Choosing techniques or typical subsystems instead? A PhD thesis

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Abstract

This paper deals with the problem of choosing techniques. When we refer to the problem of choosing techniques, we actually refer to choose from a set of given production processes-techniques -according to a specific criterion- the optimum one. The criteria which are going to be presented are the w-r criterion, the cost minimization criterion, the Bidard's algorithm and the -so called- John von Neumann's criterion. Based on the usual neo-Ricardian assumptions for the linear production techniques, we try to figure out whether a comparison of the above techniques is possible according to any of the above criteria.

The main conclusion of this paper is that it is impossible in either a neoclassical, or a neo-Ricardian "world" to choose or to rank a technique between others, according to any of the above criteriaeven in the special case of the non decomposable single production techniques. We are confident that it is possible to rank univocally the techniques in the case of corn and charasoffian economies, and of course in an economy *a ℓa von Neumann.* We conclude that in fact we do not compare or choose techniques but typical systems instead.

JEL codes: C61 - Optimization Techniques; Programming Models; Dynamic Analysis, C67 - Input-Output Models, O33 - Technological Change: Choices and Consequences

Key Words: Choice of techniques, Input- Output models, criteria of choice

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1. Preliminaries

In the beginning of this Phd-Thesis, a definition of a production technique has been given -and therefore the definition of a linear system of production-. In this analytical framework the production prices have been determined via the system of production prices.

Under these assumptions the production prices are been defined by the relations:

$$p = pA(1+r) + w\ell \quad (1)$$

$$pq = 1 \quad (2)$$

As A stands the nxn material input matrix, as p the production 1xn price vector, w and r the nominal wage and the profit rate respectively and ℓ the 1nx direct labour vector. Let also q be the nx1 typical commodity vector[2].

The production prices, moving in *a la Sraffa framework,* do not depend only on technological factors, but on the income distribution as well[3]. The last seems to differ from the neoclassical theory's Non Substitution Theorem. Nevertheless it is necessary in order to define the absolute (and not the relative) production prices, to normalize them first with a typical commodity. The price normalization needs the use of normalization equations[4]. It has been shown that with the normalization equation to vary, it is possible for many price-based magnitudes to change, mostly in the case of decomposable techniques.

More specific, it has been shown that in the special case of decomposable single production systems it is possible, with price normalization:

1. The dimension of the production systems changes. In other words the number of the produced commodities and therefore the number of the production processes in use. That's why after the price normalization, a typical subsystem occurs, which uses a technique $[N, L]$, different than technique $[A, \ell]$, which the given system of production uses.
2. With price normalization it is possible to change, not only the absolute production prices of the commodities, but the relative as well..
3. In the special case of decomposable techniques a change in price normalization changes the maximum profit rate[5] and the maximum nominal wage.
4. In the special case of decomposable techniques a change in the price normalization occurs a change in the capital intensity (in price terms) of the (typical sub-)system.
5. Based on facts 4. and 5. we conclude that it is possible for the shape, the place, or the slope of the w-r curve[6] to change.

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[2] It is obvious there are n equations with n+2 unknowns (the price vector, r and w). The system can be solved by the use of the price normalization equations and the exogenously set of r or w. If the above system is solved then the prices are fully determined.

[3] The w-r relation is the relation that reflects the income distribution

[4] We have seen that price normalization is possible with the use of typical commodities, such as Sraffa's, Miayo's Vassilakis' and P.Voygiouklakis-Th.Mariolis's standard commodities.

5 In the case of non decomposable techniques of single production, the maximum profit rate that occurs, corresponds to the biggest eigenvalue of the material input matrix

As a result, the w-r relation is a decreasing function of the profit rate. In the case of single production[7], the w-r curve can be linear, convex or concave. The capital intensity of the (typical sub)system, multiplied by -1, is also the slope of the w-r curve. In the special case of the linear w-r curve the capital intensity of the (typical sub)system is constant and does not change with income distribution (namely a change in the profit rate)[8].

In bibliography four typical commodities are known. The standard (typical) commodity of Sraffa, which is just the right eigenvector of the material input matrix, for the case of non decomposable single production techniques. In the case of non decomposable single production techniques the presence of Miayo's standard commodity is possible, which is consisted of the standard (typical) commodity of Sraffa and a orthogonal semi-positive vector on the price vector. On the other hand on the decomposable systems of production, it can be found relatively (to Sraffa's and Miayo) Vassilakis' and Vougiouklakis-Mariolis standard commodity. These typical subsystems main property is that the price vector is independent of income distribution and therefore linear w-r curves occur.

Based on the above, and on the definition of G. Stamatis, the choice of technique is the choice of the most profitable one. In other words we refer to the technique that for a given profit rate (nominal wage) brings the biggest possible nominal wage (profit rate).

The problem of technological choice, was the subject of a controversy which took place from the last 50's till early 70's, between the neoclassical and the neoricardian school (Theory). The neoclassical Surrogate Production Function was the "battlefield" of this controversy. An economy, which use the Surrogate Production Function, produce a homogeneous output, using a homogeneous production factor called "capital" and direct labour. In this case there is a linear relation between the profit rate and the nominal wage. A univocal ranking of techniques is granted for a neoclassical system of production. On the other hand according to the neoricardian theory, it is possible for someone to choose among a set of techniques. Nevertheless it is possible to appear some paradoxes, in a decomposable single production techniques framework. Such as reswitching and reverse capital deeping. In this PhD thesis it has been shown that the role of price normalization has been put out of the above discussion.

The choice of techniques is possible using a number of criteria. Among them are the w-r criterion, the cost minimization criterion, the market algorithm (such as the Bidard's algorithm) and the so called John von Neumann's criterion.

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[6] The last, as we have seen, has a great sense for the validity or not of the w-r criterion

[7] But for the case of well-behaved joint production case

[8] As we have seen, the capital intensity in price terms is mostly a price magnitude. Prices are affected by income distribution and therefore by the profit rate. As a result the capital intensity as a production prices function depends on the profit rate

2. The w-r criterion

According to the w-r criterion, a technique is been chosen if for a given profit rate (nominal wage) the biggest possible nominal wage (profit rate) occurs.
The w-r criterion is known also as the criterion of profit maximization. The approach on this criterion is possible on mathematical and diagrammatical terms. In the case of the mathematical approach, can stand the following separately:
$w^{(a)}(r,y) < w^{(b)}(r,y)$,(3)in this case technique (b) instead of (a), as for a given profit rate and a given price normalization (with typical commodity y) brings the bigger nominal wage
$w^{(a)}(r,y) = w^{(b)}(r,y)$ (4)in this case the economy is indifferent in using either of the two techniques
$w^{(a)}(r,y) > w^{(b)}(r,y)$ (5) in this case technique (a) is chosen instead of (b)
It is clear, from the above relations that the choice of techniques depends on price normalization in the general case, as not only the production prices, as absolute measures, but the profit rate as well, depend on the price normalization. In the special case of non decomposable neighboring single production techniques (in other words techniques that differ in only one commodity's production process) the validity of the above relation is granted, and the ranking of the techniques is univocal. The last, nevertheless, does not retract the possibility of the reswitching phenomenon.). In the presented PhD thesis the extended anaphora in price determination, took place in order to make clear, that the w-r criterion does not rank techniques but typical subsystems instead.
The w-r relation can change with price normalization. Consequently the nominal wage, for a given rate of profit, can be changed too.
For non decomposable techniques the is no reason why, the ranking should be univocal in the general case[9]. It is only possible for these techniques to be univocally ranked when they are neighboring, or in the special case that the price vectors of these techniques (typical subsystems) can be compared. As a result in order the choice of technique to be univocal should stand:
From equations (1),(2),(3), (4), (5), occur:

$$\ell^{(a)}[I - A^{(a)}(1+r^*)]^{-1} > \ell^{(b)}[I - A^{(b)}(1+r^*)]^{-1} \quad (6)$$

$$\ell^{(a)}[I - A^{(a)}(1+r^*)]^{-1} = \ell^{(b)}[I - A^{(b)}(1+r^*)]^{-1} \quad (7)$$

$$\ell^{(a)}[I - A^{(a)}(1+r^*)]^{-1} < \ell^{(b)}[I - A^{(b)}(1+r^*)]^{-1} \quad (8)$$

On the other hand the decomposable single production techniques cannot be compared and ranked in the general case, no matter if they are neighboring (or not). It has been proved that in the case of the decomposable single production techniques, when the maximum profit rate of the typical subsystem changes, the maximum wage rate

[9] As Th. Mariolis have shown the ranking even of non decomposable techniques can change with price normalization. On the other hand G. Stamatis (1990b) and (1994) have shown that the ranking of non-neighboring techniques can be changed with price normalization without nevertheless the most profitable technique to change. In other words the w-r curves bellow the outer envlelope can change.

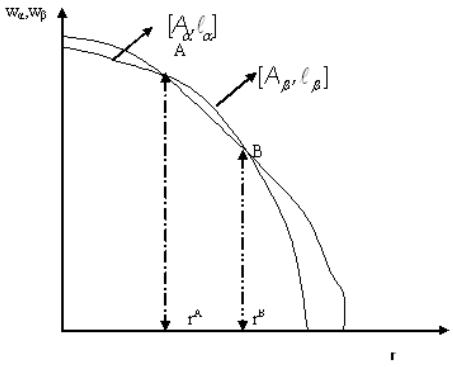
changes too. It is obvious that the capital intensity, as a price magnitude, changes also with price normalizing. In this case it is absolute possible for the w-r relation as a whole to vary. As a conclusion two non decomposable techniques can be univocally ranked only by coincidence.

On the other hand, based on the w-r diagram[10], it is obvious that points upon, and never under, the w-r curve[11], are been chosen. Diagrammatically speaking, the (re)switch points can be found in the intersection points of -the typical subsystem's- w-r curves. These points can be moved, appear or even disappear with a change in the price normalization. The reason is that not even the shape, the place but the slope of the w-r curve as well changes with price normalization. In other words in single production techniques, with changing the price normalization, the capital intensity of the system, and therefore the slope of the w-r curve also changes, without a mutual change in the most profitable technique. The univocal ranking of techniques (in a diagrammatical way of speaking, the stability of the switch points) is only possible when the non decomposable techniques are neighboring. In this case the ranking of the techniques is based only in technological factors and does not change with price normalizing[12], (as the income distribution variables are endogenously determined).

In the other hand in decomposable techniques, the slope, the shape and the place, of the w-r curves can differ with price normalization, no matter if the techniques are neighboring or not. As a result not only the (re)switch points but the most profitable technique can change with price normalization. Therefore the choice of techniques, depends not only on technological factors, but on the typical commodity as well.

Nevertheless the w-r criterion, signifies one very crucial point namely who takes the productive decisions. The w-r criterion, supposes the existence of one "collective capitalist", who takes decisions on the income distribution, the price normalization and lastly on the the choice of techniques –or typical subsystems. Of course the existence of such a "collective capitalist" seems to be non realistic enough in a capitalist-wise

[10] Diagrammaticaly the w-r relation can be stated as follows



Graph 1:The w-r Relation

[11] Is known as the outer envelope theorem. The opposite (the choice of points under the w-r curve) would be non orthological.

[12] It is obvious that in this case the Non Substitution Theorem seems to be satisfied.

built economy. On the other hand the w-r criterion seems realistic enough in central planning economies and socialistic economies.

3. The cost minimization criterion

Opposite than the w-r criterion, the cost minimization criterion can only be used in neighboring techniques. The cost-minimization criterion is an alternative criterion of choosing techniques. This criterion can be said to be closer to the capitalistic reality, as the decisions about the production plans , are been taken by an individual capitalist and refer to a given production process, where the production prices of the used means of production are exogenously given. More specific, according to the cost minimization criterion, the technique that is been chosen is such that for a given profit rate, and therefore for given production prices, no other technique brings extra profits[13]. As we have pointed out in our thesis above, the cost minimization criterion can be applied only in neighboring techniques. Let us be more specific about how this criterion works: for a given profit rate, the production prices are been calculated for a single technique. For the price of that technique, it is examined whether any of the available alternative techniques brings extra profits and no extra cost[14].
Subsequently according to the cost minimization criterion, it is possible to hold separately:

$p^{(a)}q < p^{(a)}A_j^{(b)}(1+\bar{r}) + w^{(a)}\ell_j^{(b)}$ (9)in this case technique (b), for a given profit rate (with typical commodity y)- does not bring extra profit, and as a result technique (a) is been chosen

$p^{(a)}q = p^{(a)}A_j^{(b)}(1+\bar{r}) + w^{(a)}\ell_j^{(b)}$ (10)in this case either technique (b) or (a) can be chosen, as for a given profit rate (with typical commodity y) does not bring extra costs

$p^{(a)}q > p^{(a)}A_j^{(b)}(1+\bar{r}) + w^{(a)}\ell_j^{(b)}$ (11)in this case technique (b) is been chosen as for a given profit rate (and in prices of technique (a)) (normalized with typical commodity y) does not bring extra costs

And as a result hold

$p^{(a)}q \le p^{(b)}q$ (12)

$p^{(a)}q = p^{(b)}q$ (13)

$p^{(a)}q > p^{(b)}q$ (14)

It is obvious that even in the case of the cost minimization criterion price normalization affects the validity of this theorem. In other words there can be a change in the direction of the relations (9)-(11).

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[13] However the production prices have already been normalized on order to be fully determined

[14] In mathematical terms the existence of extra profits with the use of a technique (b) in the production prices of technique (a) is that the fully determined price vector of technique (a) –of course for a given profit rate- should be greater than the production prices that occur for technique b in prices of technique a:

$p^{(a)}q \ge p^{(a)}A_j^{(b)}q(1+\bar{r}) + w^{(a)}\ell_j^{(b)}q$

Another disadvantage of the cost minimization criterion is that it holds only for neighboring techniques.
Another question that arises is whether the cost minimizing technique is also the most profitable. In other words, the equivalence between the cost minimization criterion and the w-r criterion is disputed. As it has pointed out in the so far analysis the cost minimization criterion, is equal to the w-r criterion only in the special case of non decomposable neighboring techniques, normalized of course same wise, or even in the case of decomposable single production techniques with a typical commodity –for decomposable single production techniques, let it be v, that is produced by the production process, that the neighboring techniques differ, or with a joint commodity v, that include commodity v, or a commodity that enters directly or indirectly in the production process of commodity v[15]. The equivalence of the two criteria is granted nevertheless for the special case of non decomposable, neighboring single production techniques.
The relation of the cost minimization criterion and the Non Substitution Theorem is obvious. In the case of the Non Substitution Theorem the technique that is been chosen is the technique that minimizes cost and can fulfill any type of demand with just an adjustment of the activity levels of the system. Therefore the Non Substitution Theorem can be said to hold as a generalization of the cost minimization criterion in an economy as whole and not in a given production process.
Nevertheless the w-r criterion and the cost minimization criterion have a common spot. The w-r criterion has debatable results in joint production systems[16] and the cost minimization criterion cannot be applied (mostly in the primal form) in joint production systems.

4. Bidard's algorithm

On the other hand, C.Bidard, implies a "new "criterion of choice in the case of joint production techniques. The Bidard algorithm is based on the cost minimization criterion and "Levhari's market algorithm[17]" for the joint production case. This algorithm moves in a Sraffain frame[18]. In Bidard's algorithm are also been compared joint production techniques for a given profit rate and there for a given technique's prices. The Bidard's algorithm's function can be described as follows: two or more neighboring joint production techniques are been compared-for a given profit rate, and therefore for given prices- for the production process that they differ. The technique-production process, that is been chosen is the technique-production process that does not bring extra costs and no other technique in that prices does not bring extra

[15]see G. Stamatis, 1997
[16] As Ch.Bidard and E.Klimovsky (2000) state, and opposite –but correct however- that Sraffa in the last chapter of his book states
[17] D.Levhari (1965)
[18] As production prices are normalized with a typical commodity such that the means of production have the same composition with the surplus product (normalized a la Sraffa).

profits[19]- for given prices and profit rate-. Mathematically the above can be described by:

$$\forall i \neq j, p_j B_i \leq (1+r) p_j A_i + w\ell_i \quad (15)$$

Bidard also points, that the choice of technique is comprehensive, or in other words the techniques can be univocally ranked, when one of the bellow equal terms hold:

1. Have an r-net output in common
2. The sign of the determinants of the r-net output matrices is the same

It is obvious so far that the Bidard's algorithm is a –sort of- generalization of Cost minimization criterion for the joint production case. The possibility of univocal ranking of techniques is because the common composition of the means of production and the real wages (net output of the system).

Nevertheless in the general case, Bidard's algorithm does not always hold. In the special case, that Bidard describes, the prices have been normalized with Sraffa's standard commodity. In this case the surplus product and the means of production have the same composition[20]. If the price normalization was a different one, nothing could ensure that the surplus product and the means of production would have the same composition. In other words Bidard sets a priori a common composition of surplus product and means of production.

G.Stamatis[21] had shown, in terms of the numerical example of Bidard, that it is possible for a changing real wage the ranking of techniques to change (and in other words a non comprehensive choice of techniques) –also in terms of the Bidard's example it is absolute possible the existence of non-square techniques[22]. Even in Bidard's algorithm there is a choice of typical subsystems and not techniques. It is obvious that in Bidard's example quasi-(actual)standard subsystems (Srafaian) are been compared for a given profit rate, and for given prices. Just like happens in the case of cost minimization criterion. The goal is to find techniques that do not occur extra costs.

5. Charasoffian systems, Corn economy and the so-called John von Neumann criterion.

Nevertheless, there are a couple of cases that techniques can be univocally ranked. This is possible for charasoffian systems of production and in corn economies. A criterion of univocal ranking is also the –so called- von Neumann's criterion.

Coming up next there were presented different cases of univocal technique ranking, like the charasoffian systems of single production, and the –so called- von Neumann criterion.

In corn economies there is a commodity that consists both a mean of production and the net product of the given economy.

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[19] In other words a technique is not profitable in prices of the technique that comes to substitute

[20] And the standard ratio of surplus product and the used means of production is the real switch point which Bidard and Klimovksy (2000) describe.

[21] G.Stamatis (2001) and (1996)

[22] According even to Bidard, a technique is a set of production processes which can satisfy any type of demand.

In other words both inputs and outputs have the same unit measure. As a consequence the profit rate is the ratio of two homogeneous magnitudes, the surplus product and the used means of production. That's the reason why the profit rate and the production prices are independent of price normalization. As a consequence the choice of techniques, in the case of corn economies, deals with choosing that technique that has the biggest standard ratio of surplus product and used means of production.
In charasoffian systems of production, labour is a self-reproduced production factor. Also the means of production have at the same time the role of commodities that consist the real wage.[23] Consequently in a la Charasoff frame, the profit rate is the standard ratio, between two homogenous magnitudes, the surplus product and the used means of production (real wage commodities), which have the same composition. In other words holds.

$$\sum_{i=1}^{n}(1-a_i)=\sum_{i=1}^{n}a_i \quad (16)$$

In this case, and because of the common composition, regardless the price normalization, the profit rate will be independent of the price normalization, and therefore endogenously defined.
For this reason, when we compare charasoffian systems of production, we choose the systems that have the biggest standard ratio of surplus product and used means of production, or in other words the biggest profit rate. The profit rate in the case of the corn economies is defined as:

$$r_{c.e}=\frac{1-a_{cc}}{a_{cc}} \quad (17)$$

The profit rate in the case of the charasofian models of production corn economies is defined as:

$$r_{ch}=\frac{px}{pAx} \quad (18),\text{where x the production activity levels vector}$$

The profit rate in the case of the von Neumann model is defined as:

$$r_{v.N}=\frac{pBx}{pAx} \quad (19)$$

An a la von Neumann, economy in the other hand, is nothing more than a charasoffian standard systems in the case of joint production. In a von Neumann frame, the existence of non square techniques is also possible. Because of the same composition of inputs and outputs, the technique that has the biggest profit rate-that is equal to the material growth rate of the system- is been chosen. The choice of techniques is such that the use of any other technique does not occur extra-profits[24]. The choice of techniques in the charasoffian systems of single production is univocal and independent of price normalization. In other words in this case the profit rate is

[23] That's the reason why, the commodities that consist the real wage, enters directly in the material input matrix
[24] The last is synonymous with the existence on no other technique that can be r-productive for the profit rate of the given technique

endogenously defined, regardless the price normalization and the income distribution.[25] As G.Stamatis shows, von Neumann's solution is so general that can be applied for any type of linear technique, like:

- Decomposable and non decomposable linear single production techniques
- Non separateable and non decomposable joint production techniques
- seperatable and non decomposable joint production techniques
- seperatable and decomposable joint production techniques
- Non separateable and decomposable joint production techniques

Nevertheless in the case of John von Neumann's criterion, there can be more that two efficient solutions, or in other words more than one techniques that maximizes both the profit rate and the equal growth rate.

6. Conclusions

As a conclusion, it is possible only in corn economies and in charasoffian systems, to be a univocal ranking of techniques that is independent of price normalization. It was shown that not only in the w-r criterion but in the cost minimization criterion as well, a necessary condition in order the choice of techniques (or to be more correct -typical subsystems) to be univocal, is that the techniques should be neighboring and non-decomposable. Nevertheless we have seen that in the case of decomposable techniques (or more correct typical subsystems) not only for the w-r criterion but for the cost minimization criterion as well the choice of techniques can change with a change in price normalization. Bidard's algorithm on the other hand, as a generalization of the cost minimization criterion for the joint production case, depends also on price normalization.

On the other hand corn economies and charasoffian systems of production (and consequently John von Neumann's criterion) are the only cases[26] of techniques which can be univocally ranked.

The point's that two technique's (typical subsystems') w-r have in common, called switch or reswitch points. These points have the following properties:

These techniques have for a given wage rate the same profit rate

Have the same production prices vector.

Based on the 2nd property Ch.Bidard and E.Klimovsky, and for the special case of joint production, have claimed that it is possible in points that two or more –but not all- w-r curves intersect the price vector for the compared techniques, not to coincide. These techniques called fake switch points and as they believe there can be not a real change of techniques in addition to the real switch points[27]

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[25] The last of course is not absolute valid as the direct labour is a reproductive production factor and consequently the income distribution has already been completed in an a la charasoffian or a la von Neumann model

[26] No matter if they are decomposable or not techniques of joint or single production

[27] As G.Stamatis have (2001) shown these point does not consist fake switch points, but real switch points instead. In K.Manoudakis(2010), in w-r criterion terms, is shown that there is no reason why the transition from one system to another should not be happened. The main conclusion is that not only the real switch points, depend on price normalization and can be

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appeared or disappeared or moved with a change in the typical commodity. In this point of view any point fake or real can be, according to Bidard's andKlimovsky' s point of view, fake.

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