The Notion of “Substitution” Reconsidered: Economical, Biophysical, Epistemological and Historical

A paradigm is a tacit agreement not to ask certain questions. (Tim Allen, University of Wisconsin)

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Kozo Mayumi
Faculty of IAS
The University of Tokushima
Tokushima City 770-8502
Japan
mayumi@ias.tokushima-u.ac.jp
The Objective of my talk: Brain storming!

Contents of my presentation:

1. A critical reconsideration of the notion of “substitution” in the standard economics;

2. An introduction of “holon”: functions and structures;

3. An application of the ideas about “holon” to energy substitution or “replacement” in the case of large-scale agro-biofuels
1. A critical reconsideration of the notion of substitution in the standard economics

What is the origins of the “accepted” definition of substitution in utility theory and production theory?

Misunderstanding of Marshall’s work and Marshall’s own (and his followers) misunderstanding:

However, one of the important points we should remember here is that Marshall wanted to analyze the economic actuality of his own time and place
1-1. Constancy of marginal utility of money

* Marshall meant quasi-constancy of marginal utility
* The assumption of quasi-constancy of marginal utility of money fits very well for the middle bracket incomes.
* The middle class individual spends a substantial part of his or her income on numerous mere conveniences.
* All these items constitute marginal expenditures in relation to the whole income. Since the number of these items is numerous, a variation in income causes one of these items either to disappear from the budget or become a new item of expenditure.
Under these circumstances the utility of money among the mere items is practically the same. That is to say, the individual finds it very difficult to decide whether to buy one item or the other. This is the situation of indifference. So any item can be substituted by any other item as you please, so that the utility level can keep constant!
A fallacy of ambiguity, when an abstraction (abstract belief or hypothetical construct) is treated as if it were a concrete, real event, or physical entity.

An optimal budget does not necessarily include all commodities, but only those whose marginal utility at the initial level is larger than the marginal utility of money for the whole income.

As already implied in the previous discussion, the commodities in utility function structure for any particular Individual cannot include every commodity available on the market: hierarchy of want.
Marshall’s demand law is valid only for a restricted range of price levels, so that the total area under that demand curve is not necessarily proportional of the total utility of the commodity in question. So, Marshall’s famous graphical analysis for welfare problems can be used provided that we can prove that the prices involved belong to such an interval.

However, once a mathematical formulation is adopted, we can easily forget the nature and its restriction of the mathematical representations.
Marshall’s analytical framework indicates the local characteristics of the utility structure. Even after observing that any regular function is quasi-constant over a small interval of the independent variable, we cannot pass this observation to the quasi-constancy over any interval!

This is the typical misunderstanding of the vast majority of so called the mathematical economists: misunderstanding the mathematical distinction of the local and global nature of functions.

Unfortunately, this notion was also introduced into the production function theory of the standard economics and many related misconceptions are still used without serious concern.
*Duality between utility maximization and cost minimization

* Formalism nonsense in the welfare foundations

*Cobb-Douglas function specification prevails.

*Everything is jelly like a substance

*Scale issues are totally missed.

*Time horizon is often ambiguous.

*No distinction between fund and flow

*What are produced within the economic process?
Cobb-Douglas Function

\[ Y = AK^\alpha L^{1-\alpha} \]

Suppose that \( K, L, \) and \( Y \) are represented in terms of US dollar. The dimension of the left-hand side, US dollar, is compatible with that of the right-hand side as a whole if \( A \) is a dimensionless pure number, since \( \alpha + (1 - \alpha) = 1 \)

However, each term on the right-hand side, i.e., \( K^\alpha \) and \( L^{1-\alpha} \) does not make any sense unless \( \alpha = 0 \) or 1.

Suppose \( \alpha = 1/2 \)

Is there any operational meaning of \( \sqrt{100 \text{USdollar}} \)?
Taking logarithmic form will be worse.

\[ \ln Y = \ln A + \alpha \ln K + (1 - \alpha) \ln L \]
\[
\ln z = 2 \left\{ \frac{z - 1}{z + 1} + \frac{1}{3} \left[ \frac{z - 1}{z + 1} \right]^3 + \frac{1}{5} \left[ \frac{z - 1}{z + 1} \right]^5 + \ldots \right\}
\]

\[
\ln[\text{\$1}] = 2 \left\{ \frac{1}{2} + \frac{1}{3} \left[ \frac{1}{2} \right]^3 + \frac{1}{5} \left[ \frac{1}{2} \right]^5 + \ldots \right\}
\]

Due to the violation of dimensional homogeneity, it is impossible to calculate 1 US dollar minus 1 or 1 US dollar plus 1! We know that \( \ln 1 = 0 \) if 1 in \( \ln \) is a pure number.


However, the following fact must be reminded for the fairness to Cobb and Douglas themselves.

When we carefully read Cobb and Douglas’ important classic paper (1928), one remains awed by their meticulous attitude. They devoted almost half of their paper to the task of how to create the indices for capital and labor, not the prices. They were also very careful about avoiding the generation of pseudo measures with the inconsistent ranking order of capital and labor indices.

Production Function with decreasing marginal rate of substitution

\[ f(x, y) = \sqrt{xy} \]

\[ x = e^{u^2-2} \]
\[ y = e^{v^2-2} \]

\[ g(u, v) = e^{(u^2+v^2-4)/2} \]

NOT decreasing marginal rate of substitution

\[ x \geq e^{-1} \]
\[ y \geq e^{-1} \]
This example indicates that change in unit of measurement in production scheme or biophysical analysis might change the mathematical or analytical structures such as the notion of convex set that is frequently used in the standard economics. Thus the basic framework of the standard economics cannot deal with the issue of scale. The argument of whether or not the ecosystems is a convex or not is truly a nonsense formalism adopted by the notorious standard economists.!

e.g.

_The Economics of Non-Convex Ecosystems_
Partha Dasgupta and Karl-Göran Mäler, 2004 Springer
2. An introduction of “holon”: functions and structures

My main concern is the biophysical side of the economic process for the longer time horizon. So I will elaborate the concept of holon (originally introduced by Koestler) to cope with the issue of energy substitution or replacement.

Arthur Keostler *The Ghost in the Machine*  
Macmillan 1968
2-1 A holon is a thing that has both functions and structures in relation to “why” and “how” questions.

Three main epistemological problems associated with holons:

(1) the scale and the material structure matter to realize “organized structures” for fulfill “functional relations”
A structural representation of particular function as a template mapping onto two structural types (two different realizations). Here the scale and the material structure matter to accomplish the particular function (flying) to be realized.

A representation of an essence of a particular function mapping onto two different structural types that both fulfill that function (flying)
Three main epistemological problems associated with holons:

(2) it is impossible to have a 1:1 mapping between “organized structures” and “functional relations”
same function - keeping time – several structural types (templates/organized structures)

**Level n+1**
meaning of the function

**Level n - whole**
seen as the expression of a function

*Need to coordinate at the social level the activity of different individuals*

*Clock keeping record of time*

**Same why**

**Many hows**

**Spring-powered clock**

**Electronic clock**

**Sand-clock**

**Pendulum clock**

**Water-clock**
same organized structure - a given clock – several functional types

Level n-1
Adequate materials

Level n - whole
Realization of an organized structure

Parts organized in a whole

Many whys

Source of cash

Weight for a scale

Part of a pendulum

Piece for a museum

Replacing a missing letter

STOP
Three main epistemological problems associated with holons:

(3) the universe of possible mappings between “organized structures” and “relational functions” is open and expanding
Emergence = an open set of possible whys . . .

SCREEN in front of a keyhole for privacy

OBJECT to be lunched by a sling

TOOL for preparing drugs

WEDGE to put under an unstable printer

and many more . . .
3. An application of holon to energy substitution or “replacement” In the case of large-scale agro-biofuels
Non-working population: 302.2 Gh
Active population: 201.5 Gh

Compartment of Society:
- Sleeping leisure: 161.2 Gh (80%)
- Economic sectors: 36.3 Gh (20%)
- Other sectors: 36.0 Gh (>99%)

WHOLESOCIETY

Total Human Activity (THA): 503.7 Gh

Exo-energy consumption:
- 121 GJ/year per capita
- 14 MJ/hour

Requirement of exosomatic energy:
- 23 GJ/hr
- 7 Exa Joules

MuSIASEM scheme
Human Time Allocation Pattern Change: Labor Hours

1. In the United States as late as 1850 the average working hours per week were 70.

2. The first attempt to limit the child labor under 12 to a ten-hour day was made only in 1842 in Massachusetts.

(The ten-hour day did not become a widespread rule for the other workers until 1860.)
Human Time Allocation Pattern Change: Agriculture Sector

1994 USA

Population 260,000,000  \(24 \times 365 = 8760\) hours
Total Human Time 2,277,600 million hours
Sleeping etc (10 hours) 949,000 million hours
50% non-economically active (14 hours x 50%) 664,300 million hours
Service/Government 140,400 million hours (6%)
Other Economic Sectors 93,600 million hours (4%)
Agriculture 4,700 million hours (0.2%)

Human time allocated to agriculture
60 x 24 x 0.002 = 2.88 minutes out of 24 hours
Equivalence class of structural types generating a required set of functions. The essence is generated by the mutual information carried out by a network of components organized in a whole.

The heart metaphor

Functional Type

Realization

Type A \(\rightarrow\) human heart

Template encoded in DNA

Structural types

Realization

Type B - artificial heart

Template encoded in a blueprint
Functional type

The heart $\rightarrow$ an effective supplier of blood flow to the rest of the body

The energy sector $\rightarrow$ an effective supplier of energy carriers to the rest of society
In the case of the heart:

Any form of structural type (human heart or artificial heart) used to supply blood flows to the rest of the body must be compatible with what is expected from the rest of network.

The constraint by the rest of network is so strong that a significant restructuring of the rest of network is almost impossible.
In the case of the biofuel sector:

The constraints coming from the rest of the network are of different nature (biophysical, economic, cultural), but still a society is expecting a given supply of energy carriers in terms of quality and quantity.

An introduction of a new energy resource would result in a major restructuring of societal metabolism.

Impredicativity: the characteristics of the parts affect the characteristics of the whole and viceversa
Biomass Based Society: Calm and Quiet?
Biomass Based Society: Calm and Quiet?
Coal Based Society: Structural Change
Oil Based Society: Tremendous increase in “power level”
Distribution Issue Matters!

Homo? americanus?

“Dog-life” in the North

Homo africanus?

“Dog-life” in the South

Bifurcation in the meaning of “dog-life” depending on the context
What is produced in the economic process?

1. Goods and services. Yes, but,

The economic process has the goal of reproducing and expanding the various fund elements different levels and scales shown in the two figures.

The economic process not only produces goods and services, but more importantly, produces the processes required for producing and consuming goods and services.
Ethanol Production from Corn (USA) - 1 hectare

- **WATER**: 2,500 tonnes
- **LAND**: 1 hectare
- **SOIL EROSION**: 12 tonnes
- **POLLUTION**: * NP leakages (sea dead spots) * pesticides residues

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**Fertilizers**  
**Pesticides**  
**Irrigation**  
**Tractors**  
**Drying**  
29 GJ

**Transport**  
**Plant steel**  
**Cements**  
**Steam**  
**Electricity**  
31 GJ

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12 hours  
66 GJ gross supply

14 hours  
6 GJ net supply
Ethanol Production from Sugarcane (Brazil) - 1 hectare

- **15 GJ** Fertilizers
- **5 GJ** Pesticides
- **Transport Plant steel Cements**

**WATER**
- 10,000 t

**LAND**
- 1 hectare

**SOIL EROSION**
- Variable!

**210 hours**
- Ethanol Production from Sugarcane (Brazil) - 1 hectare

**90 hours**
- Ethanol Production from Sugarcane (Brazil) - 1 hectare

**134 GJ** gross supply

**117 GJ** net supply
<table>
<thead>
<tr>
<th>Ethanol Production from Corn (USA)</th>
<th>Ethanol Production from Sugarcane (Brazil)</th>
<th>Fossil Liquid Fuels (average benchmarks)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Output/Input</strong> = 1.1/1</td>
<td><strong>Output/Input</strong> = 7/1</td>
<td><strong>Output/Input</strong> &gt; 12/1</td>
</tr>
<tr>
<td><strong>power of worker</strong> = 2,300 MJ/hour</td>
<td><strong>power of worker</strong> = 67 MJ/hour</td>
<td><strong>power of worker</strong> = 2,300 MJ/hour</td>
</tr>
<tr>
<td><strong>net supply</strong> = 6 GJ/ha</td>
<td><strong>net supply</strong> = 117 GJ/ha</td>
<td><strong>net supply</strong>: 30,000-300,000 GJ/ha</td>
</tr>
<tr>
<td>huge land demand for energy</td>
<td>huge land demand for energy</td>
<td>negligible land demand for energy</td>
</tr>
<tr>
<td><strong>net supply</strong> = 230 MJ/hour</td>
<td><strong>net supply</strong> = 390 MJ/hour</td>
<td>net supply &gt; 25,000 MJ/hour</td>
</tr>
<tr>
<td>huge labour demand for energy</td>
<td>huge labour demand for energy</td>
<td>negligible labour demand for energy</td>
</tr>
</tbody>
</table>
August 21, 2009

The Earthscan

The Biofuel Delusion

The fallacy of large scale agro-biofuels production

Mario Giampietro
Kozo Mayumi
Jevons’ paradox: in the medium/longer term, an increase in output/input ratio in using a resource leads to an increased use of that resource rather than to a reduction.
September 1987 In front of the Department of Economics building
Vanderbilt University, Nashville, TN, USA
Appendices
An example of Pseudo measure: “dispersion”

\[ E = \sum_{i=1}^{s} p_i^2 \]

\[ H = \sum_{i=1}^{s} p_i \ln p_i \]

\[ \sum_{i=1}^{s} p_i = 1 \]
Both of these indices reach their minimum for the microstate of lowest order, namely, 

\[ p_1 = p_2 = \ldots = p_s \] 

(and only for this),

and their maximum for any macrostates of highest order, \( p_k = 1 \) for any \( k \) (and only for this).

These indices produce inconsistent magnitudes of \( E \) and \( H \) depending on the values taken by \( p_i \). \( E \) does not rank order in the same way \( H \) does.
So, \( E \) and \( H \) are pseudo measures. Generalizing this example we can conclude that creating an index that is not a pseudo measure is a difficult problem.
One who knows enough is enough will be always happy. If we know to be content, our mind can always be rich. If we don't know to be content, then we can never be rich in mind even with much money.

Devote Yourself to Others without Paying Attention to Yourself
Benefit All Humankind