The True Mystery of the World is the Visible, Not the Invisible

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Some literature

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- Kurz, H. D. and Salvadori, N. (1995). *Theory of Production. A Long-Period Analysis*. Cambridge: Cambridge University Press. Paperback edition 1997.
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1. Introduction

- What does the proverbial “Man from the Moon” see when looking down on earth?
- The social metabolism of humankind
- Mesopotamia: one of the “cradles” of humankind and also of Input-Output-Analysis and National Accounting
- Outside Babylon’s Ishtar Gate: clay tablets inform about the productivity in barley production.
- Ca. 2.100 BC: output/seed input ≈ 20 (in classical Greece ≈ 6; Roman Empire ≈ 4)

(1) Production, consumption and growth

- "Productive consumption" or "Necessary Input": seed, consumption of workers, fodder of working animals, ...
- T. R. Malthus: *Material rate of surplus* =

$$\frac{Surplus}{NecessaryInput}$$

a = Necessary input per unit of gross output;

$1 - a$ = net output per unit of gross output;

rate of surplus: $(1 - a)/a$

- Leontief inverse: $(\mathbf{I} - \mathbf{A})^{-1}$
- Perron-Frobenius Eigenvalue:

$\mathbf{q}^T = (1 + G)\mathbf{q}^T\mathbf{A}$ or $\lambda\mathbf{q}^T = \mathbf{q}^T\mathbf{A}$

- Checking historical records about the size of population, army, the power and glory of the realm
- Social metabolism: Consumption and growth

(2) Value and income distribution

- The British Classical economists: circular flow and physical real costs
- A system without a surplus product

$$8_A + 5_B = 18_A$$

$$10_A + 3_B = 8_B$$

"The agents of production are the commodities themselves. … They are the food of the labourer, the tools and machinery with which he works, and the raw materials which he works upon." (James Mill, 1826)

- A system with a surplus product and a competitive rate of return on capital advanced:

$$(12_A p_A + 9_B p_B)(1 + r) = 28 p_A$$

$$(11_A p_A + 16_B p_B)(1 + r) = 32 p_B$$

Surplus: 5A and 7B

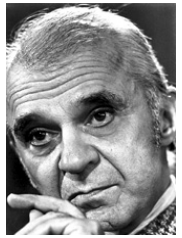
Standard of value: $p_A = 1$

Unknowns: p_B and r

- Input-Ouput Analysis: The Economics of the Social Metabolism

The "Visible" contains a key to the problem of consumption and economic growth and to the problem of value and distribution.

2. Leontief and the F-twist



Faye Duchin in a recent webinar put forward the request: Identify the objective of Leontief for creating IO economics

- Economics should start from "the ground of what is objectively given." Its concepts should refer to magnitudes that can be "observed and measured".
- He adopts a "naturalistic" or "material" perspective.
- The *homo oeconomicus* gives "too much room to imagination and too little to facts"
- The concept of *circular flow* "expresses one of the fundamental objective features of economic life."

- Milton Friedman (1953): “Theory is to be judged by its predictive power”; the realism of assumptions should be of no concern.
- Paul A. Samuelson (1963): It is a contradiction to maintain that all consequences of a theory (i.e., its predictions) can be valid and the assumptions and the theory built upon them are not valid. And it is absurd to maintain that if only some consequences are valid, that theory and assumptions are important though invalid. The theory cannot but predict the correctness of the assumptions on which it is based.

Leontief (1971)

- "The uncritical enthusiasm for mathematical formulation tends often to conceal the ephemeral substantive content of the argument behind the formidable front of algebraic signs."
- Assumptions are chosen by mathematical convenience, "but it is precisely the empirical validity of these *assumptions* on which the usefulness of the entire exercise depends."
- "Younger economists … seem by now quite content with a situation in which they can demonstrate their prowess … by building more and more complicated mathematical models … without ever engaging in empirical research."

- Are small errors more dangerous than big ones?
- The accumulation of small errors
- The tailors of Laputa (Jonathan Swift's *Gulliver's Travels*)

- Input-Output is about interdependencies; it is bound to take into account feedbacks, boomerang effects, compensating mechanisms ... – and provides a much less partial kind of economic analysis than partial equilibrium theory.

$$\mathbf{Bp} = (1 + r)\mathbf{Ap} + \mathbf{Cq} + \mathbf{Lw} \qquad (1)$$

$$\mathbf{u}^T\mathbf{p} = 1. \qquad (2)$$

B = gross output matrix

A = material input matrix (fixed and circulating capital goods)

C = matrix of land inputs

L = matrix of labour inputs

u = vector of commodities defining the standard of value

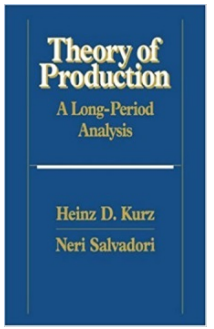
p = price vector

q = vector of rent rates

w = vector of wage rates for the different kinds of labour

r = general rate of profits

For a treatment of fairly general systems, see H. D. Kurz and N. Salvadori, *Theory of Production*, Cambridge: Cambridge University Press



Some stripped down versions:

B = **I** and **C** = **0**:

$$\mathbf{p} = (1 + r)\mathbf{Ap} + \mathbf{Lw} \qquad (1^*)$$

Solving equation (1*) for **p**, we get

$$\mathbf{p} = [\mathbf{I} - (1 + r)\mathbf{A}]^{-1}\mathbf{Lw} \qquad (3)$$

$$r = f(w_1, w_2, \ldots, w_m), \qquad (4)$$

$\partial r/\partial w_j < 0$ and $\partial w_i/\partial w_j < 0$ $(i, j = 1, 2, \ldots, m; i \neq j)$

The case of a uniform wage rate w:

Reduction to dated quantities of labour

$$\mathbf{p} = w\mathbf{l}_0 + (1 + r)w\mathbf{l}_1 + (1 + r)^2 w\mathbf{l}_2 + \ldots$$

Vertically integrated technical coefficients

(tackling inter alia environmental issues):

- Let **k** designate the vector of stocks of capital goods needed to support the production of the net output vector **y**, where $\mathbf{k}^T = \mathbf{x}^T\mathbf{A}$. Obviously, $\mathbf{k}^T = \mathbf{y}^T[\mathbf{I} - \mathbf{A}]^{-1}\mathbf{A}$.
- Define $\mathbf{H} = [\mathbf{I} - \mathbf{A}]^{-1}\mathbf{A}$
- **H** is the matrix linking the quantities of the capital goods, **k**, to net outputs, **y**: $\mathbf{k}^T = \mathbf{y}^T\mathbf{H}$.
- The vertically integrated labour input coefficients are given by: $\mathbf{v} = [\mathbf{I} - \mathbf{A}]^{-1}\mathbf{l}$

3. Diffusion dynamics, selection pressure and IO Tables

What does input-output matrix **A** mean? An utterly simple illustration in terms of a one-good model:

Inputs (a, l) produce one unit of the product

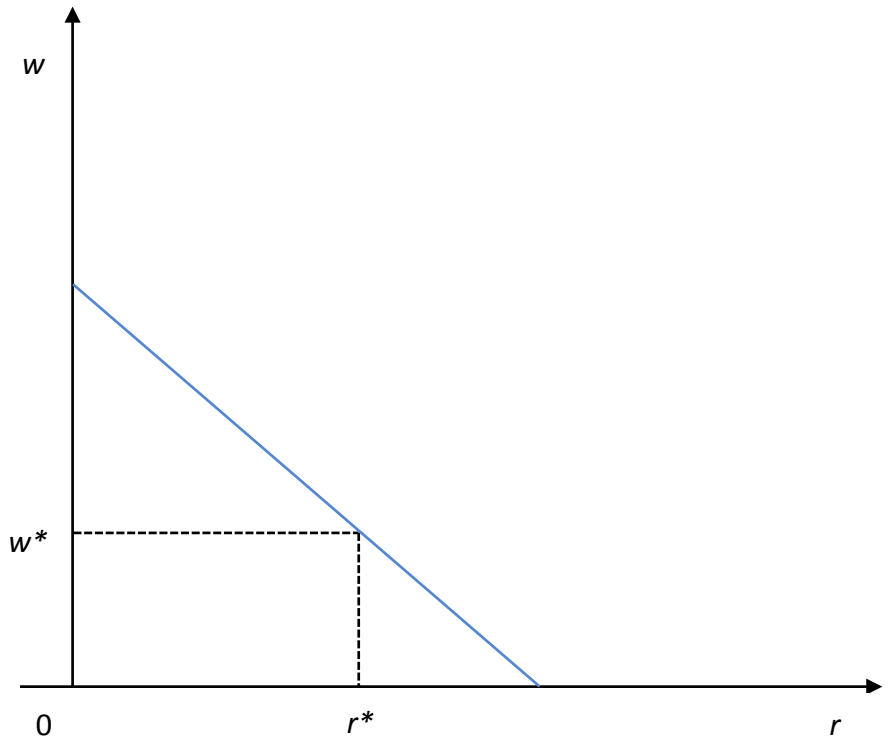
$$1 = a + ra + wl = (1 + r)a + wl.$$

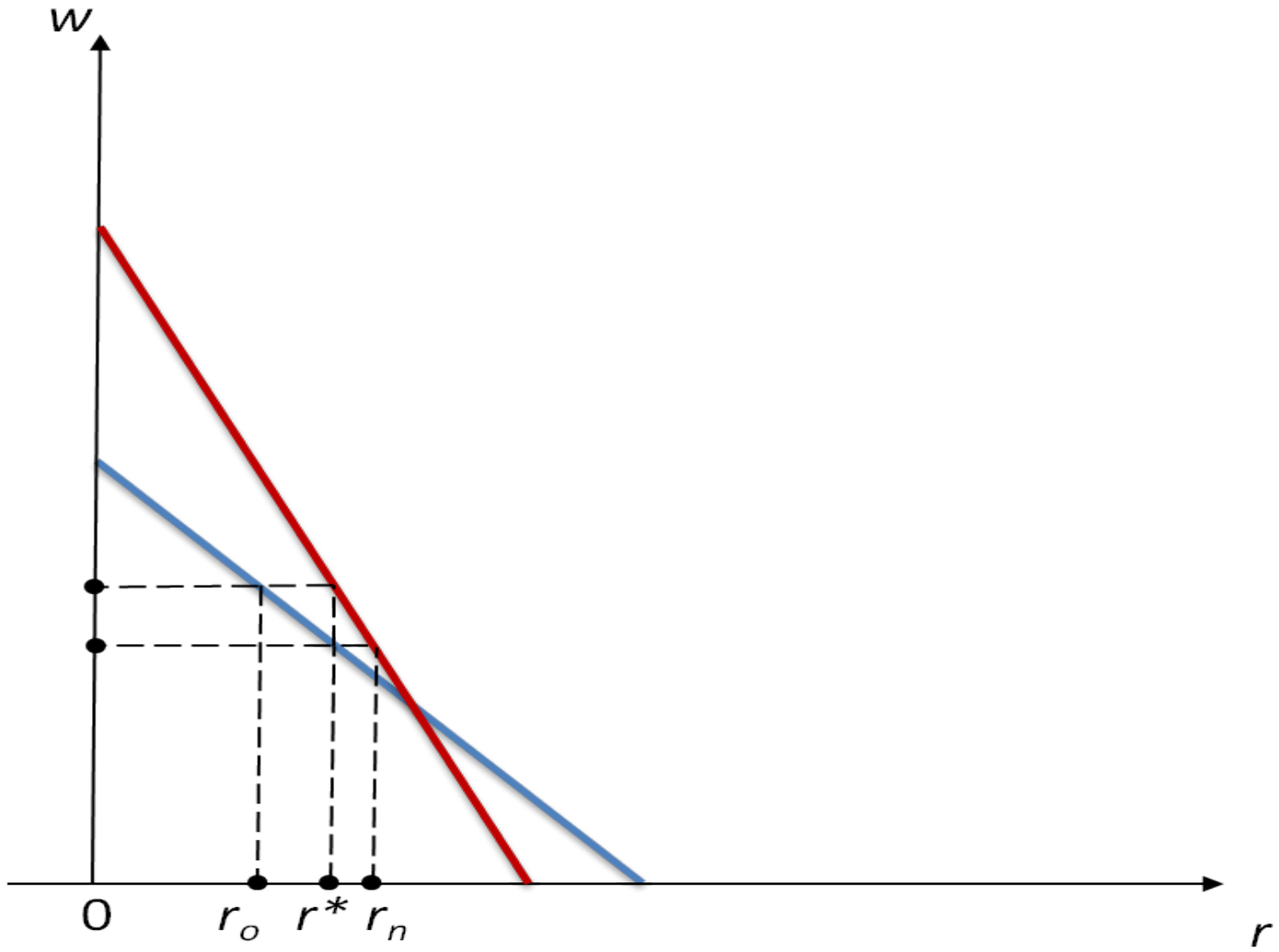
Solving for *w* gives the wage curve:

$$w = \frac{1-(1+r^*)a}{l}$$

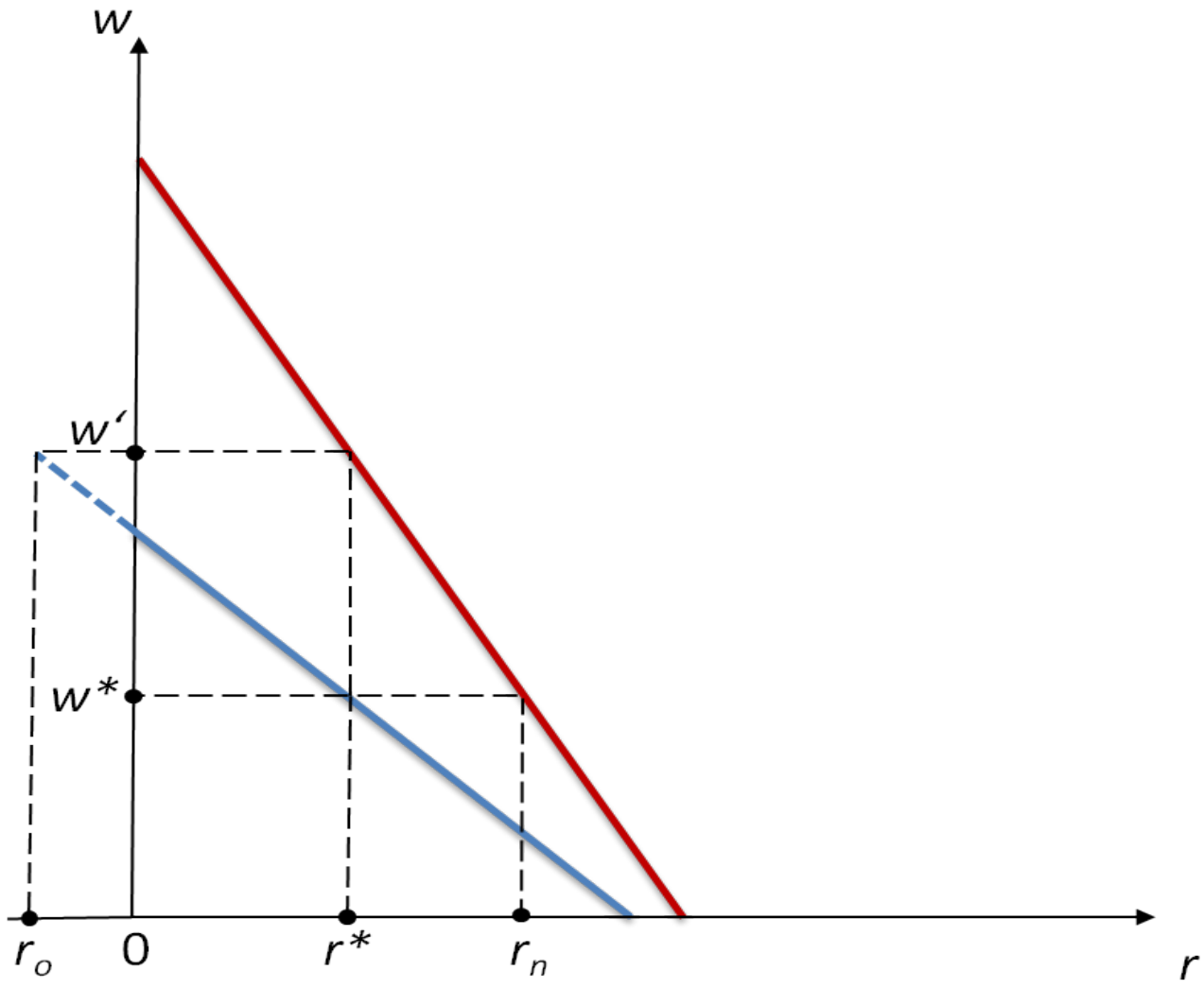
Assume that the long-term general rate of profits, r^*, is constant.

The wage curve of a given technique





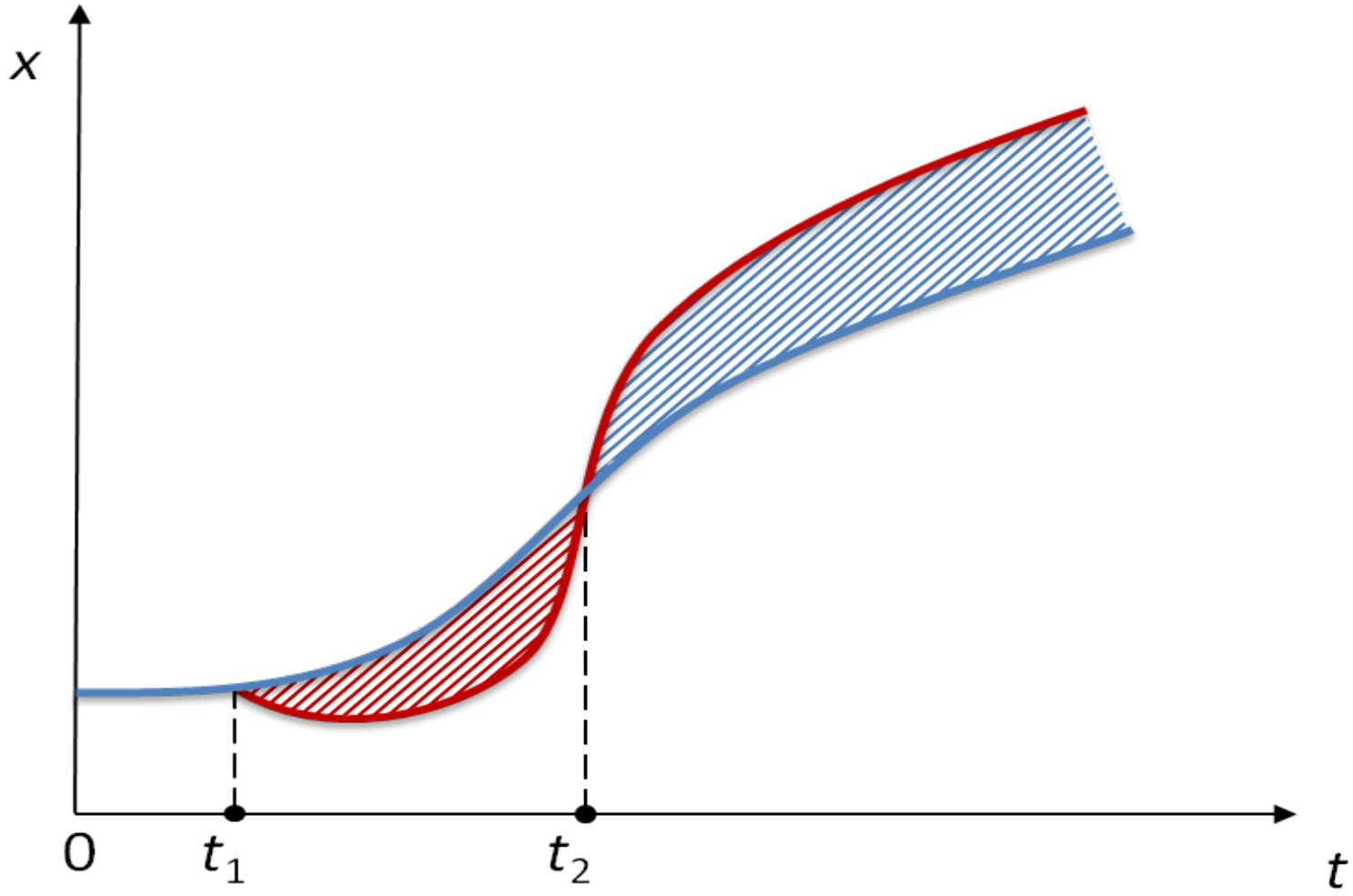
Technical progress: The static incumbent firms can survive



Technical progress: The static incumbent firms cannot survive

- Whether a particular invention endangers the survival of existing firms that do not innovate depends not only on the kind and magnitude of technical progress, but may also depend on the real wage rate in the initial situation.
- In the case in which there is a sequence of technical changes, we may at any point in time find a whole population of firms that have survived up until then, exhibiting different efficiencies and yielding different profit rates. The size and composition of the population will change over time, reflecting inter alia the sequence of technical changes and the wage adjustment mechanism at work.

- Diffusion-driven dynamics are typically non-steady. They follow sigmoid patterns, but typically not simple logistic curves. The process of "creative destruction" (Schumpeter) may engender technological unemployment
- See Ricardo "On Machinery" and more recently Leontief and Duchin
- What matters is the time profile of job losses and gains over a longer period of time.



Development of employment with and without technical change

Innovations, differential growth and imitation

- There are essentially two ways (or a combination of them) by means of which new knowledge can gain momentum and gradually penetrate the system
- by *differential rates of growth* of the pioneering and the incumbent firms or
- by the incumbent firms *imitating* the pioneer.
- In the former case the higher profitableness of the pioneering firm will allow it to grow more swiftly, which will gradually increase the weight of the new method relative to the old one. (Asymptotically old firms vanish.)

... and Input-Output Tables

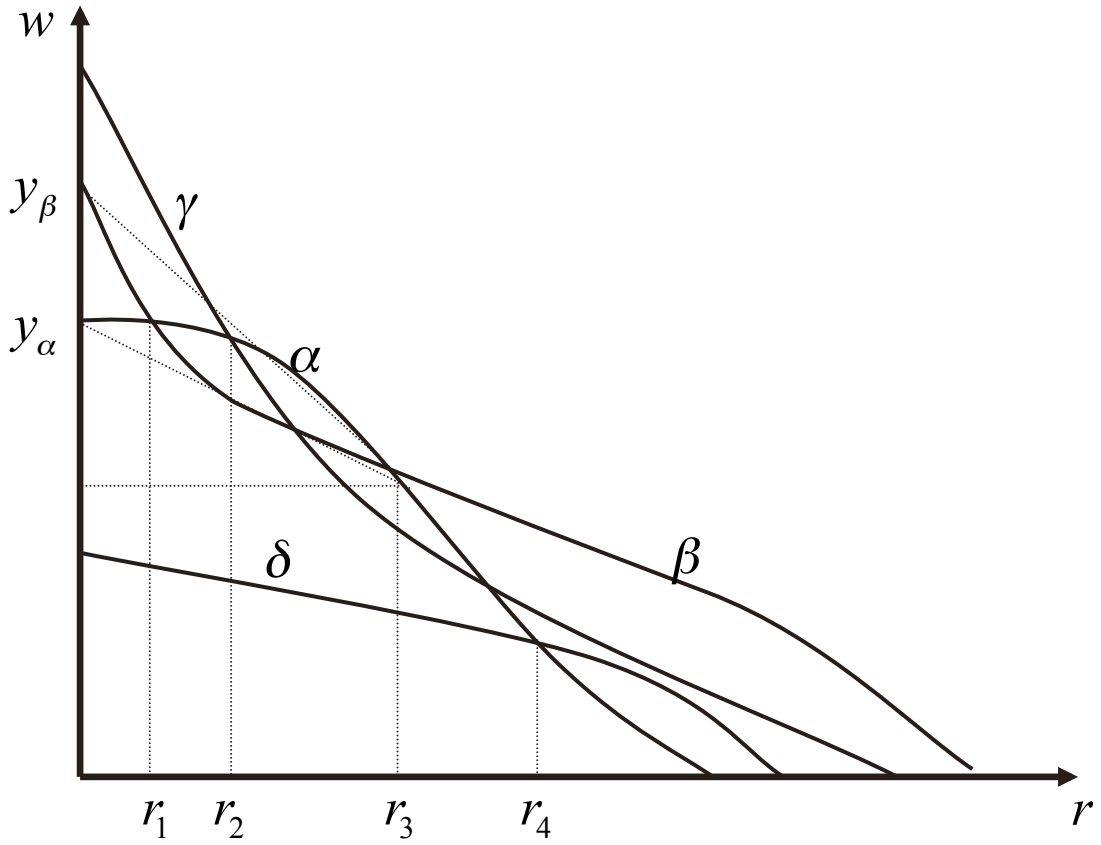
- Matrix **A** does *not* represent a single technique consisting of as many processes as there are products, one process for each product (in the case of single production). It rather represents an *aggregate* account of the quantitative structure of production observed *ex post* in an economy. Typically, several processes will be employed per product.
- Coefficients a_{ij} will therefore reflect not only the coefficients of production of all the processes employed in a given industry, but also the activity levels at which these processes have been operated. If in the production of the quantity Q_i of pro- duct *i* altogether *m* different linear processes are employed whose coefficients of production are given by a^k_{ij}

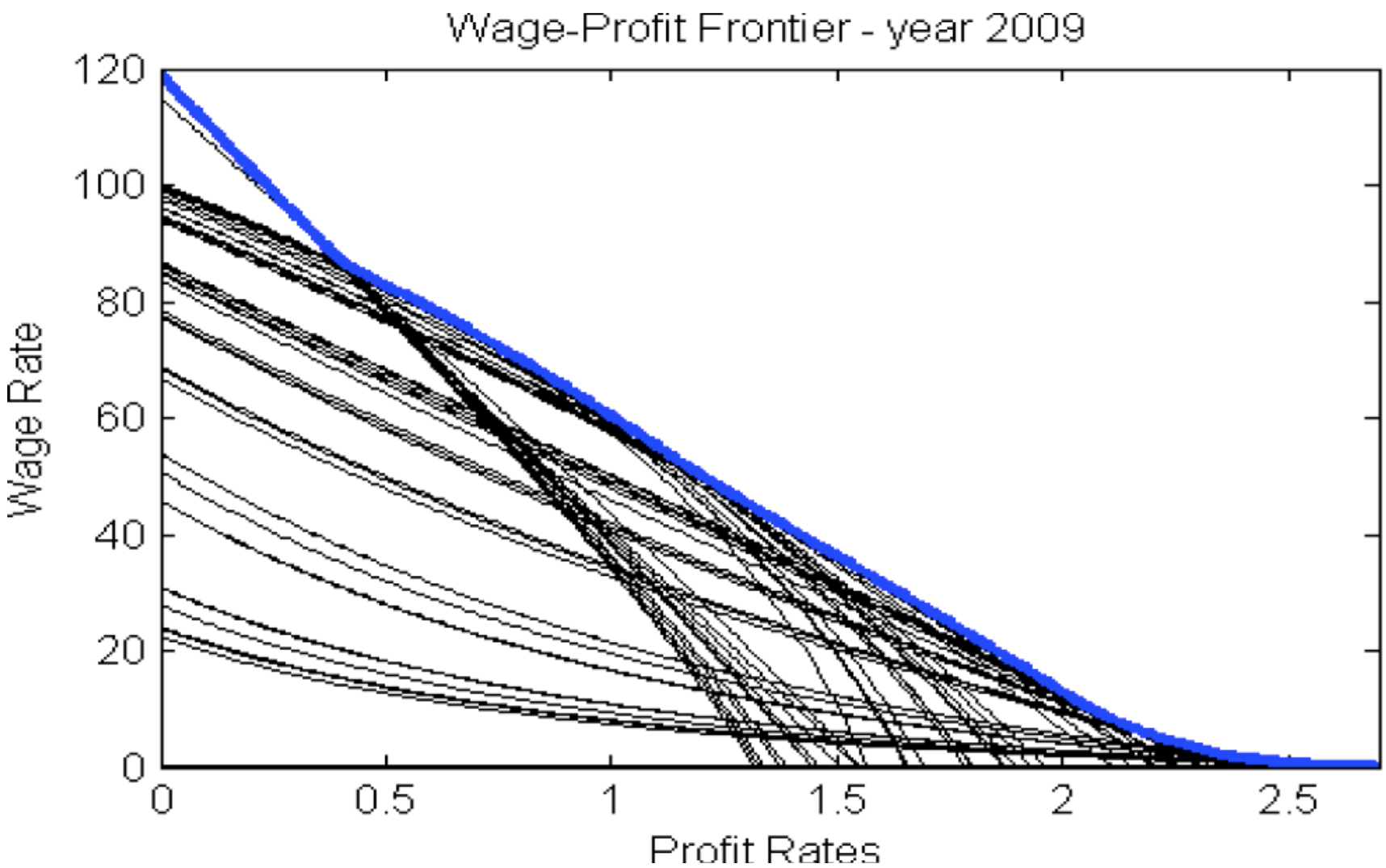
$$a_{ij} = \frac{\sum_{k=1}^{m} a_{ij}^{k} q_k}{Q_i}$$

- Coefficients a_{ij} thus refer to fictitious processes and the technique made up of such processes is also fictitious.
- Problem of choice of technique. From all real methods of production available in the economy for the *n* different products, build up all alternative techniques. To each of these corresponds a *w*–*r* curve that can be plotted in a single *w*–*r* diagram. Probably not not all techniques allow for positive rates of profit, given the real wage rate.

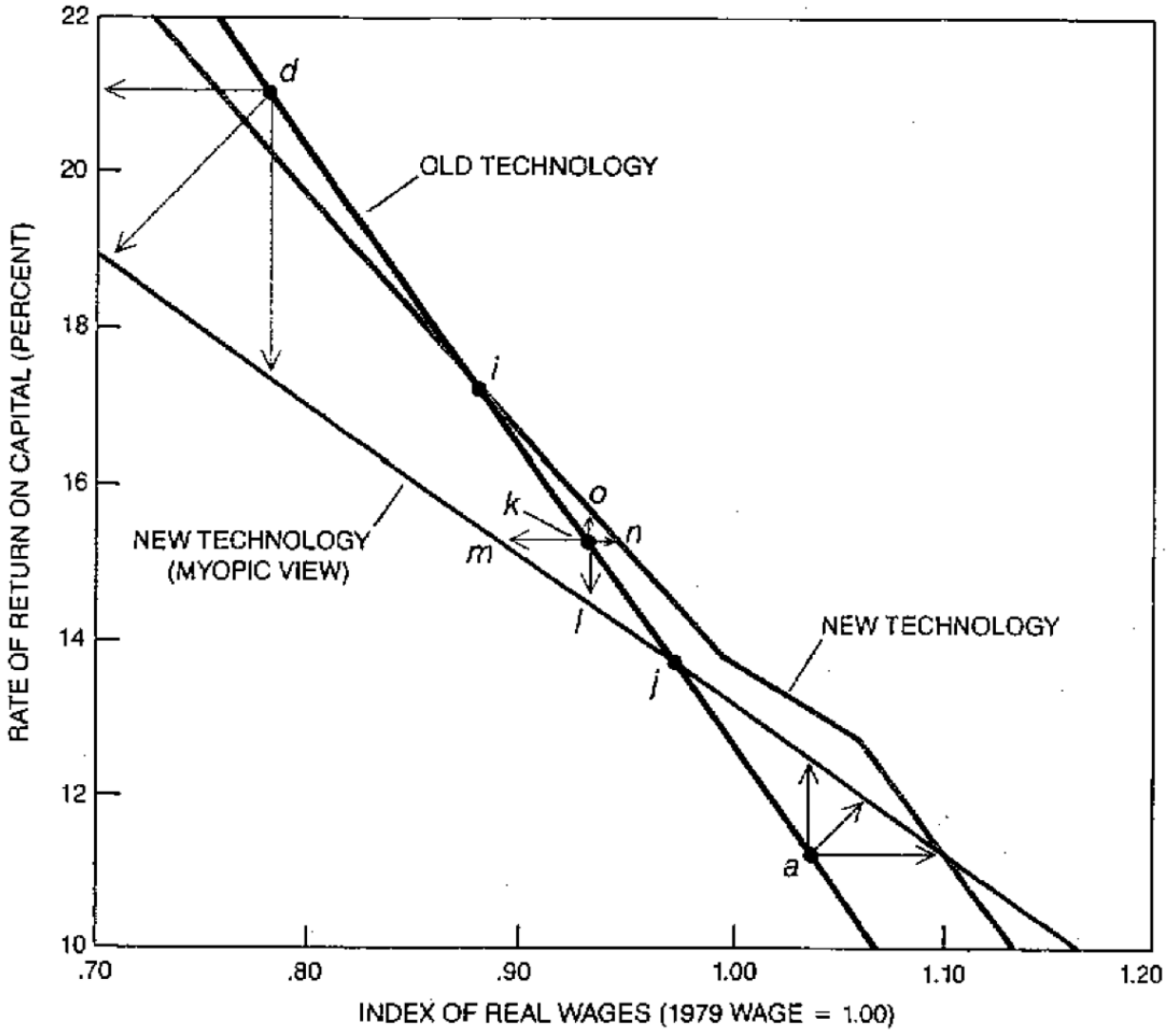
4. What about substitution in production?

Two questions: (i) It is important, but how important? Is it ubiquitous (marginalists) or difficult (Leontief and the classical economists)? (ii) Do conventional laws of input demand and output supply hold in general?




Wage-Profit Frontier - year 2009
Wage Rate
Profit Rates
0
20
40
60
80
100
120
0
0.5
1
1.5
2
2.5

Leontief on substitution and technical change



Partial equilibrium analysis and compensating effects

- The microeconomic "laws of input demand" (Hicks, 1939, Samuelson, 1947), derived within a partial equilibrium framework, are of little use in a more general context.
- A change in the (service) price of a primary input may induce, for example, a qualitative change in input use, including produced inputs (capital goods) of various types.

See Opocher, A. and Steedman, Ian (2015). *Full Industry Equilibrium*. Cambridge: Cambridge University Press.

- In the case of just *two* inputs (primary or produced) or of an arbitrary number of only primary inputs no problem arises: the conventional laws of input demand correctly predict the substitution effects.
- With more than two inputs, both primary and produced, a parametric change in one input price entails a variety of compensating effects in other prices through cost and price adjustments across the economy.
- There is a fundamental difference between primary inputs and produced inputs: While the price of a primary input *either* increases *or* decreases relative to all other input prices, the price of a produced input increases relative to some input prices *and* decreases relative to others.
- **Hence, no "law of input demand" can predict the qualitative change in produced input use, even if all pairs of inputs are Hicksian substitutes.**

- A simple relationship between produced input use and produced input price (in terms of some numéraire) lacks any theoretical meaning.
- It can happen, for example, that an increase in the wage rate is associated with an increase in the employment of labour per unit of output. (Schumpeter, 1912)

We thus get at the industry level phenomena reminiscent of the phenomena of reswitching and capital reversing at the level of the economy as a whole. The simple and seemingly unobtrusive "laws" of input demand and output supply are violated.

[Poor John Stuart Mill (1848), who wrongly contended: "Happily, there is nothing in the laws of value which remains for the present or any future writer to clear up; the theory of the subject is complete."]

The wage frontier

The outer envelope of all effectively available techniques would give the proper wage frontier. It is made up of the best-practice techniques in the given circumstances corresponding to alternative levels of the real wage rate.

Substitutability amongst inputs via substitutability amongst processes – large or small?

Fixed capital and “Rent goods”

- Fixed capital goods that are obsolete and therefore have been superseded, are still worth employing, if effective demand is brisk. They belong to techniques represented by wage curves that are located below the wage frontier.
- They may be compared to land in so far as they are employed as means of production for what they can get, although they are not currently produced.
- Knut Wicksell aptly spoke of “rent goods”

- An IO-table represents not only a set of multiple processes of production in use during a given year.
- It also reflects a particular stage in the diffusion of new processes and the fixed capital goods employed in them and the elimination of old processes and fixed capital goods, and the levels of effective demand across industries and processes.
- While the choice of technique literature refers to technical knowledge available to cost-minimising agents at a given moment in time, an IO-table, by construction, conveys the impression that there is *no choice of technique* possible in the year under consideration.

- A choice exists only across several years. In this perspective, there are as many alternatives as there are years, one for each year reflected by a w–r relationship. (See the wage curves constructed from input-output tables above.)
- If the techniques available in other counties are taken to be eligible alternatives in the home country, the choice set is increased accordingly. However this implies the assumption of a costless transfer of knowledge worldwide.
- *w-r* curves corresponding to later years typically tend to dominate those corresponding to earlier years for levels of the rate of profits close up to the feasible maximum rate. This reflects: first, the diffusion of already known and more profitable processes to the detriment of less profitable ones and thus a movement towards the wage frontier; second, the introduction of entirely new processes reflecting new knowledge, i.e. technical progress, and thus a movement of the frontier.

- The problem of technical change over time is thus confounded with the choice of technique at a particular point in time.

5. Systems of production-cum-disposal: "Where there's muck, there's brass"

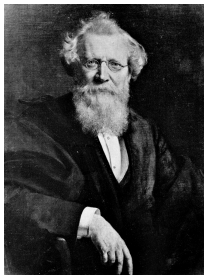
A remarkable early source of information of how waste products drive innovations and technological progress:

Simmonds, P. L. (1873). *Waste Products and Undeveloped Substances: A Synopsis of Progress Made in their Economic Utilisation during the Last Quarter of a Century at Home and Abroad*. London, UK: Robert Hardwicke

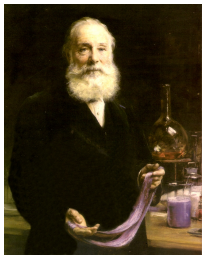
- Joint production is the only realistic image of the world in which we live: production processes typically generate not just a single physically discernible product, but many, including, e.g., industrial waste, heat, waste products, “muck”: in short, goods AND bads.
- Some bads have to be destroyed or moved to places where they can do no harm.
- This necessitates the study of systems of production-cum-disposal.

- If waste disposal is costly, there is a potentially powerful incentive to firms to explore in their *R&D* departments the useful properties of the waste and then use this knowledge in order to transform it into goods. In this way costly disposal activities are replaced by profitable production ones – the transformation of bads into goods.
- Serendipity: A case in point is the discovery of aniline (indigo colour), which paved the way to the rise of the chemical industry.
- A simple illustration

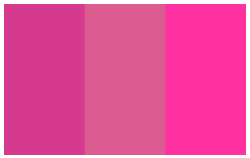
- In 1856 the German chemist August von Hofmann (1818-1892) asked his student William Henry Perkin (1838-1907) to produce quinine from coal tar, but got instead a dark mud with a foul smell and a purple tint.



- Perkin abandoned his academic career, founded a company and produced the first synthetic aniline colour: mauve or mauvein:



- In 1859 Hofmann discovered the second synthetic aniline colour and called it magenta.



From invention to innovation to imitation

- Queen Victoria of England, Empress Eugénie of France and Empress Sissi of Austria appeared in public, wearing mauve robes.
- They were imitated by the crowds.
- The period is also known as the Mauve Decade.
- At the age of 36, Perkin sold his company and went back into academics.
- Synthetic organic chemistry was founded.
- Rise of the German chemical industry

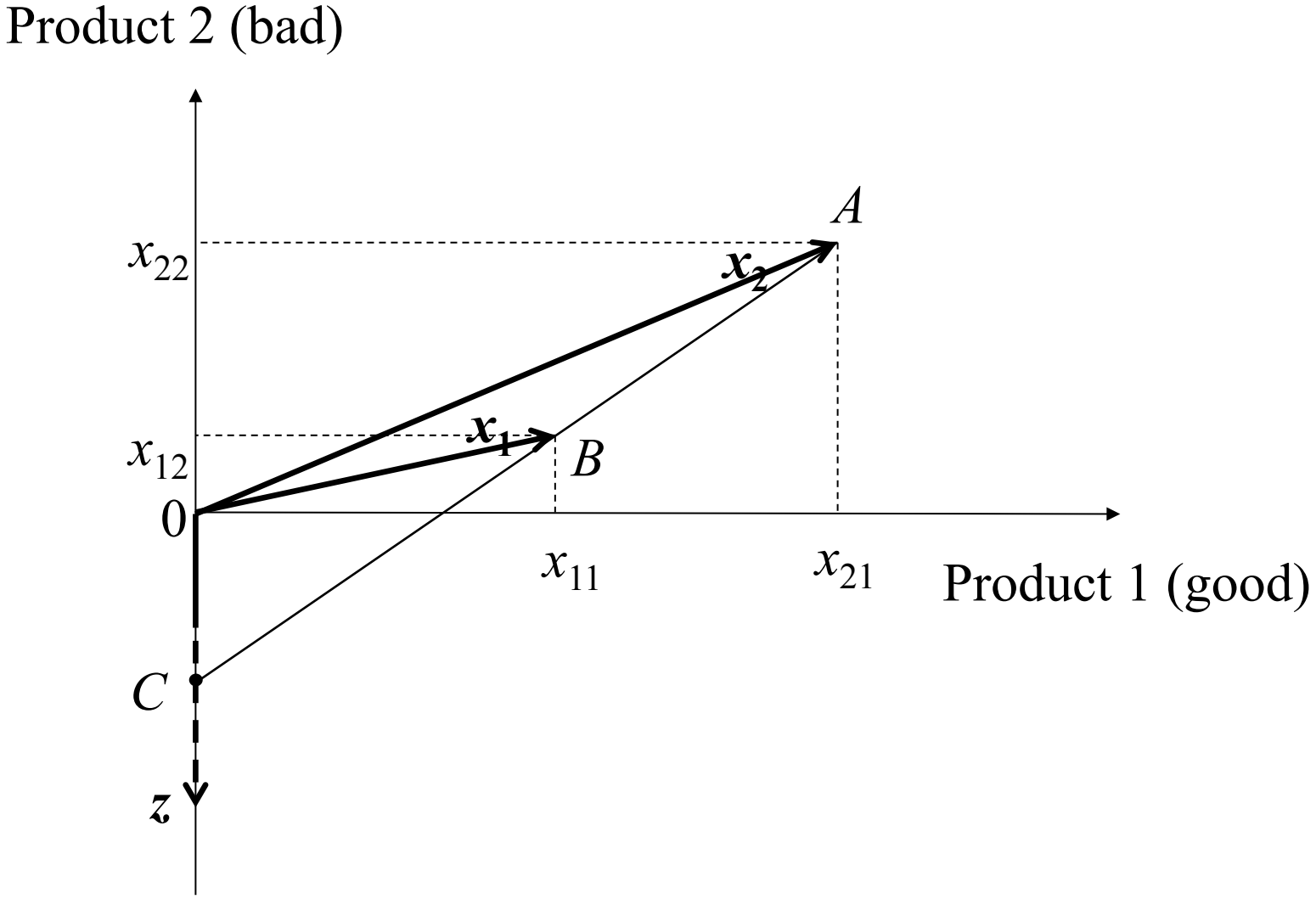
Queen Victoria

Eugénie, Empress of France

“Sissi”, Empress of Austria (LHS: the historical one, RHS: the “real” one – Romy Schneider)

But the innovation renders former goods bads that have to be disposed of ... – here the collection of old clothes

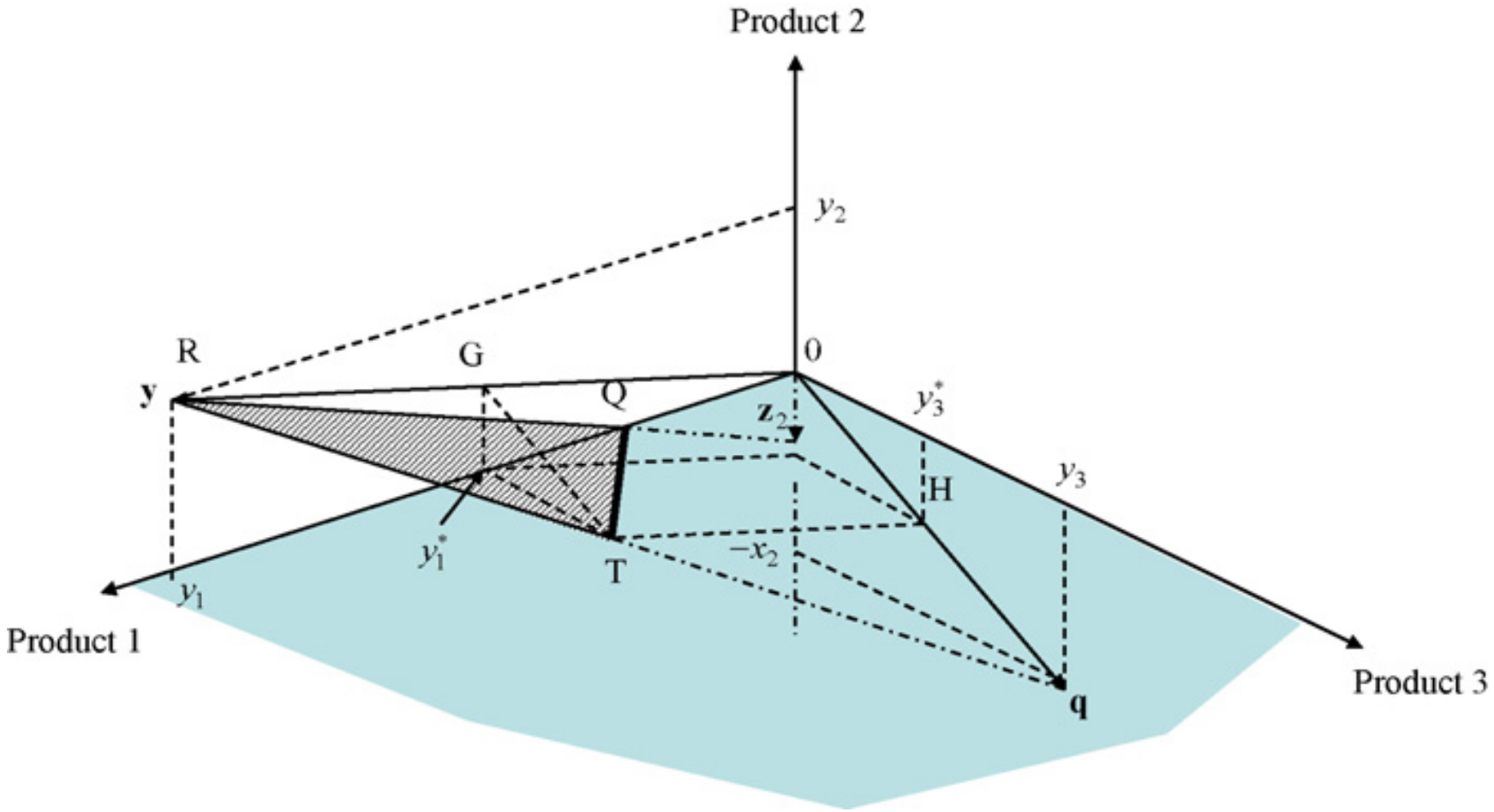
- Technical progress solves some problems, but typically gives rise to new ones, which is especially due to the joint effects it has, of which some are wanted, while others are not. Perhaps most important case: CO2
- The rise of *material sciences* and *engineering techniques* and their role in propelling technical progress is partly a result of the jointness of production.
- A simple illustration: two products, product 1 a good, product 2 a bad that has to be disposed of. Disposal is costly. Disposal process: **z**.



A system of production-cum-disposal

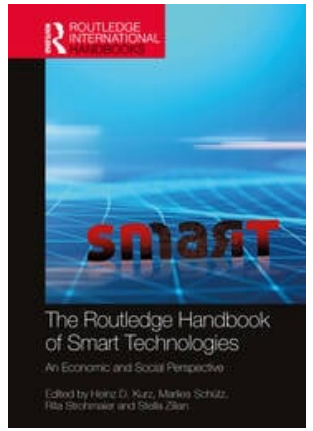
- Technical progress in the disposal industry may trigger a switch to a system of production-cum-disposal that generates (but also removes) more waste.
- In case the authority overseeing the disposal of waste trifles with its responsibility, it may cause a lot of trouble.
- A lesson to be drawn: there is generally no *a priori* distinction between goods and bads. Whether a product is one or the other depends not only on the needs and wants of people but also on the available methods of production and disposal. What in one system is a bad, might in another one be a good.

A simple illustration: The case of a process-cum-product innovation and of the potential elimination of a disposal process

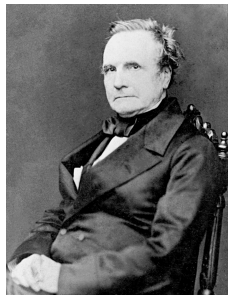


6. On the Second Machine Age

- Machines learn human skills such as perception, cognition and communication
- Artificial Intelligence Systems (AIS)
- New forms of dynamically increasing returns to scale
- The rise of a new type of monopoly – "superstar firms" (Autor et al.), based on AIS, platforms and networks
- "Winner-takes-all dynamics" (Stiglitz)



- Charles Babbage (1791-1871): polymath, Lucasian Professor of Mathematics at Cambridge University (Isaac Newton‘s former chair), inventor, mechanical engineer and philosopher.



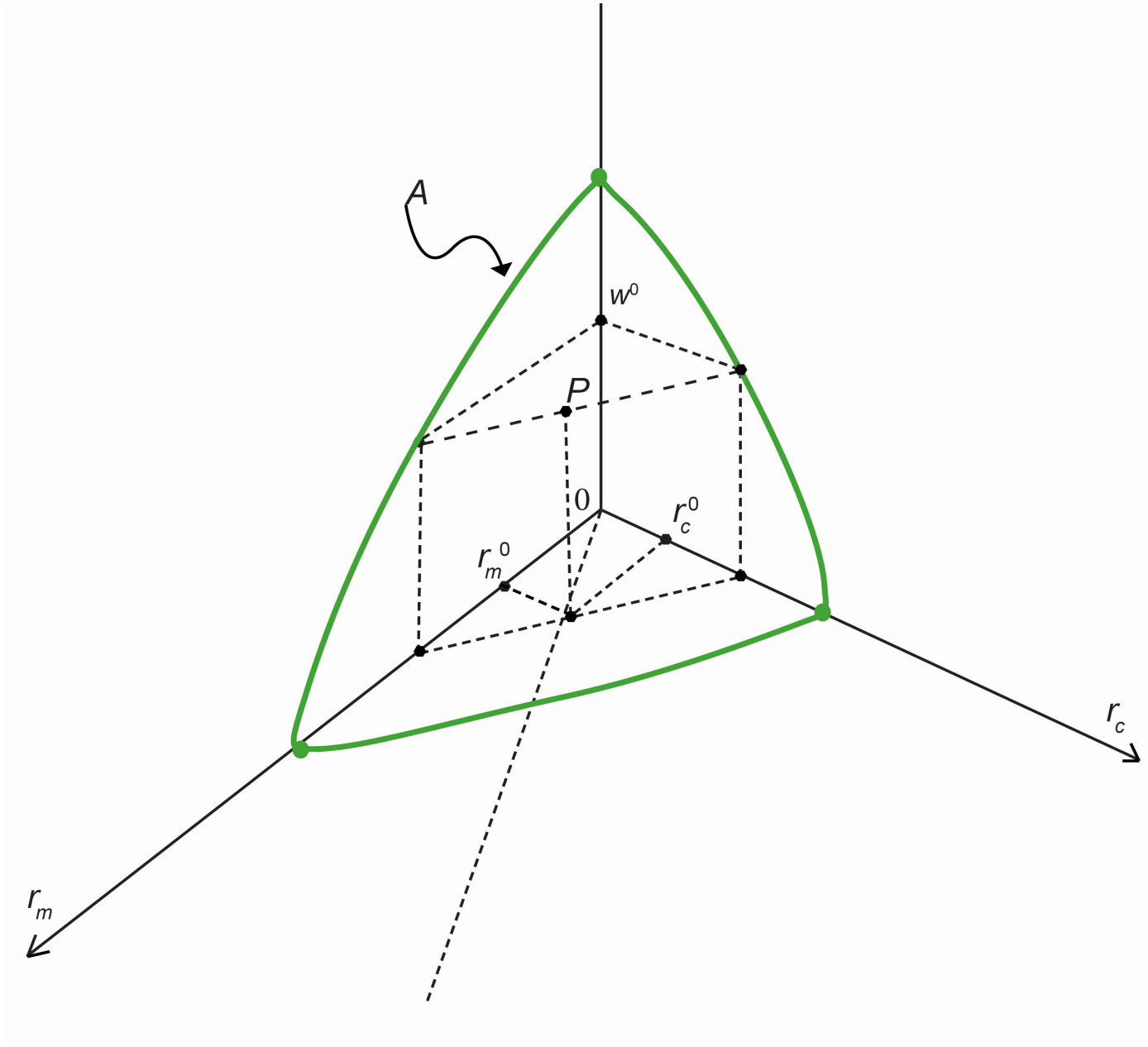
- He superintended the development of the “Analytical Engine” in 1837, a mechanical, general-purpose computing machine, which paved the way to the computer. He did so with the mathematician Ada Lovelace, the daughter of the poet Lord Byron. (The programming language ADA is named after her.)

- Division of labour extended from mechanical to mental operations, foreshadowing the concept of artificial neural networks as a branch of AI

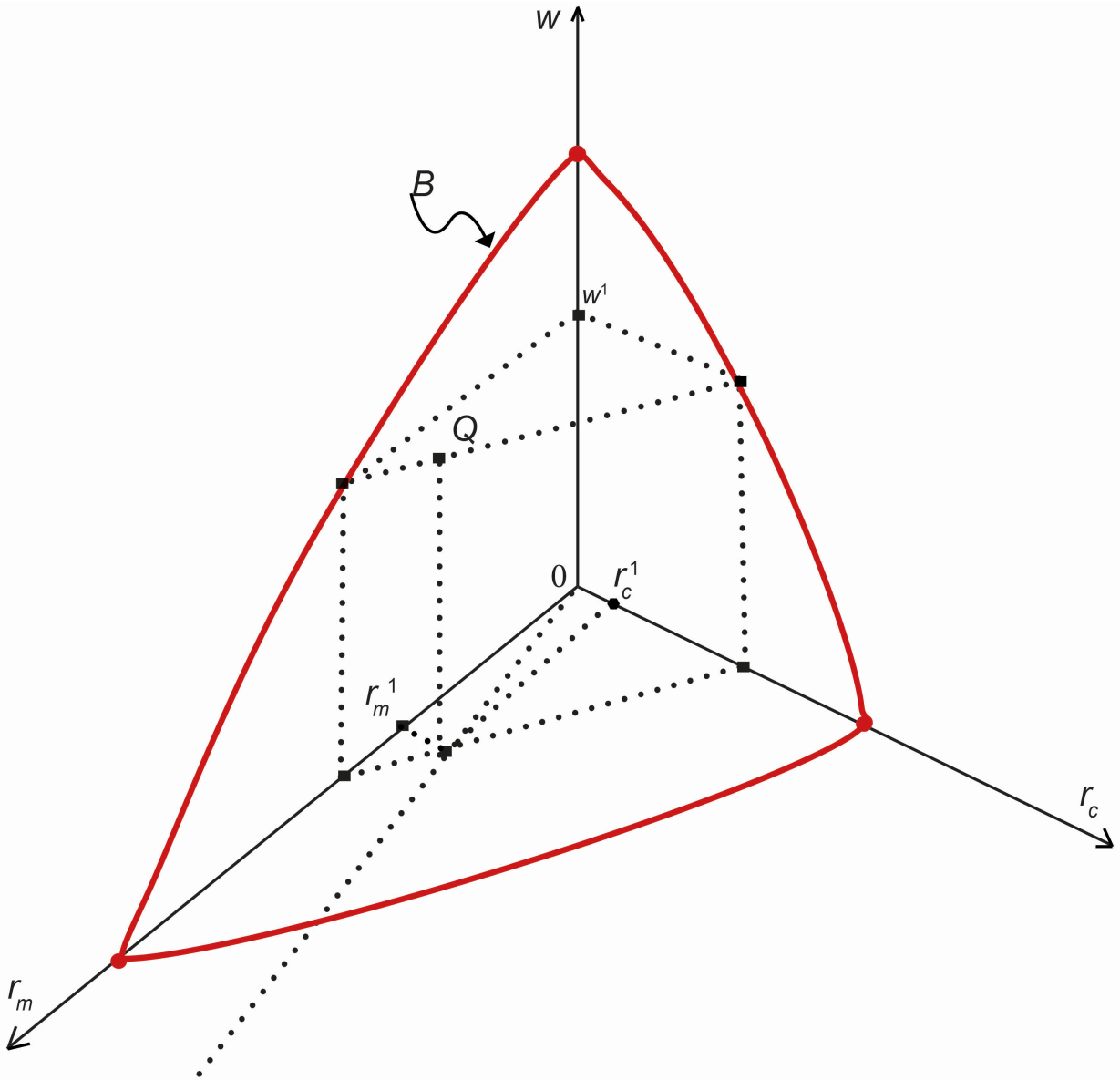
The wage frontier with a monopolistic (*m*) and a competitive (*c*) sector and skilled (*s*) and unskilled (*u*) labour:

$$\Phi(w_s,\ w_u,\ r_m,\ r_c) = 0$$

- Let the wage differential be $\delta > 0$, i.e., $w = w_s = (1 + \delta)w_u$, $w_u > 0$
- Assume also that $\partial r_m / \partial w < 0$, $\partial r_c / \partial w < 0$ and $\partial r_c / \partial r_m < 0$
- Then we can represent the wage frontier pertaining to a given state of economic development.


A
w^0
P
0
r_c^0
r_m^0
r_c
r_m

- The monopolistic segment yields a higher rate of return than the competitive segment.
- The profit rate differential tends to rise as the application of AIS by superstar firms deploys their increasing returns property.
- Similarly, the wage rate differential between skilled and unskilled labour increases.


w
B
w¹
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0
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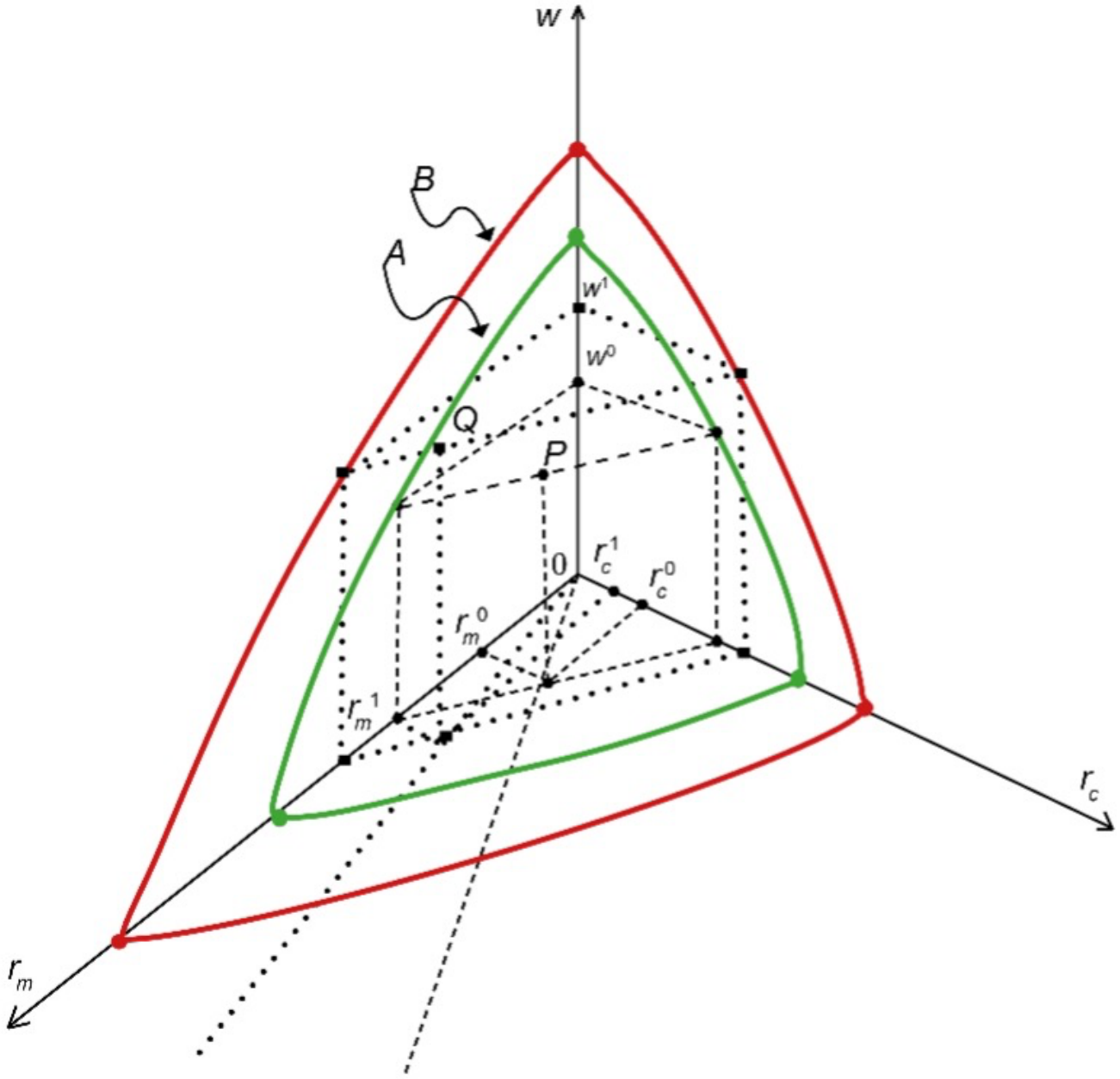
r_m


w
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Q
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r_c¹
r_c⁰
r_m⁰
r_m¹
r_c
r_m

- The new wave of technological progress benefits first and foremost the monopolistic segment and to some extent also skilled workers
- It is often detrimental to the interests of unskilled workers, who may be replaced by machines, and also to that of firms in the competitive segment.
- There is a double segmentation – amongst firms/ capital owners and amongst workers.
- A falling share of wages reflects the diminishing negotiation power of workers
- [Further treats: political and informational power, undermining the sovereignty of individuals and states. Competition policy to the fore!]

- Babbage enunciated the principle: “Every person employed should derive advantage from the success of the whole”, i.e., socio-economic development should be inclusive and equitable.
- David Ricardo: In cases in which the loss is far greater on one side , than the gain is on the other, those who gain could not even in principle compensate those who lose.
- Innovations should be steered in directions that are favourable to the living conditions of humankind and other species at large and ward off dangers threatening their survival.

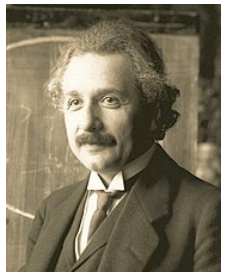
- Schumpeter: innovations involve processes of "creative destruction". People typically admire the innovator for the creative part and tend to forget the destructive part (technological unemployment, bankruptcy of firms etc.).
- The principle of accountability requests that both parts have to be imputed to the innovator. How to involve the innovator in compensating the losers?
- In the absence of ideal risk markets and in view of fundamental uncertainty, the costs and benefits of innovations will only become clear as time goes by. This excludes the possibility of compensating the losers *ex ante* and necessitates compensating them *ex post*.
- A scheme of redistributing income and wealth appears to be indispensable and cannot be rejected with reference to the efficient functioning of ideal markets, because in the turmoil caused by the process of creative destruction there are no such markets.

7. Concluding remarks

An important message of the argument is that technical change cannot generally be studied within a partial framework of the analysis, because one of its characteristic features is that it often affects the economic system as a whole, directly or indirectly. An innovation in one part of the system may resound in several other parts and revolutionize the technical conditions and work routines there, which in turn may generate feedbacks to the part from which it started. An IO-framework is badly needed.

- Anthropogenic Age: a rapidly growing importance of global public/collective bads (relative to private goods), which would have to be fought by policy measures. But are governments up to the task? I wonder.
- The planet is literally on fire, but instead of trying to extinguish the fire, some madmen, concerned only with their own ego, are fuelling it. Greed and lust for power accelerate the journey towards the abyss and more and more monstrous fake news try to hide it. War is peace.

Albert Einstein



"I do not know the size of the universe, but I know that the stupidity of mankind is infinite."

May input-output people successfully fight stupidity!