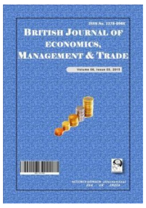

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A New Economic Theory for Space Exploration

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Author's contribution

The sole author designed, analyzed and interpreted and prepared the manuscript.

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ABSTRACT

The objective of this paper is to discuss the consequences of space industrialization. Initially, the purpose of space industrialization is to find new sources of energy. If, this quest is successful, there will be an unlimited supply of energy for the planet at prices equivalent to taxes. All aspects of economic activities will be impacted. Supply-demand equilibrium prices, production, labour, wage and capital will be formulated very differently from their conventional definitions.

Keywords: Space industrialization; energy sources; unlimited supply; demand; production; labor; wages; capital; consumer surplus; producer surplus; added values.

JEL Classification: O12.

1 INTRODUCTION

Space exploration will change the established economic models forever. Modern economic theory is based on one fundamental element, demand, [1],[2],[3],[4]. It is to profit from demand that economic activities start. As resources become scarce, and demand stays monotonically

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increasing, due to population increase, urbanization, proximity, evolution of tastes, a plethora of choices and many more social factors, those who see to the demand, profit more and more. Thus, they create an economic disequilibrium where consumer pays ever higher prices and producer gains ever higher profits. The initial aim of space exploration is to search for new sources of energy. Imagine that it is possible to harvest the energy of the sun from a lunar base and transfer this energy to earth with no risk for the planet. This would mean an everlasting energy supply that could satisfy all the energy needs of the planet. The whole of economic structure would change. The fundamental theory of demand and supply in which the price is at the point of equilibrium would no longer apply. In the face of infinite supply, the demand-supply equilibrium point is the point determined at the level of taxes. The tax is paid by the population of the planet for the maintenance, upkeep, and continuation of the space industry, to ensure the continuation of the energy supply, [5],[6],[7],[8],[9].

The main beneficiaries of low energy prices are consumers. Cheap, safe, and infinite energy source would have enormous consequences for the society. Demand will no longer be an incentive for profit based economic activities in the domain of energy. Economic activities will be based on producing real values. Real values are the values of products that advance humanity towards a world where humanity will no longer be preoccupied with basic needs such as food, shelter, health and jobs. Productivity will be geared towards satisfying these basic human needs. There will be indefinite supply of technical jobs, and by consequence every single person who can work will work. The new labour will be an intelligent, innovative, dynamic, and resourceful work force that will open new horizons and new objectives to reach for. The ideal wage will not be at the equilibrium of demand and supply of labour. It will be determined based on the level of productivity of each economic activity.

Capital will also take a new form. In an environment of economic security, consumers will have little incentive to save. There will be a high propensity to spend. Consumer spending is equivalent to producer surplus. Producers will have direct access to capital through producer surplus. Thus, one can completely bypass the intermediaries in the form of banks. Direct and continual flow of capital will assure the smooth functioning of economic activities. The two elements of consumer security and continuous flow of capital will eliminate business cycles as are experienced today, [10]. In conclusion space exploration will open the door to a whole new level of economic theory that is not funded on demand. Finally, economic thinking can liberate itself from the frivolity of demand and build a solid scientific foundation for human development.

2 SPACE EXPLORATION: SUPPLY-DEMAND EQUILIBRIUM

In this section the consequences of an unlimited supply of energy and energy by-products are discussed. In classical economics demand is represented by a convex curve where the point of convexity is usually the equilibrium point of supply (S) and demand (D). This is shown in Fig. 1.

In Fig. 1, the hyperbola $(CC^{'})$ is the consumer preference curve. (p_1) is the equilibrium price where the supply and the demand curve intersect. (q_1) is the quantity demanded at equilibrium. At this point consumer surplus is optimal. $(p_2)$is the maximum price level accepted by consumer. (q_2) is the maximum quantity demanded. The equilibrium price (p_1) is the mid-point between the origin and the intersection of the vertical axis with the preference hyperbola curve (CĆ), $(p_1 = \frac{Op_2}{2})$. The convexity of demand is due to the fact that the second derivative of price with respect to quantity consumed is positive; meaning that the optimal point of the curve is the point closest to the origin. This is shown in the formulation of the coefficient of the elasticity of demand (λ_{λ_q}). The coefficient of the elasticity of demand (λ_{λ_q}) is calculated as:

$$\lambda_{\lambda_q} = \frac{q}{\lambda_q} \times \frac{\partial \lambda_q}{\partial q} = 1 + \lambda_q + q \times \frac{\partial^2 q(p_q)}{\partial^2 p_q} \tag{2.1}$$

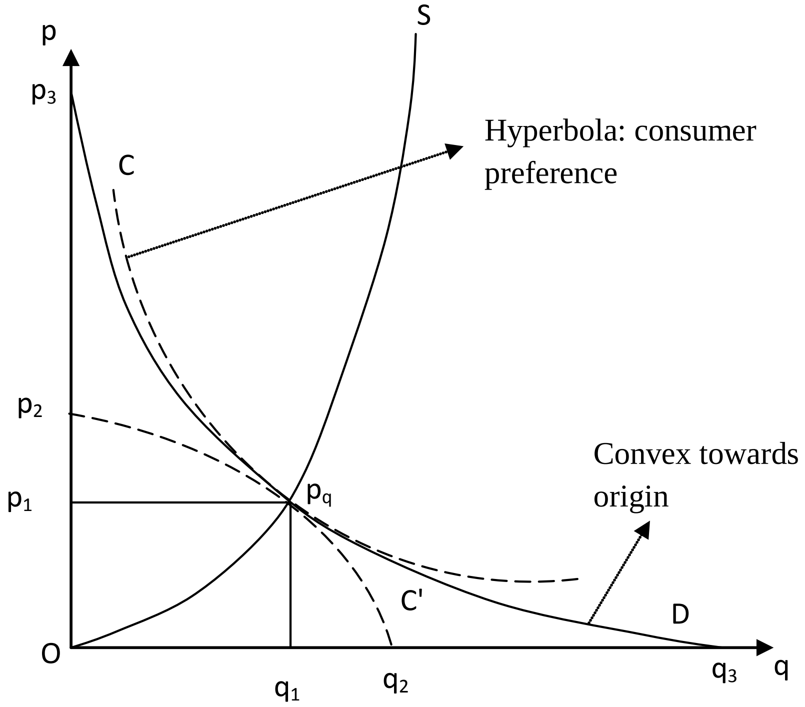

Fig. 1. Supply and demand

(λ_q) is the elasticity of demand. At equilibrium the elasticity of demand is equal to one,($\lambda_q = 1$). At ($q < q_1$), the elasticity of demand is less than one, ($\lambda_q < 1$). At ($q > q_1$), the elasticity of demand is greater than one, ($\lambda_q > 1$). The 2nd derivative of demand with respect to price is positive, ($\partial^2 q(p_q) > 0$), while the 1st derivative of demand with respect to price is negative ($\partial q(p_q) < 0$). Therefore, the fraction ($\frac{\partial^2 q(p_q)}{\partial^2 p_q} < 0$) is negative. At equilibrium, the coefficient of the elasticity of demand ($\lambda_{\lambda_q} = 1$) is equal to one. Both at ($q < q_1$) and ($q > q_1$) the coefficient of the elasticity of demand ($\lambda_{\lambda_q} < 1$) is less than one and thus the convexity property of the demand curve is assured. Demand does increase as prices go down; but as supply changes demand will always cross supply at the point of convexity. The behaviour of demand does not change, when supply becomes unlimited. This property of the demand curve will be used later on to calculate new energy prices. Conventional elasticity of supply is expressed as ($\lambda_p = -\frac{q_s}{p} \times \frac{\partial p}{\partial q_s}$), where ($q_s$) is the quantity supplied. The fraction($\frac{\partial p}{\partial q_s} < 0$), is negative since the derivative of price is negative, ($\partial p < 0$), and the derivative of the quantity supplied is positive ($\partial q_s > 0$). Therefore the elasticity of supply is positive ($\lambda_p > 0$). It is reasonable to say that in the conventional economy supply reacts to demand. Space industrialization based on energy production, allows for an infinite supply of energy and energy by-products, this will render the elasticity of supply perfect, i.e., ($\lambda_p = \infty$), which implies that supply will be perfectly responsive to demand, while demand stays convex as before. What is the consequence of such an evolution? The answer is given in Fig. 2.

In Fig. 2, the horizontal supply line represents a perfectly elastic supply that keeps its elasticity in time. The quantity demanded does not increase immediately as the price goes down. This implies that within a short time interval (Δt) the demand may stay at the same level (q_1) as before the price drop. This eventually changes and demand

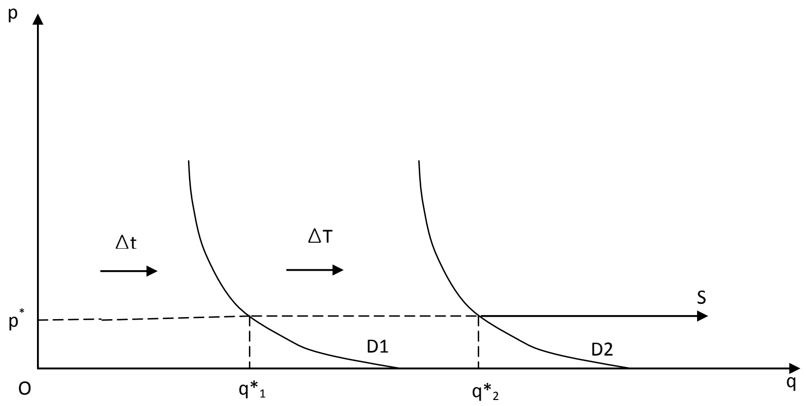

Fig. 2. Evolution of supply

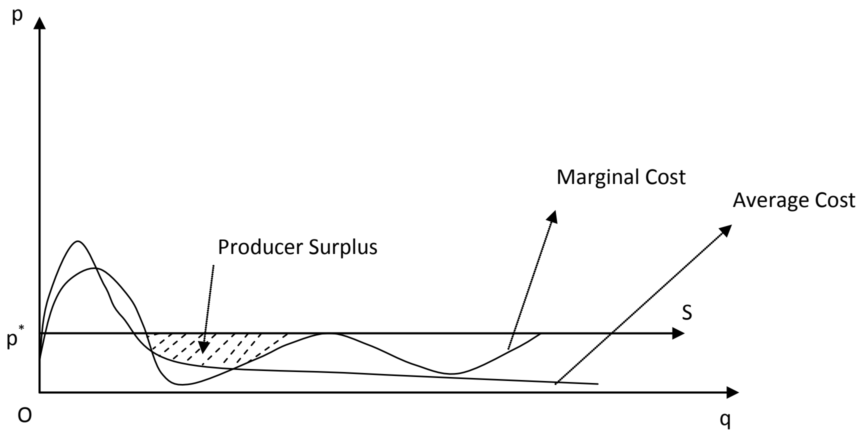

Fig. 3. Producer surplus

evolves in time intervals (ΔT) which are longer than the initial time interval (Δt). This is due to the elasticity of demand and the convexity of the demand curve. Supplier sets the price at (p^*). How is this price level determined? The answer has to begin with supply. Supply is unlimited and can see to the energetic needs of the plant. This was the assumption from the start. At this level of supply, energy becomes a public good. The pricing of public goods is called taxing. The price a supplier can ask for by necessity is at a tax level. This tax is calculated as follows:

$$\begin{aligned} p^* &= \left(\tfrac{p_1}{4} \times (1-\rho)\right) \\ \rho &= \tfrac{p_1 q_1}{p_1 q_1^*} \end{aligned} \tag{2.2}$$

(p_1) is the equilibrium price in Fig. 1. (q_1) is the quantity consumed before space industrialization shown in Fig. 1. (q_1^*) is the quantity consumed at equilibrium after space industrialization as is shown in Fig. 2. (ρ) is the tax rate. This formulation corresponds to the standard calculations of taxes. Due to the new form of energy supply, producer surplus is redefined in

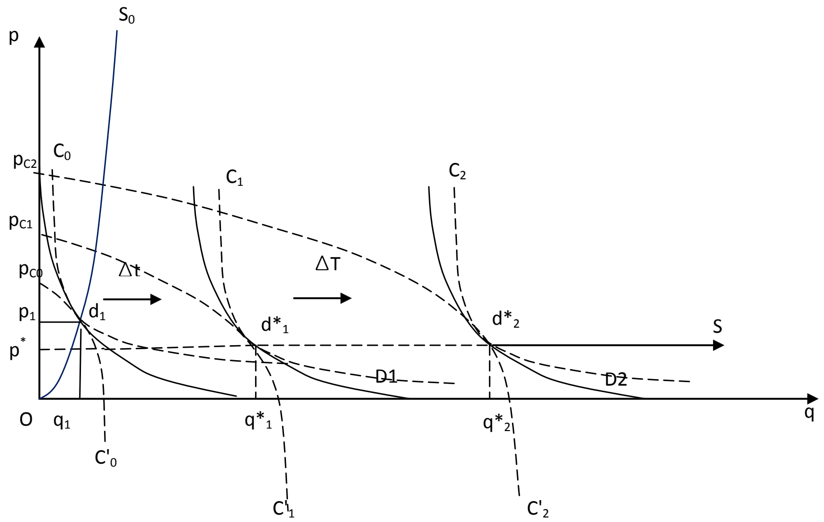

Fig. 4. Consumer surplus

a manner shown in Fig. 3. Consumer surplus on the other hand will keep its traditional form as is shown in Fig. 4.

After period (ΔT) the average and marginal costs go down while the quantity supplied increases at a constant price (p^*). This translates into an increase in producer surplus, (the shaded area in Fig. 3).

In Fig. 4, the consumer surplus before the space industrialization is the area ($\Delta(p_1 d_1 p_{C_0})$). The advent of space industrialization after a period (Δt) increases the consumer surplus by the amount equal to the area ($\Delta(p^* d_1^* p_{C_1})$) which is greater than the consumer surplus before the space industrialization. After period (ΔT) the consumer surplus will still increase by the amount equal to the area ($\Delta(p^* d_2^* p_{C_2})$) which is still greater than the area ($\Delta(p^* d_1^* p_{C_1})$).

3 SPACE EXPLORATION: NEW PRODUCTION

The main beneficiaries of low energy prices are consumers. Cheap, safe, and infinite energy supply would have enormous consequences for the society. Demand would no longer be an incentive for profit based economic activities in the domain of energy. So far it is demonstrated that if the supply of energy products satisfies planetary needs, then demand will stay convex and evolves (shifts to the right) within time intervals (ΔT). A priori this is due to development of more and more uses of energy source. Price would be set at a tax level which makes it possible for all to have access to energy products. The impact of space industrialization and unlimited supply of energy redefines production. Production (P) would be a function of producer surplus ($\delta\sigma_p$),consumer surplus($\delta\sigma_C$), and the level of added values created (AV), ($P = f(\delta\sigma_p, \delta\sigma_C, AV)$). The function ($f(\delta\sigma_p, \delta\sigma_C, AV)$) is non-linear monotonically increasing function. To explain this, lets assume that at the beginning of space industrialization, production is positive at (Δt), ($P^t > 0$). Production after interval (ΔT) is ($P^T = P^t + f(\delta\sigma_p^T, \delta\sigma_C^T, AV^T)$), since production at any time interval is positive, then production during time interval(ΔT) is positive ($P^T > 0$), and since ($P^t > 0$), then the function ($f(\delta\sigma_p, \delta\sigma_C, AV) > 0$) must be positive. The non-linearity of the function ($f(\delta\sigma_p, \delta\sigma_C, AV)$)is due to the behaviour of its elements. To justify the new definition of production and show that production in the space industrialization era is monotonically increasing, the following theorem is introduced.

Theorem: Given that in the space industrialization context a production process (P) continues in successive states ($\epsilon_0, \epsilon_1, .., \epsilon_n..$) and that the transition from state (ϵ_i) to state (ϵ_{i+1})produces strictly positive consumer surplus ($\delta\sigma_C > 0$), and producer surplus ($\delta\sigma_p > 0$), and the added value ($AV > 0$), then at each successive state (ϵ_i),the production process (P) is at its maximum capacity. Note that a state is the level of technological advancement of the production process.

Proof: ($P^0 > 0$)the production process at the start, state (ϵ_0) is positive. Let the next state be defined as ($P^1 = \sup(P^0, P^1)$). This is due to the assumption that both the consumer and producer surplus are positive($\delta\sigma_C^1 > 0$), ($\delta\sigma_p^1 > 0$), and that pricing at a tax level assures that the added value ($AV^1 = \delta\sigma_C^1 - \delta\sigma_C^0 = \Delta\delta\sigma_C^1$) stays positive at each successive state. Since tax level pricing assures positive consumer and producer surpluses and added value, it can be concluded that at each successive state ($P^i = \sup(P^{i-1}, P^i)$), the production process is at its maximum and thus the production function is monotonically increasing. □

Figs. 5, 6, 7 depict the evolution of production as a function of consumer and producer surpluses and added value at each state (ϵ_i). Fig. 5 depicts the production function as a convex monotonically increasing function of consumer and producer surpluses. Fig. 6 depicts the production function as a constricted convex monotonically increasing function of consumer surplus and added value. Fig. 7 depicts the production function as an expanded convex monotonically increasing function of producer surplus and added value. (q) is the quantity produced. The shape of the production function depends on the relative development of consumer surplus to producer surplus and added value.

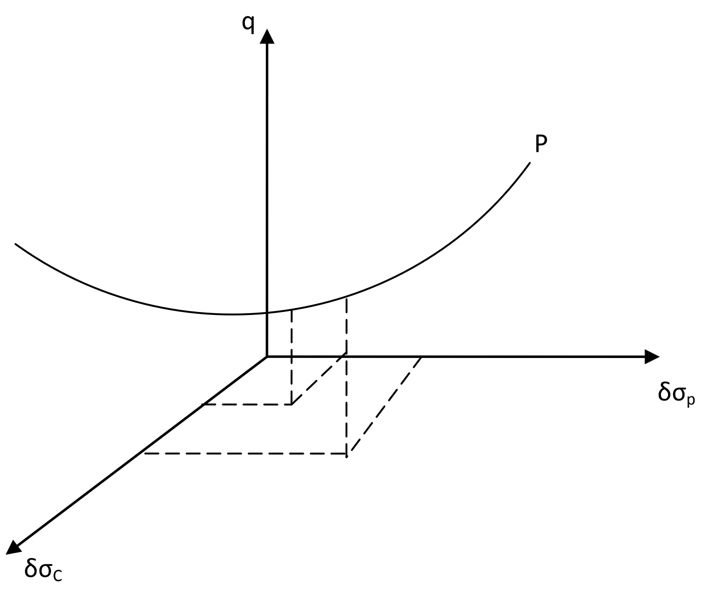

Fig. 5. Evolution of production with respect to consumer and producer surpluses

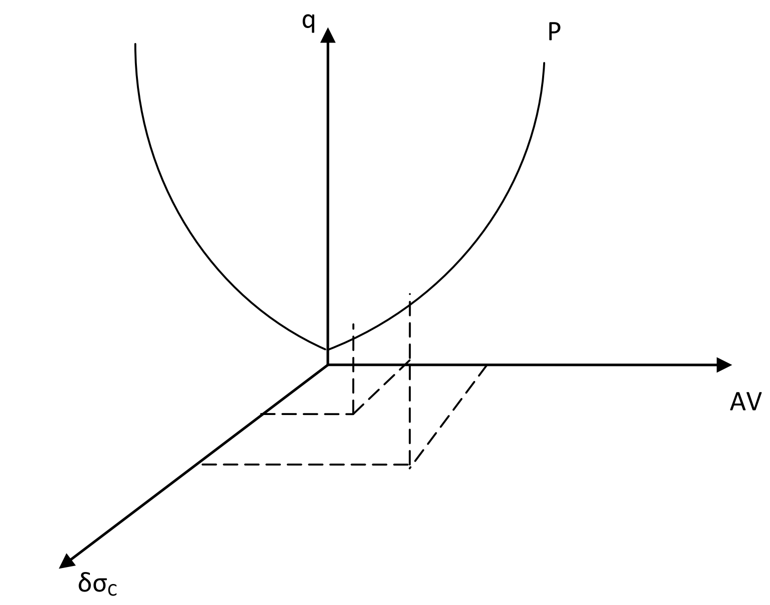

Fig. 6. Evolution of production with respect to consumer surplus and added value

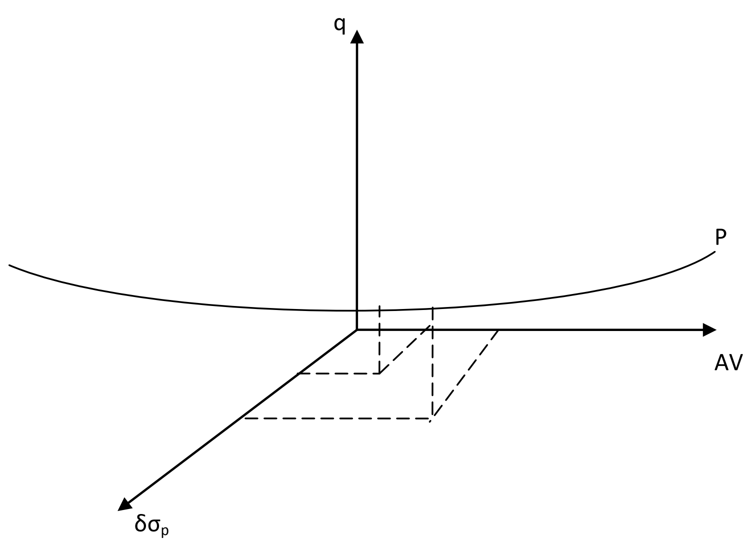

Fig. 7. Evolution of production with respect to producer surplus and added value

4 SPACE EXPLORATION: NEW LABOR AND WAGE

So far it is established that in the new age of space industrialization, supply of energy products are unlimited. It is shown that unlimited supply of energy after space industrialization, transforms this resource into a public good. In this situation the price of energy as a public good has to be similar to a tax. An unlimited supply does not automatically translates into an increase in demand. It takes time for demand to react to this form of supply. Demand increases incrementally during each period(ΔT). Production evolves from state (ϵ_i) to state (ϵ_{i+1}), and it is shown that this evolution is optimal during each interval (ΔT). The optimality of production is the result of strictly positive and monotonically increasing consumer and producer surpluses, ($\delta\sigma_C > 0$), ($\delta\sigma_p > 0$). The added value (AV) is the difference in the level of consumer surplus between two intervals (ΔT), ($AV^\tau = \delta\sigma_C^\tau - \delta\sigma_C^{\tau-1} = \Delta\delta\sigma_C^\tau$) for each ($\tau \in \Delta T$). The added value (AV) is positive from one period to another. In the context of space industrialization the supply of labour can be defined as a function of added value (AV), ($L^i = \Phi(AV^i)$), where (L^i) is the quantity of labour used in production during state (ϵ_i). The unit of labour defined as a function of added value (AV) is the number of labour hired per added value(AV^i) during each state (ϵ_i). Let the quantity of labour at the beginning of space industrialization (ϵ_0)be given as a positive quantity ($L^0 > 0$). After the start of the space industrialization,(ϵ_1), labour can be formulated as ($L^1 = L^0 + \Phi(AV^1)$), and the same formulation applies to other consecutive states (ϵ_{i+1}), ($L^{i+1} = L^i + \Phi(AV^{i+1})$). Given that the added value ($AV > 0$)is strictly positive and increasing after space industrialization, the function ($\Phi(AV^{i+1})$) is a monotonically increasing function. The non-linearity of ($\Phi(AV^{i+1})$) is due to the fact that the added value (AV) evolves within time interval (ΔT). Fig. 8, represents labour (L) as a non-linear function of added value (AV).

Wage (W) corresponds to the new definition of labour. Wage represents the value of labour. Wage is defined to be a function of producer surplus ($W^i = \Omega(\delta\sigma_p^i)$), where ($W^i$) is wage,

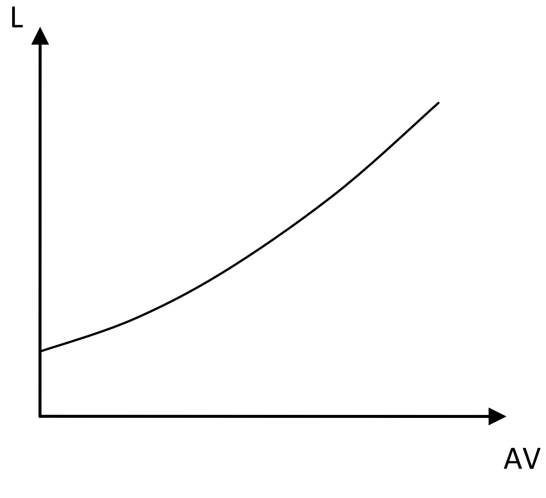

Fig. 8. Labour as a function of added value

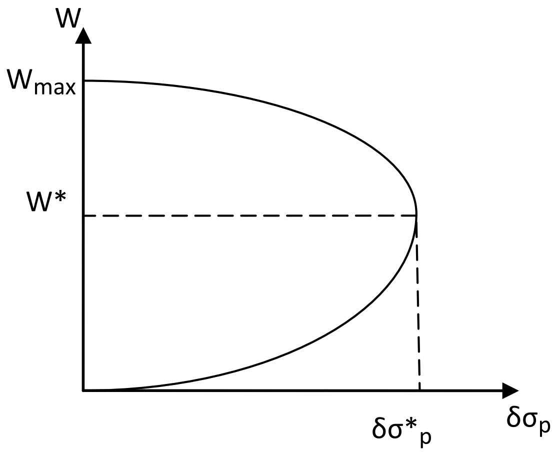

Fig. 9. Wage as a function of producer surplus

and $(\delta\sigma_p^i)$ is the producer surplus and the function $(\Omega(\delta\sigma_p^i))$ is a non -linear monotonically increasing function at state (ϵ_i) of production. The function $(\Omega(\delta\sigma_p^i))$is monotonically increasing since it is shown that the producer surplus is strictly positive and increasing at each state (ϵ_i) of production. The non-linearity of the function $(\Omega(\delta\sigma_p^i))$ is due to the behaviour of producer surplus $(\delta\sigma_p^i)$. The unit of wage is the price of labour per unit of producer surplus. Let (W^0) be the wage level at the start of space industrialization,state (ϵ_0) of production then at state (ϵ_1) the wage is formulated as $(W^1 = W^0 + \Omega(\delta\sigma_p^1))$. Consequently, wage at any state (ϵ_{i+1}) is formulated as $(W^{i+1} = W^i + \Omega(\delta\sigma_p^{i+1}))$. Fig. 8, depicts wage (W) as a function of producer surplus $(\delta\sigma_p)$. In the lower segment of the graph, wage increases as producer surplus increases. At any state (ϵ_{i+m}) for any positive $(m > 0)$, producer surplus reaches an optimal limit which defines a limit for the wage level. $(\delta\sigma*_p)$ is the limit or the optimal level of producer surplus, which corresponds to (W*) the wage limit or optimal wage. In the upper segment of the graph the wage level (W_{max}) corresponds to producer surplus equal to zero $(\delta\sigma_p = 0)$ since this wage level does not correspond to producer surplus. Once the correspondence is established, as the producer surplus increases wage drops to levels that correspond to producer surplus.

5 SPACE EXPLORATION: NEW CAPITAL

Traditional capital is defined to be the function of savings of both consumers and producers. Savings vary as a function of interest rates. Given the new economic background, and the assurance of continual positive surpluses, consumers spend more and save less, and producers are encouraged to invest rather than save and thus the overall level of savings will go down. The downward trend in savings will render the notion of interest rate obsolete. Thus savings will be inelastic with respect to interest rates. Since producers have no real incentive to save due to the possibility of infinite demand and continuous supply, they are more inclined to invest their surplus into production to assure the continuity of supply by improving technological requirements. In the context of the new economic environment mainly the space industrialization, capital can be redefined as as function of producer surplus, $(X^i = \Lambda(\delta\sigma_p^i))$,

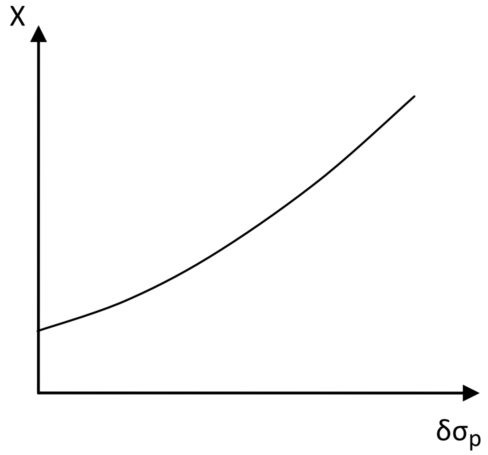

Fig. 10. Capital as a function of producer surplus

where (X^i) is capital, and ($\Lambda(\delta\sigma_p^i)$) is a non-linear monotonically increasing function of producer surplus at state (ϵ_i) of production. Let capital at the beginning of space industrialization, (ϵ_0) be positive ($X^0 > 0$), then at state (ϵ_1), capital is formulated as ($X^1 = X^0 + \Lambda(\delta\sigma_p^1)$) which is similar to wage and labour formulation. Since it is assumed that capital at each state of production is positive, then capital at state (ϵ_1) is positive,($X^1 > 0$), and thus the function ($\Lambda(\delta\sigma_p^1) > 0$) is positive. Therefore capital is monotonically increasing. As the formulation of capital is recursive, then at all consecutive states ($\epsilon_{i+m}, m > 0$), capital ($X^{i+1} = X^i + \Lambda(\delta\sigma_p^{i+1})$) is positive and monotonically increasing. The non-linearity of the function ($\Lambda(\delta\sigma_p)$) is due to the nature of the producer surplus and the way it evolves during each interval (ΔT) and each state (ϵ_i). Fig. 9, depicts the evolution of capital with respect to producer surplus.

6 CONCLUSION

The aim of this paper is to open the way to a new way of economic thinking. Present economic laws are based on one fundamental concept, and this concept is demand. In the conventional economy demand is the incentive behind all activities. Supply has one main function, and it is to accumulate profit by satisfying demand. In fact for almost all products and natural resources supply is limited. Finite supply makes for fierce competition among producers. Though the outcome of competition is beneficial for consumers as it pushes prices to equilibrium, it is observed that in the majority of cases, the prices stay at relatively high levels. For the most part, only a fraction of the worlds population has access to products that are essential for survival.

In this paper the hypothesis of unlimited energy supply due to space industrialization is explored. If it was possible to have an infinite supply of energy sources, and energy by-products, what would be the consequences for the world economy? An answer is provided under the context of solar energy exploration from a lunar base. The consequences for the economy would mainly be the dominance of consumer surplus which in turn triggers producer surplus. Significant consumer surplus and positive producer surplus translates into the creation of added value. Capital which will depend on producer surplus due to the production of goods with real economic values is perpetually replenished and there is no need to rely on savings and interest rates. Lunar based energy exploitation will open a whole new horizon for humanity with the possibility of human evolution beyond imagination.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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