PRICES FOR REGULATING AND MEASURING MARXIAN LABOR VALUES.

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Introduction

Cain, murderer of his own brother, "committed many other execrable actions, and among these -as Flavio Josefo writes-, 'when he invented weights and measurements, he transformed the innocent and noble naturalness in which the people lived, while they were ignorant of such things, into a life full of swindles." (Kula, 1980, 3)

To count and to measure is equivalent to sin. The fact that counting -especially persons- is a sin is sustained by the well-known fact that the idea to make the census of the Lord's people was suggested to David by the devil himself. (Kula, 1980, 16)

Measurement is "the process of associating numbers with physical quantities and phenomena" (Encyclopedia Britannica). "Measurement begins with definition of the **measurand**, the quantity that is to be measured, **and it always involves a comparison of the measurand with some known quantity of the same kind**. If the measurand is not accessible for direct comparison, it is converted or 'transduced' into an analogous measurement signal."[2]

Usually the Marxian Theory of Value (MTV) is presented as an explanation of prices and of exploitation. Most of the time MTV is seen as a failed explanation of prices and as an unnecessary detour for the understanding of prices or even exploitation. This is, in short, the redundancy criticism of MTV. This tendency can be seen in a wide spectrum of theorists: Samuelson (1971), Robinson (1966), Marco Lippi (1976), Howard and King (1985), Steedman (1977) among others. Such an interpretation, I think, is plausible and valuable. Nevertheless I will argue that this perspective is not the most useful for the scientific development of MTV in particular and for economic theory in general. This article accepts that Marx did not properly work out the relationship between labor values and prices. However although Marx's argumentation was insufficient his argument is basically correct: labor values and prices are strongly linked in present day capitalism. There is empirical support for this connection Shaik, 1984, Petrovich (1987), Cockshott, Cottrell and Michaelson (1994), among others have shown a strong correspondence between labor values and current prices. Thus one important problem of MTV is to explain such empirical evidence.

The opinion I will try to sustain is that prices are a **practical way**, in developed mercantile societies, of organizing social labor. To accomplish this, **market prices** must be close to labor values. Market prices gravitate around **production prices**; thus my assertion implies that both set of prices must be close to labor values. This article follows the suggestion of Perry Anderson (1983) that Marxian theory must respond to its critics by growing and consolidating. To accomplish such an objective in MTV the **redundancy criticism** has to be faced. This article does not aim to be an exegesis of the Marxist theory of value but a new approach to the labor

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[2] Emphasis mine

theory of value inspired by Marx, Marxist theorists[3] and measurement theory[4]. My main conclusion is that pricing is a real process of measuring labor values in present day capitalism. Therefore MTV is indispensable for the understanding and transforming of capitalism into a superior form of social organization. Such a proposition is against the accepted thinking of Marx's critics. Even for many Marxists it is necessary to build a new Marxian theory without MTV. My conclusion is the opposite: MTV is absolutely necessary to scientific thinking although it may be necessary to redefine certain elements and to provide more evidence for some of its arguments.

In the first section I will analyze the relationship between exchange value, labor value and the measuring process. The second section is devoted to the problem of justifying measurement and to explaining why it is indispensable to measure labor values in everyday life. These first two sections assert that labor value is far from being redundant and the third is a criticism of the common redundancy argument. The fourth section contains a summary and conclusion.

I Exchange value, labor value and measurement.

In this section it will be sustained that the Classical Theory of Value (CTV) made a great discovery by linking exchange value, labor value and the measuring process. It will be also maintained that CTV inverted the linkage: labor value measures exchange value in CTV, but the correct perspective is that exchange value measures labor value. This idea came from Marx who defined the measurand more carefully than CTV even if more refinement is still necessary.

From Adam Smith's point of view, metals and grains cannot constitute exact measures of the value of other goods.

> Labor alone, therefore, never varying in its own value, is alone the ultimate and real standard by which the value of all commodities can at all times and places be estimated and compared. It is their real price; money is their nominal price only. (Smith, A., 1979, 51)

Adam Smith emphasized:

> The distinction between the real and the nominal price of commodities and labour, is not a matter of mere speculation, **but may sometimes be of considerable use in practice**. (Smith, A., ibid.)[5]

To demonstrate the practical utility of this distinction Smith gives the example of the sale of land for perpetual rent. In these transactions the owners of the property right seek to keep the same real value of their rent, and thus that rent should not be fixed as an amount of money.

The measurement of the exchange value problem was further developed by David Ricardo, as can be seen, for example, in a letter from Ricardo to Say:

> ...You sustain that a manufacturer must make an inventory of everything he possess, rating every article to its ordinary price, to know for sure if the value of its capital has increased. Such a procedure would only inform him whether the value of his capital in terms of money has increased: maybe this would satisfy the manufacturer, but it is not the way in which a political economist must judge the increased value of capital. During the depreciation of our currency (bank notes) **many people thought that the value of their capital had increased while the reality was quite the contrary**, only because it was worth a larger amount of pounds. Money, whether paper or metallic money, can always lose value. Therefore it cannot be a correct measure of the other commodities, over a six-month span.[6] (Ricardo, D. 1963a, 163-164)

Ricardo made a distinction between use value and exchange value, and stressed that the first is an essential condition for exchange value which has "the relative amount of labor as almost exclusively determining the relative value of commodities" (Ricardo, D., 1963b, 10). Even if Ricardo was always concerned with the "other determining causes of the exchange value," the first and second edition of *The Principles of Political Economy and Taxation* did not include the

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[3] Farjoun, E. and Machover, M. (1983) is enlighten. Also are important Kühne (1979) and Weeks (1981).

[4] For this see the apendix to this paper.

[5] Emphasis mine.

[6] Emphasis mine.

softening words: "almost exclusively." Nevertheless Ricardo finally concluded that labor time had a definitive character in determining the exchange value of commodities. From the beginning of his book, there is an ambiguity in Ricardo, because he defined value as exchange value and labor sometimes as **its cause** and in other places as **its measure**.[7] Ricardo stated that Smith "after most ably showing the insufficiency of a fluctuating medium, such as gold or silver, for the purpose of determining the varying value of other things, has himself, by fixing on corn or labour, chosen a medium no less variable." (Ricardo, D. 1963b, 7) Ricardo underlined the Smithian confusion between the amount of labor applied in production and the amount of labor that can be acquired with a commodity. If what Smith stated were correct,

> ...If the reward of the labourer were always in proportion to what he produced, the quantity of labor bestowed on a commodity, and the quantity of labour which that commodity would purchase would be equal, and either of them might measure accurately the variations of other things ... (Ricardo, idem)

When Ricardo had to face the discrepancy between the "labour bestowed" on a commodity and the labor which that commodity would purchase, he did not find surplus value, instead he discussed the conveniences of one or another measure of exchange value. The relationship between exchange value, labor value and measurement was always important in Ricardo's analysis, appearing in chapter XX of his *Principles*, and it remained as a problem in his unfinished essay "On Absolute Value and Exchangeable Value."

> If we could dispose of a perfect measurement of value, which was not subject to increases or decreases, we would be in condition to find through it the real variations, also the proportional variations of the rest of the things, and we could never attribute the variations of the measured commodity to the commodity that has been used as a measure.(Ricardo, D., 1974, 175)
> Any commodity produced with the same amount of labor would be "a perfect measure of value, if the proportion in which the commodities are distributed between wages and benefits were always the same." (Ricardo, D., 1974, 178)

As he had already said in his *Principles*, Ricardo asserted that it is not possible to find any good that is not "itself exposed to the same variations as the things the value of which is to be ascertained; that is, there is none which is not subject to require more or less labor for its production."(Ricardo, D., 1963b, 24). But, even if such a thing were possible, Ricardo concluded that the measure would not be perfect first due to the differences in the rotation periods of capital (this is stressed i*n The Principles*) and second to differences in the distribution of income among social classes (pointed out in *The Principles* and also in "Absolute Value and Exchangeable Value").

Ricardo used a physical analogy to discuss the value measurement problem: when it is a matter of measuring a length, a comparison is used between a conventional standard, a meter (for example, made of wood), and the object under study. If the measurement is intended to determine how temperature changes alter a specific material, for example a piece of metal, then **the conclusion is not independent** of the material used in the standard of measurement. The meter could suffer similar variations to those of the studied material. It may happen that the standard of measurement increased in size more than the material measured, so that the conclusion would be incorrect: we would say that the metal reduced its length with the increase of temperature. Thus the "absolute" enlargement of the metal would be not perceived, because of the characteristic of the standard of measurement employed. It is possible to interpret Ricardo's concern about this point in the light of the actual Theory of Measuring (**TM**). That the object studied and the

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[7] It seems to me that Ricardo is ambiguous on this point because he does not establish clearly the relationship which exists between labour as a cause and labour as a measure of exchange value. Blaug states that while Ricardo affirms that labour is the fundamental cause of exchange value, his theory would lose nothing if this idea was eliminated. The idea that labour can be used as a measure of exchange value would be left to take its place (n.d. pp. 70-71)

standard of measure could have been affected by the same variables could be interpreted as the error problem in TM.

Breaking the connection

In CTV the relationship between exchange value and labor value is contradictory because labor value is both the cause of exchange value and the way of measuring it. This weakness was seized on by Ricardo's critics, who took the argument to the extreme that the exchange value is only what it seems to be: a proportion in which commodities are exchanged.

> Value denotes consequently nothing positive or intrinsic, but merely the relation in which two objects stand to each other as exchangeable commodities." (Bailey, S., 1967, 4-5)

Bailey repeated, endlessly, his argumentation: if value is understood to be exchange value, then it is not correct to talk about the measure of value because every good has multiple values; to keep all of them invariable, they should stay fixed, in which case the need of any measure of value disappears.

Bailey did not criticize a more fundamental problem concerning the postulation of labor as a measure of exchange value: labor value is not observable and exchange value is. Thus it is impossible that the yardstick be unobservable and the measurand observable.

If the measurand is exchange value and labor value is the measure Bailey was right: the exchange value of every commodity has a number assigned to it, in money terms, or a set of numbers in relative price terms. According to this there is no necessity to measure exchange value.

Bailey attacked CTV for its logical weaknesses. However other attacks were more political in intent, and soon after CTV was qualified as mistaken and pernicious.[8] Mark Blaug summarized the opposition of the dominant class to the classical theory of labor value:

> "Meanwhile the theory of labor value kept its strength in contemporary thought, the idea that profit is an appropriation of surplus value produced by labor reached the intelligence easily. The growth of industry and the development of a conscious proletarian class was all that was needed to create the argument that the laborers were exploited." (Blaug, M., n.d, 248)

Ricardo's theory caused opposition among his contemporaries. This was clearly expressed by Scrope:

> Of course, the publishing of hastily adopted opinions based on weak and imperfect evidence -opinions that, demolish the principles of sympathy and common interest that keep together society, cannot be less than deeply pernicious, **even if they were true- is equivalent to a crime**. (Quoted in Blaug, M., op. cit., 249)[9]

Even if CTV was initially conceived as a useful tool for the dominant class, it was transformed into something dangerous and criminal from Scrope's point of view.

In the same way counting and measuring was considered a sin, to measure production by the labor embodied in it became sinful, because it was against social harmony.

Reestablishing the link between labor value and price.

Unlike the classical thinkers, Marx did not consider that labor measures exchange value, but that the latter is the measure of the former. Hence exchange value is the necessary form of the appearance of value. Marx gave to human labor in theory the same key role that it has in practice: value is the time of abstract social labor applied in the production of commodities. As Makoto Itoh (Itoh, M. 1980, pp. 47-79) underlined, this idea underwent considerable change during Marx's treatment of exchange value.

> When at the beginning of this chapter, we said in common parlance, that a commodity is both a use-value and an exchange value, we were accurately speaking wrong. A commodity is a use-value or an object of utility, and a value. (Quoted by Itoh, 1980, pp. 51).

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[8]See for this Dobb, M. (1975, 125-6).
[9]Emphasis mine.

It can be said that Marx, as CTV did, confused measurand and measure itself in the first section of chapter 1 of *Capital* and he clearly separated both concepts in third section of the same chapter introduced until the second German edition of *Capital*.

Even though Marx does not use the measurement idea very much, he does introduce it occasionally and at other times it would be easy to interpret his work using such an approach. For example in the third section of chapter 1 of *Capital* entitled "The Value-Form or Exchange Value" Marx used the relations of equivalence exactly as we would in the present day theory of measurement.

Occasionally the measurement concept appears clearly. An example would be his discussion of money as a measure of value in chapter 3 of volume I of *Capital*:

> It is not money that renders the commodities commensurable. Quite the contrary. Because all commodities, as values, are objectified human labour, and therefore in themselves commensurable, their values can be communally measured in one and the same specific commodity, and this commodity can be converted into the common measure of their values, that is into money. Money as a measure of value is the necessary form of appearance of the measure which is immanent in commodities, namely labour-time. (Marx, 1979, 188)

Marx here is considering money as to be a standard of value, hence it should be divisible and so on. He briefly touches the possibility of measuring value directly. Owen proposed to transform labor from a **natural** standard of value to a **practical** standard of value.

> To make labour the standard of value it is necessary to ascertain the amount of it in all articles to be bought and sold. (Owen, R., 1927, 262)

Marx criticized this possibility because in a mercantile society nobody knows the amount of labor embodied in production. This is not only because of the technical difficulties involved in measuring it but because discrepancies between labor expended in production and labor appropriated by exchange is the essence of mercantile production. Money cannot represent labor time directly because in mercantile societies labor is not translatable directly into social labor. Thus it can be said that a great portion of measurement error is inherent to mercantile society and specific to this kind of society.

Marx asserted that Ricardo paid more attention to exchange value (relative value) than to absolute value (labor value) (Marx, 1980, 152). Marx was right on this point and the link established by CTV was partially correct if exchange value is the practical measure of labor value. The measurand is the embodied labor of Ricardo or more precisely the **value defined by Marx**. When a commodity is bartered or sold for money every exchanger considers that the value of both poles is equal. The seller and the buyer are measuring the value of the commodity as equivalent to the value obtained in the exchange. The previous statement is easy to understand for commodity money but with fiat money it is not so easy. The exchanger who sells by fiat money is measuring the value of his commodity by the value of the possible commodities that he may obtain with such money. **Pricing is a form of measuring labor values**.

Defining the measurand

Even Ricardo inverted the measurand and the measure although it may be said he made a great advance in defining the measurand. For him the embodied labor is the direct and indirect labor spent in producing each commodity. This is the first approximation to definition of the measurand. Ricardo also touched on the problem of qualified labor and concluded that such labor affected different industries almost in the same proportion. Therefore the existence of qualified labor does not modify the influence of wages on prices.

Marx made considerable advances in labor value theory. Human labor has to be measured to be organized and the ways in which it is measured together with the errors which accompany this

process have real effects. Such errors determine important aspects of our everyday reality. In order to organize labor it is necessary to take into account that the means of production have different useful lives, that the diverse labor processes have unlike efficiencies due to a variety of causes, that the performance of certain tasks is more skilled than others, and so on. These and other problems have to be analyzed in the light of their implications. Some of these implications are briefly analyzed below.

The better defined measurand is the labor value of Marx and not the embodied labor of Ricardo. Marx defined the measurand as value. This is the abstract labor socially necessary to produce commodities. Abstract labor is a requisite of cooperative labor: to consider the total amount of labor expended in the production of a particular commodity as a portion of social labor. Obviously this aspect of value is closely related to Ricardo's embodied labor. However Marx has reflected more deeply than Ricardo in his analysis. This can be seen when he asserts that in mercantile societies it is necessary to reduce concrete labors to undifferentiated human labor. All the ramifications of the value concept will not be discussed here. We will restrict ourselves to the concept of socially necessary labor. Marx refined the Ricardian idea of embodied labor:

> It might seem that if the value of a commodity is determined by the quantity of labor expended to produce it, it would be more valuable the more unskillful and lazy the worker who produced it, because he would need more time to complete the article...
> Socially necessary labour-time is the labour-time required to produce any use value under the conditions of production normal for a given society and with the average degree of skill and intensity of labour prevalent in that society. (Marx, 1979, 129)   Socially necessary labour-time is the labour-time required to produce any use value under the conditions of production normal for a given society and with the average degree of skill and intensity of labour prevalent in that society. (Marx, 1979, 129)   Socially necessary labour-time is the labour-time required to produce any use value under the conditions of production normal for a given society and with the average degree of skill and intensity of labour prevalent in that society. (Marx, 1979, 129)

Normal conditions of production involve "the level of development of science and its technological application, the social organization of the process of production, the extent and effectiveness of the means of production, and the conditions found in the natural environment." (Marx, 1979, 130). As the products are sold at the same price productivities superior to the average are rewarded and lower productivities penalized. This mechanism punishes laziness and rewards industriousness. The capitalist society gives this same treatment to natural disadvantages, insufficiency of capital accumulation, etc. We will examine this latter because it is necessary to focus on the other basic aspect of Marx's definition of value: the measurand. Marx asserted that "*substance"* of value is labor and that the *"measure of its magnitude"* is "*labour-time*." (Marx, 1979, 131). According to Marx we have one measurand: value and two measures: price and labor time. At the very least this seems confusing if not contradictory. However this could be interpreted in the same way that a chemist sometimes uses a direct measurement for concentration (a quantity of some dissolved substance per unit of volume) and in others circumstances uses an indirect measure as in the case of light absorbed by the solution containing the substance under examination. It is possible to use prices in capitalist or market socialist societies and to use labor time in planned societies. To give only one price to each commodity is to treat all differences of productivity in the same way. It is to consider each commodity as produced by an average amount of labor. Thus the measuring process is a social and historically determined activity. It would be possible to treat laziness and natural disadvantages differently. We could average the labor spent in the first case and not in the second. A second problem of measuring value by prices implicit in Marx's definition of socially necessary labor may now be considered. This is the case of the reduction of skilled labor to simple or unskilled labor. This problem has been considered unsolvable by Marx's critics. A recent example may be found in the work of John Elster (1986).

Marx's solution is to reduce skilled labor to simple labor by considering labor spent in training (Meek, 1975, 157-200). However it seems to me that capitalism reduces skilled labor to unskilled labor paying different wages rates not in proportion to training time[10]. As in the previous case there are at least two different solutions for each problem related to MTV. There is a capitalist solution and one related to a planned society.

Marx's definition of socially necessary labor focusses on the following:

a) There is a **practical** social necessity that must be satisfied, skillfulness and industriousness should be considered in organizing social labor.

b) Such a necessity is solved in capitalist society by the pricing mechanism.

c) To understand the practical implications of the capitalist solution to this problem the concept of labor value is absolutely indispensable.

d) Using labor value as a basis it is possible to find another solution to the economic problem.

Even Marx's definition of the measurand is not complete. Like his discussion of the reduction of skilled labor to simple labor, it leads to a critical evaluation of the capitalist solution and suggests that another kind of solution may exist which would be more useful to human beings. There is an obvious necessity to find a solution to the problem of reducing skilled labor to unskilled labor in order to resolve problems like the comparison of techniques.

In general given that Marx's definition of the measurand is incomplete, three attitudes are possible:

a) To declare the problem unsolvable (a position very frequent with Marx's critics).

b) To accept without any further consideration Marx's solution when such a solution exists (the dogmatic position).

c) To analyze Marx's proposition and to refine or modify it to fit particular situations (The fruitful attitude).

The process of measurement in a capitalist society is pricing and this measures labor value. However all processes of this sort involve error.

Measurement and error.

The second element from measurement theory that is implicit in CTV and in MTV is the error problem. In current literature it is accepted that all measurement involves error. Length without error is an abstract idea. Therefore any observable length must be interpreted as the real length plus (or multiplied by) an error term. Market prices or current prices are observable but natural prices are not. The latter are the gravitational centers of the former, so that it is possible to understand market prices as natural prices modified by an error term. But this interpretation is in conflict with the idea of labor as a measure of exchange value because there are many exchange values and there is only one measure.

Understanding error is easier if it is interpreted as the measuring link between exchange value and labor value in the very opposite way proposed by CTV. If price is the measure of value, which is the thesis of this paper, the value of every commodity can be measured by money (price is the

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[10] Wage differences -some five times the amount of others- which often occur within countries cannot possibly be accounted for by differences in time spent in training. For example if a member of a given profession spends half his working life in training then one hour of his work should -according to Marx- be valued at twice that of an unqualified worker. On the other hand, the indirect labour spent in training may not necessarily be reflected in the wage of the worker who has benefited from it. This is reinforced by the fact that there are important and persistent salary differences between workers who have the same qualifications. See Botwinick (1993).

monetary expression of value Marx *dixit*[11]). Indeed it can be measured by any other commodity in the same way that length or temperature can be measured using many different standards. In the same perspective there are two kinds of error: systematic errors such as production prices or absolute rent deviations and random errors caused by supply-demand discrepancies. It is possible to analyze, for example, deviations between production price and labor values as errors. These errors have a distribution with a mean of zero for an additive error term (or mean 1 for a multiplicative error term), as Marx implied, and it is possible to calculate the standard deviation of such a distribution. Marx concluded that the deviations explained by systematic discrepancies between labor values and production prices are small.[12] This last statement is ambiguous. Small could have very different meanings in different problems. For example in spectrometry an additive error of 10^{-8} may be admissible and in stellar magnitudes a multiplicative error of 10 might be reasonable.[13] In all measuring processes admissible error is defined in terms of the purpose of that process. As we discussed above CTV were concerned with practical problems. Therefore the problem of error should be discussed in CTV when the motivation for measuring something becomes a topic for discussion. Considering prices as measuring labor values helps us to understand why errors are unimportant for one aspect of the analysis and become central in another part. This is the point of ignoring systematic errors in volumes I and II of *Capital* and giving them a central role in volume III. With gold currency and production prices that diverge from labor values the loss or gain of the seller is exactly offset by the gain or loss of the buyer. Multiplicative errors average one over time. Thus investigating the origin of the surplus in capitalist society can be carried out ignoring the discrepancies between values and production prices:

> The formation of capital must be possible though the price and the value of a commodity are the same, for it cannot be explained by referring to any divergence between price and value. (Marx, 1979, 269)

Where error is considerable is necessary to understand consequences of this. Ricardo and Marx asserted that discrepancies between labor values and production prices are small. Ricardo's assertion that labor explains 93% of exchange value is well known. In the same way Marx wrote:

> In whatever way prices are determined, the following is the result:
> (1) The law of value governs their movement in so far as reduction or increase in the labour-time needed for their production makes the price of production rise or fall. (Marx, 1981, III, 280)

According to Marx a fall in the labor value of a commodity usually occurs with a rise of the organic composition of the capital producing the commodity. The rise in organic composition should increase the production price while the fall in labor value diminishes the production price. Therefore if Marx's assumption is generally true it implies that the organic composition effect is smaller than the labor value effect most of the time.

This assertion was not proved by either Ricardo or Marx but empirical evidence suggests it may be valid (Shaikh, 1984). Our interest here is to point out that considering price as a measure of value is consistent with treating discrepancies between labor values and production prices as systematic errors. The analysis of errors leads to understanding the practical necessity of measurement.

Summarizing this section:

1. Prices should be interpreted as a measure of labor value.

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[11] The idea of monetary expression of value is in Foley (1982) Vroy, De (1981).
[12] Marx suggested this from my point of view see below.
[13] See the very interesting article of Kuhn (1987, 202-247).

2. Discrepancies between labor values and production prices should be interpreted as systematic errors in measuring the process of labor values.

The second aspect of measurement remains to be analyzed. This is the link between values and prices: why should labor values be measured?

II.Why should labor values be measured?

Adam Smith stated clearly the problem of the conservation of value through time. Precious metals do not preserve their value in time; therefore -extrapolating- contracts could be made based on units of wages, **as is done on many occasions today**. Ricardo established that the measurement of value from the scientific point of view requires the inclusion of reality and he built his conceptual tools for that purpose. Ricardo and Smith did not address themselves enough to answering the question of why measurement is necessary. Marx even though he did not treat the question explicitly left many clues for the solution of this problem.

We find the outlines of three basic ideas in Marx:

a) Any type of society is obliged to produce its material conditions of existence, and must organize its social labor. We will call this the process of the regulation of social labor and it is a problem common to all types of economic system.

b) The regulation of social labor requires the measurement or calculation of the labor time spent on the production of different commodities.

c) The regulation of social labor has different historical solutions: independent primitive communities, slavery, feudalism, and so on. Capitalism is one system of social labor regulation in which the measurement of social labor is done unconsciously, and in which measurement error is used for regulation.

To develop these three ideas, let us begin with the concept of regulation which is our main interest.

1. Regulation and measurement of social labor

Regulation means:

The control or adaptation action of an output to a desired value in terms of an input.

The problems of regulation are studied in many disciplines, perhaps the most similar to those in economy[14] are to be found in biology, and that science provides us with a useful example of the phenomenon. To regulate temperature, the brain reacts to changes in body temperature, and orders actions to maintain it within a certain range: it increases perspiration to cool the body down or contracts the blood vessels to avoid heat loss. To regulate temperature, it is necessary to establish a relationship between the "errors" or deviations (the difference between current temperature and vital need temperature) and the corrective actions. To a greater deviation there must correspond a more intense correction than to a minor deviation. The perception of the deviations is an essential element for regulation; a second element is a repertoire of corrective actions related to the errors. In this example, the process occurs automatically and unconsciously. We could say that the regulation of the body's temperature is an unconscious process in which the deviations of the temperature of some magnitude are related to some corrective actions.

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[14]There is a whole movement which originated in France named "Regulationist". None of the contents of this article has an intentional relationship with that school. To see more about this school, there is an excellent resume in Boyer, R., "Technical Change and the Theory of 'Regulation'", CEPREMAP, March 1987.

The control systems are not perfect because they require deviations of some magnitude to react. If the environmental temperature exceeds a certain value, our organism has no way of maintaining the body temperature within the vital limits and so we die. Within the range that the thermic regulation system operates, it is essential that the brain is informed about the temperature; it would be nonsense to pretend to regulate it without any information about temperature. Also, it would be impossible to talk about regulation without a repertoire of corrective actions. The efficiency of the control systems depends on the measurement of the variable to be controlled, and on the ability to act on it. Difficulties of different types may arise when designing a system of regulation. For example, the regulation of heat in a metallurgical oven raises different problems of measurement than those implied in a kitchen oven for cooking. Corrective actions to regulate the temperature in a domestic oven are minimal in comparison to those of a nuclear reactor. However, the measurement of the variable and the "reaction" to the errors is always the same. If, for example, in a control system one of these was absent, there would be no control.

If a problem such as the temperature regulation of an organism can seem so complicated, what can we say about the problems of social labor regulation? The social organism is very complex and presents very different control problems. One of the most important regulating variables is a worker's labor.

> ..The law of the value of commodities ultimately determines how much of its disposable labor-time society can spend on each kind of commodity. But this constant tendency toward equilibrium comes into play only as a reaction against the constant upsetting of this equilibrium. (Marx, K., 1979, I, 476)

In a hypothetical society, conformed by free laborers,

> Labor time would play in that case a double part. Its apportionment in accordance with a definite social plan maintains the correct proportions between the different functions of labour and the various needs of associations. On the other hand, labour-time also serves as a measure of the part taken by each individual in the common labour and of his share in the part of the total product destined for individual consumption. (Marx, K., 1979, I, 172)

In this quotation, and in other parts of his work, Marx outlined a vision of the organization of social labor as a regulated system. What should be produced in common? How much should be produced? How should the product be distributed between the members of the society? How should the best technique be chosen? With these questions we are signalling vital factors of social labor regulation.

When we assign the means of production and the amount of labor to the different branches of production, the amounts of different commodities that can be consumed at present, and in some way into the future, are determined. The goods that can be consumed now must be distributed between the producers so that labor is not wasted. The fact that there is a need to socially regulate human labor does not imply that all labor is regulated in the same way. **For example, domestic work is indispensable labor that is not regulated through measuring**.[15]

Marx said that it is important to distribute social labor in relation to the volume of social needs, and this is the role of the law of value. What is the volume of social needs? One might think that it would be a list of everything necessary to survive. Nevertheless, such a list would not have any relationship to actual human capabilities and knowledge. From the extensive set of needs there would be a subset of what is possible after taking into account the restrictions imposed by the availability of labour. **Only by establishing needs in terms of labor would it be possible to determine the feasible consumption region** of a society and choose the amount of required needs. It makes no sense to pose the problem of how much clothing, food, etc. to produce if this

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[15] A very interesting perspective linking MTV, domestic labor and gender is in Laibman, D. (1992, chap. 3)

is not selected from those combinations which are feasible. Therefore, the variables would be the amounts of social labor that could be assigned to the production of the different goods, given certain technical circumstances. These could be modified, but not at will; they are **data** for labor regulation. **When the technical conditions in a society are changed, it is important to consider the labor that the new techniques require and then decide if they are convenient or not for society**. If a new technique requires more labor for the same results than a previous one, it implies a loss for someone if it is adopted. It is almost impossible for any society to judge this as correct. This is so even if the mistaken decision is adopted in a class society and the cost of the mistake will be paid only by the dominated classes. Another aspect of the regulation of social labor is the establishment of the quantity of means of production. Let us suppose that the amount of goods for human enjoyment that can be produced with current technical knowledge is set. That does not mean that this amount can be produced immediately. It may well be that the supply of means of production must be increased before society is in condition to produce the desired quantity. So, labor will have to be transferred from the production of current consumption and dedicated to future consumption. The effect of such an effort can only be understood in terms of labor. Finally, the consumer goods must be distributed among the producers. To do this it is indispensable to account for individual labor time, and to establish the relation with the labor that is required to produce different goods. In a society of free men and women the product could be divided according to individual needs, but even in this case the calculation of labor time would allow for a clear understanding of the nature of distribution. If one production unit receives goods that cost double its labor time, the other units would receive less.

To regulate social labor means to assign social labor to accomplish certain established goals in terms of social labor time, and for this to take place one requirement is to measure the social labor spent in the production of different commodities.

Capitalism is a form of regulation of social labor where it seems that the goals in terms of social labor are not established. Apparently what we have said above can refer to a primitive autonomous community or to a planned society of the future, but not to capitalism. But it is impossible for capitalism to be a form of progressive production without resolving, with some degree of efficiency, all the above mentioned problems. To substantiate this idea we must analyze how these problems are resolved in an unconscious way within capitalist society. In the same way that we regulate unconsciously the temperature of our bodies, the social organism regulates collective labor. To support our argument, we should discuss each of the above problems one by one. However limitations of space do not permit this here. Instead, we will discuss the problem that seems to be the clearest for us: the choice of techniques. We propose to examine why the selection of technique should be made in terms of labor, and how that solution is approached in capitalism.

2.   *Choice of technique and the measurement of value*

We will argue:

a)   to choose the better of two different techniques it is necessary to take labor value into account,

b)   the right choice of technique cannot be made by using the accounting of physical units,

c)   capitalist accounting, profitability, fails to choose the best technique in some circumstances.

In first place, I will argue my points using a numerical example. Assume a pure corn model where 0.4 tons of seed and 0.6 of a worker-year are necessary to produce 1 ton of corn per year. I call this technique A. If technique B is available and requires 0.2 ton of seed and 1 worker-year to produce 1 ton of corn, it is a problem of economics to decide if technique B should replace A or which of these techniques is the best.

First, in terms of physical accounting, it is impossible to say if technique B is better or worse than technique A because the second requires less seed but more direct labor than the former. Thus in physical units it is impossible to choose the best technique. Now in labor value terms, technique A produces corn with value $m_A = 1$ worker-year/ton, but technique B will result in $m_B = 1.25$ worker-year/ton. Thus production possibilities will be reduced with the second technique, and society will be impoverished if technique B is chosen. In a pure corn model, production per employee and consumption per employee are both equal to $1/m_i$, this variable is the reciprocal of the value of corn. It is impossible to derive similar conclusions from physical unit accounting **even in a pure corn model. Thus the meaning of the development of the productive forces is the reduction of labor values**. The previous affirmation cannot be expressed in physical terms. Let us examine the capitalist choice of technique with the same numerical example.

Capitalist Choice of Technique

If the wage rate is 0.4 ton per year and assuming that all the wage is paid in advance.[16] The profit rate for technique A would be:

$$r_A = 0.36/(0.4+0.24) = 56.25\%$$

For technique B the new rate of profit would be:

$$r_B = 0.4/(0.2+0.4) = 66.67\%$$

Given that the new technique is more profitable, capitalists will adopt it. With this selection, capitalists **will adopt a regressive technique** because the labor value of corn with the first technique would be 1.0 worker-year per ton, and with the second technique labor value would increase to 1.25 worker-year per ton. Here the more profitable technique means more labor value per unit of product. The explanation for this is, that the price of the labor force takes into account not living labor but paid labor, and the latter should be lower than the former to obtain a capitalist surplus.

In this example the well known switching of techniques occurs. If the wage is greater than some critical wage rate w_1 then technique B becomes less profitable than technique A, so that the capitalist choice of technique becomes equivalent to a choice based on labor value. So there are two regions, one where the capitalist choice of technique is wrong being based on production of corn per worker if $w<w_1$ and the other where it is right if $w>w_1$. The NeoRicardians criticized Neoclassical theory because the reswitching of techniques occurs (Sraffa, 1960). But according to the former analysis, **even the switching of techniques is a practical problem**. It represents the possibility of a wrong capitalist choice of technique based on prices that do not take into account the real social cost but the capitalist cost of production. The most profitable technique for $w>w_1$ is B. This implies a greater cost in terms of direct and indirect labor, i.e. a higher social cost. Nevertheless, it represents less cost in corn per unit of product and therefore less capitalist cost.

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[16] All calculations are made in corn i. e. in price terms.

This occurs because wage is the monetary expression of paid labour and not of direct labour.[17] Thus it may happen that if constant capital is economized and more money is spent in variable capital the result may be a higher labour value per unit of product. This is an intrinsic error of capitalist production in the measurement of the labour used. It is worth emphasizing that this error will have a regressive effect only when technical change implies a decrease in the organic composition of capital. When the technical change comes about through a rise in the organic composition of capital, the error by which direct labor is measured may imply that the decrease in the labor value of the product may be greater than was estimated in monetary terms. Thus, this may lead to the non-introduction of a convenient technical innovation but not to technical regression. Marx broached this idea when he pointed out that American wages being higher than those in Britain a situation had arisen whereby Britain was producing machines to be sold only in the United States (Marx, 1979, I, 516). However, Marx did not go on to state that Britain was wasting an opportunity to use a technique which would reduce the value of the product. He also missed another possible reading of this situation: a lowering of salaries within one country may lead to the adoption of regressive techniques. This occurs in our numerical example.

As far as we know, the marxist literature on technological change concentrates on such things as the problems of the law of the falling rate of profit or whether the organic composition of capital rises or not (for example, Laibman, 1992). Schefold asks: How does productivity increase as a result of technical progress? (1986, 252) when he analyzes the relationship between fixed capital, accumulation and technical progress. His answer to this question lacks clarity because he accepts the existence of different kinds of productivity. On this point the NeoRicardian literature can only treat the choice of technique in terms of prices. It is therefore unable to include the idea that technological regression may result from capitalists following the criterion of profitability.

A second aspect of capitalist choice of technique is that, if prices of inputs are not proportional to labor values, reducing monetary costs is not the same as reducing labor values of inputs. Since this cannot be analyzed with the pure corn model, some generalization is necessary.

The Case of n Commodities

The previous analysis can be applied to an n commodities case. It can be showed that:
$$\mathbf{ZM} = 1 \qquad\qquad (1)$$
where $\mathbf{M}$ is a row vector of labor values[18], $\mathbf{Y}$ is a column vector of final demand in physical units, $\mathbf{Z} = \mathbf{Y}/\mathbf{LX}$, that is, the vector of net product per worker, and $\mathbf{L}$ is a row vector of labor requirements per physical unit of gross production.

Expression 1 defines a straight line in a n-dimensional space, **which defines feasible production with full employment** and divides the commodity space into two regions:

a) an unemployment region: below the straight line there is a region of feasible production with unemployment.

b) unfeasible production: above the line lies the region of unfeasible net product per worker.

Figure 1 illustrates the production possibilities for a two- commodities case (put figure 1 near from here). It is obvious that equation (1) also defines the possibilities of consumption per

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[17] This was pointed out by Marx (1979, I, 515)

[18] As usual $\mathbf{M}=\mathbf{L}(\mathbf{I}-\mathbf{A})^{-1}$ where $\mathbf{L}$ is a row vector of labor coefficients and $\mathbf{A}$ is the input-output matrix in physical terms.

worker. So the reduction of the value of at least one good, increases the possibilities of consumption. From this it follows that a correct choice of technique increases the consumption per worker, and on the contrary, a wrong choice of technique diminishes the possibilities of consumption. There is no problem in applying a choice of technique based on labor values to an n commodities case. In the general case, as in the pure corn model, it is impossible to choose a technique based on physical quantities (real terms).

Figure 1
Labor value and production feasibility
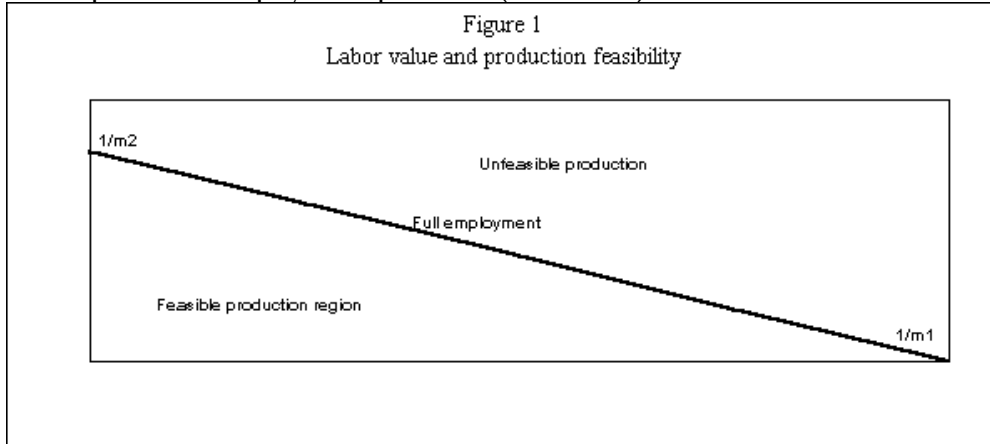
Depending on the wage rate, the capitalist choice of technique in the general case will be wrong in one region and right in another. Right means to select a technique that improves consumption per worker in at least one commodity; wrong has two meanings: i) capitalists choose a technique that diminishes consumption per worker, ii) capitalists reject a technique that will improve consumption per worker.

Capitalist choice of technique will be wrong or right not only because of differences between labor and paid labor, but also because of differences between prices and values. If current prices of commodities p_i are different from prices proportional to values[19], capitalists will make a right or a wrong selection of technique. But even if prices are proportional to labor values capitalist may make a wrong choice of technique because living labor must be underestimated to obtain a surplus.

The correct choice of technique in industry j requires:

$$\mathbf{M_1}a_1^j - \mathbf{M}_0 a_0^j + l_1^j - l_0^j < 0 \quad (2)$$

where subscript means time, and a_0^j is jth column of $\mathbf{A}$ in time 0, l_0^j is direct labor coefficient for industry j in time 0. The meaning of (2) is simple: a better technique requires that labor value should diminish.

The previous decision in price terms, with perfect information (i.e. prices after new technology), requires:

$$\mathbf{P_1}a_1^j - \mathbf{P}_0 a_0^j + w_1 l_1^j - w_0 l_0^j < 0 \quad (3)$$

where $\mathbf{P}_0$ is a row vector of current prices and w_0 is the wage rate.

If prices are considered as a measure of value, it is necessary to interpret $\mathbf{P}_1 = \alpha_1 \mathbf{M}_1 <\varepsilon_1>$ and (3)should be rewritten as:

$$\alpha_1 \mathbf{M}_1 <\varepsilon_1> a_1^j - \alpha_0 \mathbf{M}_0 <\varepsilon_0> a_0^j +;_1 \alpha_1 l_1^j -;_0 \alpha_0 l_0^j < 0 \ (4)$$

[19] From my point of view, for a price comparison to have any meaning both prices must belong to vectors $\mathbf{P}_1$ $\mathbf{P}_2$ such that the value of money ß is constant. In addition if $\mathbf{P} = ß\mathbf{M}$, prices are value-prices, "prices equal to values" in Marx's words.

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where α_1 is the monetary expression of value defined by **MY**/**PY** in time 1

$<\varepsilon_1>$ is a diagonal matrix whose element $\varepsilon_{i,i}$ is error term for price i

$;_1\alpha_1 l_1^j$ is labor cost for industry i

$;_1$ is the wage share in time 1.

In addition, Ricardo asserted in his answer to Say that measuring capital in money terms might be enough for a manufacturer but not for a political economist. Neither of them would be satisfied today with this kind of measurement in order to select a technique. It can be shown that if prices are proportional to labor values, the usual deflation would eliminate changes in the monetary expression of value α_0. Even eliminating errors caused by inflation, measurement in terms of prices would not be accurate because of the errors $<\varepsilon_i>$ and $;_i$. The influence of the wage share in the determination of prices should be seen as an error which causes the underestimation of labor costs.

Therefore expression (4) illustrates quite well the idea of prices measuring labor values although with error. This is common to all measuring processes.

The choice of a technique requires us to determine wich is cheapest measured in terms of labor value. Economic growth is possible if capitalist society selects, most of the time, techniques that reduce labor spent in production. With an explicit accounting of labor values, an efficient selection of technique is possible. However, capitalist society calculates profitability based on prices and does not consider labor values. Nevertheless, capitalist society has made the right choice most of the time. What is the explanation of this? It **is due to the fact that capitalist accounting approximates to accounting in labor value terms**. It is suggested here that prices are very close to labour values in present day capitalist societies. Therefore, most of the time, the choice of a technique based on prices will produce the same result as one based on labour values. **Because prices measure labor values, decisions in price terms are analogous to decisions in value terms**. This seems to occur despite the fact that to select a technique only paid labor is taken into account. The reasons for this may be that, in capitalism, organic composition usually rises and it has been shown that in this case the underestimation of direct labour on the choice of techniques will not have negative consequences as if organic composition of capital would decrease. In the case of rising organic composition of capital the underestimation of living labor has as a result that capitalist neglect a technique that would increase consumption per worker and do not adopt a technique that would reduce such consumption.

III Redundancy argument

The previous two sections argue that measuring and regulating labor values is a necessity in capitalist economies. This section is devoted to explaining why intelligent people believe that labor value is redundant. Two answers are given: redundancy seems reasonable and its defenders confuse mathematical determination with real determination.

It seems that Marxist theory can be easily upheld without considering the relationship between prices and labor time. This is both because the labor theory of value gives impulse to the criticism of capitalism, and because the regulation of social labor is carried out without a conscious measurement of labor time. Bailey's criticism of the labor value theory was continued by neoclassical theory (Samuelson, 1971, 399-431) which considers prices only as preference orders, and the Neoricardians (Steedman, 1977) who understand prices to be the result of the technical conditions of production. The latter have elaborated the most complete criticism of the necessity of value for explaining prices. Neoricardians claimed that labor values in Marxian economic theory are redundant:

> Marx's value reasoning -hardly a peripheral aspect of his work- must therefore be abandoned in the interest of developing a coherent materialist theory of capitalism. (Steedman, 1977, 207)

The choice of technique is a good example of the Neoricardian criticism: a) Capitalists choose techniques to maximize profits based on prices of inputs. b) Only after that selection, are labor values determined. Therefore, according to Steedman (Steedman, 1977, 65), labor values do not play any role in the choice of technique.

Lippi arrived at the same conclusion of redundancy by making a very refined critique of MTV (Lippi, 1976). He criticized Marx's idea of linking exchange value and labor value both because of their insufficiency and also because the link leads to contradictory results (for example in the transformation of values to production prices.) Lippi gave his implicit "naturalism" as an explanation of Marx's failed intent to relate exchange value and labor value (Lippi, 1976). Like Neoricardians, Lippi concluded it is necessary for Marxian economics to abandon labor value.

I agree with Lippi that Marx's argumentation linking exchange value and labor value is insufficient. So this article is an response to his critique.

The reply to the redundancy argument is the following: measuring labor value is a practical necessity for regulating social labor. It is impossible to reproduce capitalist society without the regulation of social labor. For example if capitalists choose techniques that reduce the labor value of products, they make the right choices. To reduce labor values is a practical need. To reduce costs in price terms is an imperfect way of accomplishing this. For this reason, labor values seem redundant in capitalism, but this illusion should be unmasked in theory and in reality. Here it is argued that prices measure values with some error, which is necessary for the reproduction of capitalist society. However, this in some circumstances involves serious obstacles to reproduction. In a planned economy, prices that distort labor values must be redundant: for example, it would be possible to use labor values to organize social labor, and workers would be aware of the labor time consumed by society and surplus time destined for accumulation. So a social practice that considers redundant prices as a distortion of values is necessary, in order that the money form of value should disappear. But in capitalist society things make their appearance upside down, so that labor values seem redundant. Nevertheless, the arguments against the necessity of value concepts seem strong. Why is this so? It is because the mathematical expression of problems seems irrefutable. The basic support of Steedman's criticism of the

redundancy of value is that it is possible to construct a model to determine production prices with inputs in physical units. Most of the literature uses a model with the same inputs in physical units to determine labor values. Thus -concludes Steedman- labor values are redundant because it is unnecessary to obtain values from physical data and therefore production prices. **This criticism confuses real determination with mathematical determination.**[20] It is possible to calculate the exchange rate from Mexican pesos to Indian rupees by converting pesos into US dollars, and then dollars into rupees. But it does not mean that is possible to convert Mexican pesos into rupees without the previous conversion to US dollars. This is a practical fact. Exchange from pesos to dollars and from this to rupees reflects a practical necessity, this is **real determination**. The direct conversion from pesos to rupees is possible only theoretically and this is a mathematical determination. The conversion from pesos to dollars is redundant only in logical terms. To increase the consumption per employee of a certain good, it is necessary to reduce the labor time spent in its production. This can be accomplished by reducing living labor or the labor spent on the means of production or both. This economic proposal can not be reduced to a proposal using only concepts in physical units, because for example, an improvement in conditions of production means nothing without labor time.

<div align="center">IV Summary and conclusions</div>

For this we have examined the relationship between measurement and labor value. First, we have seen that the classical theory of value treats social labor both as the cause of exchange value and as the measure of it. We argued that in the classical approach, social labor measures exchange value because of the need to solve practical and theoretical problems. Marx turns the terms around when he criticizes capitalist economic practice and theory: price is a measure of value that makes regulation of social labor possible. To accomplish this, market prices must be close to labor values. According to Marx, labor value is the measurand and price is the measure. The human activity that reproduces the society's material living conditions is largely based on labor with a high degree of cooperation, and that requires a regulation that demands measurement. As in any other process of measurement, prices measure labor values with errors: systematic and random. Deviations between labor values and production prices are cases of systematic errors. Discrepancies between current prices and production prices are random errors. These errors are in some way necessary for the capitalist reproduction of society. Nevertheless, they are at the same time obstacles to this reproduction.

We illustrated this through the problem of selecting a technique. Marx argued that to develop the productive forces means to save labor time. Capitalists reduce monetary costs to obtain a larger profit. The Neoricardian theorists thus infer that theory can be valid even without the concept of labor value. But the important thing is capitalist practice. The material progress achieved up to date by capitalism is due to the saving of labor time in the production of a larger amount of commodities. So the theorists may ignore the concept of labor value but the capitalists are compelled to diminish the labor value of their products.[21] They are not aware of it but they do it. In the same way some Australian indigenous people procreated even though they were unaware of the relationship between procreation and copulation.

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[20]. See for this Freeman (1984, 221-264) who discussed the distinction between derivation and determination in a similar way.

[21]". ..Exchange is ruled by the law of value, a law that has two clauses: competition forces all producers to produce with the minimum input of concrete labor time, and forces a tendency toward a normal rate of profit in all industries." (Weeks, 1981, 40)

We believe that this paper is an adequate answer to the redundancy argument used against the labor theory of value, but we do not think that the Neoricardian criticism of Marxist theory of labor value will soon be defeated. This is because rational arguments are combined with ideological interests.

This development of the labor theory of value may offer an explanation of empirical results showing the strong correspondence between labor values and current prices. It would be a fruitful line of investigation. However its acceptance does not depend only on the benefits it may bring but also on the defeat of opinions such as Scrope's, who find criminal intentions within the truth.

Appendix: Some Aspects of The Theory of Measurement

Kyburg (1984) distinguishes 3 approaches to The Theory of measurement: a)one oriented towards the practical needs of scientific disciplines b) a mathematical approach which seeks to systematize and generalize the measurement procedures common to different situations c) a philosophical approach which combines the two previously mentioned in order to consider the relationship between measurement and the construction of theories.

The main interest of the first approach is to find a procedure which will produce useful results for the members of a particular discipline. A good example of this kind of work may be found in Baird (1962). Its starting point is the presupposition that al measurement involves error. It therefore proposes techniques for the estimation and reduction of this error. This kind of approach is of considerable social importance and has had an interesting historical development. This can be appreciated from one of the slogans of the French Revolution which was: "one king, one law, one weight, one measure" and which resulted in the development of the metric system. The slogan originated in the need for the standardization of measurements in an era when there was an enormous range locally-observed measurements. Moreover feudal landowners fraudulently increased the measurements they used to collect tribute (Kula, 1980, Ch. 21-24). The development of many of the technical and scientific aspects of physical measurement is analyzed by Klein (1974) He mentions, for example, the importance of the measurement of temperature from the physical point of view. Before the precise measurements of the modern thermometer an instrument called a thermoscope could give qualitative readings.

The mathematical approach aims mainly at the construction of an axiomatic theory of measurement procedures. Luce and Narens (1994, pp. 219) suggest that Helmontz, Hölder and Von Neumann (von Neumann and Morgensten, 1953) "clearly had the idea of axiomatizing qualitative structures as possible models of empirical attributes and in the latter two cases of establishing, as mathematical theorems, the existence and uniqueness of numerical representations."

The first problem of measurement theory is that of representation. This consists of demonstrating that a series of properties of the arithmetic of numbers can be applied to a great variety of empirical situations. "This is done by showing that certain aspects of the arithmetic of numbers have the same structure as the empirical situation investigated." (Suppes and Zinnes, (1963, 4)

The problem of representation is resolved by defining the properties of the operations and empirical relations used in the process and demonstrating that they are isomorphic or homomorphic with certain conveniently selected operations and numerical relations.

The second problem treated by mathematical theory is that of **uniqueness**. This consists of drawing up a rigorous definition of the scale of measurement. Thus, it demonstrates, for example,

that the scale of measurement permits certain operations to be carried out using the measurements involved but excludes others. The procedure for measurement of weight uses a ratio scale in which the quotient of two different weights is meaningful. An interval scale is used to measure temperatures because the quotient of two temperatures is meaningless but the difference between them is meaningful. The ordinal scale does not admit the use of either the quotient or the difference and only the relationship ≥ is meaningful. This scale is used in neoclassical economics and in such measurements as that of air quality (Roberts, 1979. 64)

The empirical and mathematical approaches to measurement are linked. The mathematical approach accepts that the empirical structure being analyzed is, in a certain sense, "given". " "The practical approach makes use of and depends on the structures that happen to have been explored by mathematicians; the raw materials are forced to fit some relatively familiar structure. There are good reasons for this, but this reasons lie outside the experimental focus." (Kyburg, 1984, 5) Finally, the philosophical approach tries to combine the other two. It seeks, for example, to overcome the problems which measurement error introduces into an axiomatic construction. For example, when the imperfection of all measurement procedures is taken into account, important properties of the relational numerical system such as transitivity become questionable. Although error theory is a reputable area of investigation, it has played a relatively small part in the philosophical literature of measurement.[22]

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[22] Kyburg points out that scientists of the importance of Newton, Maxwell and Gauss, interested themselves in the quantitative treatment of error. However, Campbell, in his analysis of measurement error, concludes that the theory of Gauss is "indefensible" (1957 p.161) because any reasonable error function should define a maximum limit for error in both directions, without stating how this should be done. Krantz et al (1971) state that "few error theories exist today" and undertake to deal with them in a subsequent book. (1984, 7n)

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