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Concepts from classical physics in political economy
1. **Equivalence in exchange:**

\[ C \to C \]
Signatures of capitalist market economy

1. **Equivalence in exchange:**
   \[ C \rightarrow C \]

2. **Exchange with money:**
   \[ C \rightarrow M \rightarrow C \]
Signatures of capitalist market economy

1. **Equivalence in exchange:**

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2. **Exchange with money:**

   \[ C \rightarrow M \rightarrow C \]

3. **Expanding money:**

   \[ M \rightarrow C \rightarrow M' \]
Symmetry and conservation in exchange

\[ C \Leftrightarrow C \]
Example from Volume 1:

If $1 \text{ coat} \cong 20 \text{ yards of linen}$

then $20 \text{ yards of linen} \cong 1 \text{ coat}$
Symmetry in exchange

- **Example** from Volume 1:
  
  If 1 coat $\equiv$ 20 yards of linen
  
  then 20 yards of linen $\equiv$ 1 coat

- The exchange relation is **symmetric**:

\[
\begin{array}{c}
C
\end{array} \quad \equiv \quad \begin{array}{c}
C
\end{array}
\]

\[
\begin{array}{c}
1 \text{ coat}
\end{array} \quad \equiv \quad \begin{array}{c}
20 \text{ yards of linen}
\end{array}
\]
Emmy Noether (1882 - 1935)

**Symmetry and conservation**

If a system has a **symmetry property**, then it possesses a **quantity** that is unchanged.

\[ S \rightarrow S' \]
Emmy Noether (1882 - 1935)

Symmetry and conservation

If a system has a symmetry property, then it possesses a quantity that is unchanged.

Marxian hypothesis

In a system of symmetric exchanges,

\[ C \rightleftharpoons C, \]

the conserved quantity is social labour time.
Labour time as the conserved quantity

Social production system

- corn
- labour
- iron
- sugar
Labour time as the conserved quantity

Social production system

- corn
- labour
- iron
- sugar

Labour is a universal and redeployable resource
Social time as the conserved quantity

Social production system

Social labour is therefore an abstract quantity
Figure: An object O with a mass ...
Labour time as the conserved quantity, cont’d

Figure: ... has weight only interaction with gravitational field
Figure: A commodity C with a use value ...
Labour time as the conserved quantity, cont’d

Figure: ... has labour value only interaction with social production field
Labour time as the conserved quantity, cont’d

Figure: Labour value is conserved under symmetric exchange
Labour content as conserved quantity, cont’d

Testable law

Market *prices* of a commodity-type $C$ are *statistically linked* to its labour value
Testable law

Market prices of a commodity-type C are statistically linked to its labour value.

Figure: Proportion of commodities with different ratios $P(C)/\Lambda(C)$

Conservation laws of market exchange

\[ C \Leftrightarrow M \Leftrightarrow C \]
Colliding agents of market exchange

Exchange with money commodity

Agent A: \( C \rightarrow M \)

Agent B: \( M \rightarrow C \)

- Labour value of \( C + M \) is conserved
Colliding agents of market exchange

Exchange with financial asset

Agent A: $C \xrightarrow{F_a} $

Agent B: $F_a \xrightarrow{C}$

- Labour value of $C$ is conserved
- Asset $F_a$ represents claim on value
Ludwig Boltzmann (1844 - 1906)

Large systems with energy constraints

Uncoordinated interactions among particles produce stable distribution of energy
Ludwig Boltzmann (1844 - 1906)

Large systems with energy constraints

Uncoordinated interactions among particles produce stable distribution of energy

Marxian hypothesis

Uncoordinated market exchange,

\[ C \rightleftharpoons F_a \rightleftharpoons C, \]

will by itself produce stable distribution of money \( F_a \)
Testable law

The distribution of money across exchanging agents is Boltzmann

Figure: Proportion of agents with different amounts of money
Testable law

The distribution of money across exchanging agents is Boltzmann.

Figure: Distribution of income in USA

Agents of exchange: credit and debt

Exchange using credit and debt

Agent A: \[ C \rightarrow F_a \]

Agent B: \[ o \rightarrow C + D \]

- Labour value of \( C \) is conserved
- Legal obligation \( o \) that creates \( D \) and \( F_a \)
Agents of exchange: credit and debt

Figure: Two agents with mutual debt obligations
Agents of exchange: credit and debt

Figure: Repaying debt has \textit{symmetric} effect on asset
Agents of exchange: credit and debt

Figure: Increasing debt has symmetric effect on asset.
Testable law

The financial surpluses of all economic sectors sum to 0.
Testable law

The financial surpluses of all economic sectors sum to 0.
Laws of credit and debt

Testable law
The financial surpluses of all economic sectors sum to 0

![Chart showing net lending/borrowing, 2007](chart.png)

Testable law
In a credit system with interest, firms with different rates of profit will polarize into rentiers and debtors
Non-conservation laws of capital accumulation

\[ M \rightarrow C \rightarrow M + \Delta M \]
Breaking symmetry in production and consumption

Figure: Symmetry and conservation reigns in market exchange
Breaking symmetry in production and consumption

Figure: Surplus labour and product extracted via market mechanism
Figure: Profit income is a symbolic claim on surplus product
Breaking symmetry in production and consumption

Testable law
Real profit income arises through the extraction of surplus labour

Testable law
Aggregate profit income is determined by capitalist expenditure
The general signature of capital

\[ M \rightarrow C \rightarrow M' \]
General signature of capital

hides its material basis

\[ M \rightarrow \left[ C \Rightarrow C + \Delta C \right] \rightarrow M' \]
Exponential growth through reinvestment

Exponential growth of claims on value

\[ M \rightarrow C \rightarrow M' \rightarrow C \rightarrow M'' \rightarrow C \rightarrow M''' \rightarrow \cdots \]
Exponential growth through reinvestment

Exponential growth of claims on value

\[ M \rightarrow C \rightarrow M' \rightarrow C \rightarrow M'' \rightarrow C \rightarrow M''' \rightarrow \cdots \]

must be backed by material expansion of

\[ M \rightarrow \left[ C \Rightarrow C + \Delta C \right] \rightarrow M' \]

\[ \uparrow \]

\[ L \]
Constraints on average profitability

Testable law

**Average profit rate** is determined by investment level and **exponential growth** of labour and productivity.

Figure: Trajectory of average profit rates in US and UK

Constraints on average profitability

Testable law

Average profit rate is determined by investment level and exponential growth of labour and productivity.

Figure: Trajectory of average profit rates in US and UK

Summary
By applying concepts from classical physics, the signatures

\[ C \rightarrow C \quad C \rightarrow M \rightarrow C \quad M \rightarrow C \rightarrow M', \]

can generate fruitful hypotheses and testable laws of capitalist market economies.
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For more details:

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*Thank you for listening!*