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ENTROPY AND ASSIMILLATIVE CAPACITY AND A REVISED THEORY

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ENTROPY AND ASSIMILLATIVE CAPACITY AND A REVISED THEORY OF FACTOR-UTILIZATION

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ABSTRACT: The recognition of two important concepts in science, namely the assimilative capacity of nature and the entropy of law of thermodynamics enables the formulation of an alternative framework for factor-utilization in economics. This framework, which includes environmental capital (KN) as a factor, enables the illustration of the entropy law being the driver of diminishing marginal returns and the limited ranges of substitutability between factors. The paper also illustrates the estimation of KN utilization as point-estimates for Australia. These estimates when compared with the rates of economic growth suggest the presence of entropy.

1. INTRODUCTION

Concepts of entropy and assimilative capacity have seldom found recognition in mainstream economics. Notwithstanding controversies surrounding the relevance of entropy (Daly 1992; Townsend 1991; and Gowdy and Messner 1998), the lack of recognition, is due, at least in part, to mainstream's exclusion environmental capital (KN) from the list of explanatory factors for output (Y) determination. For example, frameworks of factor-utilization in most widely used texts (Mankiw 2004, Taylor 2009) have usually confined the explanation of Y to the role of Labour (L) and manufactured capital (KM). The exposition of these frameworks {Y = f(L, KM)} in these texts includes the display of diminishing marginal returns of Y with respect to the utilization of (KM, L) and the substitutability between KM and L. The exposition, however, fails to recognize the role of entropy stemming from KN utilization as the primary source of such diminishing marginal returns. Further, the recognition of

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[Ψ] With the usual disclaimers, I remain grateful to T. N. Srinivasan, Azad Singh Bali and Krishnan Chandramohan for useful comments. Further, the formulation of basic ideas in this paper was feasible primarily due to collaboration with environmental scientists both at the National University of Singapore and Macquarie University assimilative capacity that is inherent in KN leads to a limited domain of substitutability between factors. The object of this paper is to propose a conceptual framework that permits the illustration of these effects.

The relevance of entropy to economics has been persuasively argued by Georgescu-Roegen (1970), Ruth (1993), Cleveland and Ruth (1997) and Gowdy and Messner (1998). The paper also draws on the work of Schneider and Kay (1994) who propose a reformulated version of the entropy law with reference to ecological systems.

As illustrated in the next section, combining the concept of assimilative capacity with that of entropy enables the development of a framework to illustrate entropy as the primary source of diminishing marginal returns. This illustration is made with reference to a factor-utilization framework that includes KN; that is, {Y = g(L, KM, KN)}.

The paper is structured as follows. The next section deals with the display of a specific factor-utilization framework that stems from the recognition of KN and its assimilative capacity. This display then enables in Section III, the illustration of how the utilization of KN can raise the level entropy and thereby become the source of diminishing marginal returns (Section IV). Besides, as shown in Section V, the altered factor utilization framework limits the extent of substitutability between factors. Section VI provides a methodology for estimating the utilization of KN within a macroeconomic context. The estimates are illustrated with reference to Australia and support the observation that economic growth is an entropic process.

II. ASSMILATIVE CAPACITY OF KN AND FACTOR UTILIZATION

Following Ruth (1993) and Gowdy and Messner (1998), KN has to be represented by ecosystems and not individual resources or items as for example suggested by Fisk

(2011). As illustrated in environmental science (Landis 2008), ecosystems are capable of retaining their characteristics up to a certain limit of contamination and utilization. The domain of this limit represents assimilative ability and the upper limit of the domain defines assimilative capacity. The definition of such domains requires a metric for KN. As indicated in Thampapillai and Ohlmer (2009), this metric could take the form of an index that aggregates the various attributes of an ecosystem. In other studies (for example, Thampapillai 2012) where the utilization of KN is estimated at the aggregate level, the same metric as that applied to KM stock can be applied to KN. This latter approach is considered in Section VI.

Consider now the factor-utilization function:

$$\{Y = g(KN, \overline{KM}, \overline{L})\}, \tag{1}$$

Figure-1 illustrates this function. Here KM and L are held constant at some level $\overline{KM}$ and $\overline{L}$; and the illustration is based, as explained above, on the premise that the size of KN is quantifiable. As illustrated the domain axis displays a clear distinction between the accumulation and utilization of KN. The accumulation of KN runs from left to right, whilst its utilization runs from right to left. Note that the accumulation of KN will involve a much longer time compared to the utilization of KN.

In conceptualizing the relationship between Y and KN (given fixed levels of KM and L), it is possible to argue that the assimilative capacity of KN enables the portrayal of a specific shape as per Figure-1. As shown, the function has a fixed domain. Such domain exists because there is a fixed upper limit for KN. The laws of nature and the level of economic activity dictate this upper limit. For example in the case of KN being represented by air quality, the law of nature dictates that there cannot be more than 20% oxygen in the air. Similarly, it is not possible to exceed a certain level of dissolved oxygen in water. So, in the primitive state, where ($Y = 0$), KN has maximum capacity which is denoted by KN_U. However, this upper limit can reduce in the context of economic activity leading to higher levels of Y. For the function displayed in Figure-1, the upper limit is defined as KN_A.

For the moment ignore the issue of time and consider an increase in KN, say from the origin whilst holding KM and L constant. There will be an increase of Y. However, beyond a certain threshold level of KN, denoted by KN_T in Figure-1, increases in KN, have no further effect on the size of Y. This can be explained in the reverse order as well. That is, when KN reduces in size from its upper limit (KN_A) – again whilst holding KM and L constant, Y remains unaffected until KN reduces to KN_T. When KN reduces below KN_T, then Y begins to fall. This can be explained by the fact that KN has the characteristic of *assimilative ability*. Therefore, for the factor-utilization function displayed in Figure-1, the domain ($KN_T \leftrightarrow KN_A$) is the region of assimilative ability, and KN_T denotes the boundary between the two zones. In the primitive case where ($Y = 0$), the domain of assimilative ability is represented by $\{0 \leftrightarrow KN_U\}$. The state ($Y = 0$) is consistent with the lowest level of entropy for the system representing KN. Unlike in the standard factor-utilization function in economics texts, the rational zone of production in Figure-1 will be the zone of assimilative ability. The reasons for this are outlined below.

III. ENTROPY AND FACTOR UTILIZATION

Figure-2 displays a family of curves for the factor-utilization function (Y), where $\overline{KM}$ and $\overline{L}$ remain fixed - but at different levels; for example, $(\overline{KM}_{3}, \overline{L}_{3}) < (\overline{KM}_{4}, \overline{L}_{4})$, and accordingly $Y_4 > Y_3$. That is, as the level of $(\overline{KM}, \overline{L})$ gets higher, the size of Y becomes larger. Further, because raising the intensity of KM and L inevitably involves the enhanced utilization of KN, the maximum upper limit of KN recedes to the left. As a result, the zone of assimilative ability becomes smaller. The enhanced utilization of KN for achieving higher levels of Y enables the illustration of the law of entropy. A simplified expression of this law is that when matter is transformed from one state to another, entropy increases. Entropy by itself is the amount of energy or matter that is not available for work. Hence, the utilization of KN and the associated reduction in its upper limit leads to the increase in entropy of the remaining stocks of KN. This in turn warrants the utilization of higher quantities of KN for further increases in Y of similar magnitudes. Support for this proposition comes from the work of Schneider and Kay (1994) who submit a reformulated second law with respect to ecosystems. They relate the thermodynamic concept of energy gradient dissipation to biological systems and provide evidence to support the claim that more mature (complex) ecosystems will harness greater amounts of incoming solar energy For example, a 400-year Douglas fir forest retains 90% of incoming energy whilst clear-cut grassland retains only about 60% of incoming energy. The corollary of this evidence is that KN utilization leaves behind an ecological system that has high entropy and hence of lower quality. As a result, successive increases in Y warrant successively greater utilization of KN.

Another feature in Figure-2 is that the gradient of the factor-utilization function, δ, for a given value of Y is shown to be steeper at higher levels of $(\overline{KM}, \overline{L})$ than at lower levels. This implies that when KN deteriorates to a level below its threshold level (KN_T), then the fall in output is much faster at higher $(\overline{KM}, \overline{L})$ levels than at lower levels. Hence, this gradient is a convenient proxy for KN's rate of degradation. The explanation proposed thus far enables the argument that at higher intensities of $(\overline{KM},$

$\overline{L}$), KN becomes increasingly fragile. A variety of contexts regardless of whether it is a farm-firm or a factory floor with a production line or the overall economy, illustrate the feature of increasing fragility of KN. For example, the higher the intensity of industrial plants on a lakeshore – the lesser the intensity of the ecosystem supporting the lake – and hence higher the vulnerability of the lake.

In order to reinforce the conceptualization presented in Figure-2 consider the movement from **a** to **b** in Figure-2 involving an output increase from Y_3 to Y_4. This increase in output is associated with the contraction in the domain of assimilative ability by $\{KN_3 – KN_4\}$. This contraction is in fact the amount of KN utilized to support the increase in output. Such utilization raises the entropy of remaining stock of KN. That is, if $\{\Delta k = (KN_3 – KN_4)\}$ is the amount of KN that is utilized or lost when Y increases from Y_3 to Y_4, then further increases in Y would warrant Δk to increase due to entropy.

IV TRANSFER OF ENTROPY AND TIME

Figure-3 illustrates the transfer of entropy from KN to KM and L in the form of diminishing marginal returns. For illustrative purposes, suppose that K represents a composite measure of KM and L. Further, suppose that the utilization of KN can be also measured in the same metric denoted by k. The left hand panel of Figure-3 displays the family of curves for the function $\{Y = g\ (KN,\ \overline{KM},\ \overline{L})\}$ that was considered thus far. The right hand panel illustrates the elicitation (from the left hand panel) two types of functions both displaying diminishing marginal returns. But the primary source for this display is evident in the left hand panel. Also, note that when the utilization of KN is ignored in the right hand panel of Figure-3, the role of KM and L is over-stated. For example, output level Y_3 could be attributed to the role of (KM+L) as K_3. But, as shown, when the utilization of KN is also considered, the output level Y_3 is truly due to the influence of $(K_3 + \Delta k_2)$

Consider now the introduction of time. Figure-4 displays two functions drawn from Figure-2 pertaining to $(\overline{KM}_{3,}\ \overline{L}_3)$ and $(\overline{KM}_{4,}\ \overline{L}_4)$. The time taken for the movement from point **a** to point **b** is relatively short (T_0 to T_1) compared to the time taken for the movement from point **a** to point **c** (T_0 to T_T). The former involves utilizing KN whilst the latter involves augmenting KN. The move (**a** → **b**) will give higher income within a short time but at the cost of higher entropy and fragility. Alternatively, the move (**b** → **c**) will not add to income but over a longer time would lower entropy and enhance stability of the resource system. As an example consider the fact that a tree can be felled and a table made from it – all within a week. But it could take several years for a seedling to grow into a tree of the same dimensions as that was felled.

If business managers and policy makers acknowledge this type of factor-utilization functions (that is, as shown in Figures1-4), then one would expect to observe changes in business strategies and the policy environment5. Increasing the intensities of KM and L to achieve higher levels of output may not always prove to be prudent, because with the increasing fragility of KN, production capability could be easily lost. These pressures become more explicit when we consider substitution behaviour within the framework of isoquants.

V. ENTROPY ASSIMILATIVE CAPACITY AND FACTOR SUBSTITUTION

In order to keep the illustration at a two-dimensional level, KM and L will continue to be regarded as a composite factor input (K) as in the previous section. So, the expression in (1) will be modified to read as $\{Y = g_1[K, KN]\}$. The isoquants that describe this factor-utilization function are shown in Figure-5. Note that there is a correspondence between these isoquants and the factor-utilization function shown in Figure-2. One can envisage the existence of a family of infinite number of curves (of the type shown in Figure-2) in KN-Y space. If one were to take a series of horizontal cross-sections on Figure-2, then the isoquants of the type displayed in Figure-5 would unfold.

Consider the isoquant labelled $I_1I_{1.}$ Substitutability between KN and K begins when the size of KN falls below its threshold level KN_T. That is there no substitutability between factors in the region of assimilative ability which is defined by $\{KN_T < KN < KN_1\}$. Substitutability between KN and K also ceases at some extremely low level of KN, where output approaches zero. At this level the isoquant tends to become asymptotic to the vertical axis implying that infinite quantities of K are required to replace KN. For each isoquant, the region of substitutability ranges between 0 and KN_T. However, with a higher isoquant, say I_2I_2, the gradient of the isoquant (dK/dKN), namely ($MRS_{K,\ KN}$) is shown to be steeper. That is at higher levels of Y, larger quantities of K need to be given up for a small increase in KN.

In standard microeconomic theory, the ridge lines help distinguish the convex region of the isoquant from the rest. This then helps understand the nature of substitution behaviour in the rational zone of production. It is not possible to directly extend this rationale to the conceptualization proposed here. This is because the region of convexity which displays the possibility of substitution behaviour is also the region of vulnerability. The rational zone of production is the region of assimilative ability where no substitution possibilities exist. If decision makers are to be guided by the rationality of retaining sustainability and stability, then ridge lines will consist of the vertical line drawn at KN_T and the line or curve that connects the upper limit of the successive factor-utilization functions.

In standard theory, the analysis of isoquants also helps determine the input mix of factors. The difficulty in extending this to the revised framework is the absence of a price for KN. But, it is certainly clear that a decision maker should not choose a production strategy that involves the region ($0 \leftrightarrow KN_T$). This is because the producer runs the risk of losing his/her production capability. Alternatively, the producer may nominate, (if they are able identify it), the upper limits (that is KN_1, KN_2, ..., KN_Q) as the basis for an expansion path, but, needs to be cautious of the fact that the gap between the upper and lower thresholds (KN_T) becomes progressively narrower as the intensity of K gets higher.

Further, if the price of KN is deemed to be zero, the budget line is always horizontal, and the utilization strategy for KN would always be within the region of assimilative ability. One major implication of the framework considered thus far concerns the relationship between the government and business. If governments wished to force business managers to operate within the region of assimilative ability and higher stability, then they would have to place taxes on K so that the choice of factors occurs at a stable level of output. This type of government intervention can have a positive spin-off. It could force industries to innovate and extend the productivity of KN by way of technology instead of by accumulating more K.

VI. ESTIMATION OF KN AND EVIDENCE OF ENTROPY

This section deals with the extension of the concepts advanced thus far to illustrate KN utilization at the macroeconomic level. The availability of aggregate level data on L, KM and pertinent aspects of KN – especially its depreciation – is the basis for choosing the macroeconomic level for the illustration. Following earlier analyses (Thampapillai 2012), this illustration involves the display of discrete point-estimates of KN utilized for each year in a time series 1970-2011 for Australia. The presence (or absence) of entropy at the aggregate level can be ascertained by comparing the rate of increase of Y with that of KN utilized; that is, $\left(\frac{\dot{Y}}{Y}\right)$ and $\left(\frac{\dot{KN}}{KN}\right)$. That is, to examine whether progressive attempts to increase Y require progressively greater rates of utilization of KN. Therefore in the context of an increase in $\left(\frac{\dot{Y}}{Y}\right)$, the evidence of entropy may be ascertained by the display of:

$$\left\{\left(\frac{\dot{KN}}{KN}\right) > \left(\frac{\dot{Y}}{Y}\right)\right\} \qquad (2)$$

The elicitation of the point-estimates of KN follows the assignment of specific functional forms for the aggregate level factor-utilization functions {Y=f(KM, L)} and {Y=g(KM, L, KN)}. Most macroeconomic texts describe the former in terms of a Cobb-Douglas (CD) function of constant returns to scale:

$$Y_t = \alpha_t \, KM_t^{\theta_t} \, L_t^{\lambda_t} \qquad (3)$$

Where θ_t and λ_t represent the factor shares of national income (Y_t) in time t accruing respectively to KM and L and owing to constant returns to scale ($\theta_t + \lambda_t$,= 1). These factor shares of income are explicit in the income accounts where the following identity prevails:

$Y_t \equiv$ {Compensation to Employees (CE_t)} + {Operating Surplus (OS_t)} (4)

Hence:

$$\lambda_t = \frac{CE_t}{Y_t}; \qquad \theta_t = \frac{OS_t}{Y_t} \qquad (5)$$

The function in (3) could be extended to the context of {Y=g(KM, L, KN)} by recourse to the principles of environmental accounting where

{Y_S (Sustainable Income) = Y (National Income) – D_{KN} (Depreciation of KN)} (6).

Suppose that D_{KN} is a constant proportion η of Y. That is, $\eta = [D_{KN}/Y]$. Then multiplying (3) by (1−η) would be tantamount to stating the expression in (6). However, the expression in (3) needs modification to explain the role of KN. For this purpose, assume the existence composite capital $\overline{K}$ which includes both KM and KN; that is $\overline{K}$=KM+KN. Further assume that the composite capital $\overline{K}$ will receive the same factor share of income as KM in (1). This assumption implies that the factor share of income (θ) is shared between KM and KN and the function that includes role of KN utilization is:

$$Y_t = (1 - \eta_t)\,\alpha_t\,(\overline{K}_t)^{\theta_t} L_t^{\lambda_t} \qquad (7)$$

The underlying premise in (6) is that the utilization of KN is synonymous with the depreciation of existing stocks of KN. Figure-6 displays the two functions: (3) and (7). This display is a variant of the right hand panel of Figure-3. As per the function labelled {Y=f(KM, L)}, income level Y_t would be attributed to the role of KM_t and, such attribution over-states the contribution of KM_t. The exacerbation of factor contribution is assumed to be D_{KN}.

The role of KN in determining Y_t can be then explained by the fact that the amount of $\overline{K}$ needed to explain Y_t, namely $\overline{K}_t$ is greater than KM_t. Hence for every point on the locus describing {Y=f(KM, L)}, there exists a corresponding quantity of $\overline{K}$ which is in excess of KM. The locus of these points, namely the coordinates of ($\overline{K}$, Y) constitutes the function described in (7). Further, with respect to the formulation offered in (7), should ($KN_t \rightarrow 0$), then ($\eta_t \rightarrow 0$), and the definition of factor-utilization, would tend towards that offered in (3). The basis for identifying KN is also provided in Figure-6. Here, Y_t is attributed to KM_t in {Y=g(KM, L)}; and the same quantum of Y_t is also attributed to $\overline{K}_t$ in {Y=g(KM, L, KN)}. Because ($\overline{K}_t = KM_t + KN_t$), the quantity of KN_t utilized in the formation of Y_t would be ($\overline{K}_t - KM_t$).

The value of $\overline{K}_t$ can be resolved by equating (2) and (6) as follows:

$$\overline{K}_t = \left(\frac{1}{(1-\eta)}\right)^{\frac{1}{\theta}} \cdot KM_t \qquad (8)$$

And hence:

$$KN_t = \left[\left(\frac{1}{(1-\eta)}\right)^{\frac{1}{\theta}} - 1\right] \cdot KM_t \qquad (9)$$

Table-1 provides an illustration of the estimates of KN for Australia by recourse to the application of (9).This table contains also the pertinent information required for the estimation. In this illustration D_{KN} has been confined to the cost estimates provided in the World Development Indicators for: of CO2 and particulate emission damages; energy and natural resource depletion. Had other components of D_{KN} such as bio-diversity loss, soil erosion, deforestation and water pollution been considered, then the size of KN would be considerably larger. Nevertheless the application of the test proposed in (2) above reveals that the average values for $\left(\frac{\dot{Y}}{Y}\right)$ and $\left(\frac{\dot{KN}}{KN}\right)$ over the 30 year period 1970-2009 are respectively 0.03 and 0.07. That is, on average, a 3 percent increase in economic growth requires a 7 percent increase in KN utilization. This observation does suggest that economic growth is accompanied an increase in entropy.

VII. CONCLUDING REMARKS

As illustrated above, the recognition of entropy and assimilative capacity enables the conceptualization of a specific type factor-utilization framework. The adoption of such a framework would have far reaching implications policy analyses – especially with reference to the trade-offs between higher income targets and the vulnerability of supporting ecosystems. Attention would also be given to policy initiatives that focus on minimizing the extent of environmental capital depreciation. Examples of these include: the development of renewable and low green house emission technologies instead of further exploration for fossil fuels; and the promotion of innovative closed-loop production systems that reuse wastes and emissions. Further the estimates of KN at the macroeconomic level indicate the presence of entropy at least in the Australian context.

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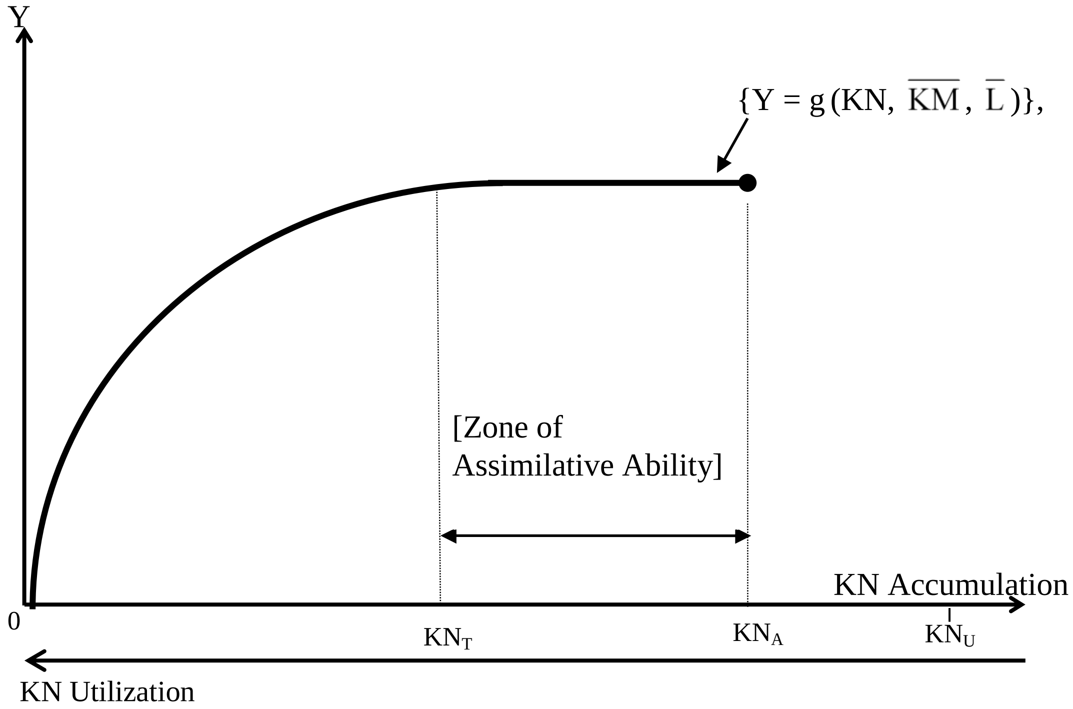

Figure-1: Assimilative Capacity and Factor-Utilization

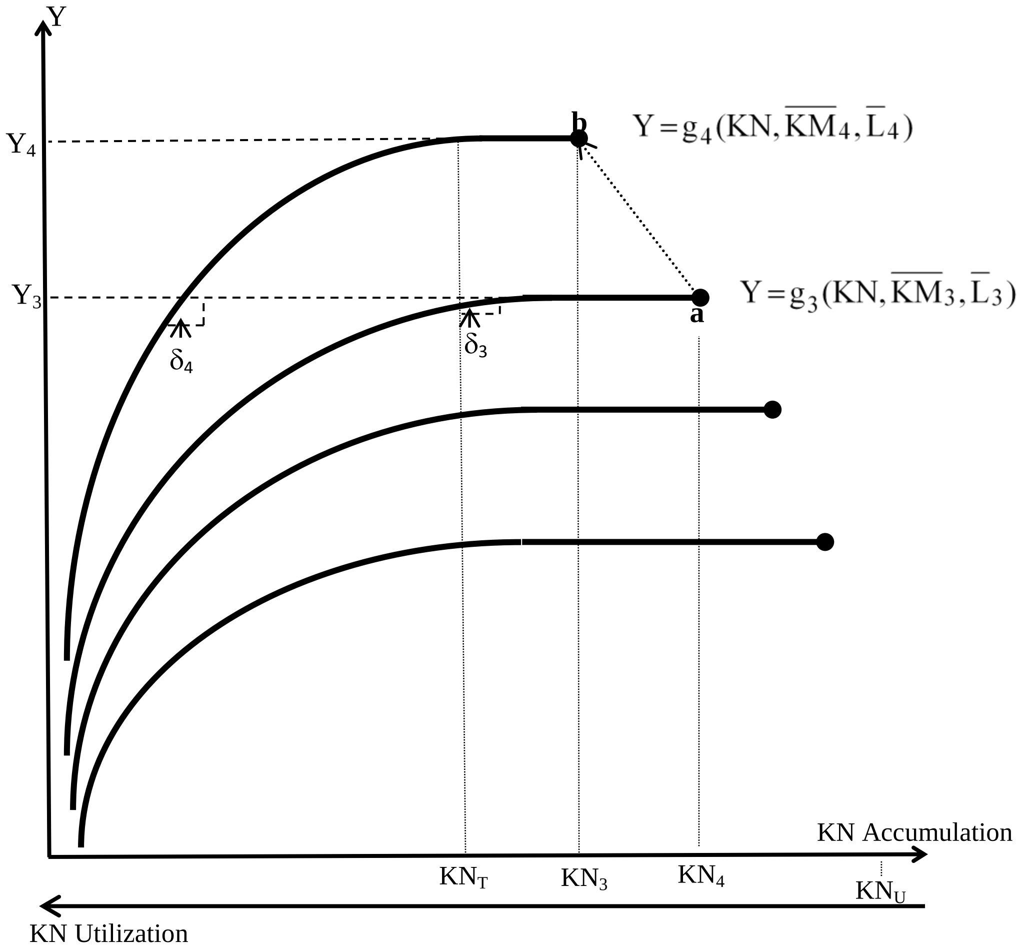

Figure-2: Entropy and Factor-Utilization

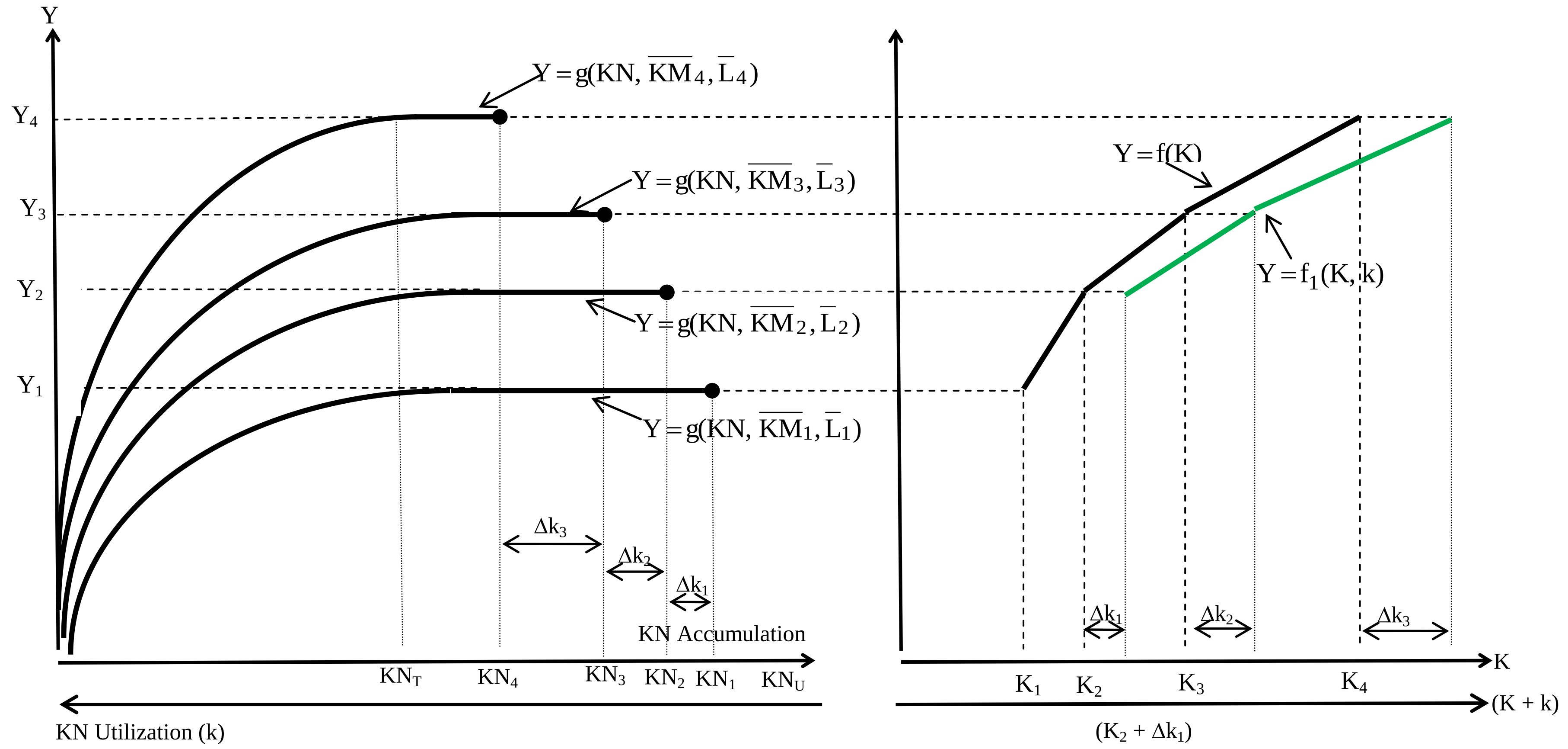

Figure-3**:** From Entropy to Diminishing Marginal Returns

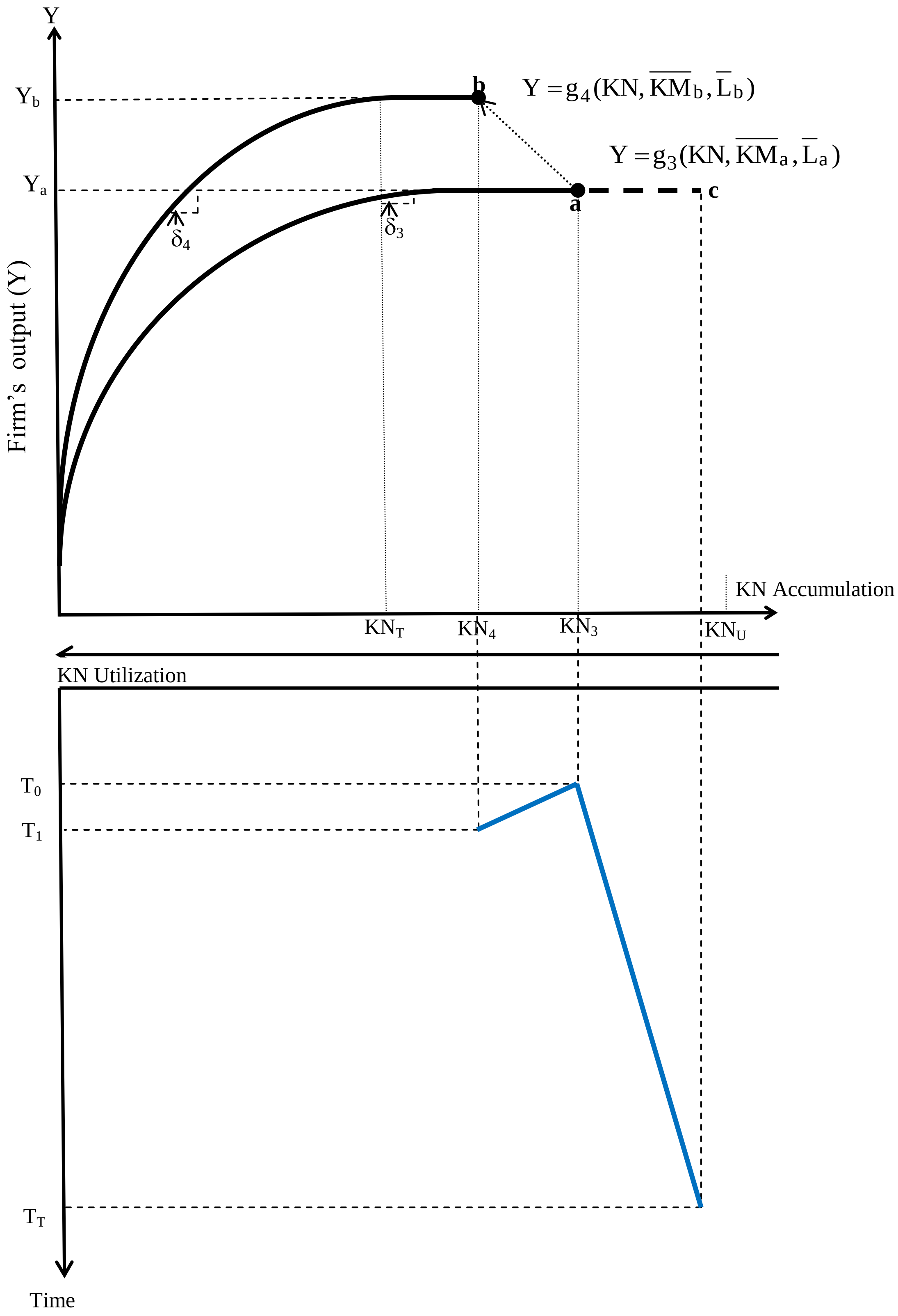

Figure-4: Utilization Vs Augmentation of KN and Time

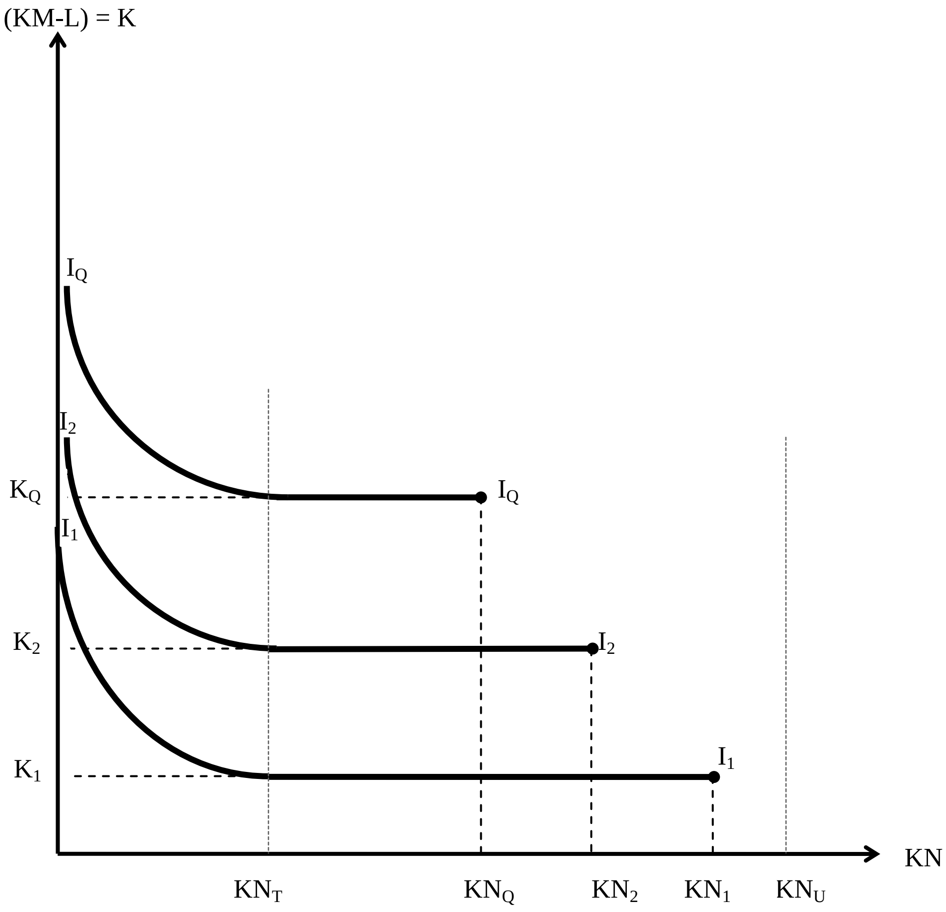

Figure-5: Revised Theory of Isoquants

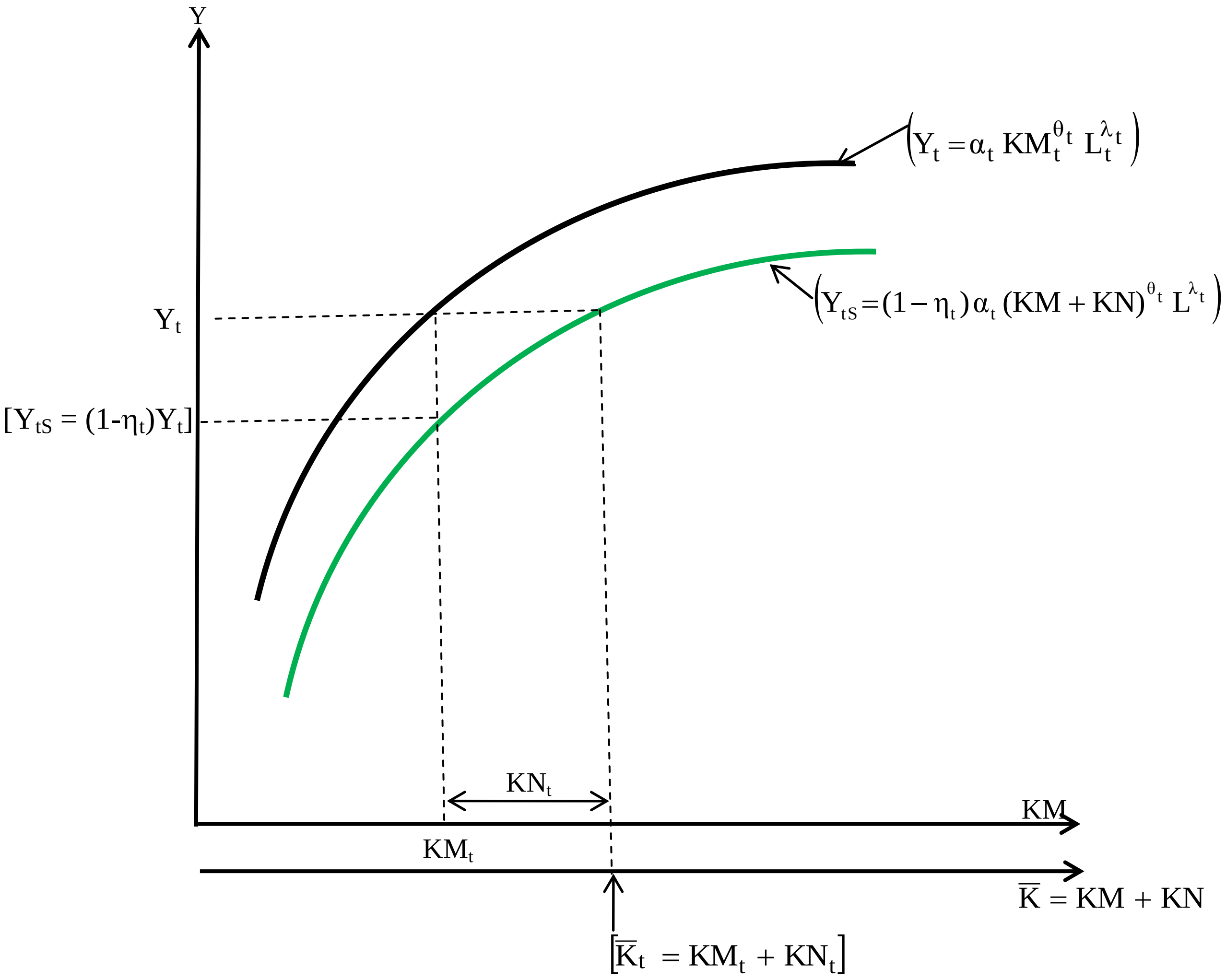

Figure-6: The Conceptual Basis for the Estimation of KN

Table-1: Estimates of KN Utilization and Income in Australia

Year	D_{KN}	KM	Y	η	θ	KN_t
1970	1.401E+10	1.731E+12	3.146E+11	4.454E-02	4.367E-01	1.904E+11
1971	1.603E+10	1.777E+12	3.217E+11	4.983E-02	4.318E-01	2.233E+11
1972	1.575E+10	1.818E+12	3.358E+11	4.691E-02	4.361E-01	2.117E+11
1973	1.820E+10	1.872E+12	3.526E+11	5.161E-02	4.251E-01	2.486E+11
1974	2.416E+10	1.915E+12	3.707E+11	6.518E-02	3.728E-01	3.796E+11
1975	2.490E+10	1.956E+12	3.691E+11	6.747E-02	3.763E-01	3.989E+11
1976	2.692E+10	1.998E+12	3.706E+11	7.263E-02	3.870E-01	4.299E+11
1977	3.050E+10	2.035E+12	3.732E+11	8.174E-02	3.842E-01	5.057E+11
1978	2.947E+10	2.084E+12	3.904E+11	7.549E-02	4.128E-01	4.365E+11
1979	4.352E+10	2.131E+12	3.997E+11	1.089E-01	4.232E-01	6.672E+11
1980	4.812E+10	2.187E+12	4.142E+11	1.162E-01	4.134E-01	7.615E+11
1981	4.503E+10	2.255E+12	4.323E+11	1.042E-01	4.013E-01	7.111E+11
1982	4.127E+10	2.293E+12	4.117E+11	1.002E-01	3.865E-01	7.207E+11
1983	3.835E+10	2.341E+12	4.333E+11	8.849E-02	4.240E-01	5.718E+11
1984	4.172E+10	2.399E+12	4.468E+11	9.339E-02	4.240E-01	6.243E+11
1985	5.066E+10	2.464E+12	4.647E+11	1.090E-01	4.268E-01	7.652E+11
1986	3.614E+10	2.525E+12	4.824E+11	7.492E-02	4.333E-01	4.971E+11
1987	3.977E+10	2.595E+12	5.083E+11	7.824E-02	4.493E-01	5.159E+11
1988	3.794E+10	2.681E+12	5.304E+11	7.154E-02	4.569E-01	4.729E+11
1989	3.041E+10	2.763E+12	5.404E+11	5.628E-02	4.457E-01	3.835E+11
1990	3.858E+10	2.810E+12	5.222E+11	7.388E-02	4.368E-01	5.398E+11
1991	3.379E+10	2.845E+12	5.239E+11	6.450E-02	4.388E-01	4.669E+11
1992	3.322E+10	2.893E+12	5.553E+11	5.982E-02	4.492E-01	4.259E+11
1993	3.560E+10	2.946E+12	5.667E+11	6.282E-02	4.526E-01	4.542E+11
1994	3.533E+10	3.019E+12	5.959E+11	5.930E-02	4.478E-01	4.415E+11
1995	3.437E+10	3.084E+12	6.168E+11	5.573E-02	4.411E-01	4.281E+11
1996	3.771E+10	3.154E+12	6.403E+11	5.889E-02	4.320E-01	4.758E+11
1997	3.559E+10	3.237E+12	6.694E+11	5.317E-02	4.396E-01	4.283E+11
1998	3.816E+10	3.331E+12	6.950E+11	5.491E-02	4.334E-01	4.636E+11
1999	3.941E+10	3.436E+12	7.407E+11	5.320E-02	4.391E-01	4.555E+11
2000	5.749E+10	3.517E+12	7.479E+11	7.687E-02	4.372E-01	7.061E+11
2001	6.139E+10	3.609E+12	7.759E+11	7.912E-02	4.502E-01	7.252E+11
2002	6.251E+10	3.719E+12	7.909E+11	7.903E-02	4.493E-01	7.479E+11
2003	6.493E+10	3.848E+12	8.332E+11	7.793E-02	4.545E-01	7.521E+11
2004	7.095E+10	3.982E+12	8.590E+11	8.259E-02	4.530E-01	8.346E+11
2005	8.481E+10	4.128E+12	8.941E+11	9.485E-02	4.552E-01	1.011E+12
2006	9.666E+10	4.284E+12	9.308E+11	1.039E-01	4.539E-01	1.171E+12
2007	1.086E+11	4.461E+12	9.716E+11	1.118E-01	4.567E-01	1.322E+12
2008	1.451E+11	4.619E+12	9.696E+11	1.496E-01	4.599E-01	1.952E+12
2009	1.067E+11	4.758E+12	9.613E+11	1.110E-01	4.577E-01	1.394E+12