RICARDO'S LABOR THEORY OF VALUE IS ALIVE AND WELL IN CONTEMPORARY CAPITALISM

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Abstract: This article, by utilizing Ricardo's numerical examples, derives theoretical statements about the deviations of relative values (prices) from relative labor times. These deviations result from the presence of capital and the distributive variables (rate of profit and wage) and production (turnover) times. Furthermore, Ricardo argued that the intertemporal changes in relative (market) prices were no different from the respective changes in natural (or equilibrium) prices. Both depend primarily on changes in unit labor values and secondarily on capital intensities. The article continues by testing the extent to which Ricardo's thesis holds by utilizing input-output data from the US and Chinese economies. The derived empirical results lend overwhelming support to Ricardo's thesis, which is conformable with major aspects of Marx's theory of value.

Keywords: David Ricardo; value and distribution; price-value deviations

1. Introduction

The objective of this article is two-fold: First, to present and critically evaluate Ricardo's theory of value as an explanation of the movement of relative prices of commodities depending upon changes in their relative labor times. Second, to test the validity of this theory using data from actual economies. We argue that Ricardo clearly defines his theory of value; nevertheless, the differences in interpretation persist and have to do with the temptation of economists to read in Ricardo their own theory of value. For example, Marshall (1920) was keen on the idea of continuity in economic theory and made an effort to fit Ricardo and his theory of value into a partial equilibrium garment attributing to him a kind of a cost of production theory of price

determination (Marshall 1920, 672). By contrast, S. Hollander (1985) places Ricardo's theory of value in the tradition of general equilibrium analysis, which begins with Smith and culminates in Walras and the modern neoclassical economists. The idea behind this view is that prices and distributional variables (wages and profits) are co-determined. Stigler (1958, 366) posited that Ricardo held an empirical labor theory of value in which the required relative labor times in the production of commodities are the key determinants of their respective relative prices. However, this should not be interpreted to suggest an analytical labor cost theory of value. The idea is that the labor time is only one of the determinants of the relative prices along with others accounting for the cost of production, providing that rent is excluded in the estimation of the cost. In the heterodox camp, Sraffian economists (not all) emphasize the sections of Ricardo's *Works* that refer to his valiant but unsuccessful efforts to define an invariable measure of value presented as something akin to Sraffa's standard commodity while Ricardo's theory of value is regarded merely as a cost of production theory excluding rent (Steedman 1982). Marxian economists, more often than not, treat Ricardo's theory of value as if it were similar to Marx's and not surprisingly find incongruities. As we argue, Ricardo was chiefly concerned with the parity of relative labor times and natural or equilibrium prices and he used the word "value" to indicate exchange ratios or relative prices. By contrast, Marx uses the same word "value" to indicate the socially necessary abstract labor time embodied in commodities. Furthermore, the monetary expression of Marx's value, that is, the "direct price" is closely related to the (average) price of production, that is, the price reflecting the economy-wide average rate of profit, which is a more concrete center of gravitation of the ever-fluctuating market prices (Tsoulfidis 2010, ch. 4 and the literature cited there).

The structure of the remainder of the article is as follows: Section 2 discusses Ricardo's statements on the theory of value and his insistence for an explanation of the variations of relative prices induced by variations in relative labor times necessary for the production of commodities. Section 3 deals with Ricardo's labor theory of value and its modifications arising from the presence of fixed capital, the changes in wages as well as differences in turnover times. Section 4 shows that the effects of these variables on the movement of relative prices are not only minimal but also predictable rendering his theory of value in the same line of research as that of Marx's. Section 5 tests empirically Ricardo's theory of value using data from input-output tables of China and the USA for meaningfully selected years. Section 6 summarizes and makes some concluding remarks.

2. Ricardo and the Labor Theory of (Relative) Value

Ricardo in his introduction of the *Principles* states that his major objective is to determine the laws of distribution in the economy, and he further argues that

progress in such an endeavor is possible if and only if we have developed a consistent theory of value, that is, a theory of determination of relative prices (Ricardo 1951a, xiv–xv). Ricardo starts by endorsing Smith's labor theory of value; however, unlike Smith, he argues that the theory of value based on labor time is not restricted to the so-called "early and rude state of society" but is general enough and may apply to modern societies where production takes place with capital and wage labor. However, Smith's initially correctly stated principle of relative prices being determined by relative labor times needs further qualifications, which are necessary to supersede a number of challenging issues that even in our times are regarded hard to deal with.

Ricardo already knew from Smith that market prices are determined by the ephemeral forces of demand and supply. However, over time, Ricardo argued, that the ever-fluctuating market prices are attracted to something more fundamental than the mere forces of demand and supply; that is, the natural prices that reflect the principle of equal profitability. Thus, if the rate of profit of an industry is above the economy's average, the subsequent acceleration of capital accumulation increases the supply relative to demand, and the market price of the industry falls, thereby, restoring the economy's average rate of profit. The converse process will take place in the case of a shortage in profitability. Ricardo argued that the principal determinant of the movement in "natural prices" of commodities is their respective labor times. Hence, there is a role for demand and supply; however, these two concepts have characteristically different meanings and content from those usually utilized. For example, in neoclassical demand and supply schedules, each and every point represents a potential equilibrium price and quantity combination. In Ricardo, both demand and supply are regulated by profitability and by no means should be thought of as neoclassical schedules (Garegnani 1983).

Ricardo accepts Smith's distinction between use value and exchange value and that the value in use of a commodity is merely a precondition for exchange (Ricardo 1951a, 6). There are goods whose value derives from their value in use; however, these goods are scarce and, therefore, are non-reproducible (e.g., rare paintings, coins, books, and wine), whose value depends on the "varying wealth and inclinations of those who are desirous to possess them" (12) and not on the quantity of labor that went into their production. For the non-reproducible goods, Ricardo argued that they are only an infinitesimally small percentage of the totality of the available goods, and that the overwhelming majority of goods are reproducible whose relative prices are determined by the relative quantities of labor and not on higher or lower wages:

> The value of a commodity, or the quantity of any other commodity for which it will exchange, *depends* on the relative quantity of labour which is necessary for its

production, and *not* on the greater or less compensation which is paid for that labour. (Ricardo 1951a, 11; emphasis added)

The trouble with the above definition is that only the relative prices of commodities, that is, the visible part of the exchange, is known while the relative quantities of labor times remain unknown, in Ricardo's time, because of the lack of data. Consequently, even in the case of two goods it would be nearly impossible to identify the exact source of this change. This is not a particularly difficult problem in our times because we can estimate the exact relative direct and indirect labor requirements per unit of output using the available input-output and employment data. It is interesting to note that despite of difficulties in the labor theory of value Ricardo continued his efforts for solutions and categorically excluded the easy way of giving in to a cost of production theory of value. For example, notes Ricardo: "The main cause of *change* in relative values of commodities is the increase or decrease in the amount of labour required to produce them" (Ricardo 1951a, 36; emphasis added).

Furthermore, Ricardo's cost price is in effect the natural price, which he treats as if it were the same with the actual market price. The possible deviations of the two kinds of prices, in the long run, are expected to dissipate and so they are treated as if they were the same:

It is the cost of production [= natural price] which must ultimately regulate the [market] price of commodities, and not, as has been so often said, the proportion between the supply and demand: the proportion between the supply and demand may, indeed, for a time, affect the market value of a commodity, until it is supplied in a greater or less abundance, according as the demand may have increased or diminished; but this effect will be only of temporary duration. (Ricardo 1951a, 232)

The want of data on labor time prompted Ricardo, in the search of an invariable measure of value; that is, a commodity whose production would always require the same amount of labor and whose value would remain the same regardless of changes in the distributive variables. In modern parlance, two are the requirements of an invariable measure of value: (a) zero relative price elasticity with respect to the technical conditions in production, that is, zero substitutability in production and (b) zero relative price elasticity with respect to changes in wages or profits. These two properties characterize a commodity as an invariable measure of value with the aid of which we could identify the source of variation in the relative (and absolute) prices of all other commodities. Consequently, it could be possibly used for the estimation of the current value of output or wealth in a society and also make possible intertemporal comparisons. Ricardo devoted the rest of his intellectual life

to the discovery of such a commodity which could be determined either practically or analytically (see Ricardo 1951a, 42–44).[1] In effect, he investigated many possibilities, none of which gave satisfactory solutions because the production of all the commodities he thought of was subjected to technological change, and therefore its production required different labor times over time. Ricardo in the end hypothesized gold as the commodity that could, at least partially, perform the function of an "imperfect" but the best available "measure of value", the "nearest approximation to truth" (Ricardo 1951c, 279).

According to Ricardo, the value of gold was determined in the exact same way as with the other goods; that is, by the technique and, therefore, the necessary labor requirements in the production of gold, which pretty much remain the same over reasonably long stretches of time (Ricardo 1951a, 87). Furthermore, by using gold as a crude invariable measure of value, Ricardo managed to integrate his theory of value with his theory of money. In particular, notwithstanding the labor time spent on the production of gold was supposed to be changing so slowly (compared to the other commodities) that it could be regarded approximately constant, making possible the determination of absolute prices along with money (gold) supply on the general price level. This distinction between the real (theory of value) and the monetary economy, as well as their interaction, are of critical importance to Ricardo's theory of value and its application to the theories of foreign trade, taxation, and public debt (Tsoulfidis 2010, 2013, 2015a).

Ricardo argued that the principle according to which the exchange ratios of reproducible goods are determined by relative labor times spent on their production was also correct in capitalism. However, the principle owed to be modified so as to account for the following three main features: the differences in capital intensities between industries, the changes in wages or profits and differences in the time it takes for commodities to reach the market, that is, differences in the duration of the production process or turnover time. The fundamental principle that the relative prices of reproducible commodities depend on the relative quantities of labor necessary for their production holds to a great percentage. Hence, it is important to stress that Ricardo refers to simple labor and that complex or skilled labor is reduced to simple labor through the operation of the market. More specifically, the differences in skills or in general qualities of labor are manifested in the market, as differential wages:

> The estimation in which different qualities of labour are held, comes soon to be adjusted in the market with sufficient precision for all practical purposes, and depends much on the comparative skill of the labourer, and intensity of the labour performed. *The scale, when once formed, is liable to little variation.* If a day's labour of a working jeweler be more valuable than a day's labour of a common labourer, it has long ago been adjusted, and placed in its proper position in the scale of value. (Ricardo 1951a, 20–21; emphasis added)

Ricardo further explained that the value (relative price) of commodities is determined not only by the current labor expended on its production but also by the past labor contained in plant and equipment. He notes:

> Not only the labour applied immediately to commodities affect their value, but the labour also which is bestowed on the complements, tools, and buildings, with which much labour is assisted [. . .] of the durable implement only a small portion of its value would be transferred to the commodity [. . .] (Ricardo 1951a, 23)

In short, the relative prices of reproducible goods are determined by their respective labor times and the fixed capital also affects the fundamental principle by transferring its exchange value onto the final product piecemeal through its depreciation. Clearly, Ricardo was fully aware of the depreciation of fixed capital, but for simplicity reasons, he hypothesized that depreciation is zero and that fixed capital lasts forever.

3. Modifications of the Theory of (Relative) Value

In a capitalist economy where production takes place with the employment of both labor and capital, Ricardo argued: "The principle that the quantity of labour bestowed on the production of commodities regulates their relative value, considerably modified by the employment of machinery and other fixed and durable capital" (Ricardo 1951a, 30). In other words, the presence of fixed capital and the rate of profit affect the relative prices but only in a limited and at the same time theoretically predictable way. In order to show the effects of the fixed capital, he hypothesized a simple numerical example of only two industries producing cotton and corn; each of the two industries employs 100 workers at an annual wage rate, w, of £50. He further supposed that the cotton industry, unlike the corn, uses a machine, K, worth £5,500, which does not depreciate. The rate of profit, r, for convenience's sake is assumed at 10% and total profits, Π, that is, the product of the rate of profit times the sum of capital and wages, $r(K + wL)$. Thus, the cotton industry makes profits worth of £1,050 versus £500 of the corn industry.

One would say that with such large differences in profits earned as a result of the presence of fixed capital the cotton industry must sell at a price much higher than that of the corn industry. Ricardo shows, through an extreme for his hypothesis numerical example in which the relative prices are not out of touch from their respective relative labor times. Hence, the example is extreme in the sense that the corn industry uses no fixed capital at all as opposed to the capital intensity of the cotton industry, which is equal to £5,500/100 = £55 per worker. The relative price of cotton to corn is £6,500/£5,500 = 1.10, that is, 10% higher than the respective

relative direct labor times $100/100 = 1$. The deviation is attributed to the differences in the capital-labor ratios, K/L, provided that the wage rate is the same in the production of both commodities.

Thus, the presence of capital and the rate of profit exert a progressively limited effect on relative prices, and in the long run their effect is expected to be even lower if we invoke Ricardo's falling rate of profit argument. Furthermore, the differences in capital intensities, in reality, are by far lower than those hypothesized in the numerical example. Thus, in evaluating Ricardo's numerical model, we find it reasonable in the sense that it illustrates the labor theory of relative prices under extreme for the thesis assumptions. For example, instead of taking the two industries with a realistic and, therefore, much smaller difference in capital intensities, he shows that, even if differences in capital intensities are unrealistically large, deviations between relative prices and labor times remain comparatively very small.[2] Ricardo through his numerical example shows that the relatively small price effect of capital intensities is amenable to abstract theorization. As a consequence, the labor expended remains the dominant factor in the determination of relative prices.

In Table 1 below, we modify Ricardo's numerical example by examining two commodities A and B and by inserting pragmatism without sacrificing generality, we hypothesize that the production of both commodities takes place with the employment of capital and labor. Thus, we have Table 1.

The new givens as expected bring somewhat closer the relative commodity prices to the quantities of labor. More specifically, or

$$\frac{P_A}{P_B} = \frac{6,050}{5,650} = 1.07 > \frac{L_A}{L_B} = 1,$$

where the subscripts A and B denote the two commodities. The deviations between the relative prices and the relative labor times spent on the production of the two commodities are derived from differences in the capital intensities (K/L or K/wL). Here, it is important to note that in effect we are dealing with different capital-labor ratios since the wage rate is assumed uniform in both commodities. It goes without saying that if the capital-labor ratios were the same then no deviation would have been observed between relative price P_A/P_B and relative labor time

Table 1. Ricardo's Modified Numerical Example

	K	wL	K/L	$\Pi = r\,(K + wL)$	$P = wL + \Pi$
Commodity A	£5,500	£5,000	£55	£1,050	£6,050
Commodity B	£1,500	£5,000	£15	£650	£5,650

L_A/L_B. These results become much more pronounced, if we form the relative price of commodity A, namely,

$$\frac{P_A}{P_B} = \frac{wL_A + r\left(wL_A + K_A\right)}{wL_B + r\left(wL_B + K_B\right)},$$

(1)

and factoring out the relative labor time of the two commodities, we get

$$\frac{P_A}{P_B} = \left[\frac{L_A}{L_B}\right]\left[\frac{1+r\left(1+\dfrac{K_A}{wL_A}\right)}{1+r\left(1+\dfrac{K_B}{wL_B}\right)}\right].$$

(2)

By taking the percentage change between relative prices and labor times, we get

$$\left(\frac{P_A}{P_B} - \frac{L_A}{L_B}\right)\Big/\left[\frac{L_A}{L_B}\right] = \left[\frac{1+r\left(1+\dfrac{K_A}{wL_A}\right)}{1+r\left(1+\dfrac{K_B}{wL_B}\right)}\right] - 1$$

$$= \underbrace{\left[\frac{r}{w+r\left(w+\dfrac{K_B}{L_B}\right)}\underbrace{\left(\frac{K_A}{L_A} - \frac{K_B}{L_B}\right)}_{\text{sign of deviation}}\right]}_{\text{size of deviation}}.$$

(3)

Relationship (3) shows the size of deviations between relative values (= prices) and labor values. The sign of these deviations depends on the differences between capital intensities in the production of the two commodities, while the percentage size of deviations depends on both the capital intensities and the rate of profit (or wage). The numerical example is plausible (if not extreme in that it stands against Ricardo's thesis) because of the assumption of far too large differences in capital intensities in the production of the two commodities. Notwithstanding the sizable differences in capital intensities; nevertheless, the size of the deviation between the relative prices and the relative quantities of labor is only 7%. Moreover, the sign of the deviation is predictable depending on the difference of capital-labor ratio between the two commodities provided that the wage rate is assumed uniform and constant in the face of hypothetical changes in the rate of profit.

The effect of the rate of profit on relative prices is obtained by differentiating the relative price of the two goods with respect to the rate of profit. Thus, we get:

$$\frac{d}{dr}\left(\frac{P_A}{P_B}\right) = \frac{d}{dr}\left[\frac{wL_A + r\left(wL_A + K_A\right)}{wL_B + r\left(wL_B + K_B\right)}\right] = \frac{w\left(K_A L_B - K_B L_A\right)}{\left(wL_B + rwL_B + rK_B\right)^2}. \qquad (4)$$

Since the denominator in relation (4) is always positive, it therefore follows that the sign of the above derivative depends exclusively on the sign of the numerator. In particular, the sign is determined by the term

$$K_A L_B - K_B L_A = \left(\frac{K_A}{L_A} - \frac{K_B}{L_B}\right) L_A L_B.$$

Thus, we may write

$$\text{sign}\left[\frac{d}{dr}\left(\frac{P_A}{P_B}\right)\right] \text{ same as } \left(\frac{K_A}{L_A} - \frac{K_B}{L_B}\right) L_A L_B. \qquad (5)$$

The profit rate also affects the relative prices, but only in a limited and theoretically predictable way while its effect lessens over time; hence, we invoke Ricardo's view of the falling, in the long run, rate of profit. If, for example, we hypothesize a rate of profit of 5%, then the difference between relative prices and relative labor times plummets to approximately 3.7% (see Table 2 and Figure 1). In the extreme case of a zero rate of profit relative prices become equal to their respective relative labor times, and Ricardo's theory of value holds absolutely. Table 2 below presents selected results of our experiments with profit rates varying from zero until the hypothetical 100%. It is important to note that Ricardo was writing during a period of slowdown in economic activity in general, and in Britain in particular, and so the assumption of a 10% rate of profit is not only convenient in computations but also realistic enough for the actual state of the UK economy.[3]

Relative Prices and Elasticities for Selective Rates of Profit

r	0%	5%	10%	20%	40%	62.5%	70%	80%	90%	100%
P_A/P_B	1.000	1.037	1.070	1.127	1.210	1.275	1.293	1.31	1.332	1.347
e_r		0.026	0.053	0.086	0.114	0.119	0.118	0.117	0.115	0.112

In Figure 1 below, we show graphically the relationship between the rate of profit and the path of relative prices shown on the left-hand side axis.
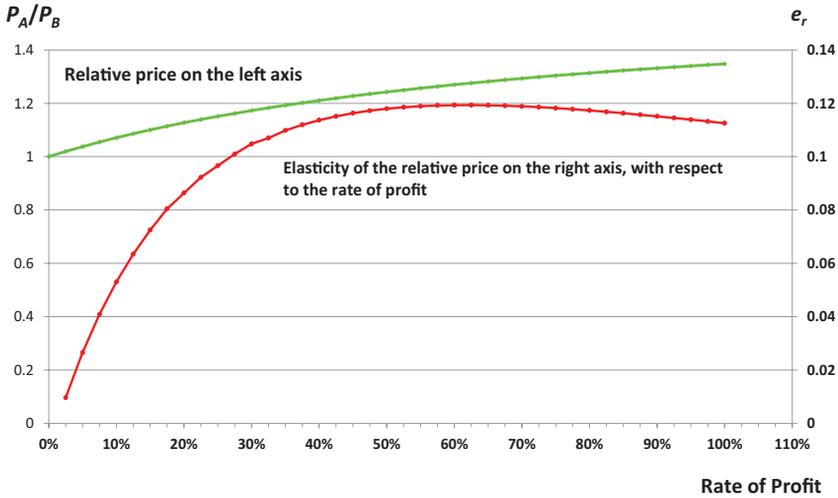
Figure 1.   Relative Price Changes and Elasticity Price with Respect to Rate of Profit

We observe that the deviations between relative labor values and relative prices are directly related to the rate of profit shown on the horizontal axis; starting from $r = 0\%$, there is zero deviation between relative price and relative value, $\dfrac{P_A}{P_B} / \dfrac{L_A}{L_B} = 1$. However, as the rate of profit increases the deviations also increase but at a decreasing rate. For example, when the rate of profit doubles (say from 10% to 20%), the deviation between relative prices and relative labor times increases from 7% to 12.7% (see Table 2 and Figure 1). From the results displayed in Table 2 and Figure 1, it becomes abundantly clear that past a point the relative price becomes increasingly less sensitive to changes in the rate of profit. In effect, the second derivative of relative price with respect to the rate of profit gives

$$\frac{d^2\left(\dfrac{P_A}{P_B}\right)}{dr^2} = -\frac{2w\left(wL_B + K_B\right)\left(K_A L_B - K_B L_A\right)}{\left(wL_B + rwL_B + rK_B\right)^3} < 0. \tag{6}$$

The negative sign in relation (6) is derived from the mere fact that the capital–labor ratio in the production of commodity A is higher than that of commodity B, it follows that the second derivative will be negative, which is another way to say that the relative price path will be concave.

Thus, it comes as no surprise that the elasticity of relative price with respect to the rate of profit, e_r, displayed in Table 2, is smaller, in fact, much smaller than one in absolute value.[4] In particular, we have,

$$e_r = \frac{d\left(\dfrac{P_A}{P_B}\right)}{dr} \frac{r}{\left(\dfrac{P_A}{P_B}\right)} = \frac{w\left(K_A L_B - K_B L_A\right)}{\left(wL_B + rwL_B + rK_B\right)^2} \frac{r}{\dfrac{wL_A + r\left(wL_A + K_A\right)}{wL_B + r\left(wL_B + K_B\right)}}$$

$$= \frac{w\left(K_A L_B - K_B L_A\right)}{\left(wL_B + rwL_B + rK_B\right)\left(wL_A + rwL_A + rK_A\right)} < 1. \tag{7}$$

As a consequence, the elasticity of the relative prices with respect to the rate of profit measured on the right-hand side axis of Figure 1 increases each time by a decreasing rate until the attainment of a maximum (62.5, 1.19) and then for very high and, at the same time, unrealistic rates of profit turn to a downward direction. The results in Table 2, as well as those shown in Figure 1, are not far from those one expects to find in actual economies and, therefore, are realistic and lend overwhelming support to Ricardo's intuition. If we now invoke Ricardo's "fundamental law of distribution" that is, the inverse relationship between the profit and wage rates: "[. . .] in proportion then as wages rose, would profits fall" (Ricardo 1951a, 77, 111).

The idea is that an increase in the wage rate causes a decrease in the rate of profit and thus the estimated relative prices approximate even more closely the relative labor times. The converse will be true if the wage falls and the rate of profit increases. In both cases, Ricardo argues, the effect of a changing wage not only is minimal but also predictable.

In terms of Ricardo's modified cotton–corn numerical example, a rising wage results in a fall in the rate of profit. The price of good A (cotton) in Ricardo's modified numerical example will change, since the producer estimates a profit on the machine equal to 9% instead of 10%. The final price, therefore, will fall to £5,945, and the price of good B (corn), which uses no fixed capital will become £5,585 and therefore the relative price $P_A/P_B = 1.064$. We observe that a fall in the rate of profit by 1% brings the relative price of the two goods even closer to their relative labor times. Ricardo, after this kind of sensitivity analysis, arrives at the following conclusion:

> The greatest effects which could be produced on the relative prices of these goods from a rise of wages, could not exceed 6 or 7 per cent; for profits could not, probably, under any circumstances, admit of a greater general and permanent depression than to that amount. (Ricardo 1951a, 36)

In terms of our more general numerical example displayed in Table 1, with capital employed by the two producers and by assuming $r = f(w)$, $\dfrac{\partial r}{\partial w} < 0$ and

$\dfrac{\partial K}{\partial w}=0$, a realistic assumption based on the idea that differences in capital intensities are quite distant from each other so as to preclude revaluations of capital and change of their characterization from capital to labor intensive and vice versa through concomitant price-feedback effects. Thus, we get

$$\frac{\partial\left(\dfrac{P_A}{P_B}\right)}{\partial w}=\frac{\left[\dfrac{\partial r}{\partial w}w-(r+1)r\right]\left(K_A L_B-K_B L_A\right)}{\left(wL_B+rwL_B+rK_B\right)^2}. \tag{8}$$

A result which is quite similar to relation (4) above derived by assuming a constant wage and a variable rate of profit. Because the bracted term is always negative, and the denominator is always positive, so the direction of price movements depends exclusively on the sign of capital–labor ratio differences. For reasons of economy in space and clarity of presentation, we do not display the second negative derivative of relation (8) and the elasticity, which coefficient is much lower than one, of relative prices with respect to wages. Both estimates can be straightforwardly derived by the interested reader.

The third and final modification of Ricardo's theory of value relates to the differences between the starting time and that elapsing for t completion of the production process of a commodity. Following Ricardo's numerical example (Ricardo 1951a, 37), we hypothesize an initial amount of money of £2,000 (40 workers times a £50 annual wage) invested in commodities, A and B. In commodity A, the total sum of £2,000 is invested in two equal installments in each of the two years required for the production of commodity A. At the end of the second year, the value of the commodity will be £2,310 estimated based on a rate of profit, $r = 10\%$, which is treated as a kind of opportunity cost by the producers. Thus, we may write

$$P_A=\underbrace{£1,000\times\left(1+0.10\right)}_{\text{first year}}+\underbrace{£1,000\times(1+0.10)^2}_{\text{second year}}=£2,310. \tag{9}$$

The rationale in the above estimation is that the producer of commodity A takes into account a 10% profit rate on his invested capital in the first year during which he held his money and did not put it in production and 10% on the investment in the second year. By contrast, in industry B all the money is invested in the first year so the price of commodity B will be:

$$P_B=£2,000\times\left(1+0.10\right)=£2,200. \tag{10}$$

From the above often-cited numerical example, we derive that the differences in the time of completion of the production process in the two industries utilizing the exact same amounts of labor and with uniform wage and profit rates end up with

two (not very) different prices. The deviation between relative prices and respective labor times depends on the size of the exogenously assumed rate of profit and the differential turnover times. In particular, Ricardo notes:

> This case appears to differ from the last, but is, in fact, the same. In both cases the superior price of one commodity is owing to the greater length of time which must elapse before it can be brought to market. In the former case the machinery and cloth were more than double the value of the corn, although only double the quantity of labour was bestowed on them. In the second case, one commodity is more valuable than the other, although no more labour was employed on its production. The difference in value arises in both cases from the profits being accumulated as capital, and is only a just compensation for the time that the profits were withheld. (Ricardo 1951a, 37–38)

In this way, the time that elapses before a commodity reaches the market further modifies Ricardo's theory of value. It is important at this juncture to point out that in Ricardo the lapse of time in and of itself does not create value. The labor time continues to be responsible for the exchange value of commodities. Ricardo's view is in sharp contrast to the Austrian variant of neoclassical economics, according to which time alone becomes the measurement unit of the quantity of capital and at the creator of the value of commodities. (Tsoulfidis 2021, ch. 2).

Thus, the time that elapses before a commodity reaches the market further modifies Ricardo's theory of value. It is important at this juncture to point out that in Ricardo the lapse of time in and of itself does not create value. For him the labor time continues to be responsible for the exchange value of commodities. Hence, Ricardo's view is in sharp contrast to the Austrian variant of neoclassical economics, according to which time alone becomes the measurement unit of the quantity of capital and the creator of the value of commodities (Tsoulfidis 2021, ch. 2). However, the deviation of relative prices from relative labor times, despite the notable difference in turnover time, is minimal and predictable. In particular, the relative price of the two commodities will be £2,310/£2,200 = 1.05, and the deviation from the respective labor times is only 5%. Alternatively, the proximity of relative prices to relative labor quantities is 95%! If we formalize Ricardo's example, and replace $n = 2$ and $r = 10\%$ we may write

$$\frac{P_A}{P_B} = \frac{wL(1+r) + wL(1+r)^n}{2wL(1+r)} = \frac{wL(1+r)\left[1+(1+r)^{n-1}\right]}{2wL(1+r)}$$

$$= \frac{1+(1+r)^{n-1}}{2} = 1.05, \tag{11}$$

and the size and the direction of change in relative price with respect to turnover time, will be

$$\frac{\partial \left(P_A / P_B \right)}{\partial n} = 0.5 \ln \left(1+r\right)\left(1+r\right)^{n-1} \approx 0.05 > 0, \tag{12}$$

while the change in the rate of change (the second derivative) will be negative

$$\frac{\partial^2 \left(P_A / P_B \right)}{\partial n^2} = 0.5 \ln^2 \left(1+r\right)\left(1+r\right)^{n-1} \approx -1.3 < 0, \tag{13}$$

that is, the relative price of the good with the same investment but longer maturity time, other things being equal, will be higher than its relative labor time; however, as the turnover time increases the increase in relative price will be diminishing according to the second derivative of the above relation. Finally, the elasticity with respect to turnover time n and by assuming that $n = 2$ following Ricardo's numerical example, will be

$$e_n = \frac{\partial \left(P_A / P_B \right)}{\partial n} \frac{n}{\left(P_A / P_B \right)} = \frac{\ln \left(1+r\right)\left[\left(1+r\right)^{n-1} + 1 \right]\left(1+r\right)^{n-1}}{4n} = 0.03. \tag{14}$$

Of course, we may utilize more complex cases, but in actual economies the deviations of relative prices from relative values in the face of moderate differences in turnover times are expected to be very small. This is precisely what Ricardo conveys in his numerical example in which the elasticity of the relative prices with respect to turnover time is much lower than one. If we now suppose that the turnover time, other things being equal, increases from $n = 2$ to $n = 4$, then the estimated elasticity will be $e_n \approx 0.3$. This is another way to say that although we have a ten-fold increase in e_n, nevertheless, this particular elasticity remains in the vicinity of zero and is much smaller than one; as a consequence, the price ratio of the two goods will differ from the value ratio by (only) 16.55%. These results lend support to Ricardo's thesis as this can be judged by the fact that despite an excessively high percentage increase in the turnover (waiting) time the percentage change in relative price s is far too small. In the hypothetical and exceptional cases of goods with an extremely high production time, as for example the production of wine, still the deviation of relative price is controllable. For example, if everything else is constant and with $n = 10$ the relative price becomes ≈ 1.67 (or 67% deviation) and the elasticity $e_n \approx 0.2$, a result which indicates that the rate of increase in relative price is falling and the elasticity e_n for hypothetical and exceptionally high turnover times becomes less and less responsive.

From the preceding discussion, it follows that Ricardo's insights were reasonably formulated based on his straightforward numerical examples. However, due to the lack of data, it was impossible for Ricardo to take the next step, that is, to

test empirically the validity of his propositions. Nowadays, economists have access to a wealth of relevant data, which combined with the currently available quantitative methods may test empirically Ricardo's theoretical insights. Thus, time and again, it has been shown that the estimated natural prices of commodities are closely related to labor times contained in them. The old econometric studies (not too many) on the movement of market prices (see Semmler 1984, ch. 5) lend support to Ricardo's insights. In this line of research, Fourastié ([1952] 1979, chs. 2 and 5) argued that the market price of commodities varied following the inverse of labor productivity (or unit labor values in Ricardo and Marx). The movement of market prices is also affected by technical progress.

It is important to stress at this point that Marx's theory of value is qualitatively different from Ricardo's. More specifically, in Ricardo, we have the principle that relative prices of commodities depend on relative labor times spent on their production, which holds absolutely in precapitalist societies and is modified in modern ones to account for the presence of capital, rate of profit, and turnover time. In Marx, by contrast, there are no modifications in his theory of value but forms of value. In particular, value in Marx is defined as the quantity of socially necessary abstract labor time spent on the production of commodities. This labor time remains invariant and takes on various forms starting from the elemental one of direct price, that is, the monetary expression of labor time and going to prices of production, that is, the form of value to account for the competition of capitals and the equalization of profit rates between industries. The price of production (i.e., prices that incorporate the economy's average rate of profit) form of value is introduced in chapter IX of the third volume of *Capital*, while in Ricardo the price of production and competition of capitals appear in the first pages of Chapter 1 of his *Works*. The price of production is an even more complex form of value than the direct price, which both correspond to the average production conditions in each industry. However, we do know that the average conditions are a pretty good center of gravitation of market prices, but there is another kind of price, the regulating prices of production corresponding to regulating conditions of production defined as the type of capital, where acceleration or deceleration of investment takes place (Tsoulfidis 2015b). The regulating prices of production are the most concrete centers of gravitation of market prices.[5] The hitherto empirical literature based on input–output data has ascertained that the labor values and prices of production are surprisingly close to each other and both form pretty good centers of gravitation to actual market prices (Shaikh 1984, 2016; Tsoulfidis and Maniatis 2002; Tsoulfidis and Mariolis 2007; Tsoulfidis 2008; Tsoulfidis 2021, ch. 4). In the next section, we grapple with an empirical testing of Ricardo's theory of value which shares similarities with Marx's when it comes to the intertemporal determination of actual market prices through the changes in the labor content of commodities.

4. Ricardo's Principle of Relative Prices Tested

Ricardo's labor theory of relative value is more about the long-run change in relative price depending on the change in relative labor times and less about their current time proximity (see also Shaikh 2016, ch. 9; Kurz 2018). In fact, Ricardo argued that changes in relative prices over time are explained not by changes in wages (and therefore a cost of production theory of value is ruled out) but rather by changes in the labor time required for their production. Ricardo after emphasizing the limited effect of changes in wages on the relative prices, states emphatically:

> In estimating, then, the causes of the variations in the value of commodities, although it would be wrong wholly to omit the consideration of the effect produced by a rise or fall of labour [i.e., wages], it would be equally incorrect to attach much importance to it; and consequently, in the subsequent part of this work, though I shall occasionally refer to this cause of variation, I shall consider all the great variations which take place in the relative value [i.e., price] of commodities to be produced by the greater or less quantity of labour which may be required from time to time to produce them. (Ricardo 1951a, 34)

Hence, Ricardo argued that his theory of value has an intertemporal character and that the variations in relative (natural or market) prices depend principally on variations in relative labor times (Ricardo 1951a, 232). As a consequence, the focus of our empirical analysis will be on intertemporal comparisons of relative market prices against labor values, and we will also test the extent to which relative market prices are affected by relative capital intensities. Finally, we will also test to what extent if any natural prices (or Marxian prices of production) in the long run are different from market prices. Thus, we may write the following econometric specification:

$$\ln\left(p_{t+n}./p_t\right)_j = \alpha + \beta \ln\left(v_{t+n}./v_t\right)_j + \gamma \ln\left(k_{t+n}./k_t\right) + u_j, \tag{15}$$

where p is the vector of price indexes of industries j at year t, n is the number of years ahead of the year t, v is the vector of unit (labor) values, a is the constant in the regression, β the elasticity coefficient of the unit labor values; γ is the elasticity of the capital intensity k, u is the stochastic term, ln is the natural logarithm and ./ stands for the element-by-element division between two vectors. Relation (15) indicates that the growth rates in the price indexes, which are no different from the respective growth rates in market prices, are determined primarily by the growth rates in relative labor times and secondarily by the growth rates in capital intensities. Hence, it is important to note that what is actually tested is the extent to which the growth rates in relative

vertically integrated labor productivities of industries determine the growth rates in the price indexes. The latter are treated as proxies for the respective growth rates in market prices, which in turn may be approximated by the prices of production. The idea is that market prices continuously fluctuate around their respective centers of gravitation, that is, their prices of production in Marx or natural prices in Ricardo and Smith and over the long run the ups and downs in market prices tend to cancel each other out and on average the market prices are not expected to be too different from the prices of production and can be treated as if they were the same.

It is important to note that we do not use the growth rate of the prices of production as a dependent variable for the probable pitfall of testing an identity, an issue well known from the first studies (see Shaikh 1984 and 2016, ch. 3). This is the reason why Shaikh (2016) uses the 45 degrees line and on the vertical axis places the prices of production, while on the horizontal he places labor values, and finds very high temporal and intertemporal association. Shaikh (2016, 399) refers to the pioneering study by Schwartz (1961), who tested the variability of prices indexes over the period 1918–1938 and found that despite wide variations in output (the depressionary years are included) and distributive variables the variations in prices were very limited and on average they were equal to 7.33%. Puty (2020), in his study of 27 US industries spanning the period 1856 to 2009, finds quite similar results. Namely, relative prices change on average only by 8.45% over the business cycles lending support to Ricardo's and Marx's hypothesis of low-price elasticity in the face of changes in income distribution. Our investigation is in the same spirit as the above-mentioned studies. We use the growth rates of industries' price indexes as reliable proxies of the movements in respective market prices. Subsequently, the so-estimated intertemporal changes in market prices are tested against the corresponding movements in labor values along with the capital intensities and prices of production.[6]

The input–output data that we use for the economies of the USA and China are available from the World Input-Output Database (Timmer et al. 2015); the database is at the 54 sectors level of detail, although seven of China's industries had zero entries.[7] For this purpose, we estimate the matrix input–output coefficients initially at current prices, $\mathbf{A_c}$. The next step is to deflate (in terms of 2010 prices) this matrix in order to make possible, meaningful intertemporal comparisons. The deflation method is carried out in the following way

$$\mathbf{A} = \left\langle \mathbf{P} \right\rangle \mathbf{A_c} \left\langle \mathbf{P} \right\rangle^{-1},$$

where <P> is the diagonal matrix whose main diagonal contains the price index of each industry with 2010 as the base year and $\mathbf{A}$ is the matrix of technological coefficients obtained at constant prices.

The vector of employment coefficients, **l**, is derived as the ratio of the total wages of the employed and self-employed population over the product of the real gross output of each industry times the economy's average deflated wage. Hence, the ratio of the real wage of an industry divided by the economy-wide average real wage gives us an approximate estimate of skills and, at the same time, reduces the complex labor to simple labor. Subsequently, the labor values, **v**, of each industry are estimated as

$$\mathbf{v} = \mathbf{l}\left[\mathbf{I} - \mathbf{A}\right]^{-1}.$$

The economy's real wage is equal to the average annual deflated money wage, $\bar{w}$, allocated over the basket of wage goods normally consumed by workers. Thus, we may write

$$\mathbf{b} = \left(\frac{\text{PCE}_j}{\Sigma \text{PCE}_j} \right) \bar{w},$$

where **b** is the column vector of the basket of commodities (the real wage) normally purchased by workers with their money wage, and PCE stands for personal consumption of workers from industry $j = 1, 2, \ldots, 54$. Hence, the term in the above parenthesis stands for the share of each commodity in the total workers consumption expenditures.

The prices of production are estimated by the following equation:

$$\mathbf{p} = \mathbf{pbl} + \mathbf{pA} + r\mathbf{pK}, \tag{17}$$

where **p** is a row vector of relative prices of production, **b** is the column vector of the basket of goods that workers normally consume with their money wage, $w = \mathbf{pb}$, and r is a scalar representing the economy's uniform rate of profit. Both prices of production (the left-hand side eigenvector) and the rate of profit (corresponding to the maximal eigenvalue) are estimated from the solution of the following eigenequation:

$$\mathbf{p}r^{-1} = \mathbf{pK}[\mathbf{I} - \mathbf{A} - \mathbf{bl}]^{-1}. \tag{18}$$

The vector of capital stock for the 54 industries in constant 2010 prices is provided in the World Input-Output Database (Timmer et al. 2015) along with the necessary documentation for each country. The vector of capital stock is available at constant 2010 prices and the capital–output ratio is computed by dividing element-by-element by the real output vector. The matrix of fixed capital stock coefficients was derived from the product of the column vector of investment shares of each industry times the row vector of capital stock per unit of output. The resulting new matrix of capital stock coefficients **K** possesses the properties of the usual capital

stock matrixes derived and employed in the hitherto empirical studies. The idea is that the investment matrixes contain many rows with zero elements (consumer goods and service industries do not produce investment goods) and so the sub-dominant eigenvalues will be substantially lower (indistinguishable from zero) than the dominant, which is another way to say that the equilibrium prices are determined almost exclusively by the dominant eigenvalue. The same is true with our case whose maximal eigenvalue will not be different from that we would obtain had we used a matrix of investment shares, while the difference between the dominant and the subdominant ones (which are nearly zero) is at maximum.

Finally, the row vector of vertically integrated value composition of capital (VIVCC), K, is the ratio of vertically integrated constant prices capital–output matrix pre-multiplied by the vector of unit labor values, the resulting new row vector is then divided (element-by-element) by the product of the unit labor values times the matrix of workers necessary consumption. Formally, we have

$$K = \mathbf{vK}\left[\mathbf{I} - \mathbf{A} - \mathbf{bl}\right]^{-1} / \mathbf{vbl}\left[\mathbf{I} - \mathbf{A} - \mathbf{bl}\right]^{-1}.$$

For further detail of estimations of various matrices and vectors, see Tsaliki, Paraskevopoulou, and Tsoulfidis (2018) and Tsoulfidis and Paitaridis (2017).

Having hypothesized that the growth rates in the interindustry relative price indexes are no different from the respective market prices, we proceed by subjecting to empirical testing this Ricardian hypothesis, in particular, whether or not the growth rates in relative market prices depend primarily on the respective growth rates in relative labor times and secondarily on the growth rates in capital intensities. We finally subject to empirical testing the extent to which the intertemporal growth rates in prices of production are close to the growth rates of the price indexes or what amounts to the same, the growth rates of market prices. This is also a test of the extent to which Ricardo's (and also Marx's) hypothesis of the tendential equalization of intertemporal prices of production to actual market prices holds.

The results from the economies of the USA and China for the meaningfully selected years 2000, 2007, and 2014 and input–output data of the World Input-Output Database (Timmer et al. 2015) show surprisingly high proximity. In both countries, we start with the year 2000, and their empirical findings are compared to those of the year 2007. Subsequently, we regress the findings of the year 2007 against those of the year 2014. The idea is to assess the extent to which the Great Recession 2008–2009 affected Ricardo's labor theory of (relative) value. Finally, we tested the start year 2000 against the last year 2014 to see if Ricardo's principle holds in a considerably longer time span.

In Figure 2, below, we plot the growth rates in price indexes as well as the unit labor values of each of the 54 industries of the US economy, the first three graphs in

the panel of six graphs. The regression lines and the kernel density functions indicate the similarities in distribution of both price changes and unit labor values. The notation is as follows: P_07_00 stands for the growth rate of the price index of each industry between the years 2007 and 2000. For the same period and reasons of visual clarity and convenience of presentation, we display the growth rate of unit labor values as V_07_00. The idea is that unlike market prices, which typically increase over time, unit labor values decline over time as a result of technological change, and this is the reason that we got their growth rates starting from the terminal year 2007 to the start year 2000. In case that we did the other way around, the results would be the same, albeit the slope coefficient would be with a negative sign. Ideally, both unit values and market prices are expected to be falling over the long run; although this is true for the unit labor values, it is not true for market prices in the post-World War II years at least, because of monetary issues and inflation, which are beyond the scope of the present article. Similarly, with the other variables and pairs of years, where PP_14_07 stands for the growth in prices of production over the period 2007–2014 while PP_14_00 indicates the growth rates of prices of production during 2000–2014 and so forth (see the last three graphs in Figure 2). Finally, K_07_00 (not shown in Figures 2 or 3) indicates the growth rate of the VIVCC between the years 2007 and 2000. Ditto for the other long periods and variables. We conduct the exact same test for the case of the Chinese economy and the results are displayed in the panel of six graphs in Figure 3. The empirical findings strengthen the Ricardian and Marxian thesis that the intertemporal variations in market prices depend, to a large extent, on the respective variations in labor values and that the growth rates in prices of production are not far from those in market prices.

The relative effects of unit labor values on market prices are obtained through the OLS regressions, whose results are displayed in Table 3 below for each of the two countries, time periods and set of variables. Clearly, the distributions of the deviations in the three pairs of years under study are quite similar, indicating that the changes in unit labor values and prices keep close to each other over long stretches of time and they are nearly of the same magnitude and direction. Furthermore, the independent variables are statistically significant as this can be judged by the absolute values of the respective t-ratios in the parentheses and the adjusted R-squares are particularly high for cross-section regressions. Clearly, the variations in the unit labor values are always statistically significant in explaining the movement of market prices and the estimated elasticities are not far from unity, lending support to the labor theory of value, according to Ricardo.[8] It is important to note that the capital intensity as captured in the variable K is also statistically significant but with an elasticity coefficient much lower than that of labor values. The capital intensity is not statistically significant in the case of China and for the last two periods, and the adjusted R-square suggests the elimination of this
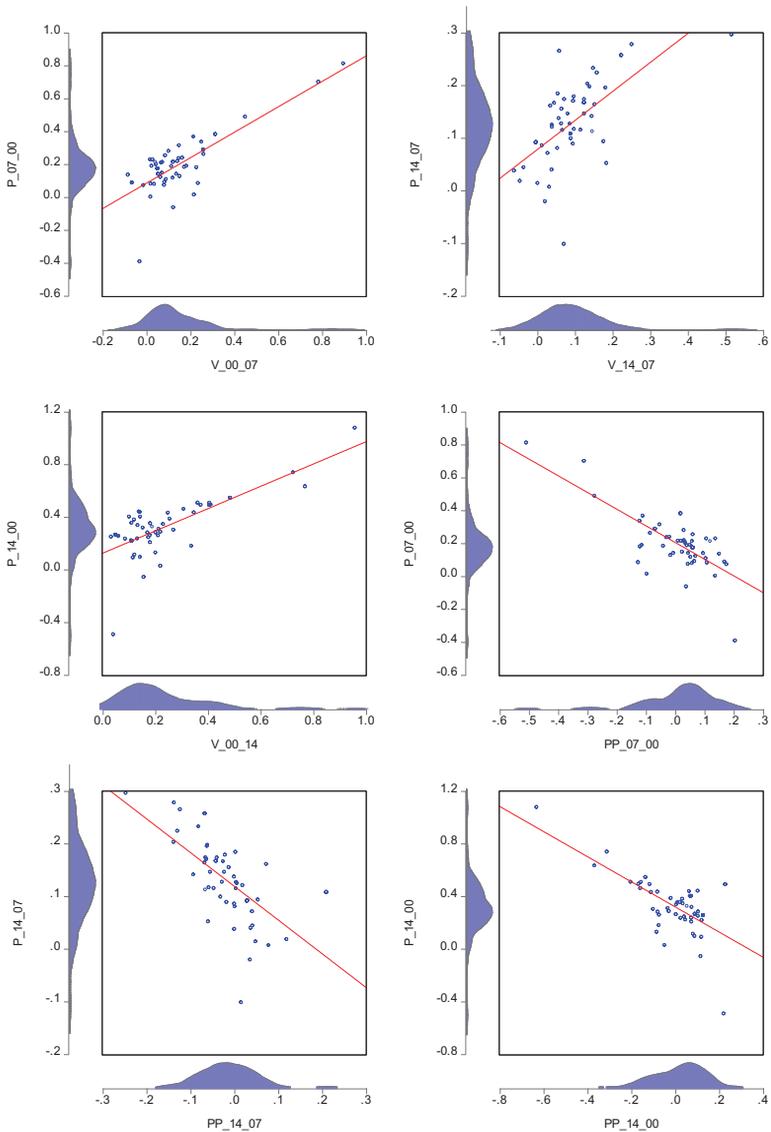
Figure 2.   Labor Values, Prices of Production vs. Market Prices, USA, 2000–2014

variable. Finally, the OLS regressions revealed the proximity of prices of production to market prices, a result anticipated by both Ricardo and Marx.

Other essential findings are that the Great Recession impacted on the US economy as this can be judged by the low elasticity of prices of production, in effect
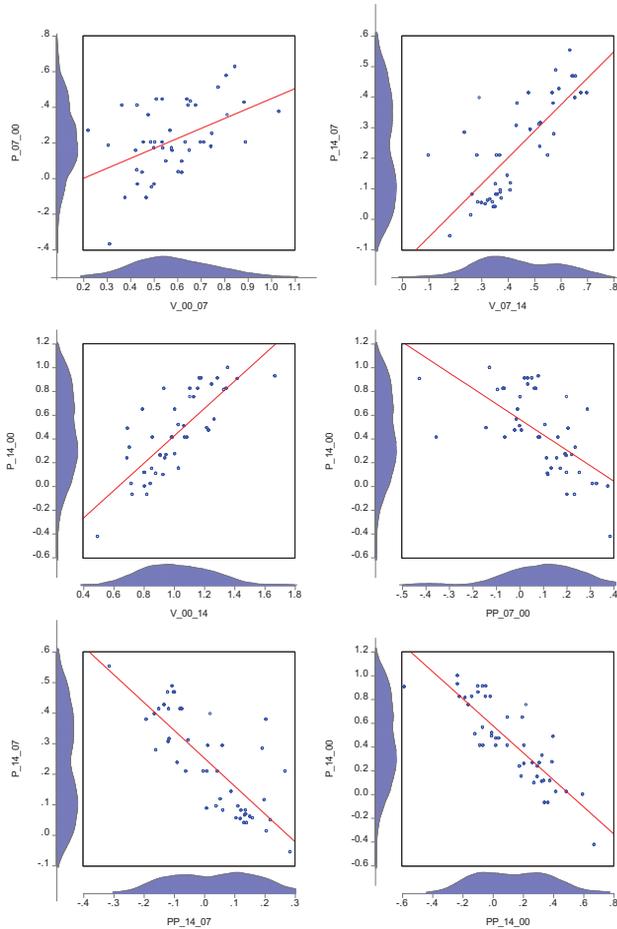
Figure 3.   Labor Values, Prices of Production vs. Market Prices, China, 2000–2014

the elasticity coefficient of the PP_14_07 is the lowest and the overall perfor-
mance is inferior to that of the other sub-periods, in both countries. However,
when we examine the entire 2000–2014 period for the US economy, the elasticity
coefficient of prices of production returns to nearly unitary; thereby, lending sup-
port to the view that in the long run the natural prices (or prices of production) tend
to equal the market prices. The results for China are also extremely good, espe-
cially in the last two periods (2007–2014 and 2000–2014) and certainly the Great
Recession does not appear to have exerted any particular effect on the Chinese
economy, at least with respect to Ricardo's labor theory of value.

Table 3.   Unit Labor Values, Prices of Production vs. Market Prices, USA and China[9]

Dependent Variable	Constant	Unit Labor Values	Vertically Integrated VCC	Prices of Production	Adjusted R-squared
USA					
2000–2007	0.086 (4.74)	0.773 (9.44)			0.624
2000–2007	0.145 (7.31)	0.797 (11.5)	−0.493 (4.69)		0.732
2000–2007	0.208 (13.4)			−1.014 (8.16)	0.553
2007–2014	0.078 (6.69)	0.551 (6.05)			0.402
2007–2014	0.074 (6.99)	0.781 (7.48)	−0.311 (3.58)		0.512
2007–2014	0.120 (14.4)			−0.641 (5.99)	0.397
2000–2014	0.127 (4.02)	0.847 (7.00)			0.543
2000–2014	0.205 (6.27)	0.857 (9.37)	−0.445 (4.33)		0.659
2000–2014	0.322 (14.9)			−0.955 (6.60)	0.445
CHINA					
2000–2007	−0.111 (1.20)	0.559 (3.67)			0.213
2000–2007	−0.259 (3.50)	0.851 (6.84)	−0.512 (5.99)		0.557
2000–2007	0.295 (12.4)			−0.839 (6.62)	0.482
2007–2014	−0.146 (3.00)	0.866 (8.13)			0.586
2007–2014	−0.130 (2.21)	0.891 (7.42)	−0.026 (0.458)		0.576
2007–2014	0.253 (16.7)			−0.912 (8.41)	0.601
2000–2014	−0.729 (5.19)	1.152 (8.58)			0.612
2000–2014	−0.611 (3.37)	1.160 (8.63)	−0.122 (1.02)		0.613
2000–2014	0.582 (19.8)			−1.139 (10.7)	0.712

5. Concluding Remarks

According to Ricardo, the required labor time spent on the production of commodities is the key determinant of natural prices, which in turn are theorized as the centers of gravitation of ever-fluctuating market prices. The unequal capital intensities between industries, the changes in the income distribution as well as the differences in turnover times do affect the relative (natural) prices of commodities, but only in a limited and at the same time theoretically predictable way.

In this article, we further modeled Ricardo's theoretical insights and showed that one should not expect dramatic changes in relative prices in the presence of fixed capital and in the face of changes in the distributive variables or turnover times. These variables must be thought of as secondary in importance for the paths of relative prices of commodities in comparison to the principal determining factor, which according to Ricardo is the relative labor times.

Thus, it came as no surprise that Ricardo's major theoretical prediction that the intertemporal variations in relative market prices, in the long run, are approximated by the natural price (or the price of production) and that the movement of market prices depends principally and decisively on the relative labor times is ascertained in the data from both the USA and China, that is, two major economies. Empirical results from a host of other countries, cross-sectionally and intertemporally corroborate Ricardo's foundational insights with respect to the determinants of relative prices.

Notes

1. Ricardo, in his last paper, written in 1823, admitted: "there is no such a thing in nature as a perfect measure of value" (Ricardo 1951b, 404).
2. Schumpeter (1954, 473–474) characterized this feature of Ricardo's work, that is, the derivation of key theoretical results based on oversimplified numerical models and extreme hypotheses, as "Ricardian Vice."
3. In effect, interest rates (on consols) during Ricardo's time were on average somewhat less than 5% (Officer 2021). Consequently, Ricardo's 10% assumption of the rate of profit is not only convenient in estimations but also realistic, if we invoke Smith's ([1937] 1776, 98–99) rule-of-thumb according to which the rate of profit is twice higher than the rate of interest on a safe loan.
4. The estimation of elasticities, displayed in Table 2, is based on the application of the midpoint formula.
5. It is worth noting the regulating prices of production remain a form of value that has not been yet empirically tested.
6. Our approach is inspired, in part, by an exchange we had some years ago with Professor Takeshi Nakatani, who opined that we cannot get direct estimates of market prices using input-output data and so objecting to the usual cross-sectional studies, which find high proximity of estimated values and prices of production to market prices. For this reason, he opted for the estimation of correlation coefficients of the ratio of unit labor values of industries over their prices in one period

against the same ratio over another period, which although not the same nevertheless bears similarities with our proposed approach.

7.   We have also tested input-output data for Germany, the USA, China, Greece, and Japan of 34 industries with results very similar to the 54-industry structure that we opted for our presentation for the economies of the USA and China. China's seven secondary industries (i.e., advertising, auxiliary financial activities, architectural activities, publishing, repair of motor vehicles and motorcycles, repair, and installation of machinery) contain zero elements and are unquestionable of minimal importance and presumably aggregated to their closely related industries.

8.   Ricardo, for instance, notes:

> No law can be laid down respecting quantity, but a tolerably correct one can be laid down respecting proportions. Every day I am more satisfied that the former enquiry is vain and delusive, and the latter only the true objects of the science. (Ricardo 1951c, 278–279)

9.   The figures in parenthesis are the absolute values of t-statistics.

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