The role of small business based structures in promoting innovation, and creating employment, as compared to oligopolistic based structures

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Abstract

The main idea of this paper is to prove that economic structures that are based on small businesses function better than oligopolies. Small business structures promote growth inducing innovation, while oligopolies seek incremental and continuous innovations. Thus the former system creates employment, and the latter modifies employment. To prove this claim, six propositions are introduced and analysed. The main argument used for the analysis is the nature of the tasks performed, and its relation to innovation. The six propositions use the variable of the tasks performed in various aspects of the comparison of the two systems.

Keywords: small businesses, oligopoly, myopic tasks, complex/composite tasks, new product, complementary product, improved product, pricing, economic growth, diffusion, Lacuna, single equilibrium, multiple equilibrium, business cycles.

1. Introduction

Innovation has become the new business obsession. Books like "The Innovation Dilemma" and ""Innovate or Die" often top the business bestseller lists. Though the crucial role played by innovation in driving economic growth, and creating employment is acknowledged, many economists do not share the new obsession. My intention is to shed some light on the topic of innovation. How can one define innovation? What are the main ingredients for innovation? What kind of economic environment encourages innovation? How innovation is related to employment? The premiss of this paper is that to encourage innovation businesses should stay small. The economy has to allow the entry of new small businesses, and even encourage it. Some economists believe that the industrial structure that best fosters productive innovation is oligopoly. I will prove to the contrary. Economic growth through innovation is only assured if in place of a few big companies competing with each other an environment could be created that allows many firms to compete, in a free market.

In this paper my aim is to provide answers to the questions posed in the first paragraph by comparing an open market system that allows free entry and operation of small businesses, system (A), with a closed oligopolistic market system, system (B), in terms of each system's structural tendency towards innovation and its effects on employment. At the microeconomics level, innovation is related to the inherent nature of the tasks performed by the labour force in both systems. If I define a task as a force applied to a point, in system (A), each worker applies force in a multi-dimensional space. Thus, it is easy to form a complex functional. In other words, the labour force hired has to perform a spectrum of tasks in either the production process or the running of a business. This element offers a comprehensive knowledge of the nature of the product to the employees. The learning process eventually encourages one or more of the employees to come up with ideas for a new product or a complementary product. In system (B) each worker applies a linear force. In this case only linear projections are possible. Any function of this simple space has a simple form. In system (B), the labour force is highly specialised. Workers and specialists perform minuscule tasks when compared to the scope of the activities. The work force is short-sighted. This makes for innovations that are predictable, continuous and incremental. Proposition1: The scale of innovation is directly related to the degree of the complexity of the tasks performed.

The complex functional of the tasks performed in system (A) eventually results in two types of spin-offs: either 1) creation of complementary products or 2) creation of new products. Proposition 2: Given equal market conditions, innovations in system (A) always lead to either new products or complementary products; innovations in system (B) always translate to an incremental evolution of the same product. An important issue is pricing. Proposition 3: In system (A), price is a function of the tasks performed by labour, and machine. In system (B), price is a function of the interaction among the market forces.

On the macroeconomics level, I prove Proposition 4: System (A) leads to a better distribution of the labour force, which leads to a balanced growth between innovation, productivity, and employment. To prove proposition 4, I take the two systems as two intelligent machines. Machine (A) starts from a nucleus of small sub-systems, and it propagates through diffusion and separation. Eventually, it develops into a large number of small intelligent sub-systems. There is always a slot for a new sub-system in machine (A). Each sub-system is made up of a number of self–organising particles or labour. When the equilibrium state in each sub-system is disturbed by exogenous factors, it experiences a phase transition. Some of its particles go through a diffusion process that eventually ends in a total separation and formation of a new sub-system. Machine (B) consists of a few large intelligent sub-systems. In system (B), any disturbance in the equilibrium state of each sub-system can only cause deformation. There is either expansion or contraction.

Extension of proposition 4 results in proposition 5: System (A) leads to multiple equilibrium points; while, system (B) leads to a single equilibrium point in the market. The advantage of a multiple equilibrium system is that it can function even if some of its sub-systems are not at equilibrium. In a single equilibrium case, once the equilibrium is disturbed, then it is unlikely that the system can continue. Finally, I will prove Proposition 6: Business cycles are directly related to the scale of a business, the larger the business the higher the occurrence of a business cycle. In system (A), business cycles are easily avoided. Any drop in demand can be considered as the factor causing the diffusion process. It can trigger innovation, and since any new diffusion can be supported by the system, it then allows companies to adjust their output. System (B) is more susceptible to business cycles. Since, system (B) can only accept contraction; it becomes much harder for companies to make adjustments reflecting any decrease in demand.

2. The microeconomic aspect of innovation in small business and oligopolistic structures

Everyone acknowledges that innovation plays a crucial role in driving economic growth. But the fact that innovation happens is mostly taken for granted; the how and why of innovation remain largely ignored. Innovation is directly dependent on the scale of production, which defines the division of labour. Innovation is thus perceived as a function of the division of labour. The more complicated the tasks performed, the more significant the scale of innovation. The larger the scale of production is, the more myopic the tasks become, and the less significant innovation becomes.

One of the most significant characteristics of the modern oligopolies has been the division of the labour force. In place of a worker, executing a composite and diverse number of tasks in a serial order, he performs a separated, isolated and a myopic task. Thus a product that could represent a composite work of several labourers becomes a social product representing the cooperative work of many workers, each of whom constantly executing the same myopic task [30-31]. The main feature of system (B) is its ability to reduce work to highly myopic tasks. In such an environment the worker is incapable of producing significant innovation; the best that can happen is a simple, continuous, and an incremental innovation. On the other hand system (A) attributes composite and often complicated tasks to their workers, and thus creates an environment where given the complexity of the task base, allows for innovations that add to economic growth. In the past the most primitive nucleus of a small business was a lone entrepreneur building some world-changing invention in his garage. Historically, such pioneers play an important role, particularly in devising radically new technologies. As the societies become more complex, and the products and the mode of production take a more intricate form, it is less and less possible to have from a garage to lab situation of the past pioneers. But, it is still possible to avoid the acute division of labour, and allow workers to perform composite tasks which in time provides them with the intellectual ability, and would encourage one or a number of workers in the business to innovate. It is to prove the above arguments and provide a more rigorous treatment of this topic that proposition one is introduced.

Proposition 1: The scale of innovation is directly related to the degree of the complexity of the tasks performed. Let's start by defining a task. A task is a force that is applied to a point to produce work. A task can be divided into two categories:

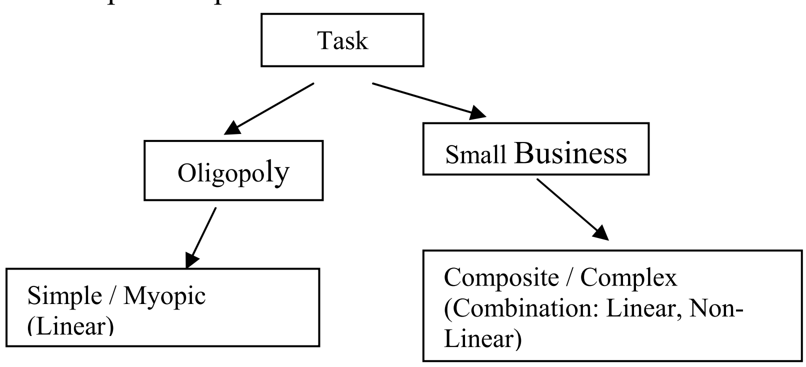

Figure 1

As is shown in Figure 1, each economic system imposes a certain type of task. In system (B), the workers are required to perform simple, myopic tasks. This implies that the physical movements relating to the production process are limited to simple directional displacements in the Euclidean space. While in system (A), workers perform composite and often complex tasks. There is a larger degree of freedom in the physical movements. Mathematically represented, myopic tasks are denoted by linear vectors in Euclidean space with rectangular coordinates; while composite tasks are denoted by vectors in non-Euclidean space, with either affine or curvilinear coordinates.

A production line in system (B), oligopolies, can be represented by a linear sequence of modules depicted in Figure 3.

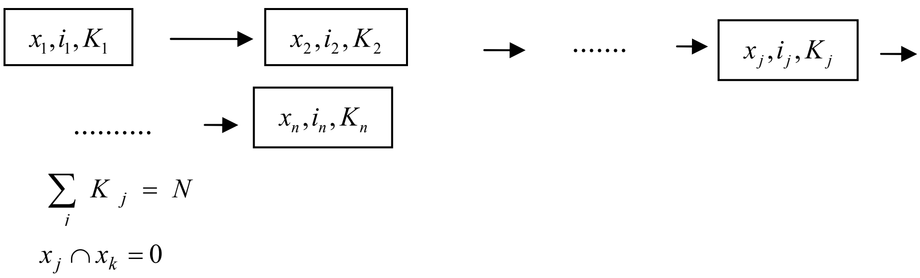

Figure 3

Each module represents a specific myopic task done by a group of workers. (x_j, i_j) is a linear vector representing a movement (task) in direction (i_j). j is the index for the task number. N is the total number of workers making a specific displacement (movement) along the production line. K_j denotes the number of workers that perform task (j). Directional movement is representational of a specific manipulation of a machine or an instrument; therefore, it corresponds to a specific type of technology. Therefore, technology and labour are interlocked [25].

A production process in system (A), small businesses, can be represented by a production line, each segment consisting of a set of modules [24, 26]. An example of such a production line with composite – complex set of modules is shown in Figure 4. Each set of modules that are connected by arrows represents a composite task, and possess a specific geometrical shape.

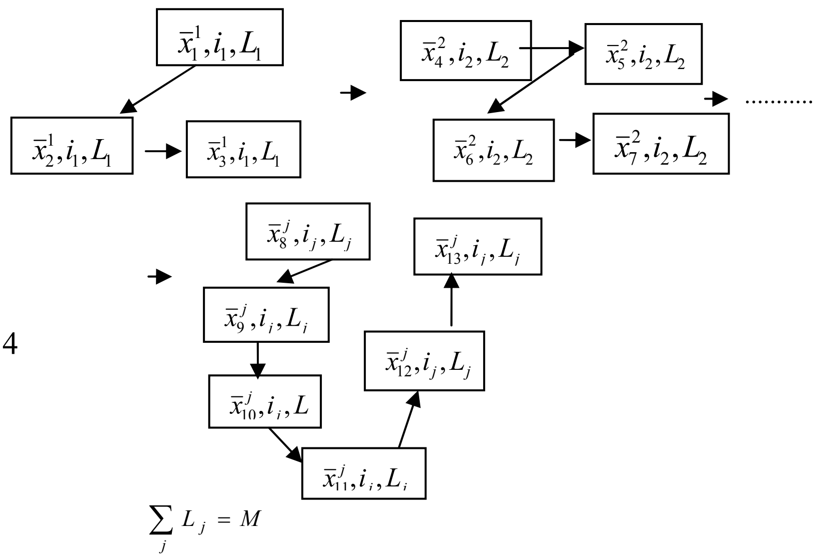

Figure 4

Each $\bar{x}_l^k$ is a module or task which can be represented by a vector constructed from affine or curvilinear coordinates. A collection of modules ($\bar{x}_l^k$) constitutes a set. Each set is a graph that is connected by ($\bar{x}_l^k$) points and possesses a certain topology. This graph can be represented by a vector function $f\left(\bar{x}^k \,\middle|\, \bar{x}^k = \bar{x}_l^k,\ l \in L_k\right)$. M is the total number of workers performing composite tasks. Innovation is the result of learning, experience, and intelligence. It is obvious that those who work in system (A), learn considerably more than those who work in system (B), simply by executing composite tasks that require the use of intelligence. They accumulate more experience, simply because they do more.

Innovation is defined either as non-significant or significant depending on whether it occurs in system (B), or in system (A).

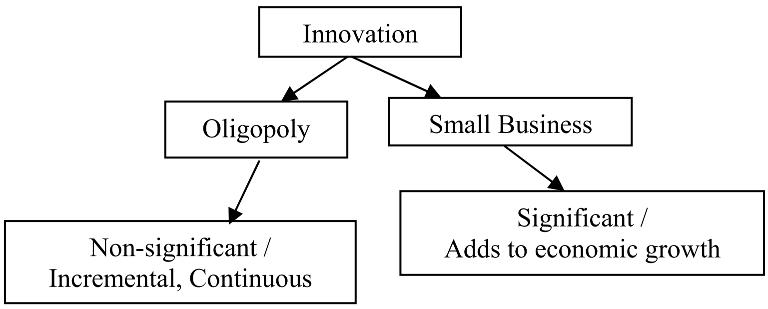

Figure 5

Non-significant innovation refers to a new technology or a technique that is capable of improving an already existing product. Non-significant innovations mainly occur in system (B), oligopolies. I identify two types of innovation in this case: 1) addition of a new module to the production line, 2) modification of an already existing module in the production line. Types one and two innovations can be demonstrated by Figure 6.

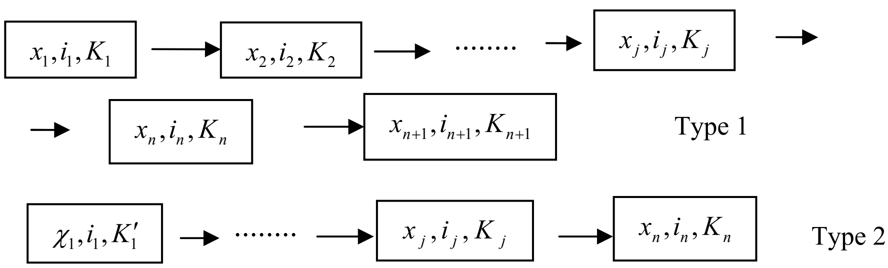

Figure 6

In figure 6, innovation type one is depicted as an addition of a new module in the production line. A linear vector (x_{n+1}, i_{n+1}) is added to the production line in order to modify and improve the product. Innovation type two is depicted by replacing modules (x_1), and (x_2) by module (χ). Whether innovation is an addition to or replacement of the already existing modules, it signifies linear projections. Both (x_{n+1}, i_{n+1}) and (χ) are linear functions of one or more of the modules in the production line or some new combination of linear movements (displacements) directed towards modifying a product; thus, they are a mapping from a linear space to a linear space. Innovations no matter whether they are an addition of a new module or a modification of an already existing module result from application of learning, experience, and intelligence. It is a worker who by using his experience, learning and intelligence comes up with a new innovation. But, experience gained at work is not sufficiently significant due to the myopic nature of the tasks performed in oligopolistic systems. Therefore, combination of narrow experience, learning, and intelligence, can naturally lead to non-significant innovations. In all cases, whether innovation means adding a module or improving on already existing module(s), it can only lead to incremental improvements on an already existing product. The impact of such innovations is not usually significant, since it does not lead to a noticeable increase in the employment level, and does not add to social wealth in any substantial way.

Significant innovations are the type of innovations that contribute to economic growth. These types of innovations are the technologies or techniques that allow for the production of new or complementary products. Significant innovations are more likely to occur in system (A), small business system. Innovation in the context of system (A) is: 1) Addition of a new set of modules, 2) Replace an existing set of modules with a new set of modules. This is done either by re-arranging one set of modules, or designing a new set of modules. 3) Design a brand new routine of a series of sets of modules, some of which are modification of old sets, some are new. Figure 7 depicts a new routine to replace the old routine of Figure 4. The new production line consists of two sets of modules. Set one consists of 7 new sub-modules, ($\bar{\delta}_1^1$, ..., $\bar{\delta}_7^1$). Set two consists of 16 sub-modules, of which 5 are the tasks from the old production line, ($\bar{x}_8^2, \bar{x}_4^2, \bar{x}_1^2, \bar{x}_{11}^2, \bar{x}_{10}^2$). Similarly to system (B), any addition or improvement is a function of already existing modules, or a combination of new set of modules. With one major exception that innovation in this context is a projection from a curvilinear or affine space to a curvilinear or affine space. A worker in system (A), draws a considerable experience from his environment working in a small business. This worker by using his intelligence, learning, and experience is capable of innovation that is significant; since the base experience he draws from is more complex than oligopolistic experience. It suffices to compare Figure 6, with Figure 7 to find out that innovation in system (A) is more complicated than in system (B).

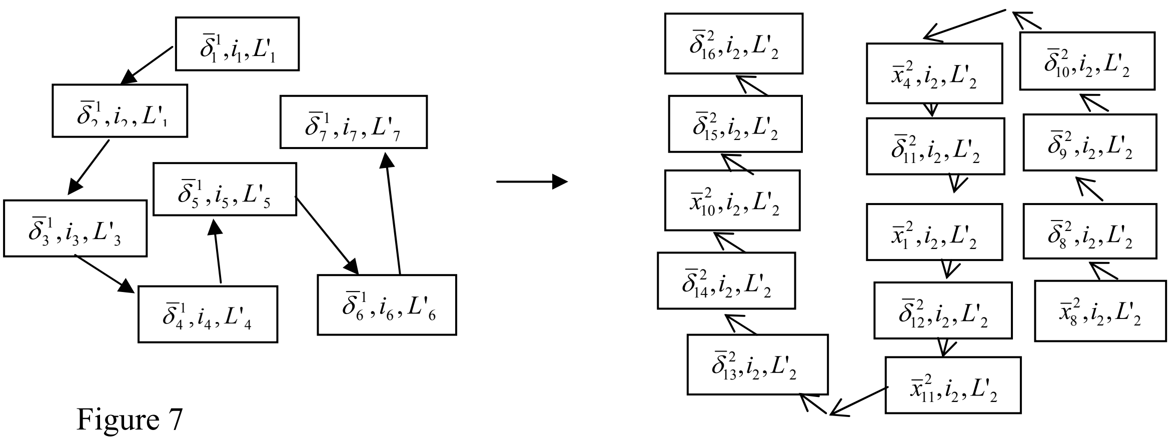

Figure 7

The scale of innovation is directly related to the complexity of the tasks performed. This conclusion can be used to prove proposition 2. *Proposition 2:* Given equal market conditions, innovations in system (A) always lead to creating either new products or complementary products; whereas innovations in system (B) always translate to an incremental evolution of the same product. A product can be defined as manipulation of raw material by man and machine given a certain level of technology, into a specific form for a particular use. A product can be defined as a multiplication of the tasks along the production line by the raw material [5, 6]. Take system (B), and the production line as is defined in Figure 3 as an example, one can write a general formula for a product as follows.

$$Q = \prod_{j=1}^{n} K_j x_j \times R \qquad (1)$$

Q represents quantity produced of a product, and R represents raw material. The equation above commonly known as the production function gives the maximum number of output given the input. In fact, this equation resembles the Cobb-Douglas production function, but with one major exception. The technology and labour are not two independent variables; rather these two elements are combined into tasks performed. For each level of technology a certain level and quality of labour is required. The interdependency of labour and capital or technology is denoted by the tasks performed along the production line. This is reflected on in Equation (1). Anytime a new innovation is introduced the shape of the production function changes. Thus, by comparing the graph of the production function before and after an innovation, one can conclude whether innovation has resulted in an improved product or a new product. Innovation is introduced by an addition of a new module, or replacement of an existing module, (Figure 6), then Equation (1), can be modified as follows:

$$\begin{aligned}
&\widetilde{Q} = \prod_{j=1}^{\widetilde{n}} \widetilde{K}_j \lambda_j \times R \\
&\lambda_j = \begin{bmatrix} x_j \quad \forall j = 1,2,...,n \qquad if\ \widetilde{n} > n \\ or \\ \begin{bmatrix} \chi_j & \forall j \in J \\ x_j & \forall j \in \widetilde{J} \end{bmatrix} \quad if\ \widetilde{n} = n \end{bmatrix}
\end{aligned} \qquad (2)$$

$\widetilde{Q}$ is the quantity produced of an improved product. The improved product is the result of a modification to the production process, namely, addition of (a) new module(s), or replacement of one or more modules with new ones. Obviously, the outcome of Equation (2) is different from Equation (1). Geometrically, Equation (2) and Equation (1) differ by a linear variation. In contrast, the production function, in system (A) is given by equation (3):

$$\begin{aligned}
&\overline{Q} = \prod_{k \in \kappa} K_k f_k(\overline{x}^k) \times \overline{R} \\
&\overline{x}^k = \left(\overline{x}_l^k, l \in L_k\right)
\end{aligned} \qquad (3)$$

$\overline{Q}$ Represents quantity produced of a product in system (A), and $\overline{R}$ represents raw material. k is the index for the number of sets of modules. l is the index for the number of tasks in each set of modules. L_k, is the group of l's that are in set k. K_k is the number of workers executing a set of modules. $f_k(\overline{x}^k)$ is the vector function representing the graph of each set of modules in the production line. $K_k f_k(\overline{x}^k)$ is the labour-task input requirement. For a physical presentation you can refer to Figure 4. Introduction of an innovation transforms Equation (3) to Equation (4).

$$\begin{aligned} \widetilde{Q} &= \prod\nolimits_{k\in\widetilde{K}} \widetilde{K}_k \widetilde{f}_k(\widetilde{x}^k) \times \overline{R} \\ \widetilde{x}^k &= \left(\widetilde{x}_l^k,\, l \in \widetilde{L}_k\right) \end{aligned} \qquad (4)$$

$\widetilde{Q}$ represents the quantity produced of a product in system (A) after innovation. $\widetilde{f}_k\left(\widetilde{x}^k\right)$ is a new vector function representing the new graph of each set of modules after innovation . $\widetilde{x}^k$ represents either new modules or combination of old and new modules. $\widetilde{k}$ is the index for the number of new set of modules. Geometrically, Equation (3) and Equation (4) differ by a non-linear variation. The complexity of the change in the topological sense from the old graph points to a new product. In system (A), any innovation results in separation of the inventor from the firm. Firms stay small; there is no incentive to expand. The small business economy encourages new entries in the market. Therefore, Equations (3) and (4) are derived from two separate production lines, and producers; whereas Equations (1) and (2) are drawn from the same production line, at two different stages of its evolution, with the same producer.

One of the major differences between an oligopolistic system, and a small business system is in the price setting mechanism of each respective regime. *Proposition 3*: In system (A), price is a function of the tasks performed by labour, and machine. In system (B), price is a function of the interaction among the market forces. Traditionally, in system (A), small businesses, the objective of the producer, as long as no constraints are imposed, is to choose the optimal combination of (capital, and labour), which renders maximum profit. Formally, the producer's pursuit of monetary gains is formulated as the profit optimisation problem with no constraints [8]:

$$\underset{C,T}{Max}\, \pi(C,T) = pQ(C,T) - wT - rC - f \qquad (5)$$

In equation (5), π represents a profit function, (p) is price, (Q) is the production function, (T) stands for labour, (C) for capital or technology, (r) represents wages, (w) is return from capital, and (f) represents fixed costs. I should note that in this paper technology is synonymous to capital, since one needs capital to acquire technology; therefore, capital and technology are used interchangeably. In the conventional formulation, technology and labour are considered as two independent variables, as is shown in Equation (5). Price plays a detrimental role in finding what combination of capital and labour would maximise profit. The approach is somewhat different here. Pricing is based on how tasks along the production line are engineered. This main deviation from the traditional formulation of capital and labour reformulates Equation (5), where the production function *Q(C,T)*, is replaced by *Q(***Mod***)*. The new production function is the function of tasks or set of tasks performed, or in other words, the modules (**Mod**).

$$\begin{cases} \underset{\mathbf{Mod},p}{Max}\,\pi(\mathbf{Mod}) = pQ(\mathbf{Mod}) - \boldsymbol{\alpha}(\mathbf{Mod}) - f \\ s.t. \\ Q(\mathbf{Mod}) = \Delta(p) \end{cases}$$

$$\boldsymbol{\alpha} = (\alpha_1, \alpha_2, \alpha_3, ..., \alpha_n) \qquad (6)$$

$$\mathbf{Mod} = (\mathrm{mod}_1, \mathrm{mod}_2, ..., \mathrm{mod}_n)$$

α is a vector of monetary cost of a task. **Mod** is a vector of modules of a production line. Each (**Mod**) represents an engineered composite set of tasks. *n* refers to the number of modules along a production line. *Δ(p)* is the anticipated demand function. For a production routine several sets of tasks are engineered. The efficiency and the viability of each engineered set of tasks are tested by finding a price that corresponds to each designed set. The set is chosen that can maximise profit and its characteristic optimal price. Price plays an equally important role in the new formulation of the profit maximisation problem. Price determines the viability and the efficiency of the design of the tasks. The first order conditions calculate for what price the tasks designed are appropriate.

$$\begin{cases} \left(p + \frac{\Delta}{\Delta'}(p)\right)\frac{\partial Q(\mathbf{Mod})}{\partial \mathbf{Mod}} - \boldsymbol{\alpha} = 0 \\ Q(\mathbf{Mod}) = \Delta(p) \end{cases} \qquad (7)$$

The system of equations thus obtained calculates the price of a product for a specific design of sets of modules. The impact of innovation in determining the price is evident from the formulation of the profit maximising problem. The vector (**Mod)** takes into account any type of innovation, since innovation is defined as either an addition of new modules, or modification of already existing modules, or designing new production routines. Evidently, innovation plays an important role in price setting procedure, and determining which tasks use capital, and labour most efficiently.

In system (B), oligopolies, competition is inherently a setting for strategic interaction. Therefore, the appropriate tool for its analysis is game theory. In the oligopolistic competitive model, firms choose their price simultaneously with constant returns to scale technologies. The commonly known model of this type is the Bertrand model, and its derivative the Cournot model. The critical part of this game-theoretic approach to pricing in oligopolistic markets is choosing the strategies and the payoffs of the firms. A particular attention is paid to demand, and the technological features of the market, and the underlying processes of competition. In oligopolistic environment, technology is a means of controlling output. For the sake of simplicity, let's consider an oligopolistic system with only two firms operating the market. Two firms simultaneously decide how much to produce, $Q_j(\mathbf{Mod_j})$, and $Q_k(\mathbf{Mod_k})$. Given the oligopolistic supply, price is adjusted to the level that clears the market,

$p(Q_j(\mathbf{Mod_j}) + Q_k(\mathbf{Mod_k}))$, where $p(.) = \Delta^{-1}(.)$ is the inverse demand function. $p(.)$ is differentiable, $p'(.) > 0$, for all $Q \geq 0$. Firms produce output at a cost of $c>0$ per unit. The Nash equilibrium model of an oligopolistic (two firms) competition is a maximisation problem:

$$\underset{\mathbf{Mod}_j}{Max}\, p(Q_j(\mathbf{Mod}_j) + \widetilde{Q}_k(\mathbf{Mod}_k))Q_j(\mathbf{Mod}_j) - c \cdot Q_j(\mathbf{Mod}_j) \quad (8)$$

replacing $c \cdot Q_j(\mathbf{Mod}_j)$ by $\alpha_j \cdot (\mathbf{Mod}_j)$, the following formulation is obtained:

$$\underset{Q_j}{Max}\, p(Q_j(\mathbf{Mod}) + \widetilde{Q}_k(\mathbf{Mod}))Q_j(\mathbf{Mod}) - \alpha_j \cdot (\mathbf{Mod}_j) \cdot Q_j(\mathbf{Mod}) \quad (9)$$

$\widetilde{Q}_k(\mathbf{Mod}_k)$ is the output level of firm *k*. In solving Equation (9), firm j acts like a monopolist with an inverse demand function. An optimal production plan for firm j given its rival's output $\widetilde{Q}_k(\mathbf{Mod}_k)$ satisfies the first order condition which is the best – response function.

$$\left[p'(Q_j(\mathbf{Mod}_j) + \widetilde{Q}_k(\mathbf{Mod}_k))Q_j(\mathbf{Mod}_j) + p(Q_j(\mathbf{Mod}_j))\right]\frac{\partial Q_j(\mathbf{Mod}_j)}{\partial \mathbf{Mod}_j} = \alpha_j \quad (10)$$

From Equation (10), one can deduct that $\mathbf{Mod}_j$ is a function of $\mathbf{Mod}_k$, and symmetrically, $\mathbf{Mod}_k$ is a function of $\mathbf{Mod}_j$. The best-response function of one firm depends on the choice and the architecture of linear tasks that comprise the production line of the other firm. The implication is that innovation in the context of oligopoly is geared towards modifications that rely on the strategic response of the other firm. An oligopolist does not take risks; innovation in an oligopolistic environment is always geared towards improving an already existing product. The market equilibrium is maintained, by keeping a price level that is greater than the unit cost, and smaller than a monopoly price. This makes for innovations that are incremental, and continuous in nature.

3. The macroeconomic aspect of innovation in small business and oligopolistic structures

Proposition 4: System (A) leads to a better distribution of the labour force, which leads to a balanced growth between innovation, productivity, and employment. To prove this proposition I start with the definition of the economic growth, and what are its main elements identified according to economists. Economic growth is defined as a continuous improvement of techniques of production and unlimited accumulation of means of production. The main elements identified as factors affecting the economic growth are: the rate of investment, the rate of savings, and the rate of consumption. This list is modified by Solow and Ramsey who add technology, labour, and capital to this list. The most significant aspect of technology in conventional economic growth theory is the assumption of increasing returns to scale which provides a favourable argument for the need for large scale firms and businesses. In proposition 4, it is argued that technology limited to increasing returns to scale is not sufficient to explain the ever decreasing level of productivity, and an ever increasing rate of unemployment experienced in many industrialised and third world countries.

In proposition 1, I argued that the scale of innovation is highly dependent on the complexity of tasks performed by workers. It is equally argued that the smaller the scale of a business, the more complex the tasks performed by employees. A task is complex if it is composite and non-linear. In *proposition 2*, I argue that the complexity of the tasks performed define innovations that eventually result in creation of either new products or complementary products, while increasing return to scale innovations due to their linear nature lead to improvements of the existing products. These arguments indicate that contrary to the common belief that the accumulation of wealth is the result of the increasing return to scale innovations, it is the economic environment that encourages productivity, and employment by providing a medium that allows the free entry of small businesses. To prove proposition 4, I employ theories and techniques from the physics of phase transitions.

I consider the two systems (A), and (B), the small business system, and the oligopolistic system, as two intelligent machines. Machine (A) starts from a nucleus of small sub-systems, and it propagates through diffusion and separation. Eventually, it develops into a large number of small intelligent sub-systems. A diffusion process is a displacement of either atoms or molecules of either gas, or liquid, or solid that determines the dynamics of a great number of transitional phases that make nucleation possible. Diffusion is a phenomenon that allows a system to reach equilibrium even if the system does not start from an equilibrium state. One can consider the economic environment as a solid medium (machine) consisting of a large number of sub-systems. Each time innovation occurs there is a separation from the nucleus or the sub-system. Each separation process possesses enough potential energy to allow the new sub-system to occupy a place among the other existing sub-systems, and reach an equilibrium position. There is always a slot for a new sub-system in machine (A). Each vacant slot is called a Lacuna [11], Figure 8.

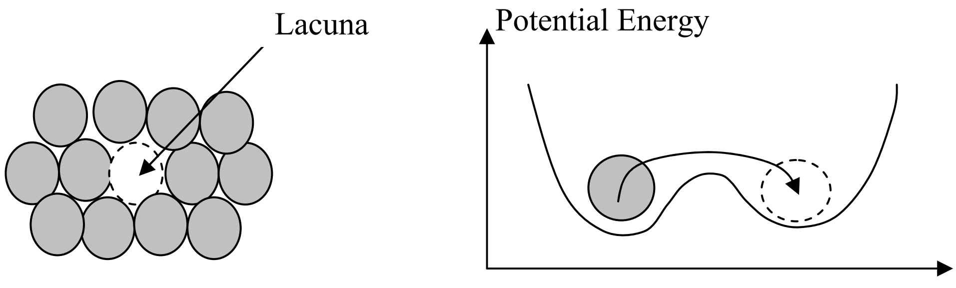

Figure 8

Each sub-system is made up of a number of self–organising particles or labour. When the equilibrium state in each sub-system is disturbed by exogenous factors, it experiences a phase transition. Some of its particles go through a diffusion process that eventually ends in a total separation and formation of a new sub-system. Exogenous factors causing a phase change are elements such as drop in the consumption level, dramatic changes in investment and savings, and unfavourable legislations. In this context innovation can be considered as the potential energy of the separation phase. Let's denote the change in free enthalpy of the energy of separation by ΔI_0. ΔI_0 represents the change in potential energy of innovation required to occupy a new Lacuna. The probability (P_0) that an innovation possess enough energy to effectuate a separation is a function of ΔI_0.

$$P_0 = C\exp(-\frac{\Delta I_0}{kD}) \quad (11)$$

Where

$$C = \frac{V}{\eta} \quad V \to \infty \quad \eta \to \infty \quad (12)$$

V denotes the capacity or size of sub-systems (small businesses), η denotes the number of exogenous factors involved in the phase transition. $V \to \infty$, denotes the limit in the capacity of a sub-system. $\eta \to \infty$, denotes the limit in the number of exogenous factors. The free enthalpy of the energy of separation, ΔI_0 can be re-written as:

$$\Delta I_0 = \Delta H_0 - D\Delta S_0 \quad (13)$$

ΔH_0 is the change in the enthalpy of the sub-system. ΔH_0 is a function of the internal energy of the sub-system as it relates to the requirement for innovation such as the complexity of the composite tasks designed, and external pressure on the sub-system such as a drastic drop in actual demand. ΔS_0 is the change in the entropy of the sub-system. This is mainly the endogenous factors that hinder the occurrence of innovation such as inefficiently engineered tasks. D denotes anticipated demand for either a new product or a complementary product. k denotes a Boltzmann like constant. In the context of this argument, k represents the degrees of freedom of demand. The degree of freedom refers to the effect of independent parameters such as consumer utility, and price on demand. Substituting Equation (13) for the change in free enthalpy of the energy of separation, ΔI_0, Equation (14) is obtained:

$$P_0 = C\exp\left(-\frac{\Delta H_0}{kD} + \frac{\Delta S_0}{k}\right) \quad (14)$$

The probability of existence of a Lacuna is given as:

$$P_L = C\exp\left(-\frac{\Delta H_L}{kD}\right) \quad (15)$$

(P_L) is the probability that there exists a Lacuna. ΔH_L is the change in the enthalpy of a Lacuna. ΔH_L relates to the variables such as the anticipated potential energy of a new product to attract demand. The probability (P_D) associated with the diffusion mechanism is given by the Equation (16). Both the enthalpy of innovation and the anticipated enthalpy of the new product are needed for the diffusion process to occur.

$$P_D = CP_0P_L = C\exp\left(-\frac{\Delta H_0 - \Delta S_0 + \Delta H_L}{kD}\right) \tag{16}$$

Machine (B) consists of a few large intelligent sub-systems. The market environment is nearly closed since the existing firms almost saturate the market. New entries are highly unlikely due to severe competition, and high operation costs due to scale economies, and price level. Obviously, in this environment, there is very little possibility of occurrence of open slots, or Lacunas, thus, (P_L)<< ε. Any disturbance in the equilibrium state of each sub-system is due to disequilibrium in the other sub-system, and can only cause deformation. This is easily deducted from proposition 1. In proposition 1, it is shown that the scale of innovation depends on the complexity of the tasks done. Since the tasks in oligoplolistic systems are shown to be linear, any innovation, which is the linear transformation of these tasks taken as basis, from a linear space to a linear space, is incremental, and continuous. Thus, the potential energy due to linear type innovation, characteristic of oligopolies is low. It can mainly cause deformation. There is either expansion or contraction. An expansion refers to the increasing return to scale innovation which usually results from a boom in the market, when households save less and spend more. Contraction refers to the decreasing return to scale innovation which is usually caused by a serious decline in market demand, or stringent government regulations.

Proposition 5: System (A), small businesses, leads to multiple equilibrium points; while, system (B) leads to a single equilibrium point in the market. Proposition 5 is an extension of proposition 4. Disequilibrium occurs due to exogenous factors such as change in the supply of the product, change in public spending, fall in consumer spending, etc. In system (A), disequilibrium leads to separation. A new sub-system is formed by occupying a Lacuna, which is independent of the parent sub-system. The new sub-system falls into a stable position till the next diffusion process. The probability of staying in an equilibrium position is derived in proposition 4, and is equal to (P_0). A generalisation of this idea is a situation where multiple diffusion processes occur simultaneously due to the availability of several Lacunas. In that case several Lacunas are filled at the same time with the condition that $\sum_i P_0^i = 1$, where (*i*), is the number of new sub-systems formed out of multiple diffusion processes. Each time a Lacuna is filled, the corresponding sub-system reaches equilibrium till the next diffusion process. This implies that diffusion and branching is time dependent, or specifically, there exists a stochastic branching random walk process [27]. Each new sub-system will have off springs (new innovations). Off spring either creates new products or complementary products. Therefore, one can assume that in time a branching phenomenon occurs that starts from the parent sub-system. By branching it is meant a stochastic random walk process where a new sub-system moves from position (*x*) to position (*y*). The branching phenomenon can be shown by imagining a lattice with few open slots or Lacunas as in Figure 9. When branching occurs

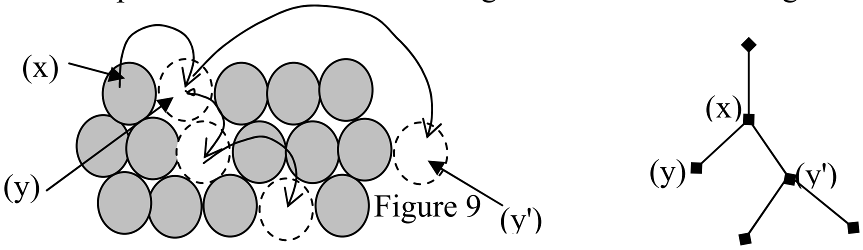

Figure 9

the new sub-system(s) branch out in either of two directions: 1) Towards producing a new product, position (y), or 2) Towards producing a complementary product, position (y'). Let $\mu = (\mu_n)_{n \geq N}$ be a random walk in discrete time on R_+^d , where d refers to those parameters that define a position. A transition kernel is defined as,

$$\alpha(x,y) := P\left(\mu_1 = y \middle| \mu_0 = x\right) = C\exp\left(-\frac{\Delta I_0(x,y)}{kD(y)}\right) = P_0(x,y) \qquad (17)$$

The transition probability of the continuous time version μ is then given by:

$$\alpha_t(x,y) := \sum_{n\geq 0} \alpha_0^{(n)}(x,y)\frac{t^n e^{-t}}{n!}$$
$$\alpha_0^{(n)}(x,y) = P_0^{(n)}(x,y) = \prod_{n=1}^{N} C_n \exp\left(-\frac{\Delta I_0^n(x,y)}{k_n D_n(y)}\right) \qquad (18)$$

where $\alpha_0^{(n)}(.,.)$ denotes the n-step transition probability. ΔI_0^n is the change in free enthalpy of the energy of separation for transition step (*n*), n=1,2,....,N. $D_n(y)$ is demand at position (y); (y) is a generic notation for any new position. k_n represents the degrees of freedom of demand $D_n(y)$, at step (n). The following assumptions can be made on the discrete time kernel $\alpha(.,.)$

1. The matrix $\alpha(x,y)_{x,y\in R_+^d}$ is invariant under translation in space and is symmetric.
2. The kernel $\alpha(.,.)$ has finite second moments,

$$\sum_{x\in R_+^2} \alpha(.,x)\|x\|^2 < \infty, \qquad (19)$$

where $\|.\|$ is the maximum norm.

3. The covariance matrix of the one-dimensional marginals

$$\mathrm{X} := \left(\mathrm{E}\left[\mu_1^i \mu_1^j\right]\right)_{i,j\in(1,2,...,d)} \qquad (20)$$

with respect to distribution

$$P(\mu_1^1, \mu_1^2, ..., \mu_1^d) = \alpha(0,x) \quad x \in R_+^d \qquad (21)$$

is assumed to be invertible, i.e., $\det \mathrm{X} \neq 0$, implying that the matrix is $\alpha(.,.)$ irreducible.

The branching random walk in R_+^d is defined in terms of the random walk μ , life time parameter Ω, which represents the life time of the sub-system between two diffusion processes. The branching process starts with migration, and ends in branching.

Migration: Each sub-system starts from a slot $x \in R_+^d$ and moves according to the law of μ.
Branching: After a mean 1/Ω exponential life time the sub-system either dies or is replaced by 2 new sub-systems resulting from a diffusion process.

Both situations occur independently for all sub-systems, independently from each other and independently of the initial configuration. Let Ψ be the random number of new sub-systems. The offsprings behave as (Ψ) independent new sub-systems that start from the parent's sub-system's final position. In this way the initial system generates a population at time (t >0).

Let $(S_{s,t})_{t \geq s}$ be a transition kernel of (μ), which describes the expected position of a new sub-system at time (t), if it starts from a position say, (x), at time (s). A position represents either before diffusion or after diffusion (separation). The $(S_{s,t})_{t \geq s}$ can be written as:

$$S_{s,t}[f](x) := \mathrm{E}^{\delta_{x,s}}[f(\mu_t)] \qquad (22)$$
$$f \in C_0(R^d)$$

Let (f) be defined as:

$$f = 1_Z$$

where (Z) represents a set of firms at time (s), with certain number of traits. $S_{s,t}[f](x)$ represents the probability of finding a descendent of a firm is set (Z), at the final position (x), and at time (t). An abbreviation $S_t := S_{0,t}$ defines a semigroup. Given Equation (18), the random walk generator (Δ_{RW}) of $(S_t)_{t \geq 0}$ on $C_0(R^d)$ is given by:

$$\Delta_{RW} f = \frac{d}{dt} S_t[f]\|_{t=0} = \sum_{y \in R_+^2} [\alpha(.,y) - \delta(.,y)] f(y) \qquad (23)$$

where δ is a Dirac delta function.

Exogenous factors in system (B) induce linear type innovations that result in either expansion, or contraction on the part of one large sub-system, inducing the other large sub-systems to react. A new equilibrium, is achieved when a new unique Nash equilibrium price is determined through game theoretic type competition [5]. From proposition (3), as long as there is a unique Nash equilibrium price, the entire system remains in equilibrium.

Proposition 6: Business cycles are directly related to the scale of a business, the larger the business the higher the occurrence of a business cycle. Proposition 6 is a direct derivative of proposition 4. By definition business cycles are periodic fluctuations in the economic activity that are due to fluctuations in investment, and demand that bring about disequilibrium [10]. During business cycle elements such as labour, productivity, and stock level are adversely affected due to serious decline in demand. The occurrence of business cycle triggers disequilibrium. What distinguishes system (A), small business system, from system (B), oligopoly, is the inventory level. In system (A), businesses have an upper ceiling on their size, thus their production level, never gets to the massive production level of oligopolies. Therefore, when business cycle occurs, it induces diffusion, i.e., innovation. This replaces halting of production to get rid of inventory, which is the trade mark of oligopolies. From proposition 4, once a new Lacuna is occupied, the new sub-system reaches equilibrium. The equilibrium in this case implies the optimal design of the production line through optimal design of the tasks performed which signifies optimal level of labour and productivity. This statement is possible since in propositions 1-3, labour and productivity are combined into one variable: the design of tasks performed, or in other words innovation. The following proposes a model of how a sub-system can expect to reach equilibrium by optimising the design of tasks performed in a business cycle situation.

$$\max_{\widetilde{x}} E_0 \sum_{t=0}^{T} \beta^t u\left((\widetilde{x}^k)_t\right)$$
$$s.t.$$
$$q_t \leq \left(\prod_{k \in \widetilde{K}} \widetilde{f}(\widetilde{x}^k)\right)_t \cdot \widetilde{Q}_t$$

where E_0 is the conditional mean of experience acquired through performing composite-complex tasks on the production line. (β^t) refers to factors such as the level of education, and the level of intelligence. u (.) is the utility function. u (.) depends on the design of tasks performed ($\widetilde{x}^k$). (q_t) is the expected consumption level during the business cycle. Both variables $\left(\prod_{k \in \widetilde{K}} \widetilde{f}(\widetilde{x}^k)\right)_t$, the overall design of the tasks on the production line, and $\widetilde{Q}_t$, the production function are considered during the business cycle, thus the justification of the use of (*t*), the cycle period. *T* represents the totality of business cycle duration. The first order conditions will provide the optimal design of tasks performed. The variable, stock level, is not significant in system (A)'s optimisation problem. New businesses do not start with an initial inventory level.

In system (B), periodic fluctuations in investment and demand have a significant effect. They always result in compression. Compression means significant dip in the production level, and massive layouts. The priority is to get rid of the already existing stocks; no modifications in the production line are envisaged unless the totality of the stocks is cleared out [29].

A good example of the resiliency of system (A) towards business cycles is the success of regional banks as compared to the big banks in America. Regional banks have avoided the worst effects of the recent slow down in the economy, while enjoying the best of its by-products. Unlike larger financial institutions, regional banks had little dealings with the stock market or the syndicated loans of large companies; consequently, the bankruptcies of oligopolies such as Enron, and WorldCom largely by-passed regional banks. Regional banks have found their free slots or Lacunas. They take clients such as small businesses that have no incentive to falsify their records or issue dodgy share options. Small or regional banks offer an alternative to the chaotic stock market, where customers can enjoy low fees, and are sure to have their money returned to them, when they ask for it. Regional banks have taken advantage of the decline in the interest rates, which are the reason for the boom in commercial property, which is a core lending business for regional banks [32].

4. Conclusion

The major contribution of this paper is to have shown that an economic system that functions based on small businesses performs better than an oligopolistic system. The main advantage of a small business system is in its ability to promote innovation. The reason is the nature of tasks performed by workers in the small business system. The limited scale of operation imposed on businesses, requires that workers perform complex – composite tasks. The combination of learning, experience, and intelligence results in innovation. Any disturbance in the market such as low demand will cause diffusion from the parent unit. Diffusion occurs when one or a group of employees come up with an invention. Inventors almost always separate from the mother company, and start up their own business. The economic environment allows for the emergence of new businesses. Many researchers have explored the design of production line from the view point of engineering design [24-26, 29]. The idea of relating the complexity of tasks to the size of a business is a new concept and has not been looked at by any researchers in the field. The paper is limited to theoretical analysis. From the practical aspect, the burden of proof is on performing experiments and investigation into the nature of the two systems through either laboratory simulation or data analysis.

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