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A panel data approach to price-value correlations

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Abstract

Resorting to stationary and non-stationary panel data econometrics we offer tests for "Ricardo's 93% theory of value" for 10 OECD countries over different time periods and aggregation levels. The theory does not find empirical support.

Keywords: value, price, fixed effects model, random effects model, panel unit root tests, panel cointegration tests.

JEL Codes: C21, C43, C52, D46.

1 Introduction

Measures of price-value correlations have recently been the subject of a critical reassessment. A recent review of the literature was offered by Kliman (2002, 2004) also highlighting its underlying theoretical debate which is of a paramount importance for Marxian/classical economics. We stick here with empirical contributions on this issue.

By way of introduction, it is worth making reference to Shaikh (1984) and Cockshott and Cottrell (1997) that estimated the following model

$$\ln P_j = \ln A + \beta \ln D_j + \epsilon_j \tag{1}$$

where j is a sectoral index, P are aggregate prices – measured by "gross output" series -, D are aggregate monetary values series (a possible measure of which is illustrated below), A and β are constants and ϵ_j is an error term. If sectoral values are the main determinants of sectoral prices it will follow that: (i) lnA = 0; (ii) $\beta = 1$; (iii) the R^2 of (1) is large. The whole of these three predictions has been termed "Ricardo's 93% Theory of Value".

Earlier contributions (Cockshott and Cottrell, 1997, 1998; Petrovic, 1987; Tsoulfidis and Maniatis, 2002), based on cross-sectional regressions, found a strong empirical support for the predictions above.

However, this evidence was recently put into question by Kliman (2002) who argued that prices and values tend to be higher in larger sectors and lower in smaller ones. In other terms, industry size drives the strong connection between prices and values. Upon using industry total costs to deflate prices and values, the support for the three predictions above vanishes.

Diaz and Osuna (2005-6, 2007) interpreted the role of size in the correlation between industry prices and values in a different way. Consider the following equation

$$\ln \frac{p_i}{p_j} = \alpha + \beta \ln \frac{d_i}{d_j} + u_i \tag{2}$$

where p_j and p_i are the (production) prices of the $j-th$ and $i-th$ commodities respectively, d_j and d_i are unit values, u is a stochastic error and α and β parameters. The $j-th$ commodity is the numeraire, which is common to all the observations so that the error is not indexed by j. In order to estimate equation (1), one has to manipulate (2) so to obtain

$$\ln \frac{p_i q_i}{p_j q_j} = \alpha + \beta \ln \frac{d_i q_i}{d_j q_j} + (1-\beta) \ln \frac{q_i}{q_j} + u_i \tag{3}$$

where q_j and q_i are the physical quantities of output of industries j and i respectively. However, q_j and q_i cannot be observed and their value can vary according to measurement units. Therefore estimates of (1) based on (3) would be plagued by an omitted variable problem. Under these circumstances, different attempts to remove this problem by deflating industrial prices and values would lead to different results and therefore to indeterminacy. In other words, the conclusions by Kliman (2002) would be correct only if deflating industry prices and values by total costs was the only legitimate way to remove the effect of industry size on estimates of (1). The problem was further discussed in Kilman (2008) and Diaz and Osuna (2008), which, however, reasserted their respective positions.

The aim of the present contribution is to use panel data econometrics to shed further light on the issue. For relative values to explain relative prices it is necessary that all the three predictions above hold. We propose to start with the prediction that $\beta = 1$ and to use panel data econometrics to account for industry unobserved heterogeneity. In the case that the data do not reject this prediction, we will move to consider the prediction that $lnA = 0$ once imposing the restriction $\beta = 1$. It is enough that only one of these assumptions does not hold to reject the proposition that relative industry values are the main determinants of relative industry prices. We apply our testing procedure to sectoral data for 10 OECD countries over different time periods and aggregation levels.

The rest of this paper is structured as follows. The next section illustrates in greater detail our testing procedure and the methods we adopt. Next we move to discuss our data sources and the way we define our variables. Then we show our results and finally we conclude.

2 Testing procedure and methods

Our testing procedure is as follows. Consider equation (2) at time t

$$\ln \frac{p_{it}}{p_{jt}} = \alpha + \beta \ln \frac{d_{it}}{d_{jt}} + u_{it}$$

Add and subtract from the left hand side $(1-\beta)$ times relative output evaluated at base year prices to obtain

$$\ln \frac{p_{it} p_{i0} q_{it}}{p_{jt} p_{j0} q_{jt}} = \alpha + \beta \ln \frac{d_{it} p_{i0} q_{it}}{d_{jt} p_{j0} q_{jt}} + (1-\beta) \ln \frac{p_{i0} q_{it}}{p_{j0} q_{jt}} + u_{it} \tag{4}$$

This equation can be rewritten as

$$\ln \frac{p_{it} q_{it}}{p_{jt} q_{jt}} = \alpha + (\beta - 1) \ln \frac{p_{i0}}{p_{j0}} + \beta \ln \frac{d_{it} q_{it}}{d_{jt} q_{jt}} + (1-\beta) \ln \frac{p_{i0} q_{it}}{p_{j0} q_{jt}} + u_{it}$$

Bring to the left hand side $\ln \frac{p_{i0} q_{it}}{p_{j0} q_{jt}}$

$$\ln \frac{p_{it} q_{it}}{p_{jt} q_{jt}} - \ln \frac{p_{i0} q_{it}}{p_{j0} q_{jt}} = \alpha + (\beta - 1) \ln \frac{p_{i0}}{p_{j0}} + \beta \left(\ln \frac{d_{it} q_{it}}{d_{jt} q_{jt}} - \ln \frac{p_{i0} q_{it}}{p_{j0} q_{jt}} \right) + u_{it} \tag{5}$$

Given that the j-th good is the numeraire we drop the j index and we define

$$\begin{aligned}
y_{it} &\equiv \ln \frac{p_{it} q_{it}}{p_{jt} q_{jt}} - \ln \frac{p_{i0} q_{it}}{p_{j0} q_{jt}} \\
x_{it} &\equiv \ln \frac{d_{it} q_{it}}{d_{jt} q_{jt}} - \ln \frac{p_{i0} q_{it}}{p_{j0} q_{jt}} \\
\mu_i &\equiv (\beta - 1) \ln \frac{p_{i0}}{p_{j0}} \\
e_{it} &\equiv u_{it}
\end{aligned}$$

and so we can write (5) as

$$y_{it} = \alpha + \beta x_{it} + \mu_i + e_{it} \tag{6}$$

It is now clear that it is possible to estimate β and to test hypotheses about it by carrying to the data the well-known one-way error component model, either in its fixed effect variant or in its random effect one. The two differ depending on the assumptions concerning μ_i. For the fixed effects model, they are considered as fixed parameters, while in the random effects model they are considered as random realizations from stochastic processes that are independently and identically distributed with a given variance (Baltagi, 2001, pp. 12-21).

We choose between the two models on the grounds of the Hausman test, which is based on the difference between their estimated values of β. The null of this test is that the two estimators produce the same results. Its basis is that fixed effects estimates are consistent but not effi cient under both the null hypothesis and the alternative one, while the random effect estimator is not consistent under the alternative hypothesis but it is effi cient under the null (Baltagi, 2001, pp. 65-66). Such test, however, does not suit all possible datasets, as its underlying assumption that the variance-covariance matrix of the difference between the two estimators is positive definite might not hold in practice. For this reason we supplement it with a Mundlak test (Hsiao, 2001, pp. 50), which is not based on this hypothesis. We further test for serial correlation in e_{it}, by resorting to the Lagrange Multiplier (LM) tests proposed by Baltagi (2001, p. 91 and p. 95). Finally, in presence of evidence of serial correlation in the residuals, we look for the most suitable specification between an AR(1) and a MA(1) process by resorting to the test proposed by Burke, Godfrey and Termayne (1990) - hereafter labelled as BGT - as illustrated in Baltagi (2001, p. 97).

The procedure above is appropriate when dealing with stationary data. However, when the time dimension of the panel grows large, a problem of spurious regression might arise with non-stationary data (Baltagi, 2001, p. 243). To overcome it, we resort to panel unit root and cointegration testing after Im, Pesaran and Shin (2003), Maddala and Wu (1999), Choi (2001) and Pedroni (1999, 2004)[1]. If the unit root and cointegration hypotheses are not rejected, we will adopt a panel dynamic least square dummy variables (DLSDV) estimator after Mark and Sul (2003) to test for $\beta = 1$, which, once again, considers μ_i as fixed constants.

For panels with both short and long time dimensions, once we find evidence of $\beta = 1$, we impose this restriction on the data and we check the 5% confidence interval of α' in the following regression

$$y_{it} - x_{it} = \alpha' + \xi_{it}$$

where ξ_{it} is a stochastic error. In this setting we can test for $\alpha' \equiv lnA = 0$,

[1] Once again an introduction to these tests is offered in Baltagi (2001, chp. 12).

because if $\beta = 1$, there will not be any omitted variable problem in (3).

3 The dataset and definitions of variables

Our data source is the STAN OECD database[2], from which we take the following variables: consumption of fixed capital (CFCC), intermediate inputs in current prices (INTI), gross output in current prices (PROD), gross output in prices for the year 2000 (PRDK), value added in current prices (VALU), the number of employees (EMPE), the number of self-employed (SELF), labour costs (LABR). We consider the following countries in the following time periods: Austria from 1976 to 2009, Belgium from 1995 to 2008, the Czech Republic from 1995 to 2009, Denmark from 1970 to 2007, Finland from 1984 to 2004, Greece from 2000 to 2009, Italy from 1980 to 2008, Norway from 1970 to 2007, Slovenia from 2000 to 2009 and Sweden from 1994 to 2008. The precise list of sectors and the level of aggregation varies from country to country depending on data availability. We give preference to the most possible disaggregated data. After Dìaz and Osuna (2005-6), among others, we restrict our attention to the private sector only, though, in keeping with the literature, we do not distinguish between productive and unproductive activities[3].

[2] http://www.oecd.org/document/62/0,3746,en_2649_34445_40696318_1_1_1_1,00.html

[3] A list of the sectors considered for each country as well as a list of numeraire sectors is available upon request.

We compute y_{it} as follows[4]

$$y_{it} = \ln \frac{PROD_{it}}{PROD_{nt}} - \ln \frac{PRDK_{it}}{PRDK_{nt}} \tag{7}$$

where the n index denotes the numeraire sector.

In order to get x_{it} we have first to compute industry money values of output (MV). After Kliman (2002) we proceed as follows. We correct LABR by the wage equivalent for self-employed (which accounts for the average opportunity cost of not being an employee)

$$LABR'_{it} = LABR_{it} \left(1 + \frac{SELF_{it}}{EMPE_{it}}\right)$$

The aggregate surplus value (S) and rate of surplus value (RSV) are respectively

$$S_{\cdot t} = \sum_i (VALU_{it} - LABR'_{it} - CFCC_{it})$$

$$RSV_{\cdot t} = \frac{S_{\cdot t}}{\sum_i LABR'_{it}}$$

We impose the restriction that sectoral rates of surplus value are all equal to the aggregate one and therefore sectoral surplus values are

$$S_{it} = RSV_{\cdot t} \cdot LABR'_{it}$$

[4]We thank Andrew Kliman for help about variable definitions.

As a matter of consequence sectoral MVs are

$$MV_{it} = S_{it} + LABR'_{it} + INTI_{it} + CFCC_{it}$$

Note that by construction, in accordance with Kliman (2002)

$$\sum_i MV_{it} = \sum_i PROD_{it} \tag{8}$$

Finally

$$x_{it} = \ln \frac{MV_{it}}{MV_{nt}} - \ln \frac{PRDK_{it}}{PRDK_{nt}}$$

4 Results

As mentioned above we use different methods depending on the length of the time span (T) of the available data for each country. Given that spurious regression can generically arise as T grows large, it is diffi cult to choose an empirical criterion to single out the countries for which to resort to unit root and cointegration methods. However, Mark and Sul (2003) present an empirical application of their estimation method for a dataset with T=40. For this reason, we consider as long panels those that have a T dimension closer to 40, namely those of Austria, Denmark, Norway and Italy. Short panels are the remaining ones. Results would not substantially change altering this classification.

4.1 Short panels

Table 1 sets out our results concerning short panels . Both the Hausman and the Mundlak tests always prefer the fixed effect model rather the random effect one, with the exception of Greece where the contrary happens. LM tests find evidence of serial correlation and the BGT test points to the AR(1) model rather than to the MA(1) one for the stochastic error. As a consequence we estimate an AR(1) fixed effects model for all the countries, but Greece for which an AR(1) random effects model is implemented. For all the countries but Sweden, the 95% confidence interval does not include the value of 1. So we consider the hypothesis that relative values are the main determinants of relative prices as rejected at the 5% level.

Regarding Sweden, we proceed as anticipated above. The estimated value of α' is 0.16 with a p-value of 0.00. Considering each year separately would produce very similar results. For Sweden too, then, there is not statistical support for relative values being the main determinants of relative prices.

4.2 Long panels

Tables 2 to 5 set out our results concerning long panels. For all the countries, but Denmark there is not evidence in support for $\beta = 1$. For Austria and Norway, series have the same order of integration, but the null of no cointegration is not rejected by the vast majority of the tests. For Italy series do not have the same order of integration.

Once resorting to the panel DLSDV estimator on Danish data - including, in accordance with this method, the fifth, third, second and first leads of Δx_{it} as well as its second and first lags[5] - the estimated value of β is 0.97 with a 95% confidence interval of $\{0.951,1.005\}$. So we find statistical evidence supporting the hypothesis $\beta = 1$. For this reason, we proceed as with Sweden in the previous section. Here, we obtain an estimated value of α' equal to 0.03 with a p-value of 0.00. Considering separate regressions for each year, one could find in some instances a value of α' not statistically different from 0 at the 5% level (such as for 1970 and 1971), but for some other years its value is highly statistically significant. Also for Denmark, then, there is not statistical support for relative values being the main determinants of relative prices.

5 Conclusions

The present contribution offers new empirical insights into the study of price-value correlations. Recently there has been a debate concerning the possibility or not to offer tests for the proposition that relative values are the main determinants of relative prices. We show that panel data econometrics can offer a test for this, overcoming possible problems of indeterminacy arising in cross-sectional estimates. The results obtained for 10 OECD countries would

[5] Leads and lags are selected according to their significance, by dropping insignificant regressors at the 5% level. All the remaining regressors are significant at the 1% level, but the constant which has a p-value of 0.06.

not find support for "Ricardo's 93% Theory of Value".

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Table 1 - Fixed and Random effects estimates and model specification tests for various OECD countries

Country	Timespan	N. sectors	β	95% confidence interval		Hausman test (p-values)	Mundlak test (p-values)	LM test (p-values)	BGT Test (p-values)
Fixed effects model									
Belgium	14	46	0.51	0.45	0.57	0.00	0.00	0.00	0.67
Czech	15	49	0.67	0.64	0.70	0.00	0.00	0.00	0.87
Finland	21	47	0.75	0.70	0.79	0.00	0.00	0.00	0.79
Slovenia	10	45	0.22	0.18	0.27	0.00	0.00	0.00	0.67
Sweden	15	31	0.94	0.86	1.02	-	0.00	0.00	0.76
Random effects model									
Greece	10	49	0.00	-0.04	0.05	0.11	0.10	0.00	0.25

Notes. The Hausman test is distributed as a χ squared with 1 degree of freedom. Its null is that the random effects model is preferable to the fixed effects one. The same null has the Mundlak test which has an F distribution with degrees of freedom equal to the number of regressors and the number of observations minus twice the number of regressors plus one. The LM test is asymptotically distributed as a N(0,1) for the number of time periods going to infinity. See Baltagi (2001), pp. 94-95. Its null is the absence of serial correlation. For Greece only, the LM test is instead the one presented by Baltagi (2001), pp. 90-91 and it is asymptotically distributed as a χ squared with 2 degrees of freedom for the number of cross-sectional units going to infinity. Its null is the absence of serial correlation and that the variance component due to sectoral specificieties is equal to zero. The BGT test is the Burke, Godfrey and Termayne (1990) test illustrated by Baltagi (2001), pp. 98-99. It is asymptotically distributed as a N(0, 1) for a large number of sectors. Its null is that the error process of the estimated equation can be modelled as an AR(1) rather than an MA(1).

Table 2 - Panel unit root and cointegration tests, 45 Austrian sectors from 1976 to 2009

Panel A: Panel Unit Root Tests. Null hypothesis: all the series have a unit root

	Y	ΔY	X	ΔX
Im, Pesaran and Shin W-stat	2.91 (0 to 3)	-24.11a (0 to 7)	0.54 (0 to 5)	-32.0071a (0 to 1)
ADF - Fisher Chi-square	50.61 (0 to 3)	668.60a (0 to 7)	81.68 (0 to 5)	900.973a (0 to 1)
PP - Fisher Chi-square	50.00 (0 to 3)	683.81a (0 to 7)	73.55 (0 to 5)	931.477a (0 to 1)

Panel B: Panel Cointegration Tests. Null hypothesis: no cointegration

Within dimension Test statistics		Between dimension Test statistics	
Panel v-statistic	-2.626027b	Group rho-statistic	1.695307
Panel rho-statistic	1.139610	Group PP-statistic	0.657860
Panel PP-statistic	0.154986	Group ADF-statistic	0.427007
Panel ADF-statistic	0.275928		

Notes: variables expressed in natural logarithms. For a definition of the variables see equations (7) and (8). Panel unit root tests include intercepts. Automatic lag length selection was performed on the basis of the Schwarz information criterion. Of the seven cointegration tests, the panel v-statistic is a one-sided test where large positive values reject the null hypothesis of no cointegration, whereas large negative values for the remaining test statistics reject the null hypothesis of no cointegration. All the cointegration tests are carried out without including a trend. For lag selection in the cointegration tests we used the Schwarz information criterion. 1 percent significance level denoted by ‘‘a’’.

Table 3 - Panel unit root and cointegration tests, 35 Danish sectors from 1970 to 2007

Panel A: Panel Unit Root Tests. Null hypothesis: all the series have a unit root

	Y	ΔY	X	ΔX
Im, Pesaran and Shin W-stat	8.32 (0 to 2)	-32.67a (0 to 1)	2.49 (0 to 4)	-35.09a (0 to 3)
ADF - Fisher Chi-square	15.69 (0 to 2)	866.83a (0 to 1)	46.62 (0 to 4)	928.40 (0 to 3)
PP - Fisher Chi-square	13.08 (0 to 2)	903.82a (0 to 1)	43.75 (0 to 4)	1002.41 (0 to 3)

Panel B: Panel Cointegration Tests. Null hypothesis: no cointegration

Within dimension Test statistics		Between dimension Test statistics	
Panel v-statistic	2.687805b	Group rho-statistic	-4.86a
Panel rho-statistic	-6.942717a	Group PP-statistic	-5.46a
Panel PP-statistic	-5.782381a	Group ADF-statistic	-5.87a
Panel ADF-statistic	-6.291381a		

Notes: variables expressed in natural logarithms. For a definition of the variables see equations (7) and (8). Panel unit root tests include intercepts. Automatic lag length selection was performed on the basis of the Schwarz information criterion. Of the seven cointegration tests, the panel v-statistic is a one-sided test where large positive values reject the null hypothesis of no cointegration, whereas large negative values for the remaining test statistics reject the null hypothesis of no cointegration. All the cointegration tests are carried out without including a trend. For lag selection in the cointegration tests we used the Schwarz information criterion. 1 percent significance level denoted by ‘‘a’’ and 5 per cent significance denoted by "b".

Table 4 - Panel unit root tests, 24 Italian sectors from 1970 to 2007

Null hypothesis: all the series have a unit root				
	Y	ΔY	X	ΔX
Im, Pesaran and Shin W-stat	-1.70b (0 to 6)	-14.51a (0 to 6)	1.21 (0)	-20.5813a (0)
ADF - Fisher Chi-square	88.64a (0 to 6)	294.72a (0 to 6)	37.21 (0)	407.743a (0)
PP - Fisher Chi-square	163.88a (0 to 6)	327.27a (0 to 6)	50.01 (0)	417.104a (0)

Notes: variables expressed in natural logarithms. For a definition of the variables see equations (7) and (8). Panel unit root test includes intercepts. 1 percent significance level denoted by ‘‘a’’, 5 per cent significance denoted by "b".

Table 5 - Panel unit root and cointegration tests, 42 Norwegian sectors from 1970 to 2007

Panel A: Panel Unit Root Tests. Null hypothesis: all the series have a unit root

	Y	ΔY	X	ΔX
Im, Pesaran and Shin W-stat	6.46 (0 to 6)	-19.56a (0 to 5)	4.37 (0 to 9)	-35.63a (0 to 5)
ADF - Fisher Chi-square	39.68 (0 to 6)	529.81a (0 to 5)	53.39 (0 to 9)	1024.83a (0 to 5)
PP - Fisher Chi-square	32.12 (0 to 6)	599.37a (0 to 5)	70.29 (0 to 9)	1089.11a (0 to 5)

Panel B: Panel Cointegration Tests. Null hypothesis: no cointegration

Within dimension Test statistics		Between dimension Test statistics	
Panel v-statistic	-0.161473	Group rho-statistic	1.288781
Panel rho-statistic	-0.718028	Group PP-statistic	-0.971838
Panel PP-statistic	-1.828059	Group ADF-statistic	-1.189264
Panel ADF-statistic	-1.873610		

Notes: variables expressed in natural logarithms. For a definition of variables see equations (7) and (8). Panel unit root tests include intercepts. Automatic lag length selection was performed on the basis of the Schwarz information criterion. Of the seven cointegration tests, the panel v-statistic is a one-sided test where large positive values reject the null hypothesis of no cointegration, whereas large negative values for the remaining test statistics reject the null hypothesis of no cointegration. All the cointegration tests are carried out without including a trend. For lag selection in the cointegration tests we used the Schwarz information criterion. 1 percent significance level denoted by ‘‘a’’.