sup>5</sup>See the translation of the poem and the illustration of "qi" by Puett and Gross-Loh (2016).



# ECONOPHYSICS AND ECONOLINGUISTICS: A CONCEPTUAL ANALYSIS

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## *Abstract*

*This study aspires to discuss the capability of the economics study through its relevance with two distinguished subjects: physics, a branch of pure science concerned with the structure of matter and the interactions of the universe's fundamental elements, and linguistics – a social science study of the structure and formation of human language that applies to all aspects of human activity. This paper will cover the origin and nature of the two neologisms, the institutionalization of the terms by lexicography and publication trend in Google Scholar, the scope of the studies concerned as well as future potentials and challenges of the two interdisciplinary studies. The applications of econophysics covered in this paper based on previous research include valuation of stock options, exchange rate and economic performance due to COVID-19 pandemic. Econolinguistics includes labor market, game theory and the linguistic landscape in conjunction with the Tokyo Olympic 2020 event. The potentials of econolinguistics for future research and discovery and the challenges faced by econophysics regarding its role in economic analysis will also be discussed. This paper concludes with the hypothesis of econolinguistics and econophysics can be consolidated to perform a more comprehensive economic analysis, since the former delineates the microeconomic agents while the latter zooms out to explicate the macroeconomic events caused by those agents.*

Keywords: Econophysics, Econolinguistics, Institutionalization, Applications, Potentials, Challenges.

## **INTRODUCTION**

The study of economics has been at the forefront of academia besides other dominant human-related studies such as engineering, law and medicine. Economics assists society in deciding and formulating the best methods to allocate its finite and scarce resources. Economics offers us the mechanisms and analytical methods we need to maximize the use of existing resources while minimizing waste. Macroeconomics – a sub-field that analyses how a whole economy such as the market or other large-scale systems functions, and also microeconomics which focuses on individuals' and corporates' decisions on the

allocation of scarce resources as well as the interactions between them make it all the more reason to make economics as the haven of multidisciplinary. On that occasion, it is inevitably entangled with other relevant studies which conveniently fits in any size of research in question such as political economy, socioeconomics and behavioral economics. Nonetheless, there are other disciplines in which Economics still find limited compatibility and relation such as those in the pure sciences (biology, chemistry etc.) and other social sciences like archeology. Despite that, academicians and researchers attempted to connect economics with seemingly unrelated two scopes of studies before the turn of a new millennium in mid-1990s: physics and linguistics. The connection and nature of these interdisciplinary studies will be covered henceforth.

## **TERMINOLOGICAL OVERVIEW**

Before we delve into the origins of econophysics and econolinguistics, it is worth pondering upon the convention of the relations among different disciplines. Săvoiu and Simăn (2013) eloquently define multidisciplinary, interdisciplinary and transdisciplinary studies:

Multidisciplinary suggests distinct disciplines in discussion, as with an economist and a physicist talking to each other. Interdisciplinary suggests a narrow specialty created out of elements of each separate discipline, such as a “water economist” who knows some hydrology and economics. However, transdisciplinary suggests a deeper synthesis of approaches and ideas from the disciplines involved, and this is the term favored by the ecological economists for what they are trying to develop.

Based on this definition, we can start evaluating the nature of econophysics and econolinguistics through the opinions of various scholars regarding this matter.

The origin of the term econophysics is agreed among scholars that it was postulated by Eugene Stanley at a Kolkata conference held in 1995 to refer to the huge number of articles produced by physicists on stock and other market issues. The term was later established in written work via *Physica A* proceeding publication the following year. Even after 25 years, the term is still a novel one, and it refers to physicists' work in which financial and economic processes are considered as intricate mechanisms. The word econophysics is blandly explained as “nothing more than a combination of the words economics and physics” (Săvoiu & Simăn, 2013). On that account, the nature of econophysics is seen by a majority of academicians as an interdisciplinary study. Some scholars such as Yakovenko (2009) describes it as “an interdisciplinary research field applying methods of statistical physics to problems in economics and finance”. Even Organization for Economic Cooperation and Development (OECD) – an international organization consisting of 37 nation members that promotes policy coordination and economic freedom among developed nations – defines econophysics as “an interdisciplinary



research field, applying theories and methods originally developed by physicists in order to solve problems in economics, usually those including uncertainty or stochastic processes and nonlinear dynamics.” However, there were several attempts by researchers and scientists alike to upgrade or rebrand the current label of econophysics, such as Schinckus and Jovanovic (2013) already considering econophysics as a multidisciplinary study. They aspired to claim that econophysics can be further integrated towards being a transdisciplinary one by rethinking economics' theoretical basis as well as building entirely new models and theories more adapted to the management of financial risks and markets. However, based on the scholars' arguments, this idea is subject to the probable development of econophysics in the future. Thus, I may conclude this by giving a simpler definition of econophysics: an interdisciplinary field utilizing theories in physics to address economic phenomena via empirical analysis.

As for econolinguistics, although there is no apparent work documenting the history of this term, I believe this term had its debut in the same year as that of econophysics – 1996. The term econolinguistics appeared in the paper compilation book “Towards a Social Science of Language: Papers in honor of William Labov. Volume 1: Variation and change in language and society” with one of the articles entitled “Dimensions of A Theory of Econolinguistics” by John Baugh from Stanford University. He posited two arguments that he claimed were “neglected language universals”:

- 1) Linguistic behaviors including speech and literacy are economic commodities; the (in)ability to employ language(s) has a direct impact on personal economic prospects; and
- 2) language development and literacy are substantially determined by socioeconomic circumstances. In other words, this is similar to the sociology of language which highlights the impact of language on society.

Fumio Inoue's *Nihongo wa ikinokoreru ka: Keizai gengo-gaku no shiten kara* (Can Japanese language Survive? From an Econolinguistic Perspective) in 2001 also discussed similar topics regarding the appeal of Japanese language in economic activity. Holding on to the aforementioned premise and the discussion on econophysics, we can assume that econolinguistics is also an interdisciplinary study. Thus, I can conclude this with a simpler definition of econolinguistics: an interdisciplinary field implementing linguistic components to explain socioeconomic issues.

## INSTITUTIONALIZATION OF ECONOPHYSICS AND ECONOLINGUISTICS

### *Econophysics*

This bridging between economics and physics has been nominated with multiple names. Some describe this bridging as a portmanteau of physics and finance – phynance (Kakushadze, 2015). Although this might be equivocal since economics and finance are two different fields, the roles and approaches of phynance as described by researchers are same as how econophysics would be operated. Others merely put it as financial physics (Jovanovic & Gall, 2001). Few researchers instead insist on using the term sociophysics due to association of human behaviors in a sociological perspective as atoms, thus influencing socio-political phenomena and large-scale systems such as the global economy (Galam, 2012). Econophysicists have used a variety of tactics to share their knowledge to acquire presence in academia for their field of study. To encourage scientific acknowledgment and establishment of this new term, physics departments have hosted symposia, published many specialist publications, and developed particular courses as well as joint-collaborations with Economics faculty.

Although several attempts have been made to rename this bridging between these two disciplines, The New Palgrave Dictionary of Economics 2nd Edition includes the term ‘econophysics’ as an entry, defining “economy as a complex system; econophysics; realized volatility”. This certainly creates a strong foundation in making econophysics as an official term, further stimulating researchers to be proponents of this field.

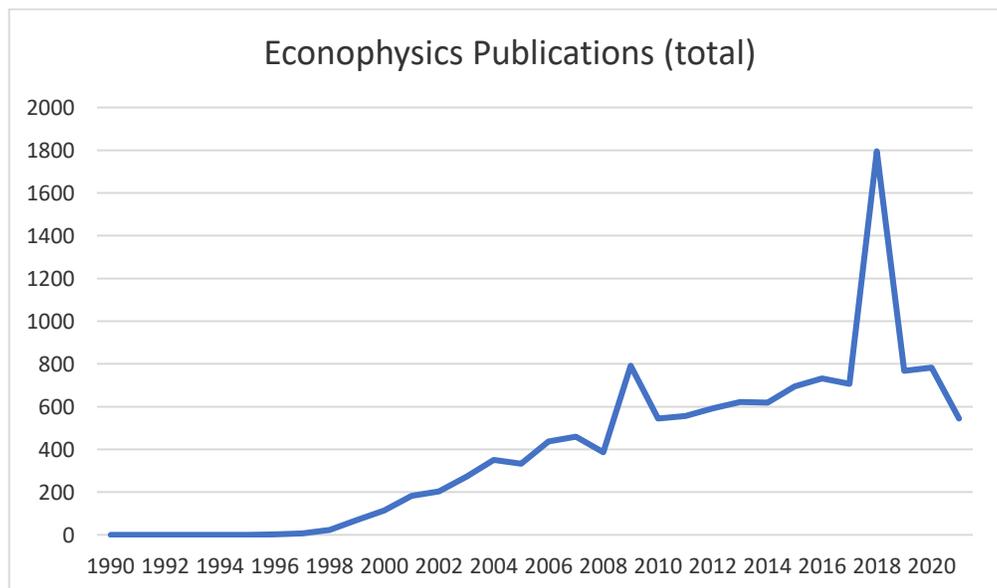


FIG. 1. GOOGLE SCHOLAR TREND FOR ECONOPHYSICS

Based on Figure 1, the trend seems to steadily increase since the debut of econophysics in 1996 with the initial publications totaling only 3 about it at the moment. Since then, the



popularity of econophysics among zealous researchers continues to bloom at a steady rate, with the exception of skyrocketing change in 2009 (785 publications) and 2018, in which the year 2018 hoards the largest amount of publications under this topic with 1,792 publications. These publications amount to 12,348 documents overall. Econophysics is not extracted to have its own journal; the physicists include this discipline among the prominent journals in Physics such as *Physica A* and *European Journal of Physics B*, according to Jovanovic and Schinckus (2012).

There are reasons for the two spikes in publication of econophysics-related articles. 2009 was the post-financial crisis of 2007-2008, also called as subprime mortgage crisis yet still during the Great Recession from 2007-2009. The financial crisis was “a severe contraction of liquidity in global financial markets that originated in the United States as a result of the collapse of the U.S. housing market. It threatened to destroy the international financial system...” (Duignan, 2019). Therefore, Professor Dirk Helbing of Switzerland's ETH Zurich along with his colleagues James Breiding and Markus Christen claim – along with other prominent econophysicists – that markets are capricious, inefficient, but self-regulating by nature as they tend to deviate from the market equilibrium. Their theories, which are based on years of experience in understanding the complex dynamics of a variety of physical systems, explain extreme occurrences like financial crises as occurring naturally as a result of interactions and feedbacks between market players (ETH Zürich, 2010).

2018 is marked by some scientists as the start of a ‘scientific revolution’ (Jakimowicz, 2018), with a majority of researches detailed the deeper integration of data science and economics via techniques commonly used in physics. In econophysics, methodological disagreements prompted physicists to admit that dealing with financial complex systems helped to a broader modelling of their discipline. The methods used by econophysicists implies that physicists may try to understand physical processes by combining aspects from financial economics and economics in general (Jovanovic et. al, 2019). Meanwhile, Colander (2018) also opined the notion of a ‘complexity revolution’, a revolution that encourages envisioning of the economy as a complex dynamic system influenced by the frequently unforeseen effects of intentional agents' activities. Hence, 2018 might not be a significant year due to global incidents, rather it is a breakthrough moment for both economists and physicists to rethink their ideas on econophysics all this time.

### *Econolinguistics*

Meanwhile, theoretical linguistics has attempted to claim its rightful place in the field by

setting the boundary of how language should be perceived and studied. However, the emergence of multiple prefixed linguistics disciplines to accommodate various sub-branches of applied linguistics such as neuro-, psycho-, and sociolinguistics is inevitable, thus showing the pivotal role of language in human life. As for econolinguistics, on the other hand, there has never been a consensus regarding the exact term or phrase to describe the relationship between the two disciplines. Linguists and economists try to find a common ground based on the roles languages play in daily life, culminating in different phrases to connect their respective disciplines such as the language economy (Marazzi, 2011) or even its obverse like the economics of language (Marschak, 1965) (Chiswick & Miller, 2007). A few of them use economic linguistics (Zabarskaitė, 2017) albeit this is the least popular among all aforementioned terms. Coulmas (2009) however took a bold remark regarding the term, saying that unlike the other established areas previously stated, econolinguistics is not a recognized subdiscipline of the language sciences, nor is there a cohesive body of knowledge that qualifies it as "economics of language," with its own journals and academic societies, as the sociology of language does.

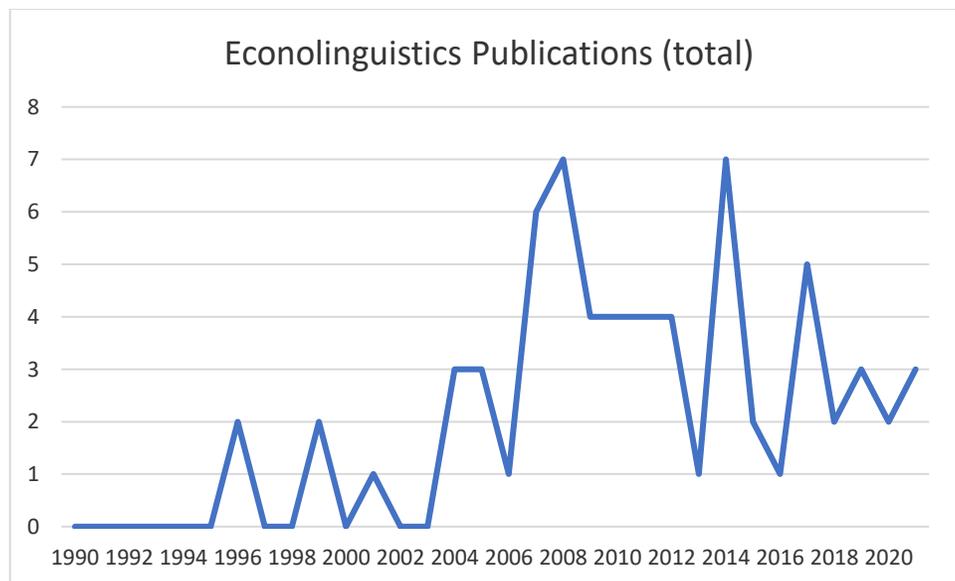


FIG. 2. GOOGLE SCHOLAR TREND FOR ECONOLINGUISTICS

Based on Figure 2, it is clear that Coulmas's opinion on the term holds since the maximum amount of publications ever released in any particular year is only 7 (which occurs only twice since its debut). Yet, the term remains afloat in scholars' radar starting in 2004 despite being undeniably exiguous among the myriads of publications released every annually. Thus, for the sake of explaining this bridging between economics and linguistics, we will discuss the scope of study based on the previous researches under any aforementioned phrase, with those under econolinguistics would be prioritized.



Furthermore, this paper aims to justify several reasons why econolinguistics seems to be so underrated and its potential in the later section to fill in the literature gap in the academia about this interdisciplinary study.

## **APPLICATION**

### *Econophysics*

The goal of econophysics is to explain and actualize models of a market's universal behaviours as an open system, where more external information is combined with new investments, similar to energy/particle inputs in quantum physics (Jimenez & Moya, 2005). Recapping the definition of econophysics in New Palgrave Dictionary of Economics stating it as “economy as a complex system; econophysics; realized volatility”. Unsurprisingly, one of the most prominent branches of physics related to econophysics is quantum mechanics. Many other physical phenomena, such as turbulence theory, scaling, random matrix theory, and the renormalization group, have been integrated and applied to the economy, boosting modern computational approaches in data analysis, risk management, artificial markets, and macroeconomics (Burda et al., 2003). Most econophysics approaches to date have focused on economic processes with a large number of components, such as financial or banking markets, stock markets, incomes, production or product sales, and individual incomes, which are primarily studied using statistical physics methods (Săvoiu & Simăn, 2013). We can see that econophysics has established its grounds on making significant contribution to the economics discipline overall. 3 applications of econophysics will be discussed in this paper: option price, exchange rate and COVID-19's impact on the economy.

### *Valuation of Stock Options (Quantum Physics)*

The Black-Scholes-Merton model, frequently known as the Black-Scholes model, is a mathematical model of financial derivative markets that may be used to derive the Black-Scholes formula. This formula calculates the call and put option pricing. It was the first commonly used mathematical method for pricing options, and it was first used to price European options. Some credit this approach with causing a large rise in options trading, as well as having a big impact on contemporary financial pricing. Options traders did not all utilize a consistent mathematical method to value options prior to the development of this formula and model, and empirical research has demonstrated that price estimates generated by this formula are near to observed values.

Fischer Black and Myron Scholes came up with a partial differential equation known as

the Black-Scholes equation in their original formulation of the model. Then, using stochastic calculus, Robert Merton published a mathematical explanation of their model, which helped to develop the Black-Scholes-Merton formula:

$$\frac{\partial V}{\partial t} + \frac{1}{2}\sigma^2 S^2 \frac{\partial^2 V}{\partial S^2} + rS \frac{\partial V}{\partial S} - rV = 0$$

in which,

$\sigma$  is the volatility or arbitrariness of the asset;

$S$  is the stock price;

$V$  is the value of the option;

$t$  is time; and

$r$  is the risk-free interest rate.

Using log-normal distribution probabilities to account for volatility in the underlying asset, their approach calculates the price of an option by subtracting the return an investor receives from the amount that the investor must pay. The model's log-normal distribution of returns is based on Brownian motion theories, with asset values behaving similarly to the biological movement in Brownian motion. The formula of a call option:

$$C = S_0 e^{-qT} N(d_1) - K e^{-rT} N(d_2)$$

In which,

$S_0$  is the stock price;

$e$  is the exponent;

$q$  is the dividend yield percentage;

$T$  is the term (one year equating to twelve months is  $T=1$ );

$K$  is the strike price;

$N(d_1)$  is the delta of the call option, meaning the difference in the call price over the stock price shift; and

$N(d_2)$  is the probability that the future stock price will be higher than the strike price, thus increasing chances that the option will be bought.

The stock price is multiplied by cumulative standard normal distribution of  $d_1$  on one side, while the strike price is discounted to time  $T$  and then multiplied by cumulative standard normal distribution of  $d_2$  on the other. We can calculate the  $d_1$  and  $d_2$  via these formulae:



$$d_1 = \frac{\ln \frac{S_0}{K} + \left(r - q + \frac{\sigma^2}{2}\right)t}{\sigma\sqrt{t}}$$
$$d_2 = d_1 - \sigma\sqrt{t}$$

The formula of a put option:

$$P = Ke^{-rt}N(-d_2) - S_0e^{-qT}N(-d_1)$$

There are several weaknesses to this pioneering approach. Firstly, it is limited to the European market: As previously stated, the Black-Scholes model accurately predicts European option pricing. For the rest of the world, it does not properly value stock options. It's because it believes that options can only be exercised when they reach their expiration/maturity date. The second one is that this model assumes constant interest rates, although this is seldom the case. The third one is that Black-Scholes model is conditioned in a frictionless market or simply explained as with no transaction costs. In the trading market, this is hardly the case because transaction expenses, such as brokerage fees and commissions, are common in trading. The fourth one is Black-Scholes model implies that the stock options have no returns. In the real trading market, however, this is not the case. The returns are the primary consideration when purchasing and selling options. Despite these drawbacks, the Black-Scholes model provides the perfect foundation for further improvement in financial economics and macroeconomics.

Since the 1950s, when mathematicians first became interested in stock market price modelling, many writers have studied the issue of price distribution. The initial concept of Gaussian distributed price movements was quickly superseded with a log-normal distributed stock price model. (Mantegna & Stanley, 2000). To put it another way, stock prices follow a geometric Brownian motion. The discrepancies in the logarithms of prices are Gaussian-distributed in a geometric Brownian motion with Itô stochastic calculus to explain the phenomenon. As a result, this is a crucial turning point of econophysics coming into play.

According to Segal and Segal (1997), quantum effects may be easily integrated into Black-Scholes model analysis by adding a separate process  $X(t)$  to the Wiener process  $W(t)$  that represents the development of public information influencing the market ( $t$ ).  $X(t)$  may be a Brownian motion in and of itself, but the combination of  $W(t)$  and  $X(t)$  cannot be described as a two-dimensional Brownian motion process. They concluded that the quantum extension of the Black-Scholes theory offers a logical, scientifically sound, and testable model for explaining market events with larger extreme deviations than classical

theory would predict. Another scientist reviewed this that in order to include market characteristics such as the difficulty of simultaneous measurement of prices and their immediate derivatives, Segal and Segal incorporated quantum effects into the Black-Scholes model. They did so by adding a process  $Y_t$  to the Brownian motion  $B_t$ , which reflects the impact of variables not concurrently quantifiable with those engaged in  $B_t$ , to illustrate the development of public knowledge influencing the market (Accardi & Boukas, 2007). While this one suggested an enhanced Black-Scholes model, other scientists ventured an entirely new model by connecting Black-Scholes equation with that of Schrödinger, thrusting Black-Scholes model into the core of quantum physics (Contreras et.al, 2010)<sup>27</sup>. They proposed a Black-Scholes-Schrödinger model based on the cross-interpretation of Black-Scholes equation from the point of view of quantum mechanics, as the imaginary time Schrödinger equation of a free particle. The econophysicists already considered market imperfection factors – short-term volatility, severe disruptions, transaction cost, asymmetric information, serial correlations, flaws in the production systems such as monopoly – that would null the assumption of Black-Scholes model regarding non-arbitrage which indirectly suggested risk-free portfolio. As a result, they developed a more general quantum model of option pricing that includes arbitrage as an external time-dependent force with a potential linked to the random dynamics of the underlying asset price. This novel model may be thought of as a Schrödinger equation in imaginary time for a particle of mass  $1/\sigma^2$  with a wave function in an arbitrage potential-generated external field force. As previously stated, this new model may be seen as a broader formulation, with the Black-Scholes model's perfect market equilibrium state serving as an example. Then they utilized semiclassical techniques - which are popular in theoretical physics – to obtain an approximate analytical solution to the Black-Scholes equation in the presence of market defects, such as an arbitrage bubble. Revisiting the Black-Scholes equation utilizing partial differential equation:

$$\frac{\partial V}{\partial t} + \frac{1}{2}\sigma^2 S^2 \frac{\partial^2 V}{\partial S^2} + rS \frac{\partial V}{\partial S} - rV = 0$$

we can compare that the Schrödinger equation uses a similar mathematical technique:

$$H(t)|\Psi(t)\rangle = i\hbar \frac{\partial}{\partial t} |\Psi(t)\rangle$$

$$H\Psi = E\Psi$$

in which,

H is Hamiltonian operator.

$\partial$  is the partial derivative with respect to time, t;

$\Psi(t)$  is Schrödinger wave function;



i is the imaginary number,  $\sqrt{-1}$  ;

$\hbar$  is Planck's constant,  $6.62607015 \times 10^{-34}$  JHz<sup>-1</sup> divided by  $2\pi \approx 1.054571726$  Js;

E is energy; and

H is Hamiltonian operator.

Vukovic (2015) supported the idea of a Black-Scholes-Schrödinger model and proved that the two equations could indeed be integrated, forming a new equation for option pricing:

$$\frac{\partial C(t, x)}{\partial t} = -\frac{1}{2}\sigma^2(S)S^2 \frac{\partial^2 C(t, x)}{\partial S^2} - rS \frac{\partial C(t, x)}{\partial S} + rC(t, x)$$

in which

C is the option price;

$\partial^2(x)$  is an arbitrary function of x; and

S is a variable of choice in most literature in finance.

The researcher stated that his finding confirmed the capability of quantum physics in observing the options price mechanism whereas Contreras et.al. (2010) mentioned that this is the fundamental of quantum social science.

**Exchange Rate (Chaos Theory)**

Statistical physics is being used by an increasing number of finance researchers to investigate the dynamical and statistical characteristics of financial data, such as time series of stock prices, exchange rates, and the growth of companies (Fan et al., 2008). In addition, a growing number of physicists from the fields of statistical physics and complexity are turning to finance as a study topic. Econophysics is mostly made up of physico-mathematical models that relate to markets. The notion of self-similarity has been expanded to read out functions that emerge as time series from economic systems, with the exchange rate being one of the most accessible parameters (Drożdż et al., 2007). Consequently, Scarlat et al., (2007) simulated a time-series analysis on the exchange rate between Romanian Leu and the US Dollar (ROL-USD) as well as considering four external factors that – according to them – would affect the performance of the exchange rate: economic reactions, the political situation, and the environmental psychology driving economic behavior; as a fourth factor, they used the closure condition which represents both the mathematical condition of probability normalization and long run economic equilibrium. There are two intriguing features in their analysis and one of them is the fact they synthesized the “Generalized Devil Staircase” (GDSC) method into their

research. The other one being the usage of Hurst Exponent and the Lyapunov Exponent. Devil's Staircase, also known as the Cantor Function, was based on the extensions of the Fundamental Theorem of Calculus to the case of discontinuous functions by Georg Cantor in the 19th century (Dovgosheya et.al, 2006). It is an infamous counterexample in mathematics because it contradicts innocuous intuitions about continuity, differentiation, and calculation. It is also thought to portray the pattern of earthquakes happening worldwide "where clusters of earthquake events are separated by long but irregular intervals of seismic quiet" (Seismological Society of America, 2008). That being the case, assuming the basic assumptions and theories about quantum physics were included in the performance of the exchange rate, the researchers attempted to interpret exchange rate movement with that of a bizarre idea explaining the pattern of a seismological phenomenon.

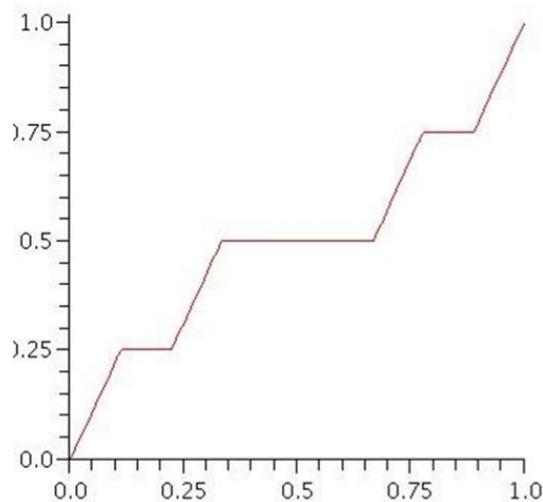


FIG. 3. THE DEVIL'S STAIRCASE (Kemp, 2015)

This concept needs a revisit of the basic understanding of basic calculus. In broad terms, a function is said to be continuous if it has no abrupt transitions. Continuous functions exhibit many desirable characteristics, including the central limit theorem. The derivative of a function at a particular point in its domain, if it exists, quantifies the function's rate of change at that point. If the x-axis represents time and the y-axis represents an object's location along a one-dimensional track, the derivative may be thought of as the object's velocity. If a function is differentiable at a point, it must be continuous at that point but vice versa is not always possible. For an instance, if a function's graph has a sharp corner at a point, the function cannot be differentiable at that point.

Consider what it means for a function to have a derivative of 0 at a certain point. This indicates that the function's rate of change has ceased to exist at that moment. That is, if we zoom in close enough to that point, the function should resemble a constant function.



It should have a graph that resembles a horizontal line. If a function is to always have a derivative nearing the zero value ubiquitously throughout the whole graph, one could assume that this implies that the function is constant. At nearly any point in its domain, its function's rate of change is zero. Thus, the viable way to understand this obnoxious concept is via iterative construction from (0,0) to (1,1) and some clarified that as n goes to infinity, the sequence of functions  $\langle f_n \mid n \in \mathbb{N} \rangle$  would eventually converge uniformly to a single function (Hanson, 2018).

The second interesting concept is the usage of Hurst Exponent and the Lyapunov Exponent, two statistical methods related to time-series analysis which are pivotal in the explanation of the chaos theory covering both statistical mechanics and pure mathematics disciplines. There are two antithetical ideas that deterministic chaos attempt to connect: unpredictability of the particles' and molecules' trajectories, and predictable motions of the celestial bodies, pendulum and the sort (Britannica, 2021). As bizarre as it may be, Dostál (2002) mentioned that the chaos theory is among the theories being more competent at explaining complex events that include nonlinearity. These theories allow us to analyze the time series as complex social, psychological, economic, and financial occurrences unfold. These theories include Hurst and Lyapunov exponents. The Hurst exponent allows us to define the chaotic degree and fractal dimension of time series. The Lyapunov exponent would gauge the prediction's power, whereas its inverted value indicates predictability.

Hurst exponent:

$$H(\tau) = \frac{\log \left( \frac{R(\tau)}{S(\tau) * c} \right)}{\log (\tau)}$$

in which

R is range;

S is the standard deviation

c is the constant; and

$\tau$  is the lag(s).

If the value of H is 0.5, it indicates a random walk process or normally distributed. If the value of  $H > 0.5$ , then it indicates a consistent or trend enhancing time-series. If otherwise ( $H < 0.5$ ), this shows anti-persistent or mean switching over time. Hurst exponent may be utilized in investing methods based on trend trading. An investor would seek companies

that have a high degree of persistence. These equities would have a H-value  $\geq 0.5$ . A H-value  $< 0.5$  may be used in conjunction with technical indicators to identify price rollbacks.

Lyapunov exponent:

$$\lambda = \lim_{n \rightarrow \infty} \frac{1}{n} + \sum_{i=1}^n \ln \left( \frac{\Delta R_i}{\Delta R_0} \right)$$

In which

$\lambda$  is the Lyapunov exponent; and

$\Delta R_0$  is the average logarithmic rate of separation or convergence of two nearby points of two time-series  $X_t$  and  $Y_t$  separated by an initial distance,  $\Delta R_0 = \|X_0 - Y_0\|$  (Rüdisüli et al., 2013)

Elert (2016) discussed the 3 conditions if the value of  $\lambda$  is as below:

- 1)  $\lambda < 0$ : Attraction occurs as the orbit approaches a stable fixed point or stable periodic orbit. Lyapunov exponents that are negative are indicative of dissipative or non-conservative systems (the damped harmonic oscillator for instance). These systems show asymptotic stability; the smaller the exponent, the more stable the system. The Lyapunov exponent of superstable fixed points and superstable periodic points is equal to  $\lambda = -\infty$ . This is similar to a severely damped oscillator in that the system accelerates toward its equilibrium point.
- 2)  $\lambda = 0$ : The orbit is a fixed location in space. A zero Lyapunov exponent implies that the system is in a stable state. With this exponent, a physical system is conservative. These systems are Lyapunov stable. Consider two identical simple harmonic oscillators with amplitudes that vary. Because frequency is independent of amplitude, the two oscillators' phase portrait would be a couple of concentric circles. The orbits would maintain a constant spacing in this case, similar to two specks of dust held in place on a spinning record.
- 3)  $\lambda > 0$ : The orbit is inherently insecure and erratic. Nearby points, regardless of their proximity, will diverge to any arbitrarily separated point. At some point, all regions inside the phase space will be visited. These are referred to as unstable spots. The orbits of a discrete system will resemble snow on a television set. This does not prevent any organization from emerging as a pattern. This phase space of a continuous system would resemble a tangled sea of wavy lines, similar to a pot of spaghetti. Brownian motion is a physical example. Although the system is predictable, the orbit that results is chaotic.

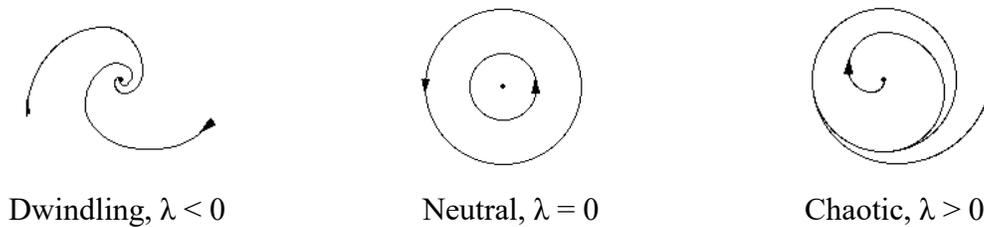


FIG. 4. FIDUCIAL ORBITS WITH DIFFERENT  $\lambda$  VALUES (Elert, 2016)

Lyapunov exponent is used to analyze and estimate economic and financial time-series (Yalamova et al., 2007). Thus, relating to the capricious nature of the chaos theory and the unprecedented devil’s staircase, it is clear how deep the study of econophysics to explain the exchange rate mechanism.

*Economic Performance and the COVID-19 (Relativity)*

Some econophysics papers are centered towards mathematics-laden descriptions, such as implementing the engineering calculus of closed Stokes integrals to evaluate Japanese economy (Mimkes, 2017), using thermodynamics and statistical physics approaches to assess the distribution adjustment in the Eurozone economy (Stanciu et al., 2012), or employing bipartite graph theory to describe the competitive advantage due to the trade war between China and the United States (Xing et al., 2018). However, the COVID-19 pandemic has inspired researchers in all disciplines to find new perspectives in their study. Ruiz Estrada (2021) sought to explain the economic casualties caused by the ensuing pandemic with the aid of Einstein – the general theory of relativity and special theory of relativity which are related to space-time continuum, as well as his most famous equation to explain the conservation of mass-energy:

$$E = mc^2$$

in which,

E is the energy;

m is the mass; and

c is the constant for speed of light, exactly the value of 299 792 458 ms<sup>-1</sup>.

Ruiz Estrada (2021) attempted to use special theory of relativity to measure adequate economic energy to overcome the COVID-19 crisis via the aforementioned formula as the foundation for this purpose, ergo a modified equation was formed to fulfill its role as an instrument to measure economic damage caused by COVID-19:

$$\ddot{E}c = IJ^2$$

in which,

$\ddot{E}c$  is the economic energy against COVID-19;

I is the inflation rate due to COVID-19; and

J is the high employment absorption speed rate.

Ruiz Estrada (2021) explained that this formula can ignite 4 scenarios depending on the condition of the variables:

- 1) Low I, high  $J^2$ : constitute huge economic energy to surpass COVID-19 impact.
- 2) High I, low  $J^2$ : constitute tiny economic energy to surpass COVID-19 impact.
- 3) High I, high  $J^2$ : constitute tiny economic energy to surpass COVID-19 impact.
- 4) low I, low  $J^2$ : constitute tiny economic energy to surpass COVID-19 impact.

The modified version removed the constant in its equation due to the fact that economic occurrences are dissimilar to the physical phenomena in terms of measurement accuracy and predictability. J is squared to recognize the spillover effect that the employment absorption rate can bring upon the economy such as rise in consumption due to the wage that workers would spend after being recently employed. However, this fresh idea certainly needs further development and clarification, particularly regarding the three components needed to form J: the sum of all new part-time jobs, plus the sum of all new technological jobs, plus the sum of all new logistics jobs. While these specified scopes of data would likely be easier to attain in the United States, it would be almost impossible to trace them in other developing countries such as Malaysia in which some part-time employment would not be recorded into the system, unless otherwise done so by an enumerator via census or filling in online surveys by the government. Thus, I would like to suggest that the manipulated variable J be derived from more widely known or accessible data, such as employment-to-population ratio which would represent the employment absorption rate (Statistics South Africa, 2008) So, the equation might need to be adjusted to redefine J.

### *Econolinguistics*

While econophysics focuses on the results of the market, econolinguistics zooms in to the agents themselves – humans. This makes the languages of humans as the center of economic analyses with linguistic tools – ranging from dialectology, sociolinguistics, language register etc. After all, foreign language education is enhanced by economic activity (Inoue, 2007), and this leads to several language rising in prominence on the global stage besides English (Crystal, 1997) such as German, Spanish, Arabic, Mandarin



and Japanese. As Chiswick (2008) mentioned, “most of the research in the economics of language focuses on what can be described as microeconomics, that is, the behavior of individuals.”. We are going to analyze 3 perspectives that are related to econolinguistics: labor market, game theory and the Tokyo Olympics 2020.

### *Labor Market (Sociolinguistics)*

Labor market consists of two aspects: ethnicity and bilingualism/multilingualism. The former is the main discussion of academicians whereas the latter one is commonly promoted by the benefits of bilingualism or multilingualism in the labor force by popular media and publications.

For the first aspect, individual earning is said to be corresponding directly to their literacy and even accents. The first generation of research in econolinguistics examined language as an ethnic feature. A person's mother tongue assigns him or her to a specific group, which may have an impact on the person's socioeconomic position and wages. Such researches included Dustmann and Fabbri (2003) by using two recent UK survey data of non-white immigrant employees, to examine the factors of language competence and the impact of language on non-white immigrants' wages and job prospects. Additionally, they addressed the issue of endogenous language learning and measurement error in language variables, which may bias or inaccuracies the study. Their findings indicate that language learning, job prospects, and wages vary significantly among non-white immigrants based on their ethnic background. Their research concluded that language competence increases job prospects, whereas a lack of English proficiency results in earnings losses. This claim is further strengthened by Saarela and Finnäs (2004) when discussing the role of two competing native languages of workers in Helsinki – Swedish and Finnish – in the income received. The study indicated that on average, Swedish-speaking men earn 17% more than Finnish-speaking males. Two-thirds of this pay disparity may be ascribed to variations in attributes, most notably education and age. The pay disparity among females of different mother tongues in this case was almost negligible. The results corroborate prior research in that they highlight the Swedish-speaking minority's favorable labor market performance in Finland and the fact that disparities across language groups are greater among men than females. But they mentioned that this research did not rule out the possibility of whether social integration would enhance wage discrimination or otherwise. While some of the research indeed postulated language as a major factor in the income inequality, a few papers refuted such claim as in a study by Cattaneo & Winkelmann (2003) which concluded that the

difference of earnings between equally qualified natives and non-natives living in the German and French linguistic regions of Switzerland have the same earning regardless of their native language, suggesting labor integration in the Swiss economic landscape. Therefore, we can conclude that the accents and literacy of a local language by non-native speakers can indeed their wage rate, subject to the social integration in a particular environment.

Whereas the first aspect relied on certain congenital factors such as accents and ethnicity, the second aspect – bilingualism/multilingualism – is widely endorsed by both academicians and laymen as an unequivocal asset to those seeking employment. A report released in March 2017 by New American Economy pointed out that while businesses in the United States advertised about 240,000 jobs targeted at bilingual employees in 2010, that number has more than doubled to nearly 630,000 by 2015. The report further explained that in the same year, Bank of America advertised more than a third of their jobs as bilingual. Meanwhile, almost one in every four online job postings at health insurer Humana required similar abilities, including over 40% of the company's ads for registered nurses. The proportion of job posts seeking bilingual workers also rose, with the proportion of bilingual job advertisements online increasing by 15.7% during the same period. The 3 most sought-after foreign languages in the USA among the employers are Spanish, Arabic and Chinese. This claim is also supported by a more recent study by Liwiński (2019) on Polish speakers as he claimed that the majority of Polish speakers are at least bilingual. He argued that with advanced levels of the other global languages such as Spanish, French, Italian, German and English, they could yield a wage premium up to 32%, 22%, 15%, 12% and 11% respectively. Another research did not just reinforce the assumption that productivity would increase, consumption would also rise due to more choices of product from the comprehension of both languages, enabling wider reach to a large array of markets sometimes exclusively to speakers of a particular language. Toulemonde (2010) elucidated the two benefits gained by learning other languages: there is a demand for bilingual employees by businesses, which drives up bilingual workers' wages. Secondly, bilingualism enables the citizen to purchase products manufactured by monolingual businesses in the other community, increasing his/her consumer surplus.

Globalization, increased international commerce, foreign direct investment, and rapid labor mobility all contribute to an increase in demand for language skills, as both economists and linguists believe that this trend will continue in the future. With increased migration and internalization of businesses and agencies, command of foreign languages has become an essential competency in the global labor market.

### *Game Theory (Pragmatics)*

Game theory has enthralled academicians throughout the ages due to its complexity and



sophistication. It aims to comprehend the strategic activities of two or more "players" in a particular scenario with predefined rules and consequences. While game theory is used in a variety of fields, it is most often employed in the study of business and economics. Thus, the "games" may include how two rival companies will respond to one another's price reductions, whether a company would buy another, or how traders in a stock market will react to price changes. Theoretically, these games are related to prisoner's dilemmas, the centipede game, the hawk-and-dove game, and battle of the sexes, peace-war, Cournot competition and much more. Linguistics is of no exception related to this well-known concept.

One of the most popular examples is the Cournot competition. It is named after Augustin Cournot, a French mathematician who invented it in 1838. The Cournot model is most often used to describe a duopoly or two major firms in a market.

TABLE 1. COURNOT DUOPOLY

Cournot Payoff Matrix		Firm Z	
		Cooperate	Defect
Firm Y	Cooperate	(a) 5, 5	(b) 0, 9
	Defect	(c) 9, 0	(d) 1, 1

Note: Figures are in hundred millions of Yen, JP¥

This theory regarding decision-making makes it a viable foundation for a situation representing rapid exchanges of arguments and counterarguments in order for one to prevail in a particular discussion or persuasion. This particular situation is also present in debates and negotiations, and researchers attempted to explain the background of the decisions made by these players in those "games". In his classic work on conventions, Lewis (1969) proposed to study communication by means of so-called signaling games, games that are of immediate relevance for linguistics. Meanwhile, extensions of Lewisian signaling games have become very important in economics and (theoretical) biology. This presents communication as the basis of decision via diplomacy, argument and persuasion, and researchers mentioned that a speaker conveys more than just the conventional truth-conditional meaning of a statement in a normal conversational context. (Benz et.al, 2015). The truth-conditional meaning is enhanced by what is implied in conversation by the usage of a phrase. According to thre cooperative principle, in pragmatics, it is conventional to believe that this method of enhancing conventional meaning is feasible because we presume that speakers adhere to, which posits that speakers are rational cooperative language users. According to this perspective on language usage, the archetypal discourse scenario involves cooperative information

sharing. This cooperative principle is regarded as false by Iten (2000) that this debate-style and the rapid exchange between interlocutors cannot be regarded by cooperative, nor be explained by Anscombe-Ducort's (1983) Argumentation Theory (AT), rather it is best derived with Relevance Theory (RT). Some linguists also opined the necessity to relabel the classical assumption of game theory about rationality to bounded rationality. (Benz et al., 2015). As a result, Glazer and Rubinstein (2016) wrote a paper entitled *A Game Theoretic Approach to the Pragmatics of Debate: An Expository Note* in which they applied this economic technique to address the logic mechanism of debates in six points:

- 1) Debate is a mechanism for a decision-maker (the listener) to elicit information from two sides (the debaters). The correct choice, from the listener's perspective, is contingent upon the revelation of many pieces of information. Both debaters are completely aware of the pertinent facts, but the listener is not. The debaters have contrasting interests in the matter at hand. Throughout the discussion, participants make arguments to support their different views by presenting concrete facts regarding the reality of certain pieces of information. The listener reaches a conclusion based on these arguments.
- 2) The listener's judgement is based on what he infers from the arguments advanced throughout the discussion. The listener may draw conclusions beyond what is obvious from the facts included in the parties' hard evidence. The pragmatics of debate is a collection of principles that guides the audience in understanding the debaters' arguments in ways other than their literal meaning.
- 3) The listener's perception of the utterances and evidence is not a question of choice.
- 4) The two debaters regard the debate as a game for two players. The listener is not an active participant in the game. The actions in the game represent the possible arguments raised by the debaters. The result of the game reflects the debaters' shared knowledge of how their arguments would be interpreted by the listener.
- 5) The pragmatics of argument is regarded as though they were selected by an imaginary designer. The designer is aware that the rules he selects will dictate the game that the debaters will play, and thus that the listener's conclusion will be influenced indirectly by the rules he chooses. The designer's objective is to increase the likelihood that the listener would reach the same conclusion he would have reached had he known all of the debaters' facts.
- 6) The designer is limited by physical constraints such as the complexity of information processing, the duration of the debate, and the cost of presenting



strong proof.

Based on the six components, I believe that the researchers assume debate as a static “game” due to the phrases such as the listener reaches a conclusion on the basis of their arguments and also listeners are not considered to be aware of the facts exchanged by the debaters. Indicating that the debater/speaker would stay put with his decisions and opinions throughout the debate. It is obvious that any debate discourse is high-paced and thus subject to constant change of mind and opinions. Hence, I would recommend seeing debates as a dynamic game instead, in which several players can take upon several courses of action at once; another suggested additional premise is: both listeners’ and debaters’ views are subject to change over time and they are also viable to forming opinions amid the argument-counterargument exchanges at any point in time.

Game theory has both a prescriptive and descriptive component. It may instruct us on how to conduct optimally in a game, or it can be seen as a theory describing how agents really behave in a game. This applies to languages as well whether we realize it or not, all under different terms – whether it is adjudication, diplomacy, arbitration etc. - to describe a dynamic “game” going between two parties to emerge victoriously.

### *Tokyo Olympics 2020 (Corpus Linguistics)*

Corpus linguistics is the study of language via the analysis of huge collections of "real-world" language usage recorded in corpora - computerized databases developed specifically for linguistic research. Additionally, it is referred to as corpus-based research. Some linguists see corpus linguistics as a research technique or methodology, while others regard it as a distinct field or theory in its own right. According to Kübler and Zinsmeister (2015), the answer to whether corpus linguistics is a theory or a technology is simply that it may be both as it relies on the use of corpus linguistics.

This branch of linguistics is used to examine the upcoming Tokyo Olympic Games' language problems, presenting two kinds of data collected from an econolinguistic perspective. (Inoue, 2016). He explained that the data includes utilizing Google Search to track changes in language-related mentions associated with the Olympics over time. The market value of language, which was historically heavily affected by conflict, is today heavily controlled by economics. In contrast to the temporary attention generated when the Olympics are held, interest in language is far more persistent, and consequently any athletic event can only have a limited impact on language.

The second issue is the city's linguistic landscape. A multilingual environment will

accompany every international sports event. However, it is claimed that the 2020 Tokyo Olympic and Paralympic Games would be managed in a mix of Japanese, English, and pictograms, which seems to be a setback in terms of language services provision. On the other hand, private businesses may potentially use multilingual services to attract consumers and capitalize on this once-in-a-generation economic opportunity. Inoue (2016) further argued that the bottom line is that sporting events and their venues may be the first to show a multilingual landscape. In particular, the Tokyo Olympics can be the catalyst. Language landscapes leave long-term traces and influences, while books and Internet searches show temporary interest. The mere exposure effect unknowingly affects people's linguistic consciousness and should not be ignored, and this corresponds to heightening albeit temporary piqued curiosity in foreign languages, which could increase the demand for foreign languages education during the heat.

Corpus linguistics is also used to analyze the metaphors used in printed media such as newspapers and books, to portray economy with movement such as accelerated, stalled or veer off (Krennmayr, 2015) or to show how a corpus linguistics approach to critical discourse analysis of 334 banks' timebanking websites in the United States of America enables a more nuanced understanding of the counter-hegemonic discursive tactics used by alternative economic exchanges (Rice 2014). Nonetheless, the econolinguistic analysis by Inoue (2016) is certainly an interesting insight into the potential of econolinguistics in the future as we will discuss in the next section.

## **POTENTIALS AND CHALLENGES**

Seeing how appealing econophysics can be and how undervalued econophysics has become to the researchers at the moment, we will discuss directly the challenges that the former faces throughout the years of its development and prospects into future contributions for the latter.

### *Econophysics*

Econophysics faces two obstacles since its emergence: philosophy and methodology. The discipline has always been compared with econometrics, another statistical-based approach to explain economic phenomena. However, the basic principle of econophysics in which this particular approach effectively made, "data first, then model..." (Rickles, 2011) makes it questionable in terms of its capability to further contribute towards mathematical economics and econometrics, let alone replacing them. However, this has not stopped later researchers to prove that econophysics has the capability to even rectify some orthodox assumptions in economics, such as the one proposed by Zapart (2015) in which in small-time scales, he claimed that the central theoretical assumption underlying prevalent economic theories is violated, and he proved how alternative behavioral econophysics can instead generate such time-scale reactions of market participants to



short-term movements in foreign exchange markets. Regarding methodology, it is a fact that sometimes social phenomena are harder to be explained comprehensively rather than physical phenomena, due to multiple intermingling of factors happening simultaneously – making the classical assumption of economics *ceteris paribus* no longer relevant. Roehner (2008) also confirmed this statement by stating that nascent stage of development of this discipline, physics was faced with the same problem, and the fundamental technique of experimental physics was established specifically to untangle these multifaceted events. On that account, we can infer a major point: we need to draw a line between econophysics and econometrics. We can say that econometrics would be the instrument to quantify economic phenomena, and econophysics would assist in improving any technique as needed, rather than having them skirmishing continually due to their differences in techniques and preferences.

### *Econolinguistics*

The so-called bridging between linguistics and economics is actually more of the effect that a particular language on a whole could impact economy, rather than dissecting “language” into its constituents instead. If we look upon our previous analysis regarding applied areas of econophysics such as option price, we can see attempts by researchers such as Vukovic (2015) to integrate financial economics into the core of quantum physics by synthesizing the formula with Schrödinger’s wave equation. This implies that in order for econolinguistics to prosper and gain more research coverage, aspiring academicians need to step up their approaches and do the same technique – relating economics with the nucleus of linguistics. I am aware of the fact that econophysics is able to thrive due to mathematics as “the common language” for communication between economists and physicists. It is harder though to find common grounds between economists and linguists since economics describes money transactions, the other expounds letters and words.

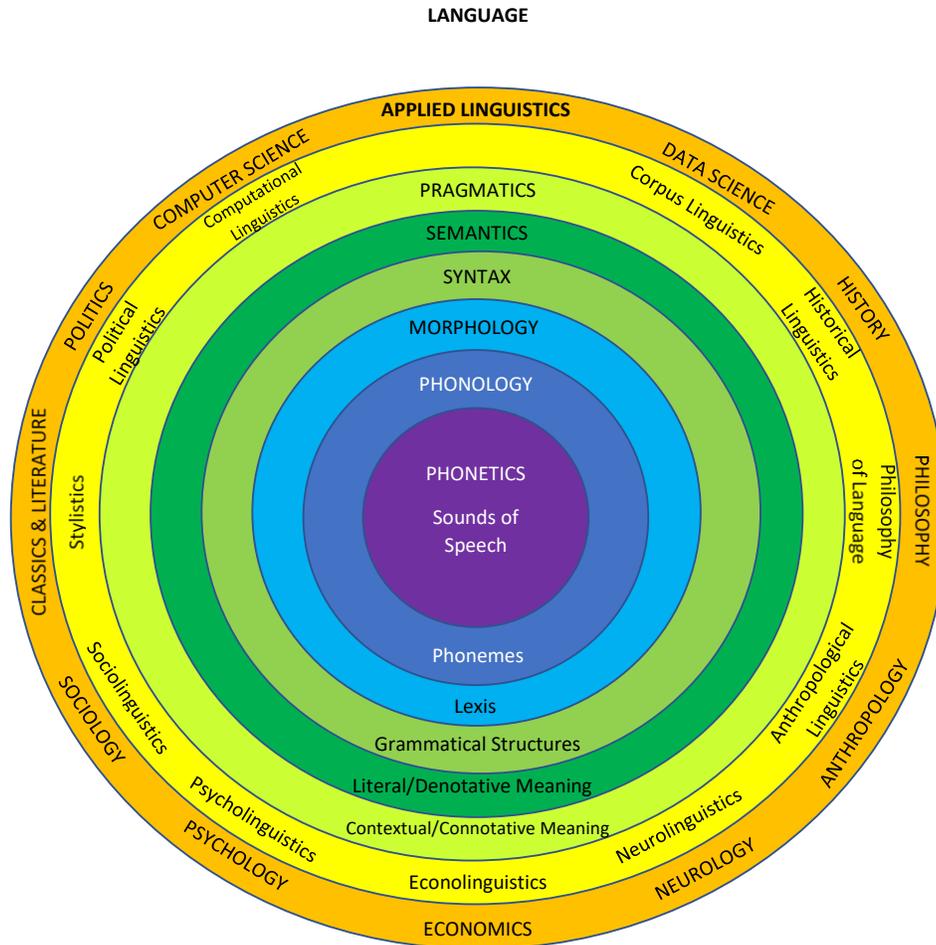


FIG. 5. LANGUAGE STRUCTURE LEVELS

Figure 5 shows my depiction of the language structure encompassing theoretical linguistics and applied linguistics. Although there are more disciplines related to linguistics besides the ones mentioned above, it goes without saying that econolinguistics can be developed further. I can propose an interesting situation into which econolinguists can consider in the future: an article in Astro Awani in September 2020 reported a view of the Deputy Minister of Science, Energy and Innovation, Ahmad Amzad Hashim on the claim about the fall of the incumbent government by the Malaysian Opposition Leader, Anwar Ibrahim. The deputy minister mentioned that “as soon as the opposition leader opens his mouth, the stock price drops drastically”. We can first analyze the stock performance throughout the week and also consider which part of that opposition leader’s speech in his news conference – such as his intonation (phonetics), lexical repertoire (morphology) or the specific words used to describe the fall of the government (semantics) - that would indeed cause the drop of stock prices, assuming that it is true. We can then scrutinize those findings to see how social media would contribute to the trending of particular phrases or words, leading to the concluding effect upon market



sentiment by both local and foreign investors. This is one of the many real-life scenarios that I find tantalizing for prospective and current econolinguists to consider for their research in the future.

Considering that econophysics explains macroeconomic activities and econolinguistics describes the condition of the microeconomic agents involved such as individuals and firms, a more ambitious research prospect is to combine both interdisciplinary perspectives to form an entirely new and comprehensive economic explication, covering both microeconomics and macroeconomics. This idiosyncratic idea would be hypothetically dubbed as econolinguistic-econophysical analysis. Figure 6 features a Venn diagram illustrating this relationship that could be paramount to pique curiosity among researchers and academicians about this matter.

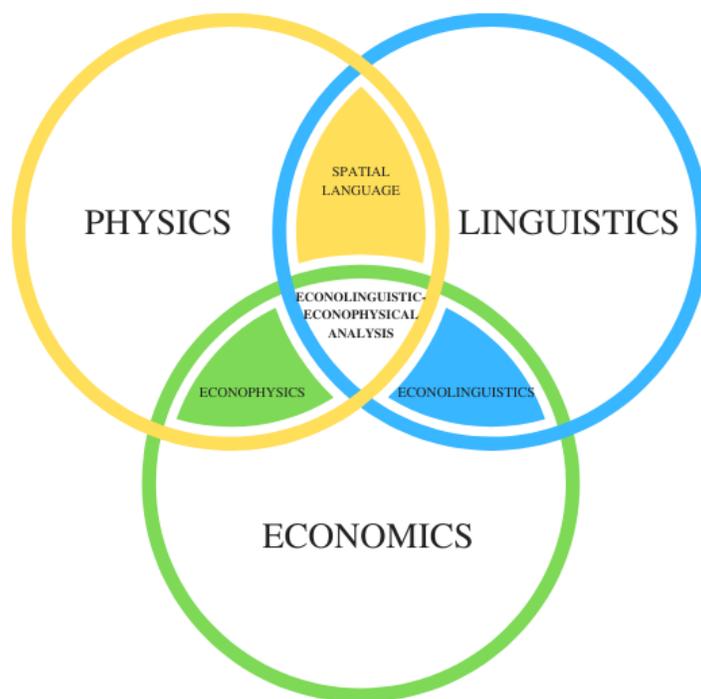


FIG. 6. VENN DIAGRAM RELATING THE THREE DISCIPLINES

## CONCLUSION

Having their debuts both in 1996, econophysics and econolinguistics offer many opportunities for improvement in academia and the industrial world. Despite the former has formal recognition as an official term but not the case for the latter, both are able to stand firm for 25 years among the plethora of other more popular academic publications released. The two interdisciplinary studies apply respective theories from their core

disciplines – physics and linguistics – to explain economic phenomena. This tacitly proves the significance of economics itself as a possible center of knowledge, as dubbed by a few researchers as the “complexity revolution” or “scientific revolution” since economics is almost in sync with physics, a branch of pure science. However, econophysics certainly needs to be redefined to avoid any confusion and ambiguity of its role in economic analyses. Inasmuch as econolinguistics not gaining total support at the moment, it is technically a new ground of research for both economists and linguists to contribute towards a better comprehension of the human-related phenomena.

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# SOCIAL MEDIA AS A COMMUNICATION MEANS JUDGING FROM THE INFLUENCE OF INTELLECTUAL CAPITAL ON THE SUSTAINABILITY OF PRIVATE HIGHER EDUCATION ORGANIZATIONS IN THE EAST JAVA REGION

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## *Abstract*

*The development of communication technology is currently growing so fast, changing the order or way of communicating for many people from conventional to electronic media which is now known as social media. This study aims to determine how the influence of social media as a means of communication in terms of the magnitude of the influence of intellectual capital on the sustainability of private higher education organizations in the East Java region. This study uses data analysis that is adapted to the research pattern and the variables studied. The model used in this study is a causality model and to test the hypothesis proposed in this study, the analytical technique used is SEM (Structural Equation Modeling). The results of this study indicate that there is a significant influence between social media as a means of communication and intellectual capital on the sustainability of private higher education organizations in the East Java region.*

Keywords: Social Media, Intellectual Capital, Organizational Sustainability.

## **INTRODUCTION**

Social media is one of the many results of today's technological sophistication. Social media is now here to provide an easy and efficient interaction service. This situation continues to encourage programmers to continue to develop the capabilities of the applications they make for the convenience of their users (Coyne et al., 2020). Social media has become an integral part of modern society. In fact, some social networks

have more users than the population of most countries. There is always a virtual space that is in great demand by its users (Gochhayat et al., 2017).

The popularity of using social media in higher education is currently an attraction in itself because it has been proven to be able to maximize it as a means of interactive tools, services, and build communication in managerial in an institution (Al-Rahmi et al., 2018; Chugh & Ruhi, 2018). The role of social media that has open access is able to encourage contributions and feedback from all its users so as to enable all elements of the organization to be able to communicate quickly and efficiently because it has connectivity or a network that can touch various links and users (Apriananta & Wijaya, 2018; Archer-Brown & Kietzmann, 2018; Huber et al., 2019). The use of social media has proven to be an effective weapon for universities as a branding strategy effort that has diversity because it allows students, lecturers and educators to exchange information, opinions, and experiences directly regarding the quality of higher education (McCoy et al., 2018). Therefore, the presence of social media with its various advantages can be one way or alternative for educational institutions or educational organizations to be adopted to be managed by universities in order to have an influence on the sustainable development of institutions (Rylander et al., 2000).

However, in Indonesia there are still higher education institutions that still use conventional capital in building their organizational systems because many do not use technology (Abidin, 2020; Cahyana, 2018). Based on this, a good university should have intellectual resources and the ability to achieve goals in developing the institution. Universities are able to develop and compete with creative innovations that come from intellectual capital. This intellectual capital must be developed in a university in order to be able to achieve the desired performance. The development of technology has now triggered universities to be able to have a competitive advantage in increasingly fierce competition. In today's world, wealth and economic growth are mainly controlled by intangible assets. The intangible asset in question is intellectual capital (IC) which is recognized as the basis for individual, organizational, and general competition in the 21st century.

Intellectual capital is one of the focuses of attention used as an approach to assessment and measurement in various fields including organizational management, information technology, as well as sociology and accounting (Petty & Guthrie, 2000; Sullivan & Sullivan, 2000). as the most important source of value in the creation and competitive advantage of organizations in an institution (Allameh, 2018; Kianto et al., 2017). intellectual capital is related to the assessment of the knowledge of an institution, especially in universities or in companies that aim to improve competitiveness and organizational performance (Pedro et al., 2020; Vargas Londoño & Cardoso Espinosa,

2021). Institutions that have high technology and professional services have a dominant factor in an assessment because intellectual capital is the key to determining the value of a company's performance (Co & Bontis, 2000). Intellectual capital researchers have also used content analysis extensively in examining annual reports used to investigate institutional IC reporting practices (Bozzolan et al., 2003; Brennan, 2001) and also to investigate differences in reporting across firms in different countries (Subbarao & Zeghal, 1997). Therefore, intellectual capital is one of the important factors that must be managed by an organization because it has an important and strategic role as an intangible asset that can be used as an investment from intangible resources such as expertise, knowledge, and organizational resource capabilities (Laksana & Dharmayanti, 2018).

Today in Indonesia, intellectual capital is applied not only in the context of global business, but also in developed countries such as America, Australia, and countries in the Scandinavian Region which have great opportunities in increasing quality Human Resources (HR) in an effort to increase added value for sustainability. management of universities as seen from the Human Capital component which describes the organization's individual knowledge stock, Structural Capital which includes non-human storehouse of knowledge in the organization, and Customer Capital which includes knowledge on marketing channels and customer relationships, the three components have their respective roles in developing intellectual capital and leading to improving organizational performance (Widodo & Priyadi, 2018).

Based on the explanation above, universities have a major role in promoting sustainable development even though their sustainability reporting is still very minimal when compared to other companies. This is due to the lack of research that leads to the concept of university sustainability compared to companies (Ceulemans et al., 2015). Therefore, this study focuses on the influence of social media as a means of communication in terms of the magnitude of the influence of intellectual capital on the sustainability of private higher education organizations in the East Java region.

## **METHOD**

This study aims to determine how the influence of social media as a means of communication in terms of the magnitude of the influence of intellectual capital on the sustainability of private higher education organizations in the East Java region. This study uses data analysis that is adapted to the research pattern and the variables studied. The model used in this study is a causal model and to test the hypothesis proposed in this study, the analytical technique used is SEM (Structural Equation Modeling) which is operated through the AMOS program. SEM is a multivariate statistical technique which is a combination of factor analysis and regression analysis

(correlation), which aims to test the relationships between variables that exist in a model, be it between indicators and their constructs, or relationships between constructs (Sugiyono, 2016). Quantitative method is a method that uses a sampling system from a population and uses a structured questionnaire as a data collection tool.

### *Participants*

Participants in this study consisted of 76 respondents, namely leaders of private universities in East Java. The selection of these respondents uses the Purposive Sampling Technique, which is a technique to determine the research sample with certain considerations aimed at making the data obtained more representative.

### *Data Analysis*

Data analysis in this study uses Structural Equation Modeling (SEM) analysis techniques, according to Sugiyono (2013), SEM is described as an analysis that combines factor analysis approaches, structural models (structural models) and path analysis (path analysis). Methods The analysis is carried out to interpret and draw conclusions from the collected data. The researcher used SPSS for windows software version 23 and SEM (Structural Equation Model) from the AMOS statistical package version 23 to process and analyze the research data. Through SEM software, not only can the causality relationship (direct and indirect) on the observed variables or constructs be detected, but the components that contribute to the formation of the construct itself can be determined. So that the causal relationship between variables or constructs becomes more informative, complete and accurate.

Furthermore, in the study, the analysis of test data on the suitability of the model was carried out through a study of various goodness of fit criteria. The following are some conformity indices and cut off values to test whether a model can be accepted or rejected, namely knowing the results of (a) Chi-square test, (b) RMSEA (The Root Mean Square Error of Approximation), (3) GFI (Goodness of Approximation). Fit Index) (4) AGFI (Adjusted Goodness of Fit Index), (5) CMIN/DF, (6) TLI (Tucker Lewis Index), (7) CFI (Comparative Fit Index).

## **RESULTS**

The model suitability test is carried out by comparing the suitability criteria with the calculation results. As with path analysis, a summary of the calculation of the suitability test parameters can be found in the "Model Fit" section of the text output in Amos. The following is a summary of the results of the model suitability test on this SEM model.

TABLE 1. GOODNESS OF FIT RESULTS

Parameters	Criterion	Result	Conclusion
chi-square	$\geq 0,05$	1.405	Good
Probabilitas	$\geq 0,05$	117	Good
GFI	$\geq 0,90$	923	Good
AGFI	$\geq 0,90$	846	Good
CFI	$\geq 0,95$	980	Good
TLI	$\geq 0,90$	969	Good
RMSEA	$\leq 0,08$	074	Good

Table 1 provides summary information on GOF (Goodness of Fit) test results in the research model as follows: (1) Parameters chi-square  $1.405 > 0.05$  indicates good criteria because the smaller the better the better, (2) the parameters of the probability value  $117 > 0.05$  indicates good results (3) parameters GFI  $923 > 0.090$  indicates good results (4) Parameters AGFI  $46 > 0.90$  indicates good criteria (5) parameters CFI  $980 > 0.95$  indicates good results (6) parameters TLI  $0.969 > 0.90$  indicates good criteria (8) Parameters RMSEA  $074 < 0.08$  indicates good criteria. Based on the results of the GOF (Goodness of Fit) test, it can be concluded that the influence of social media as a means of communication is good in terms of the magnitude of the influence of intellectual capital on the sustainability of private higher education organizations in the East Java region. Furthermore, the acquisition of the model suitability test can be concluded that the SEM model can be concluded in Table 2

TABLE 2. RESULT OF THEORETICAL TESTING

			Estimate	S.E.	C.R.	P
Organizational Sustainability (Y)	<---	Social media (X1)	1.146	.178	1.862	***
Organizational Sustainability (Y)	<---	Intellectual capital (X2)	.117	.165	.713	.476
Connection (X1.4)	<---	Social media (X1)	1.000			
Content Sharing (X1.3)	<---	Social media (X1)	1.213	.258	4.705	***
Content Creation (X1.2)	<---	Social media (X1)	1.033	.246	4.193	***
Relational Capital (X2.3)	<---	Intellectual capital (X2)	1.000			
Structural Capital (X2.2)	<---	Intellectual capital (X2)	1.014	.128	7.905	***
Human Capital (X2.1)	<---	Intellectual capital (X2)	.828	.148	5.585	***
Social sustainability (Y3)	<---	Organizational Sustainability (Y)	1.000			
Economic sustainability (Y2)	<---	Organizational Sustainability (Y)	1.353	.144	9.397	***

Based on the output above, it is obtained that the influence of Social Media (X1) on Organizational Sustainability (y) with an estimate value of 1,146 can be categorized as significant, the influence of Intellectual capital (X2) on Organizational Sustainability (Y) can be categorized as significant, the influence of Social Media (X1) on Content Sharing (x1.3) with an estimate value of 1,213 can be categorized as significant, the influence of Social Media (X1) on Content Creation (X1.2) with an estimate value of 1,033 can be categorized as significant, the influence of Intellectual capital (X2) on Structural Capital (x2.2) with an estimate value of 1.014 can be categorized as significant, the influence of Intellectual capital (X2) on Human Capital (x2.1) with an estimate value of .828 can be categorized as significant, the influence of Organizational Sustainability (Y) on Economic Sustainability (Y2) with an estimate value of 1.353 can be categorized significant. Furthermore, to find out the Squared Multiple Correlations can be seen in Table 3.

TABLE 3. SQUARED MULTIPLE CORRELATIONS: (GROUP NUMBER 1 - DEFAULT MODEL)

	Estimate
Organizational sustainability (Y)	.795
Social sustainability (Y3)	.597
Economic sustainability (Y2)	1.083
<i>Human Capital (x2.1)</i>	.426
<i>Structural Capital (x2.2)</i>	.861
<i>Relational Capital (x2.3)</i>	.535
<i>Content Creation (x1.2)</i>	.348
<i>Content Sharing (x1.3)</i>	.522
<i>Connecting (x1.4)</i>	.343

Based on Squared Multiple Correlations, it is known that Organizational Sustainability (Y) is obtained by an estimate value of 0.795, Social Sustainability (Y3) is obtained by an estimate value of 0.597, Economic Sustainability (Y2) is obtained an estimate value of 1.083, Human Capital (x2.1) is obtained an estimate value of .426 , Structural Capital (x2.2) obtained an estimate value of 0.861, Relational Capital (x2.3) obtained an estimate value of 0.535, Content Creation (x1.2) obtained an estimate value of 0.348, Content Sharing (x1.3) obtained an estimate value of 0.522, Connecting (x1.4) the estimated value is 0.343. Furthermore, to see the Measurement and Structural Model of the role of social media as a means of communication in terms of the magnitude of the influence of intellectual capital on the sustainability of private higher education organizations in the East Java region as follows:

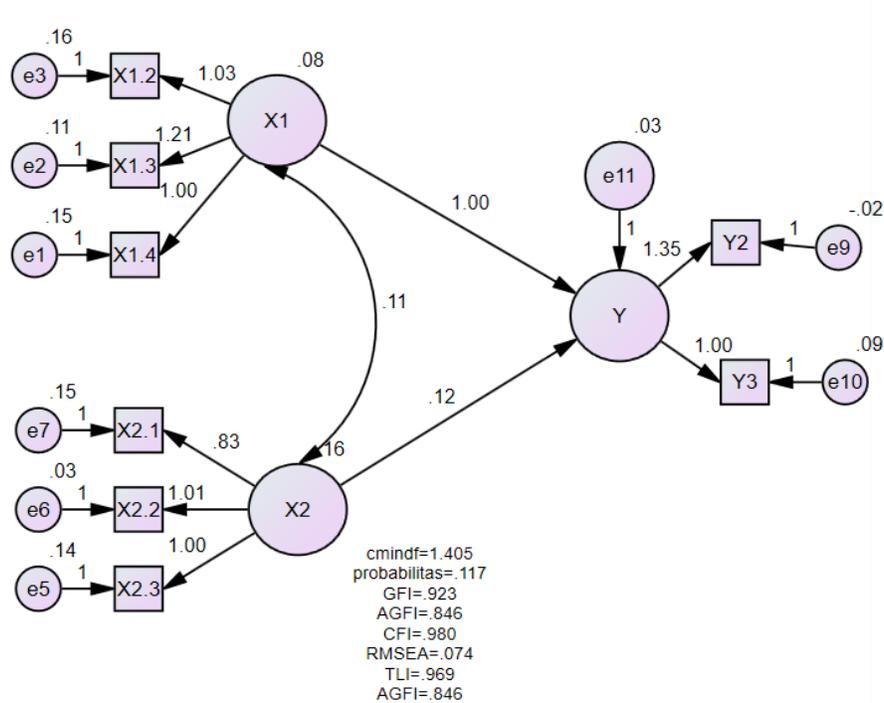


FIG 1. MEASUREMENT AND STRUCTURAL MODEL

## DISCUSSION

Based on the results of the research that has been obtained, it is known that social media has no influence on organizational sustainability even though it is known that the communication process that occurs in social media has a fairly important role in sustainability. Some virtual communities are the perfect means of interaction to reach the desired audience. Strategic thinking is one of the important keys in the interaction of organizational sustainability through social media. Recognizing the audience, the social media used, and what a network community wants and providing it, are things that organizational sustainability must be able to do to succeed in utilizing social media as a communication medium for organizational sustainability (Borwn, 2012; Wu et al., 2020). According to Safko (2012) there are four pillars supporting strategies through social media, namely communication, collaboration, education, and entertainment. The selection of the right strategy and media can affect various aspects of the company or organization, one of which is in terms of building and maintaining the image of the company or organization in the eyes of external audiences. Image is a picture of an object in the minds of audiences or consumers (Kriyantono, 2006).

While Intellectual capital has mediation on Organizational Sustainability with an estimate value of 0.117, this is because the role of Intellectual capital is also related to knowledge-based materials or university assets, or the result of the knowledge transformation process that can be in the form of higher education intellectual assets.

The intellectual assets can be in the form of information, intellectual property, leadership skills, patents, trademarks, brand equity, databases. Intellectual capital is recognized as an intangible asset of great value, but until now there are not many universities that involve the role of social media and the application of intellectual capital to the sustainability of the organization. Research focusing on the relationship between IC and sustainability was presented by Predini (2007) who stated that the relationship between IC and sustainability is manifested by improving corporate reputation and image as well as supporting technological innovation. In contrast to other researchers, Mehralian et al., (2012) explained that IC has no effect on market value so it cannot be used to predict sustainability. Regarding the inconsistent research results, Dumay (2009) explains that in practice IC is not used as much as expected by academics.

## **CONCLUSION**

This research was conducted at Private Universities in East Java Region, so the concept of sustainability referred to in this study is the Sustainability of Private Universities in East Java. The results of the research can be generalized in a limited way only to other private universities in Indonesia, not to state universities. Sustainability of an organization is the biggest challenge faced by a leader of Private Universities in East Java Success is not only talking about how an organization or university can win the competition, but also how to build partnerships. Partnership requires a communication within an organization that involves individual knowledge and Intellectual Capital. Knowledge is the lifeblood of an organization and can be identified as a crucial element for organizational survival in today's dynamic and competitive era. The conclusion of this study is that there is a significant influence between social media as a means of communication and intellectual capital on the sustainability of private higher education organizations in the East Java region.

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