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ON THE ECONOMY OF COMPUTER INDUSTRY

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ABSTRACT

This paper try to show that Von Neumann model is a more robust, useful and flexible tool than many have been realized. It tries to show that the tools of Von Neumann model are useful enough to understand the present behavior of the economy of computer industry. The paper elaborates over and explains the Von Neumann mathematical model. It shows when and how Von Neumann stationary equilibrium state will happen. It drew useful conclusions. It opens the door to further investigations on the same direction.

Keywords: *Conventional And Computer Industry, Economics Of E-Business, Information Technology, Von Neumann's Model*

1. INTRODUCTION

Von Neumann's model was first presented at a lecture at Princeton university in 1932, published in Austria in German language at 1938 [3], and translated by Oskar Morgenstern, and published in English in 1945 [4]. It also appears in the collected works of 1967 [5].

Some works done by [1], [2], [6] and [7] try to show that Von Neumann model is a more robust, useful and flexible tool than many have been realized.

This paper tries to understand the economy of computer industry using the tools of Von Neumann model. First, the Von Neumann model, its stationary equilibrium state followed by a discussion will be given. Second the computer industry case will be considered and explained using Von Neumann model. Finally, a conclusion and further work will be given.

2. THE VON NEUMANN MODEL

At Von Neumann model [3],[4] and [5], the economy is envisioned as having:

1-n goods,

2-m processes that use and create goods, the nature of these processes is defined by their inputs and outputs over a standard time,

3-Input matrix $A = (a_{ij})$,

4-Output matrix $B = (b_{ij})$, with non-negative coefficients, Von Neumann required The matrices A and B to satisfy

$$\forall\, i,j : a_{ij} + b_{ij} > 0 \tag{1}$$

this is a "strong mixing" condition designed to prevent the economy from decomposing into independent pieces,

5-An intensity vector $x = (x_i)$, with non-negative entries, Von Neumann normalized x by requiring $(\sum_i x_i = 1)$. Process i, run at unit intensity, requires an input a_{ij} of good j, and produces b_{ij} units of good j. Processes are scalable, and process i, run at intensity $x_i \geq 0$, requires $a_{ij}x_i$ units of j,

6-A price vector $p = (p_j)$, with non-negative entries, von Neumann normalized p by requiring $(\sum_j p_j = 1)$,

7- $\alpha \geq 0$, the compounder for growth,

8- $\beta \geq 0$, the compounder for interest.

3. VON NUMANN STATIONARY EQUILIBRIUM STATE

Von Neumann was looking for a stationary equilibrium state. That is, prices were to remain constant, and in each cycle, intensity vector grew (or shrank) by the constant factor $(\alpha : x^k \geq \alpha x^{k-1})$.

When aforementioned equation **(1),** is satisfied, there exist vectors $x \neq 0$, $p \neq 0$, $\alpha \geq 0$ and $\beta \geq 0$ such that :

$$\forall\, j: (A^t \alpha\, x)_j \leq (B^t\, x)_j, \tag{2}$$

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The equation says "goods must be created to be used". Von Neumann pointed out that a process might employ a tool of one age, and output that tool as an older tool, to be regarded as a different good. Similarly, storage is a process. If the accounting cycle is a year, the output of storing a 5 year old merchandize is a 6 years old merchandize, which is a different good.

$$if\ (A^t \alpha x)_j < (B^t x)_j\ then\ p_j = 0 \quad (3)$$

The equation says "goods in surplus become free goods". Since bargain sales are possible processes, only goods not absorbed by such processes are surplus. Note that with the mentioned equation **(3)**, $p_j(A^t \alpha x)_j = p_j(B^t x)_j$ or the amount received by the sellers is the amount paid by the purchasers. Von Neumann justified the above equation **(3)**.

With the observation that in the stationary state, such goods just accumulate, cycle by cycle. One should note that, if goods have a fixed price and the amount paid equal the amount received, then $p_j(A^t \alpha x)_j = p_j(B^t x)_j$.

If the *(≤)* in the above mentioned equation **(2)** is *(<)* then $p_j = 0$ is the only possible value satisfying this requirement at the mentioned equation **(3)**.

$$\forall i: \beta(Ap)_i \geq (Bp)_i \quad (4)$$

The equation shows an equilibrium condition. If a process were more lucrative than lending at interest, the process would have been run at higher intensity, and the advantage reduced.

$$if\ \beta(Ap)_i > (Bp)_i\ then\ x_i = 0 \quad (5)$$

The equation shows that the process is less lucrative than lending at interest. Note that in a stationary state economy, hindsight is foresight. Thus, it is easy to make rational decisions, as envisioned above.

Because of the above equation **(5)**, $\beta(Ap)_i x_i = (Bp)_i x_i$. Thus, Von Neumann is able to observe that: $\alpha(pA^t x) = (pB^t x)$.

4. DISCUSSION

1- Let $\alpha'$and $x' \neq 0$ satisfy only the above equation **(2)**, then $p_j(A^t \alpha' x')_j \leq p_j(B^t x')_j$, so $\alpha'(p_j A^t x') \leq (p_j B^t) x'$ and $(Bpx')_i \leq \beta(Ap\,x')_i$ by an identical argument.

2- The inner products are non-zero, and so α is the maximal rate of growth possible under the above equation **(2)**. Von Neumann also then concluded that *α>0*. Similarly, β is the smallest interest compounder possible under the above equation **(4)**. Thus, α and β of an equilibrium solution are unique. As Von Neumann pointed out, the x and p need not be.

3- Since p and x are not identically 0, some $p_j > 0$ and $x_1 > 0$, so by equation**(1)**, $x_i(a_{ij} + b_{ij})p_j > 0$, so at least one of $(xAp) > 0$ or $(xBp) > 0$, and so, by the above equation **(2)** and equation **(4)**, both are, and then $\alpha > 0$and $\beta > 0$, and $\alpha = \beta$. Thus, in Von Neumann equilibrium, the interest and growth factors are equal.

5. THE CASE OF THE COMPUTER INDUSTRY

There are two industries, one producing normal goods, and the other producing instructions per second "**ips**", computer power. In each cycle, the output of "**ips**" jumps, but not as fast, as does its consumption. The conventional industry grows conventionally. See Figure 1.

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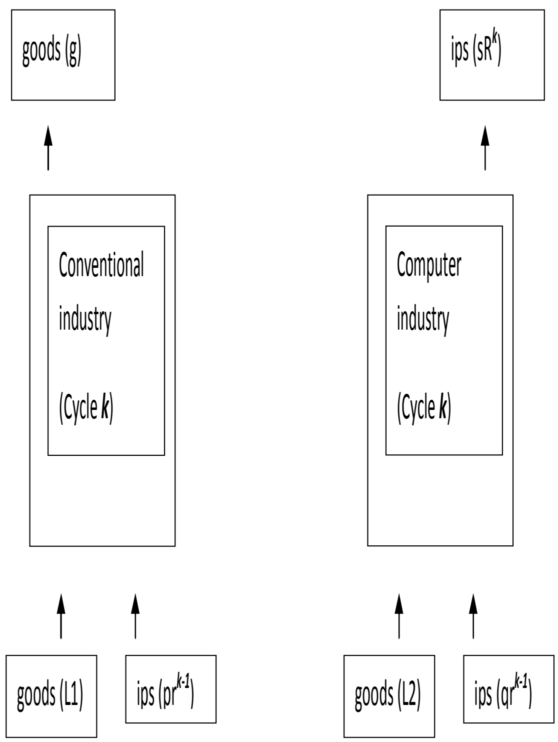

Figure 1. Conventional Industry Growth Vs. Computer Industry Growth

From Figure 1:

$$\textit{input matrix} = A = \begin{pmatrix} L1 & pr^{k-1} \\ L2 & qr^{k-1} \end{pmatrix}, A^t = \begin{pmatrix} L1 & L2 \\ pr^{k-1} & qr^{k-1} \end{pmatrix}$$

$$\textit{output matrix} = B = \begin{pmatrix} g & 0 \\ 0 & sR^k \end{pmatrix}, B^t = \begin{pmatrix} g & 0 \\ 0 & sR^k \end{pmatrix}$$

$$\textbf{intensity vector} = x = \begin{pmatrix} x_1 \\ x_2 \end{pmatrix}$$

$$\textbf{price vector} = p = \begin{pmatrix} p_1 \\ p_2 \end{pmatrix}$$

By equation **(2)** (i.e. $\forall j: (A^t \alpha x)_j \leq (B^t x)_j$)

$$\alpha \begin{pmatrix} L1 & L2 \\ pr^{k-1} & qr^{k-1} \end{pmatrix} \begin{pmatrix} x_1^{k-1} \\ x_2^{k-1} \end{pmatrix} \leq \begin{pmatrix} g & 0 \\ 0 & sR^k \end{pmatrix} \begin{pmatrix} x_1^k \\ x_2^k \end{pmatrix}$$

1- $\alpha\ (L1\ x_1^{k-1} + L2\ x_2^{k-1}) \leq g\ x_1^k$

$$\alpha \leq \frac{g\ x_1^k}{(L1\ x_1^{k-1} + L2\ x_2^{k-1})} \qquad (6)$$

2- $\alpha\ (pr^{k-1}\ x_1^{k-1} + qr^{k-1} x_2^{k-1}) \leq sR^k x_2^k$

$$\alpha \leq \frac{sR^k x_2^k}{(pr^{k-1}\ x_1^{k-1} + qr^{k-1} x_2^{k-1})} \qquad (7)$$

By equation **(4)** (i.e. $\forall i: \beta(Ap)_i \geq (Bp)_i$)

$$\beta \begin{pmatrix} L1 & pr^{k-1} \\ L2 & qr^{k-1} \end{pmatrix} \begin{pmatrix} p_1^{k-1} \\ p_2^{k-1} \end{pmatrix} \geq \begin{pmatrix} g & 0 \\ 0 & sR^k \end{pmatrix} \begin{pmatrix} p_1^k \\ p_2^k \end{pmatrix}$$

1- $\beta\ (L1\ p_1^{k-1} + pr^{k-1} p_2^{k-1}) \geq g\ p_1^k$

$$\beta \geq \frac{g\ p_1^k}{(L1\ p_1^{k-1} + pr^{k-1} p_2^{k-1})} \qquad (8)$$

2- $\beta\ (L2\ p_1^{k-1} + qr^{k-1} p_2^{k-1}) \geq sR^k\ p_2^k$

$$\beta \geq \frac{sR^k p_2^k}{(L2\ p_1^{k-1} + qr^{k-1}\ p_2^{k-1})} \qquad (9)$$

Equations (6), (7), (8) and (9) demonstrate a stationary equilibrium state. That stationary equilibrium state shows that in order to the computer industry to be lucrative and profitable (i.e. equal growth rate and interest rate or a high growth relative to interest rates), quantities of "**ips**" sold increases and the non-inflationary prices decreases cycle by cycle.

6. CONCLUSIONS AND FURTHER WORKS

In order to achieve the above mentioned goal (i.e. quantities of "**ips**" sold increases and the non-inflationary prices decreases cycle by cycle), the number of the produced new devices, that contains "**ips**" quantities, must be substantially larger. At present time, computer industry is trying to achieve that goal mainly through the following two directions:

1- Inventing new devices (i.e. tablets, ipads,…etc), substantially updating old devices (i.e. moving from mobile phones to smart phones) and creating new needs with variety of applications (i.e. cloud computing, open/closed source codes and applications,…etc),

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2- Supporting fields that require increasing numbers of "**ips**" and lead to the growth of the economics of e-business (i.e. robotics, unmanned vehicles, graphics, animation, computational biology, cloud computing, Internet of Things, information technology ….etc).

The paper shows that

- Von Neumann model is a more robust, useful and flexible tool than many have been realized.
- The paper tries to understand the economy of computer industry using the tools of Von Neumann model.
- The tools of Von Neumann model help us to understand the present behavior of the computer industry.

It remains as a further work:

- To investigate the von Neumann model tools thoroughly,
- To use the von Neumann model tools to forecast about the near and far behavior of the computer industry,
- To come up with more research and investigative ideas about and/or using Von Neumann model tools.

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