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Strategy Determined Partnerships for Innovation: A Triple Helix Analysis of the Dynamics of Partnership Conditions with Evidence from an Emerging Economy

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Abstract:
Systems emerge, grow and evolve. Triple helix relations are not immune to such conditions. We theoretically review three hypothesis that we believe play a major role in the strategic decision making of individual agents within innovation networks. Using simple mathematical deductions, we show that cluster tendencies in conjunction with knowledge levels vis-à-vis projected benefits influence the partnership formation. Using Games Theory, we further show the possible adopting strategies that agents may activate to maximize benefits.

Keywords: *Triple Helix, Games Theory, Knowledge, Innovation, Universities, Industry, Government.*

1. Introduction

Silicon Valley and Route 128 are clear examples of how university industry synergies can evolve into efficiency. The restructuring of American Higher Education in the mid-20th Century provided the important engine to facilitate this economic success(Horaguchi, 2016; Zumeta, Breneman, Callan, & Finney, 2012). Economists have long recognized that new inventions and techniques can spur economic growth and productivity(Atkinson & Pelfrey, 2010). This spur is greatly enhanced by the presence of Knowledge Generation Institutions (Higher Education Institutions and Research Institutes)

The growing reality of national and global economies is that they place large demand responsibilities on Higher Education Institutions (in this paper it is used synonymously with universities). As aptly presented by Atkinson and Pelfrey (2010), in their discussion on entrepreneurial universities in relation to the American situation, one of the critical demand responsibilities that universities are harnessed with, is the call for more interdisciplinary research, with industrial partnerships. The basis, according to them, is to innovate product development, with research as the emanating platform of ideas. The second demand-determined responsibility of universities provides that they make a conscious effort to provide a long-term approach to research that yields economic products that would still be economically viable, long after the research has ceased to be relevant.

Universities are, therefore, demand-tasked to build relevant partnerships with industry to innovate the development network, conduct research that has a long-term view of product viability and, finally, ensure that the quality of education is sustained to graduate students with not only ready-for-work skills, but more importantly, entrepreneurial ones as well. These are some of the core drivers for the evolution of universities into entrepreneurial status.

In a triple helix relation, one can strongly argue that universities can at best attain entrepreneurial status when they become counter hegemonic in their interaction within their partnerships, especially with respect to research output, patency generation, awards, diversity in funding sources and graduates; as products and critical benchmarks of performance. In short, Higher Education Institutions (HIE's) are being tasked to evolve entrepreneurial characteristics. Leydesdorff (2000), considers this as the evolution point of entrepreneurial universities, as they implement several strategies and new institutional configurations to work together with governments (control) and industries (innovation/novelty adopters) to facilitate the generation and exploitation of knowledge and technology.

Higher Education Research Institutions have been described as institutions that have evolved different mechanisms to contribute to regional and local development, as well as increase their incomes. Indeed, scholars have used many terms to describe their unique attributes, prominent among them: University Technological Transfer (Dill, 1995), Innovative Universities (Clark, 1998; Van Vught, 1999) and Market Universities (Slaughter & Leslie, 1997).

Jameson and O'Donnell (2015), argue that the concept of entrepreneurial in relation to Higher Education Institutions should be seen as an issue of innovation with emphasis on its usefulness in organisational growth. This argument, therefore, advises the conceptualization of entrepreneurial organisations as ones that creates value through innovation. Schematically, they showed that universities can evolve into entrepreneurial states by generating value as shown in Figure 1.

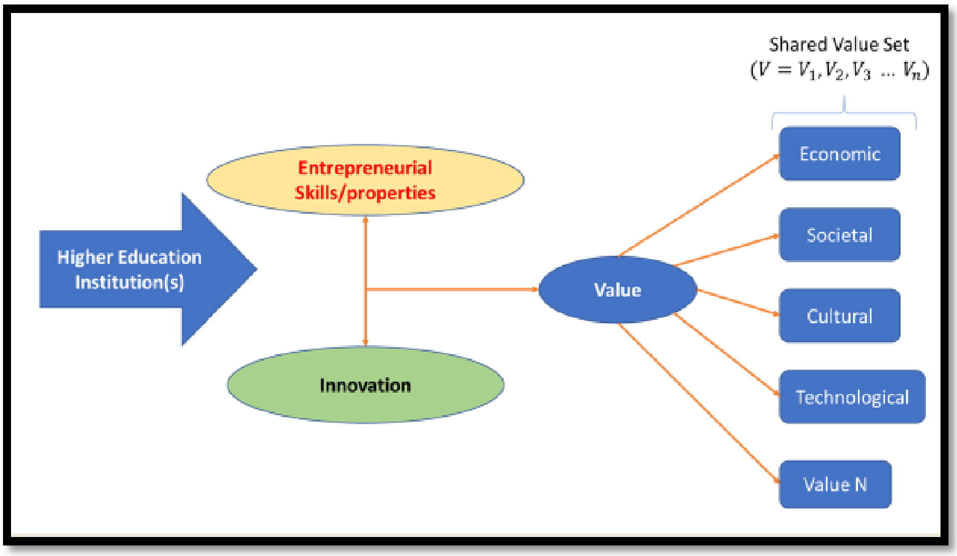

Figure 1: Evolution of Entrepreneurial HEIs through Value Creation (Jameson & O'Donnell, 2015)

Guerrero and Urbano (2017), building on the definition of Audretsch(2007) define an entrepreneurial society as one where knowledge-based entrepreneurship has emerged as a driving force for economic growth, employment creation and competitiveness. Contextually then, as argued by them, the entrepreneurial university plays an important role as both a knowledge-producer and a disseminating institution.

Characteristically, then Entrepreneurial higher education institutions are expected to empower its participants to demonstrate enterprise, innovation and novelty in knowledge generation and transfer (Gibb, Hofer, & Klofsten, 2013). Hannon (2013), reviewing the importance of Entrepreneurial Universities also argues that a key characteristic of such institutions, is their ability to create an enabling environment that aids the development of entrepreneurial systems and structures, as well as individuals by instituting strong reinforcing contingencies. These two characteristics are summaries of prior submissions made by researchers (Etzkowitz, Webster, Gebhardt, & Terra, 2000; Lazzeretti & Tavoletti, 2005; Robertson, 2008; Röpke, 1998).

Fraser (2012), in discussing entrepreneurial university models, points out that HEIs have evolved from the ideal centres designated solely for learning into systems and spheres of a more commercially viable source of innovation that relies on cross boundary value of the systems' products. Generated knowledge, then becomes a commodity of trade and paradigms for innovation and decision making.

Bellgardt, Gohlke, Haase, Parzonka, and Schicketanz (2014), discussing the role of triple helix in the evolution of technology parks, points out that, technology parks are a three-dimensional expression of the growing importance of innovation, creativity and knowledge. In such parks, these variables are considered as the economic resource. The effect is that, in highly concentrated forms, the spatial proximity of the different actors effectively influences the production of knowledge.Ivanova and Leydesdorff (2014), showed that Triple Helix dynamics provides self-organisation of innovations within the University, Industry and Government planes of interaction, as well as the possibility of predicting diversity of innovation and the life cycles of these innovations. Thus, to them, helixed partnerships tend to transform existing interactions into new ones. During the transformation process, the partners provide an enabling selection environment that fosters the generation of new systems which, in turn, supports new systems.

Deductively then, innovation and institutional entrepreneurship are direct products of a triple helix relationship between universities, government and industries. Dynamics of Triple Helix relations, may generate stability in innovation systems, since they provide the drive for a process of creative destruction and trigger disturbances that end up rebalancing economic systems; thus creating opportunities and wealth (P. K. Wong, Ho, & Autio, 2005). Entrepreneurship and innovation is, therefore, seen as the fundamental factors for economic development(Nordqvist & Melin, 2010; Poh-Kam, Yuen-Ping, & Singh, 2007; Porter & Stern, 2001; P.-K. Wong, Ho, & Singh, 2007; P. K. Wong et al., 2005).

The challenge of Triple Helix relations is that participants are assumed to be very cooperative with one another. However, as argued by Horaguchi (2016),the metaphor of the triple helix, building on the Shannon-Weaver Information Entropy Model (Shannon, 1948) provides the degree of overlap amongst, but does not reveal the internal strategy structures of a helix alliance. He, therefore, engages population ecology concepts of symbiotic relationships, in his attempt to unveil the internal structure of such partnerships; and subsequently provides evidence of research-driven alliances that evolve into self-organising structures with influential paths. Further, he calls for researchers to transcend the dichotomy of competition and cooperation as the driving forces for the relationship, because the relationship tends to evolve into a complex structure producing a mixture of unilateral and bilateral influences among participants. It is worth noting that Ivanova and Leydesdorff (2014) argue that this self-organisation and evolutionary nature of triple helix relations happens in waves with complex partners and are in no way linear. They, however, tend to follow the trajectories of technology demand and growth.

Building on the work of Horaguchi(2016) and prior deductions we hypothesis that:

- H1: Benefit optimised strategies enhance Institutional Clustering Triple Helix Relations

- H2: Partnership strategies influence the development, spread and adoption of innovation amongst helixes partnerships
- H3: Partnership strategies are driven by "what is best for me" approaches than "what is best for us"

Our paper is, therefore, arranged to highlight the conditions that would provide resolutions to the proposed hypotheses. The introduction traces the evolution of higher education institutions into entrepreneurial states and how this is enhanced within triple helix relations, while the second part highlights the individual hypothesis and how these may play out in a modelled analysis. The final part will provide conclusions and directions for possible research outcrops from this work.

2. Conceptual Assumptions Necessary for Co-evolution in Triple Helix

We start with some critical assumptions. Our assumption 1is that, there exists at least one knowledge generation institution; in this case, a university or similar (U), that has a spatially close industry (I) presence with a possibility of partnership being contingent on diffused performance of U through the number of papers authored by its staff. Government (G) is an ever-present participant in any educational system, thus our constant participant. For assumption 2, we assume that in this approach, roles of "U", "G" and "I", are clearly defined. Universities serve as agents (U_n) of knowledge whose performance value (P_u) determines levels of participation by Industry; extrapolated as proportionate funding contribution to the university at a period of interest. Government provides a relative significant input in both regulation and funding. Innovation intermediaries (I_{int}) serve as critical mediums of managing and dispersing innovation output of institutions to entice participation.

The third assumption is that, this relationship is complex in nature, hinged to an equitable creation of wealth, production of novelty and assured normative control (Vaivode, 2015). We shall not confine ourselves to defining the space of interaction[1], as we consider the interactive space in a triple helix as having an expanding frontier of technology with a large number of elements, each of which can lend itself to change and thus, give rise to useful innovation(Ricottilli, 2009). The whole relationship, then, is infused with an ability to learn and evolve per the performance and strategy adoption patterns of agents coupled with feedback conditions. It is noteworthy that Triple Helix relations are evolving complex systems that factors in history and that this allows the relationship to evolve and learn in complexity.

Finally, we strongly believe that the system has the ability to grow (size and levels), whilst the presence of competition and imitation, as well as the drive of all participants to breakeven, results in differentiation and diversification. The resulting effect is an ever-changing cycle of strategic partnerships hinged on knowledge generation and innovation.

The ability for a triple helix to generate knowledge and learn is conceptually presented as described in Figure 2 below:

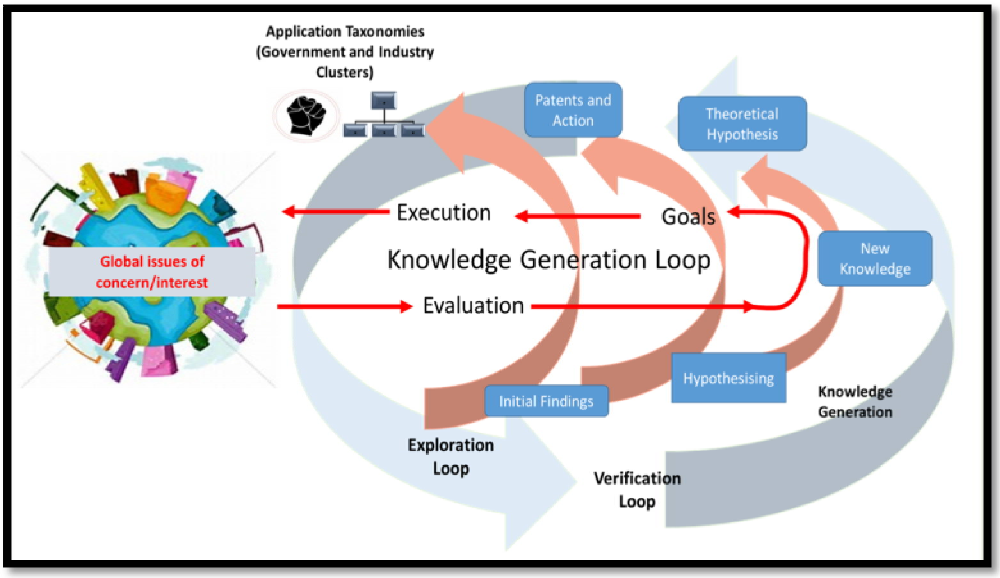

Figure 2: Hypothesized Knowledge Generation in a Typical Helix

The relationship in a triple helix can also be expressed conceptually as described in Figure3 below:

[1] Interactive spaces for agents in a complex relationship have been argued to be radically expansive and moving towards infinite possibilities in complex systems.

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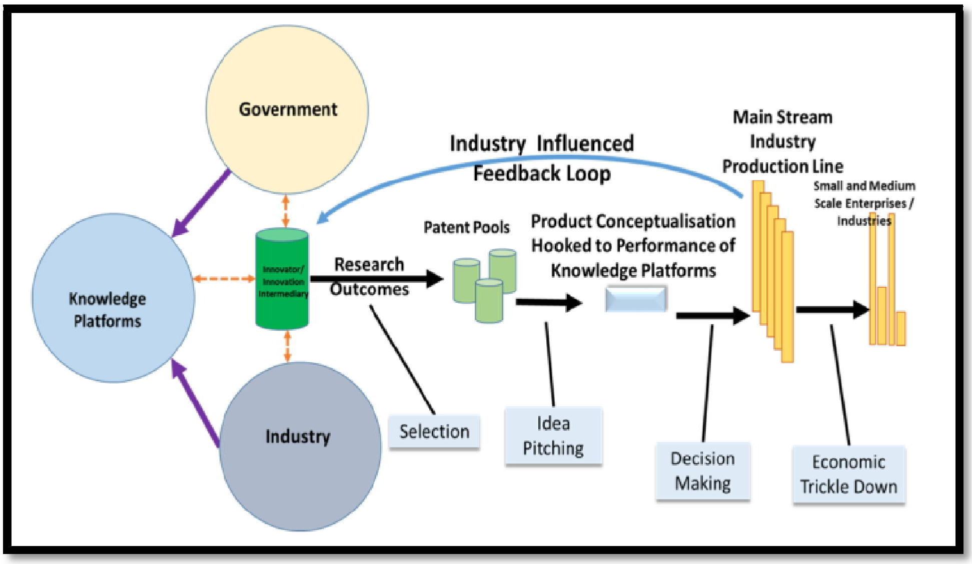

Figure 3: Working Helix Model

3. Theoretical Tests of Proposed Hypothesis

Hypothesis 1: Institutional Clustering is enhanced in Triple Helix Relations

The development of industrial clusters is strongly correlated to the satisfaction of some critical conditions. The appreciation of clusters is very relevant in any systems evolutionary relationship study. The development of knowledge hubs and industrial parks are quintessential examples of how triple helix relations develop, grow, evolve and metamorphose.

According to Porter (1998), it is important to contrast clusters from transactions among dispersed and randomly interacting economic agents. The proximities, as well as repeated interaction between the agents, is what defines clustering. Clusters invariably provide opportunities for independent and informally-linked institutions to develop a robust organisational form that offers advantages in efficiency, effectiveness and flexibility. He further argues that this relationship is further enhanced by the increased involvement of policy-makers (government) and the expansion of knowledge-based economies and the active presence of actors from knowledge-generating platforms, which is increasingly seen as a decisive factor for cluster development. Clusters analysis, we believe, provides one of the most innovative ways to review the evolutionary nature of innovation systems.

Based on our earlier assumptions, and the preceding line of reasoning, we present the first level of clustering in a triple helix system conceptually in Figure5 below. This allows us to model the tendency to cluster by assuming that the system is predictably structured Collins (2002).

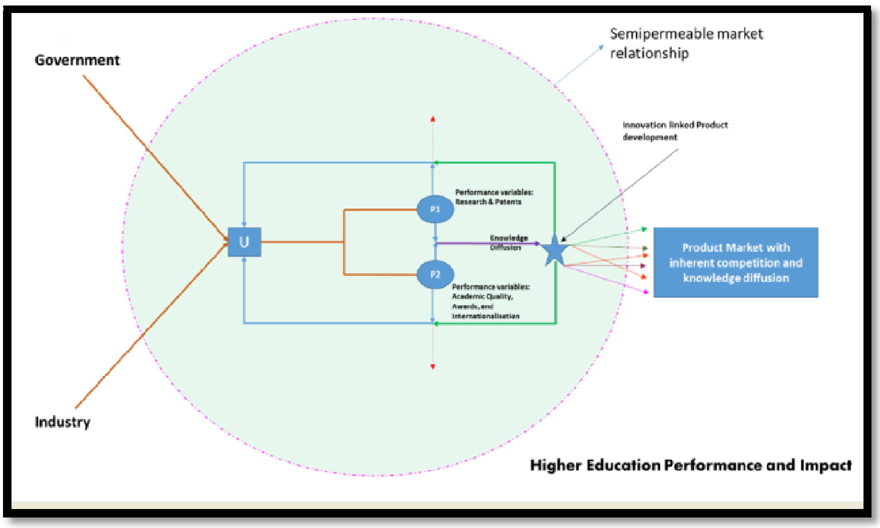

Figure 4: Level 1 Triple Helix System (Assumption 1)

Tendency for innovation partners in a network to form clusters, based on assumption 1 can therefore be deduced using the Hopkins Statistics (Banerjee & Dave, 2004; Hopkins & Skellam, 1954)model as[2]:

[2] Agent actors may also cluster on the basis of observed increase in benefits from innovation linked partnerships over a specific period. Nodes in such a cluster may initially collaborate. However, competition will and does eventually set in among them. Competition stabilizes the relationship by thinning out the complex and growing relationship through the reduction of benefits as cluster density increases.

$$H = \frac{\sum_{i=1}^{m} o_i^d}{\sum_i^m o_i^d + \sum_{i=1}^{m} v_i^d} \quad (1)\text{Tendency}$$

Where
M And n are attributes scores of actors in an innovation network that influences their location within the network
O_i is the distance of the focalactor from its nearest neighbour in the innovation network.
V_i is the distance of the focal actor from its nearest neighbour within its ego network
D is the dimensional structure of the network represented by its density.

Conforming to the typical formulation of the Hopkins Statistic model, Let $N_{ij} = N_1, N_2, \dots N_{ij+1}$ be a network of actors of individual agents(i)in an innovation network with j connections. The box suggests the possible simulation condition that can be used to test the tendency of agents to cluster within an innovation network.

3.1. Simulation

- Consider a network N with random connectivity with no re connection of $m \ll n$ nodes with members$i$ with j connections; but U_i, G_i, and $I_i \in N$
- Subsequently extract the ego networks ofU_i, G_i, and $I_i$from$N$of m. Define the distance within the three ego networks as the average path length within the individual Networks.
- Let the dimensional properties of each individual network be represented by the normalised average scores of centrality, and cohesion

Using algorithms of general predictions, it is possible to predict the emergence of clusters in agents' ego networks of similar nature. Begin by defining the structured predictability of the networks by assuming that they are in a partnership (example: university, government and industry networks) and can e volve clusters. For example, the structured prediction can be written as a joint feature function between Universities (U), Government (G) and Industries (I) networks as$\Phi(U, G, I)$. This allows you to map the changes in University networks through their diffused generated innovation as predicting clustering tendencies ofG and I to a vector of length l. Assume that the networks of University, Government and Industry have structure.

- Hypothesis 2: Growth of Industry Clusters in Triple Helix

Tian and Zhang (2008), elaborated on how inter-firm alliances catalytically result in the development of industry networks. Their agent-based model showed how knowledge complimentarily and the means of diffusion influence network formation and innovate performance. They argued that not all innovation is successful, applying this to Triple Helix relations, we argue then that each agent's awareness of performance of Higher Education Institutions must be factored into any study involving triple helix relations. Invariably, this allows for clusters in innovation to obtain a learning ability hinged on the diffusion of knowledge and the probability of innovation success.

As we have argued already, factoring in the tendency to cluster; we side with Tian and Zhang (2008) in the assertion that agents in the triple helix have a higher probability of innovating in partnership with other agents in the helix than on their own.

Information is critical for agents to be aware of innovation opportunities, this makes the knowledge levels (α_i) of and agent (i) in any innovation network very critical at any point in time (t); for universities, research output and or patent applications can be good signals for knowledge levels. Tian and Zhang (2008) suggest that the Carayol and Roux' (2003) instantaneous probability condition for an agent in a network to innovate should be considered as the exponential density function of the network: $P = (\alpha_i = \alpha) = \lambda e^{-\lambda\alpha}$; where α is average knowledge in the system.

If we assume that the probability of a new agent in the helix to innovate as it obtains a knowledge level determined as $\alpha_i$when it enters into a helix partnership; and that said agent has not already innovated prior to entering into a helix partnership, then conditionally his probability of innovating (β) on being connected to an innovation network with a known average knowledge level is

$$\beta_i = \frac{P[\alpha_i \in (\alpha, \alpha + d\alpha), \alpha_i > \alpha]}{P(\alpha_i > \alpha)} = \lambda \quad (2)$$

Thus, the probability of anew industrial partner innovating, on entering the helix relationship, when the knowledge level of universities in the network are known can be expressed as:

$$P_i^t = \int_t^{t+1} \alpha_i \beta_i^t \, dt \quad (3)$$

Where:

P_i^t denotes probability of innovation.

β_i^t denotes the conditional probability of the industry i innovating given the knowledge level of the universities

$\alpha_i$denotes the average knowledge level of auniversity or knowledge generation network.

Conditionally, if knowledge levels ($\Delta\alpha_i^t$) vary per a given period ($t, t+1$)when there is an industry partner, then change in knowledge can be expressed as

$$\Delta\alpha_i^t = \int_t^{t+1} \alpha_i^t \, dt \quad (4)$$

The probability of innovation in the partnership network can then be expressed as a relationship of the density of the network taking into consideration the variation in knowledge levels with respect to time.

$$P_i^t = \lambda \Delta\alpha_i^t \quad (5)$$

Triple helix partners, at their core have the prime aim of innovating through collaboration. If specialization amongst partners is contingent on awareness (γ) by each agent of the others particular set of skills or contribution in the partnership at a specified time, then probability of specialization in the helix can be considered as highly likely as γ gets closer to one. Awareness can be an extrapolated as the rate of diffusion within the network. This rate can be considered as proportional to the density of the knowledge network in relation to the known knowledge level. Thus, specialization reduces as each partner becomes equally involved in the generation of innovation. This allows the probability of innovation in a triple helix to be hooked to specialization and the awareness of such opportunities and can be considered as the transformed version of 5; expressed as

$$P_i^t = \lambda[\gamma max\Delta\alpha_i^t + (1-\gamma)min\Delta\alpha_i^t] \quad (6)$$

Following the deductions of Tian and Zhang (2008); we assume that the probability of industrial clustering is influenced by the distance (d) of clusters from the source of knowledge as well as the cost of the partnership in relation to the probability of innovation; whilst taking into consideration his direct and indirect connections. Let clusters form based on specialization payoffs when you consider that industry i has j connections within the innovation network and k is the density of the network that explains its structure. We can then define the payoff function (F) as being the probability of innovation multiplied by average benefits of partnership minus the cost (inclusive of risks of being in a partnership). Risk maybe seen as imitating linked cost.

$$F_i^t = P_i^t B - C_i^t \quad (7)$$

We assume that cost (C)can be expressed as

$$C_i^t = c_i(k_t) = C + \sum_{j:ij\in k_t} cd'(i,j) \quad (8)$$

Cost per time is assumed to be fixed and $\sum_{j:ij\in k_t} cd'(i,j)$ accounts for the cost of indirect and direct connections (risk) to other industrial partners in the network. This serves as the risk of partnership within the network that factors in the average normalized distance (d) between industry i and his j industrialneighbours. Thus, the payoff for partnership formation can be a reflection of 6 as

$$F_i^t = \lambda B[\gamma Max\Delta\alpha_i^t + (1-\gamma)Min\Delta\alpha_i^t] - C - \sum_{j:ijk_t} cd'(i,j) \quad (9)$$

For values of $i$and j, the paper recommends the normalised average centrality scores for i and the average centrality scores for all j neighbours.

- H3: Partnership strategies are driven by "what is best for me" approaches than "what is best for us"

Continuing our discussion, we believe that partnership network growth and sustainability is contingent on its ability to innovate whilst avoiding the pitfalls of associated with innovation. Thus, the establishment of partnerships in Triple Helix Relations result in knowledge generation, innovation and system growth. The driving force for this partnership remains the expected intrinsic benefit individual agents seek to gain for being a part of an innovation network.

Adopting an evolutionary Games Theory approach(Lan, 2010), we seek to show the benefit driven adopting strategies of partnerships in a triple helix. Thus, where three players (University: U; Government: G, Industry: I) seek to adopt a benefit optimised strategy of partnership expressed as $(Yes: Y, No: N)$;

In the set,

- Y represents the choice to partner on the part of agents
- N represents the choice of not entering into partnerships

Given the above we develop a hypothetical pay-off matrix of partnership strategy possibilities in a triple helix relation as shown in Table 1.

Partnership Strategy Set		**Agents**					
		Agent U		Agent G		Agent I	
		Y_U	N_U	Y_G	N_G	Y_I	N_I
Agent U	Y_U	x	$1-x$	$\theta_2 + \sigma_2 r_2 a_1 - \varphi_2 l_2 a_2$, $\theta_1 + \sigma_1 r_1 a_2 - \varphi_2 l_2 a_2$	$\theta_1 - \varphi_1 l_1 a_1$, θ_2	$\theta_3 + \sigma_3 r_3 a_1 - \varphi_3 l_3 a_3$, $\theta_1 + \sigma_1 r_1 a_3 - \varphi_3 l_3 a_3$	$\theta_1 - \varphi_1 l_1 a_1$, θ_3
	N_U	$1-x$	x	θ_2 , $\theta_1 - \varphi_1 l_1 a_1$	θ_1 , θ_2	θ_3 , $\theta_1 - \varphi_1 l_1 a_1$	θ_1 , θ_3
Agent G	Y_G	$\theta_1 + \sigma_1 r_1 a_2 - \varphi_2 l_2 a_2$, $\theta_2 + \sigma_2 r_2 a_1 - \varphi_2 l_2 a_2$	$\theta_2, \theta_1 - \varphi_1 l_1 a_1$	y	$1-y$	$\theta_3 + \sigma_3 r_3 a_2 - \varphi_3 l_3 a_3$, $\theta_2 + \sigma_2 r_2 a_3 - \varphi_2 l_2 a_2$	$\theta_3 - \varphi_3 l_3 a_3$, θ_2
	N_G	$\theta_1 - \varphi_1 l_1 a_1, \theta_2$	θ_2, θ_1	$1-y$	y	θ_3 , $\theta_2 - \varphi_2 l_2 a_2$	θ_2 , θ_3
Agent I	Y_I	$\theta_1 + \sigma_1 r_1 a_3 - \varphi_3 l_3 a_3$, $\theta_3 + \sigma_3 r_3 a_1 - \varphi_3 l_3 a_3$	$\theta_3, \theta_1 - \varphi_1 l_1 a_1$	$\theta_2 + \sigma_2 r_2 a_3 - \varphi_2 l_2 a_2$, $\theta_3 + \sigma_3 r_3 a_2 - \varphi_3 l_3 a_3$	$\theta_2, \theta_3 - \varphi_3 l_3 a_3$	z	$1-z$
	N_I	$\theta_1 - \varphi_1 l_1 a_1, \theta_3$	θ_3, θ_1	$\theta_2 - \varphi_2 l_2 a_2, \theta_3$	θ_3, θ_2	$1-z$	z

Table 1: Payoff Matrix of Partnership Strategies in a Triple Helix
x,y,z Represents the Plotting Axis of University, Government and Industry Respectively.

The payoff matrix is denoted as having playersθ_i $(i = 1, 2, 3)$with whom agent $i$strategically agrees to partner or not partner per period of assessment.

- $\boldsymbol{a_i}$represents the partnership size of agent$\boldsymbol{i}$ as a deduction of the density of his ego partnership network
- $r_i$represents the growth capabilities of agent i, as a deduction of the mean eigenvector centrality score of its ego network, assuming importance is synonymous to access to resources and indirectly growth opportunities.
- $\sigma_i$is the discount factor or degree of recognising the future benefits of partnerships in the helix, deduced as the average degree centrality of the ego network of i
  $\sigma_1 r_1 a_1$
- $\sigma_2 r_2 a_2$ thus, the product of one's current partnership density, importance, and degree of connections can be a
  $\sigma_3 r_3 a_3$
  fair extrapolation of the respective benefits of partners prior to entering a helix partnership.
- $l_i$is the assumed coefficient of risk (reference 8); when an agent chooses to partner.
- $\varphi_i$represents risk aversion status of agent i, determined as an inverse of the risk coefficient or initial invested resources of $\boldsymbol{i}$on entering the partnership as a proportion of total investment within the partnership.
- Thus,$\varphi_i l_i a_i$is the cost (reference 8) of partnership selection

Conditionally then,$0 \leq \varphi_i r_i, \sigma_i, l_i \leq 1$. Using configurations on three-dimensionalCartesian plane, in a triple helix the decision of an agent in choosing to partner is a dummy variable of (0 = No and 1=Yes= x or y or z) status. Thus, University Agent U choosing to partner any player in the innovation partnership can be denoted as x; thus $1 - x$ is the decision of opting out of partnership. Whilst y is choice component of a Government Agent (G) opting for partnership, and as such $1 - y$ represents the partnership opting out decision of Agent. Deductively then, z represents the partnership decision for Industrial Agents (I) when they agree to play with any of the players within the network and $1 - z$ when vice versa.

The rules governing the payoff matrix that leads to the deduction of partnership strategies in a triple helix relation can be expressed as

$$\mu = f(U + G + I) \tag{10}$$

Then, from the matrix above, the benefits of Agents in choosing to partner (Y_U, Y_G, Y_I) to form a triple helix based on the average knowledge level (performance of Universities) per a given period can be deduced as:

$$B = x[\![[y(\theta_2 + \sigma_2 r_2 a_1 - \varphi_2 l_2 a_2) + (1 - y)(\theta_1 - \varphi_1 l_1 a_1)] + [(1 - z)(\theta_3 - \varphi_1 l_1 a_1) + z(\theta_3 + \varphi_3 l_3 a_3)]]\!]$$

Summarily, this can be expressed as

$$B = x \sum_{i=2,}^{3} \alpha_i [(\theta_i + \sigma_i r_i a_i - \varphi_i l_i a_i) + (1 - u_i)(\theta_i - \varphi_i l_i a_i)] \tag{11}$$

The only undefined variables in the summarised version of 11with reference to table 1 and expression 2 is u_i which accounts for industrial and government agents.

Thus, under the same conditions, the consequences of Agents in deciding not to partner (N_U, N_G, N_I) can also be deduced as:

$$B^{-1} = (1 - x)[\![[y\theta_2 + (1 - y)a_1] + [z(\theta_3 + (1 - z)\theta_3]]\!]$$

and deduced as

$$B^{-1} = (1 - x) \sum_{i=2}^{3} [(\alpha_i \theta_i + (1 - \alpha_i)\theta_i] \tag{12}$$

The average benefit of each Agent in the partnership can then be represented as

$$\overline{B} = \frac{1}{3} \sum_{i=1}^{3} \alpha_i (\sigma_i r_i a_i - \varphi_i l_i a_i) \quad \text{(13) (Partnered)}$$

and

$$\overline{B^{-1}} = \frac{1}{3} \sum_{i=1}^{3} (1 - \alpha_i)(\sigma_i r_i a_i - \varphi_i l_i a_i) \quad \text{(14) (Not Partnered)}$$

3.2. Adopting Stability Strategies

It is critical to deduce the stability of equilibrium points in partnership formation. Using Figure 6 we can determine the local stability of our system such that the potential values of University, Government and Industry within the deduced partnership falls in the plane of Q, thereforeQ = $Q = (x, y, z); 1 \leq x, y, z \geq 0$ and has the following equilibrium points:

University = x axis = $K(0_U, 0_I, 0_G); R(1_U, 0_I, 0_G); D(1_U, 1_I, 0_G); W(1_U, 1_I, 1_G)$

Government = y axis = $K(0_G, 0_U, 0_I); V(1_G, 0_U, 0_I); E(1_G, 1_U, 0_I); W(1_G, 1_U, 1_I)$

Industry = z axis = $K(0_I, 0_U, 0_G); T(1_I, 0_U, 0_G); S(1_I, 1_U, 0_G); W(1_I, 1_U, 1_G)$

From the coordinates it can be deduced that only K and W are steady and represent the evolutionary stable states of partnership (ESSP) of the innovation system. Local point K represents instances when players have a converged strategy of partnership and are in a triple helix state. Local point W indicates points of strong divergence within the system with players opting out of partnership. The local unstable points of the evolving system are R, V, T, D, E, S. The point of convergence of partnership symbolizes the point of innovation within the triple helix and the space of the area of convergence, which symbolizes opportunities for growth and evolution can considered to be the saddle point of the system.

It is worth noting that as the probability of convergence decreases, when the coefficient of risk in partnership increases and inversely a decreased risk can be a strong indication of the probability of innovation in a triple helix partnership. These concepts are critical in determining opportunities for growth in a triple helix relation. Thus, the opportunity for growth is hinged on reducing risk or risk avoidance as well as the discount factor, which is the degree of recognizing future benefits of partnership within the triple helix.

4. Conclusion

The study has conducted a hypothetical review of clustering tendencies and how this influences growth and evolution of institutional partners within an innovation network. It further extended the analogy to explain the adoption strategies of innovation partners as they seek to maximize benefits. As research continues to review and reveal the intricate nature of innovation networks, there is the need for literature to propose diverse ways of testing and verifying different hypothesis that may arise. We have suggested a few of such ways.

5. Acknowledgement

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