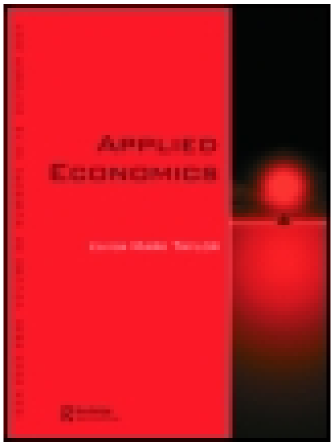

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The competitive conditions in the OECD manufacturing industry

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The competitive conditions in the OECD manufacturing industry

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The goal of this study was to assess the intensity of competition in the OECD manufacturing industry by using the Panzar and Rosse index over the period 1970–2011. For this purpose, we use the fully modified OLS method and second-generation unit root analysis to investigate the level of competition across two-digit manufacturing sectors. The results are robust and consistent with similar studies, leading to the rejection of perfect collusion and perfect competition, while providing evidence in favour of monopolistic competition. Similarly to other empirical studies, *H*-statistics are shown to be heterogeneous across manufacturing sectors. We argue that more concentrated sectors such as food and beverages, motor vehicles and furniture have low levels of *H*-statistic being thus less competitive than other industries (i.e. computers transportation equipment, printing and chemicals), where the *H*-statistic is closer to unity. Lastly, our analysis will be a useful policy tool to achieve structural microeconomic goals.

Keywords: monopolistic competition; panel data; Panzar and Rosse index; FMOLS; manufacturing

JEL Classification: L13; L60; C23; C51

I. Introduction

Despite the great number of empirical studies in the relevant literature, relatively limited articles, to the best of our knowledge, investigate the competition level of the manufacturing sector across the OECD countries by applying nonstructural methods, such as the Panzar–Rosse (P-R) (1987) model. The goal of this article was to empirically assess the level of competition prevailing in the OECD manufacturing industry. The analysis employs a widely used nonstructural methodology put forward by Panzar and Rosse (1987) (also known as the *H*-statistic) and draws upon a comprehensive panel data-set of ten OECD countries (Austria, Belgium, Denmark, Finland, France, Italy, Korea, Netherlands, Sweden and USA) spanning the period 1970–2011. The advantage of this methodology is that it uses firm-/industry-level data and allows for specific differences in production function. In other words, the *H*-statistic as a nonstructural indicator can be formally derived from profit-maximizing equilibrium conditions,

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which is its main advantage over other structural approaches (market shares, Hirschman–Herfindahl index) described in the Structure–Conduct–Performance (S-C-P) paradigm, suggested by Mason (1939) and Bain (1956). This methodological approach is a valuable and attractive tool (i.e. simple, transparent and without lacking efficiency) for assessing the level of competition under different market structures (Delis, 2010).

Further, an additional benefit of the methodology is that there is no need to specify a relevant market, given that the behaviour of individual firms provides an indication of their market power (Gutierrez, 2007), while the use of firm-level data only makes it robust to the geographic extent of the market (Bikker *et al.*, 2012). However, we must stress that the P-R model does not allow the study of explicit differences across different firms, e.g. large versus small, or foreign versus domestic firms, provided that the H-index cannot be interpreted as an ordinal statistic (Bikker *et al.*, 2012).

In spite of the large number of empirical studies devoted on this topic, none of them, to the best of our knowledge, has investigated the level of competition in the manufacturing sector across OECD countries. This is a novelty that this study carries by pooling the relevant variables (i.e. gross output and value added, prices of intermediate inputs, gross fixed capital formation, labour costs, etc.) across 10 OECD countries.

Investigating this relationship for the OECD will be interesting on many fronts. First, market power can provide valuable information on competitive pressures in various sectors of the OECD economy, reflecting pressures stemming from rules of conduct imposed by regulators as well as those arising from such factors as increasing consumer demands in terms of price and quality. Second, the estimation of the competition level in manufacturing industry has important welfare implications since it may benefit policy-makers and government officials to pursue pro-competitive regulatory reforms in order to maximize consumer surplus. Lastly, it will be interesting to measure the level of market power which can be considered as large for the OECD economy and thus have some effects on the OECD industrial production, as well as their degree of persistency. The latter may be associated with the duration of the business cycles or inflationary pressures of the OECD economy.

The motivation for this article comes from the need a theoretical framework to be provided through the employment of a profit function maximizing model, which permits the inclusion of input prices as explicit variables, in order to assess the market structure of the manufacturing sector across a number of OECD countries. After getting the analytical solution of the theoretical model, we then carry on the empirical analysis which estimates the H-statistic as the sum of the input price elasticities, generated by two reduced-form revenue equations.

Unlike previous studies, we apply the Fully Modified Ordinary Least Squares (FMOLS) pioneered by Pedroni (2000), to assess the level of competition in the various manufacturing sectors. To the best of our knowledge, no study so far has applied an extensive estimation of the P-R indices in line with the two-digit manufacturing sectors across the OECD countries, which is the real novelty of this article. The remainder of this article is structured as follows: Section II reviews the literature, while Section III builds the theoretical model. Section IV discusses the applied methodology, while Section V illustrates and evaluates the results of the empirical analysis. Finally, Section VI concludes the article.

II. Review of the Literature

The majority of the empirical studies on this topic apply the Roeger (1995) methodology to estimate industry mark-up ratios (see *inter alia* Dobbelaere, 2004; Maioli, 2004; Bottini and Molnár, 2010; Christopoulou and Vermeulen, 2012; Rezitis and Kalantzi, 2013; Polemis, 2014). Most of these studies conclude to the following major relationships: (1) estimated mark-up ratios are generally larger than one, denoting the absence of competitive conditions in certain sectors/industries, (2) there is a considerable variation of mark-up ratios across countries and industries, (3) services sectors generally have higher mark-ups *vis-à-vis* manufacturing and (4) mark-ups are lower for most manufacturing industries.

By contrast, there are quite many empirical studies applying the P-R model, particularly related to the banking sector (Shaffer, 2002; Claessens and Laeven, 2004; Beck *et al.*, 2006; Gutierrez, 2007; Yildirim and Philippatos, 2007; Bikker *et al.*, 2012; Andries and Capraru, 2014). The majority of the empirical studies seem to provide strong evidence supporting the hypothesis that monopolistic competition is the prevailing environment across European banks (Bikker and Haaf, 2002). Monopolistic competition is quite a recurrent finding due to the wide range of values the *H*-statistic can take within this scenario (i.e. between zero and one). This context enhances the importance of certain methodological issues concerning the empirical implementation of the Panzar and Rosse (1987) approach such as, *inter alia*, data, estimation techniques and sample periods under consideration.

We must argue, however, that there is a striking dichotomy between the reduced forms of the price/revenue relationship, as it is estimated in the empirical literature. A number of researchers estimate a price or a revenue function that does not include total banking assets as a control variable (Bikker *et al.*, 2012). Others, estimate a price/revenue function in which the dependent variable is either gross interest revenues or total banking revenues divided by total assets (Bikker and Haaf, 2002; Claessens and Laeven, 2004; Mamatzakis *et al.*, 2005; Yildirim and Philippatos, 2007). It is noteworthy that Bikker *et al.* (2012) show that both the price and the scaled revenue equations lead to a biased estimate of the H-index. The misspecification is due to the use of the bank revenues divided by total assets as the dependent variable, instead of the unscaled bank revenues variable. This finding yields important consequences, given that the H-index cannot be reliably used as a measure of the degree of competition; furthermore, various conditions can cause a reverse of the sign of values, regardless the degree of competition (Bikker *et al.*, 2012).

However, the application of the *H*-statistic in other areas than banking is quite limited. More specifically, Fischer and Kamerschen (2003) employ the P-R test to assess market performance in selected airport-pairs in the US. The *H*-statistic is generally positive and quite large, indicating that the carriers industry is neither in perfect competition nor in perfect colluding. They find that in all airport-pairs, the presence of the Bertrand outcome, which is equivalent to perfect competition, is resoundingly and consistently rejected, as is the outcome describing perfect collusion, which is equivalent to the joint monopoly outcome.

Tsutsui and Kamesaka (2005) investigate the competitive conditions of the Japanese securities industry over the period 1983–2002 using the P-R *H*-statistic. Their results indicate that the Japanese securities industry is not in monopoly equilibrium over the period 1983–1988 and over the period 1997–2002, while this possibility cannot be rejected over the period 1991–1996. Their basic finding is that this specific industry has not been perfectly competitive, even though it has been undergoing certain financial reforms.

In another empirical study, Coccorese (2012) applies the P-R methodology to assess the degree of competition in the Italian car insurance market in order to evaluate the considerable fine that has been imposed on 39 companies by the Italian Antitrust Authority (IAA) in 2000 due to their anticompetitive behaviour associated with a long-standing information exchange through a third independent company. The results show that the undertaking firms have earned revenues as if under monopoly or collusive oligopoly conditions, therefore, endorsing the decision of IAA.

Lastly, Liu *et al.* (2013) also employ the P-R model in order to assess the market structure of 21 listed companies in China's construction industry during the period 2009–2011. The analysis reveals that China's construction industry operates under conditions of monopolistic competition with free-entry equilibrium.

III. The Theoretical Model

Following the theoretical model in Fischer and Kamerschen (2003), the firm's profit function is given by:

$$\pi = TR - TC = \pi(y, z, \mathbf{w}, \mathbf{t}) \tag{1}$$

where $\boldsymbol{w}$ is a vector of factor prices (i.e. wages, intermediate inputs, the rental price of capital), $\boldsymbol{t}$ is a vector of exogenous variables that shift the firm's cost curve and $\boldsymbol{z}$ is a vector of variables that are exogenous to the firm, shifting its revenue function. Let y° be the argument that maximizes this profit function and y^1 be the output quantity that maximizes $\pi(y, z, (1+h)\boldsymbol{w}, \boldsymbol{t})$, where the scalar h is greater or equal to zero. Define R° as $R(y^{\circ}, z) \equiv R^*(\boldsymbol{z}, \boldsymbol{w}, \boldsymbol{t})$ and $R^1 = R(y^1, z) \equiv R^*(z, (1+h)\boldsymbol{w}, \boldsymbol{t})$, where R^* is the firm's reduced-form revenue function. It follows by definition that:

$$R^1 - C(y^1, (1+h)\boldsymbol{w}, \boldsymbol{t}) \geq R^0 - C(y^0, (1+h)\boldsymbol{w}, \boldsymbol{t}) \quad (2)$$

Using the fact that the cost function C is linearly homogeneous in $\boldsymbol{w}$, the equation can be rewritten as:

$$R^1 - (1+h)C(y^1, \boldsymbol{w}, \boldsymbol{t}) \geq R^\circ - (1+h)C(y^\circ, \boldsymbol{w}, \boldsymbol{t}) \quad (3)$$

Similarly, it must also be the case that:

$$R^\circ - C(y^\circ, \boldsymbol{w}, \boldsymbol{t}) \geq R^1 - C(y^1, \boldsymbol{w}, \boldsymbol{t}) \quad (4)$$

Rearranging and dividing by h, the above inequality yields:

$$(R^1 - R^\circ)/h = [R^*(\boldsymbol{z}, (1+h)\boldsymbol{w}, \boldsymbol{t}) - R^*(\boldsymbol{z}, \boldsymbol{w}, \boldsymbol{t})/h] \leq 0 \quad (5)$$

This nonparametric result simply states that a proportional cost increase always results in a decrease in the firm's revenue (Fischer and Kamerschen, 2003). Assuming that the reduced-form revenue function is differential, taking the limit of Equation 5 as $h \to 0$ and then dividing the result by R^* yields

$$\varphi^* \equiv \Sigma \mathbf{w}(\partial R^*/\partial \mathbf{w})/R^* \leq 0 \quad (6)$$

where $\boldsymbol{w}_i$ are the components of the vector $\boldsymbol{w}$, so that $\boldsymbol{w}_i$ denotes the price of the ith input factor.

The sum of the factor price elasticities in the reduced-form revenue equation provides the H-statistic. A value of the H-statistic between 0 and 1 considers the degree of competitiveness in the industry under study. A value less than 0 denotes a collusive (joint monopoly) competition, a value less than 1 denotes the presence of monopolistic competition, and a value equal to 1 characterizes perfect competition (price-taking firms). Furthermore, Shaffer (1982) shows that H turns negative for a conjectural variations oligopolistic market or for a short-run competitive market, equal to unity for a natural monopoly in a contestable market, and equal to zero for a firm that maximizes sales subject to a break-even constraint. The P-R methodology makes use of firm-level data. In particular, it investigates the extent to which changes in factor input prices are reflected in (equilibrium) revenues earned by a specific firm. Under perfect competition, an increase in input prices raises proportionately both marginal costs and total revenues, while under a monopoly, an increase in input prices tend to increase marginal costs, reduce equilibrium output and, consequently, total revenues.

IV. Empirical Methodology

The first step in the P-R test is the derivation of a reduced-form revenue equation. Following the specification of Shaffer and Di Salvo (1994) and Fischer and Kamerschen (2003), we make use of four reduced-form equations, provided that output quantity is endogenous. The log-linear revenue equations depict two dependent variables (GO and VA), a set of input price variables (INTERM, CAP, and LAB or WAGE) and two control variables (GOPER and EMPL):[1]

$$\mathrm{GO}_{it} = \alpha_i + \delta_i t + \beta_1 \mathrm{INTERM}_{it} + \beta_2 \mathrm{CAP}_{it} + \beta_3 \mathrm{LAB}_{it} + \gamma_1 \mathrm{GOPER}_{it} + \gamma_2 \mathrm{EMPL}_{it} + \varepsilon_{it} \quad (7)$$

$$\mathrm{GO}_{it} = \alpha_i + \delta_i t + \beta_1 \mathrm{INTERM}_{it} + \beta_2 \mathrm{CAP}_{it} + \beta_3 \mathrm{WAGE}_{it} + \gamma_1 \mathrm{GOPER}_{it} + \gamma_2 \mathrm{EMPL}_{it} + \varepsilon_{it} \quad (8)$$

$$\mathrm{VA}_{it} = \alpha_i + \delta_i t + \beta_1 \mathrm{INTERM}_{it} + \beta_2 \mathrm{CAP}_{it} + \beta_3 \mathrm{LAB}_{it} + \gamma_1 \mathrm{GOPER}_{it} + \gamma_2 \mathrm{EMPL}_{it} + \varepsilon_{it} \quad (9)$$

$$\mathrm{VA}_{it} = \alpha_i + \delta_i t + \beta_1 \mathrm{INTERM}_{it} + \beta_2 \mathrm{CAP}_{it} + \beta_3 \mathrm{WAGE}_{it} + \gamma_1 \mathrm{GOPER}_{it} + \gamma_2 \mathrm{EMPL}_{it} + \varepsilon_{it} \quad (10)$$

[1] Capital letters denote variables in their natural logarithms.

where ε_{it} denotes the error term and γ refers to the coefficient of GOPER and EMPL. The parameters α_{it} and δ_i allow for the possibility of country-specific fixed effects and deterministic trends (t), respectively. All the relevant variables are in natural logarithms and obtained from the OECD STAN database. GO and VA are the gross output and value added for each of the two-digit manufacturing sector, respectively, both expressed in real terms. The relevant dependent variables are regarded as reliable proxies for measuring total revenues (Fafaliou and Polemis, 2013; Rezitis and Kalantzi, 2013). INTERM denotes the intermediate inputs at real prices. CAP is the gross fixed capital formation at real prices, while LAB stands for the labour costs deflated by the wholesale price index obtained from the World Bank database. WAGE denotes annual wages and salaries per industry, also obtained from the OECD STAN database. GOPER is the gross operating surplus and mixed income in real terms deflated by the wholesale price index, while EMPL denotes the number of employees. The sum of the three elasticities ($\sum_{i=1}^{3} \beta_i$) yields the P-R H-statistic. The above equations will be estimated by utilizing the FMOLS technique, proposed by Pedroni (2000).

V. Empirical Findings

Stationarity and cointegration tests

We begin the analysis by examining the presence of cross-sectional dependence. The results reported in Table 1 provide evidence in favour of the presence of cross-sectional dependence in the data since for all series the CD statistics are always highly significant whatever the number of lags (from 1 to 4) included in the ADF regressions. In other words, one rejects the null hypothesis of cross-section independence.[2]

Having put in evidence the presence of cross-section dependence across all the variables involved in the empirical analysis, we now turn to the determination of the degree of integration of the series, using two second-generation panel unit root tests proposed by Pesaran (2007) and Smith *et al.* (2004). The results of these second-generation panel unit root tests (Pesaran, 2007) are reported in Table 2 and provide support of the presence of a unit root in all series under consideration.

Table 1. Cross-section correlations of the errors in the ADF(p) regressions (CD test)

Variables/lags	1	2	3	4
GO	[0.01]	[0.00]	[0.01]	[0.01]
VA	[0.00]	[0.00]	[0.02]	[0.00]
INTERM	[0.00]	[0.01]	[0.01]	[0.00]
CAP	[0.02]	[0.00]	[0.02]	[0.01]
LAB	[0.01]	[0.01]	[0.01]	[0.00]
WAGE	[0.03]	[0.00]	[0.02]	[0.01]
GOPER	[0.00]	[0.02]	[0.03]	[0.00]
EMPL	[0.00]	[0.00]	[0.02]	[0.02]

Notes: Under the null of cross-sectional independence the CD statistic is distributed as a two-tailed standard normal. Results based on the test of Pesaran (2004). Figures in square brackets denote p-values.

With the respective variables integrated of order one, we examine the presence of a long-run relationship using a number of panel cointegration battery tests: Nyblom-Harvey (2000), Fisher-Johansen (Maddala and Wu, 1999), Pedroni (2001), Westerlund (2007) and Kao (1999). The results strongly reject the null hypothesis of no cointegration in favour of the presence of a long-run relationship between gross output and value added and the set of economic variables in the panel across the panel cointegration tests considered (Table 3).

Estimation results

The findings in Table 4 display the long-run parameter estimates of Equations 7–10 based on FMOLS for the whole manufacturing industry. From the estimation results, it is obvious that the coefficients are statistically significant, the signs are the expected ones and the fit to the data is satisfactory.

Across all four models, intermediate inputs yield a statistically significant positive coefficient with respect to gross output or value added, whereas labor cost or wages each render a statistically significant positive impact on gross output or value added. In addition, gross fixed capital formation exerts a statistically positive impact on gross output or value added, while labor cost or wages exert a statistically negative effect on gross output or value added.

The H-statistic is less than one in all specifications, implying that the manufacturing industry in the OECD sample countries is characterized by

[2] Due to space limitations, the stationarity tests for each of the two-digit industry sector are not reported here, but they are available from the authors upon request.

Table 2. Panel unit root test results for the manufacturing sector

Variable	Pesaran CIPS	Pesaran CIPS*	Smith *et al.* *t*-test	Smith *et al.* LM-test	Smith *et al.* max-test	Smith *et al.* min-test
All countries						
GO	−1.65	−1.61	−1.72	4.12	−1.25	1.65
Δ(GO)	−5.82*	−5.13*	−5.42*	19.83*	−6.72*	6.23*
VA	−1.15	−1.06	−1.25	4.05	−1.19	1.38
Δ(VA)	−5.49*	−5.31*	−6.14*	18.11*	−7.85*	7.11*
INTERM	1.18	−1.02	−1.28	3.76	−1.93	1.35
Δ(INTERM)	−6.94*	−6.38*	−5.73*	17.14*	−8.90*	6.26*
CAP	−1.71	−1.52	−1.14	2.53	−1.19	1.28
Δ(CAP)	−7.09*	−6.22*	−5.53*	16.48*	−7.81*	6.85*
LAB	−1.35	−1.14	−1.36	2.12	−1.35	1.36
Δ(LAB)	−7.44*	−6.96*	−6.65*	19.75*	−8.33*	7.64*
WAGE	−1.32	−1.23	−1.34	1.91	−1.54	1.58
Δ(WAGE)	−5.84*	−5.21*	−5.82*	18.85*	−6.84*	6.91*
GOPER	−1.29	−1.10	−1.24	1.22	−1.37	1.36
Δ(GOPER)	−7.53*	−6.93*	−5.81*	19.98*	−7.46*	7.02*
EMPL	−1.36	−1.13	−1.55	1.29	−1.34	1.38
Δ(EMPL)	−5.92*	−5.64*	−7.83*	17.82*	−5.88*	5.69*
Europe						
GO	−1.26	−1.11	−1.14	1.66	−1.42	1.25
Δ(GO)	−5.71*	−5.42*	−6.59*	18.65*	−5.64*	6.43*
VA	−1.17	−1.01	−1.41	1.98	−1.39	1.36
Δ(VA)	−5.83*	−5.57*	−5.60*	21.52*	−5.89*	6.42*
INTERM	−1.25	−1.15	−1.23	1.75	−1.42	1.71
Δ(INTERM)	−6.13*	−5.84*	−6.73*	20.47*	−5.80*	6.36*
CAP	−1.10	−1.02	−1.36	2.65	−1.45	1.38
Δ(CAP)	−6.58*	−5.82*	−6.75*	19.57*	−6.41*	5.56*
LAB	−1.32	−1.23	−1.35	1.90	−1.52	1.47
Δ(LAB)	−6.69*	−6.29*	−5.70*	17.91*	−7.46*	6.19*
WAGE	−1.11	−1.01	−1.28	2.56	−1.39	1.26
Δ(WAGE)	−5.73*	−5.39*	−5.94*	16.78*	−6.19*	6.74*
GOPER	−1.20	−1.14	−1.53	2.82	−1.65	1.86
Δ(GOPER)	−5.75*	−5.50*	−7.24*	19.53*	−6.48*	6.37*
EMPL	−1.27	−1.21	−1.38	1.84	−1.24	1.39
Δ(EMPL)	−5.62*	−5.44*	−6.49*	18.79*	−6.48*	5.58*

Notes: Δ denotes first differences. For the Pesaran (2007) tests, a constant is included in the estimations. Rejection of the null hypothesis indicates stationarity at least in one country. CIPS* = truncated CIPS test. For both tests the results are reported at lag = 4. Critical values for the Pesaran (2007) test are, respectively, −2.40 at 1%, −2.22 at 5% and −2.14 at 10%. *Denotes rejection of the null. For the Smith *et al.* (2004) tests: both a constant and a time trend are included. Rejection of the null hypothesis indicates stationarity at least in one country. The null hypothesis is that of a unit root.

significant market power (SMP). It does not appear to be a significant variation between the four specifications, although the H-statistic in the fourth specification (Equation 10) has relatively high values. From the Wald tests, we conclude that the OECD manufacturing industry is not characterized by perfect competition or contestability, since the Wald test for $H = 1$ is rejected across all specifications. By contrast, the market structure in the manufacturing industry is not characterized by perfect collusion or monopoly since the Wald test for $H = 0$ cannot be accepted across all four alterative models (see Equations 7–10).

The empirical results seem to be quite robust and in alignment with other empirical studies (Dobbelaere, 2004; Bottini and Molnár, 2010; Christopoulou and Vermeulen, 2012; Rezitis and Kalantzi, 2013), thus rejecting both perfect collusion and the presence of perfect competition, while providing evidence in favour of monopolistic competition. In other words, monopolistic competition is the best description in the OECD manufacturing industry.

Table 3. Panel cointegration tests

	Nyblom-Harvey		Fisher-Johansen		Pedroni		Westerlund		Kao
Sector	F	T	Trace	Max	F	T	F	T	F
	Equation 7								
Manufacturing	**15.23***	**9.86***	**1854***	**1792***	**−38.45***	**−44.21***	**−26.92***	**−33.48***	**−19.85***
Food	16.26*	9.09*	1773*	1641*	−35.41*	−42.95*	−27.25*	−36.18*	−20.55*
Beverages	24.25*	10.24*	1852*	1771*	−34.71*	−29.83*	−36.97*	−34.82*	−35.64*
Tobacco	19.37*	9.86*	1987*	1779*	−39.47*	−48.09*	−34.54*	−39.85*	−28.52*
Textiles	24.62*	9.64*	1854*	1584*	−24.43*	−19.38*	−19.86*	−19.47*	−18.45*
Wearing	22.31*	8.74*	1848*	1639*	−37.36*	−45.11*	−33.51*	−35.32*	−27.61*
Leather	17.83*	8.71*	1808*	1621*	−32.45*	−40.16*	−28.52*	−29.61*	−22.26*
Wood	18.14*	8.25*	1644*	1529*	−27.71*	−25.46*	−23.16*	−25.30*	−23.41*
Paper	24.16*	9.79*	1810*	1732*	−35.31*	−42.46*	−32.55*	−32.39*	−24.16*
Printing	25.32*	8.64*	1471*	1253*	−27.43*	−31.39*	−24.60*	−22.35*	−21.53*
Coke	25.32*	9.94*	1904*	1781*	−34.15*	−44.62*	−35.18*	−36.93*	−27.33*
Chemicals	25.65*	9.08*	1736*	1651*	−33.16*	−39.65*	−33.25*	−32.97*	−25.61*
Pharmac	27.83*	13.42*	1937*	1811*	−39.15*	−46.71*	−36.45*	−38.93*	−27.64*
Rubber	26.35*	9.11*	1895*	1793*	−36.14*	−43.65*	−35.94*	−34.95*	−25.62*
Other	26.73*	9.06*	1673*	1515*	−31.14*	−37.66*	−29.46*	−28.93*	−23.65*
Metals	23.66*	8.46*	1531*	1495*	−27.13*	−29.65*	−27.63*	−28.92*	−22.67*
Fabr. Metals	28.65*	12.95*	2395*	1924*	−44.15*	−47.65*	−42.61*	−42.98*	−44.66*
Computers	21.52*	7.94*	1638*	1499*	−28.15*	−22.67*	−22.06*	−22.91*	−21.62*
Electrical	25.03*	11.56*	1892*	1761*	−39.56*	−37.58*	−39.15*	−32.84*	−34.16*
Machinery	21.55*	10.52*	1782*	1573*	−32.57*	−27.58*	−32.19*	−32.08*	−31.06*
Motor	20.36*	7.56*	1384*	1208*	−21.54*	−17.55*	−19.18*	−18.84*	−17.54*
Other transportation equipment	20.34*	9.46*	1635*	1414*	−26.45*	−31.82*	−22.60*	−21.35*	−21.54*
Furniture	24.25*	11.57*	2189*	1785*	−34.64*	−37.15*	−32.14*	−32.06*	−34.15*
	Equation 8								
Manufacturing	**17.56***	**9.24***	**1973***	**1809***	**−39.34***	**−42.16***	**−28.71***	**−35.64***	**−21.36***
Food	18.14*	9.25*	1882*	1763*	−36.31*	−40.26*	−29.45*	−34.47*	−22.95*
Beverages	23.52*	12.34*	1695*	1528*	−32.84*	−27.71*	−29.45*	−29.12*	−30.11*
Tobacco	23.46*	9.94*	2435*	1895*	−43.65*	−47.81*	−35.96*	−38.56*	−29.40*
Textiles	19.87*	9.57*	1796*	1496*	−26.54*	−27.58*	−23.96*	−24.71*	−19.53*
Wearing	24.55*	8.90*	1905*	1685*	−38.14*	−41.74*	−34.36*	−32.61*	−28.71*
Leather	18.15*	8.63*	1831*	1614*	−30.57*	−37.16*	−31.64*	−28.17*	−21.34*
Wood	19.83*	8.52*	1690*	1562*	−28.45*	−21.46*	−24.62*	−23.65*	−25.46*
Paper	26.15*	9.92*	1944*	1783*	−34.64*	−43.71*	−36.93*	−35.18*	−27.13*
Printing	23.76*	7.43*	1535*	1309*	−26.73*	−30.25*	−24.46*	−21.57*	−20.53*
Coke	26.84*	9.47*	1906*	1722*	−35.61*	−45.13*	−36.34*	−37.84*	−28.39*

(*continued*)

Table 3. Continued

	Nyblom-Harvey		Fisher-Johansen		Pedroni		Westerlund		Kao
Sector	F	T	Trace	Max	F	T	F	T	F
Chemicals	27.54*	9.66*	1836*	1681*	−32.45*	−38.13*	−35.38*	−33.84*	−26.34*
Pharmac	28.55*	12.25*	2188*	1904*	−44.45*	−46.12*	−39.36*	−38.87*	−28.35*
Rubber	27.58*	9.64*	1958*	1762*	−35.47*	−42.16*	−36.38*	−36.85*	−28.33*
Other	25.57*	9.14*	1725*	1544*	−33.47*	−38.12*	−30.34*	−29.85*	−24.35*
Metals	22.57*	7.93*	1590*	1432*	−24.14*	−25.16*	−26.30*	−25.84*	−23.08*
Fabr. Metals	29.55*	13.24*	2456*	1873*	−44.08*	−45.13*	−46.34*	−45.83*	−47.34*
Computers	22.54*	7.23*	1781*	1533*	−27.42*	−23.15*	−26.33*	−24.86*	−22.35*
Electrical	26.65*	10.43*	1954*	1672*	−34.87*	−35.36*	−36.49*	−35.30*	−37.46*
Machinery	22.65*	10.03*	1679*	1443*	−29.38*	−25.37*	−26.94*	−25.31*	−27.41*
Motor	19.08*	8.45*	1477*	1339*	−24.35*	−25.35*	−20.49*	−22.37*	−17.45*
Other transportation equipment	21.75*	7.44*	1556*	1328*	−24.76*	−28.24*	−20.46*	−19.54*	−21.54*
Furniture	29.83*	12.43*	2095*	1839*	−34.85*	−35.31*	−36.49*	−35.35*	−37.40*
	Equation 9								
Manufacturing	**18.16***	**8.73***	**1774***	**1693***	**−36.51***	**−40.16***	**−24.59***	**−32.93***	**−17.15***
Food	19.84*	12.46*	1906*	1875*	−39.62*	−45.66*	−28.95*	−37.25*	−19.58*
Beverages	23.05*	11.54*	1545*	1206*	−26.73*	−24.04*	−25.47*	−23.16*	−26.43*
Tobacco	21.90*	14.35*	2456*	1908*	−42.77*	−46.82*	−31.46*	−38.09*	−24.33*
Textiles	19.64*	9.43*	1525*	1452*	−24.54*	−26.36*	−24.36*	−25.09*	−23.45*
Wearing	22.85*	10.13*	1877*	1681*	−40.36*	−40.17*	−32.15*	−30.14*	−23.71*
Leather	19.91*	9.04*	1913*	1671*	−31.83*	−36.04*	−27.73*	−26.17*	−22.13*
Wood	20.52*	9.34*	1717*	1614*	−29.65*	−20.74*	−22.25*	−23.44*	−25.14*
Paper	27.51*	10.35*	1892*	1689*	−35.32*	−42.77*	−35.54*	−32.44*	−26.16*
Printing	23.67*	8.84*	1654*	1397*	−26.65*	−30.43*	−23.35*	−22.17*	−20.42*
Coke	28.55*	10.44*	1827*	1654*	−36.70*	−44.93*	−37.80*	−36.45*	−29.36*
Chemicals	27.96*	11.54*	1988*	1935*	−36.25*	−39.72*	−34.45*	−36.74*	−27.65*
Pharmac	29.12*	14.54*	2278*	1948*	−45.23*	−45.67*	−38.42*	−39.47*	−30.11*
Rubber	28.55*	10.08*	1784*	1695*	−36.23*	−44.67*	−37.48*	−35.64*	−27.64*
Other	26.16*	10.08*	1726*	1549*	−32.26*	−37.64*	−30.43*	−26.61*	−22.64*
Metals	21.15*	8.32*	1622*	1510*	−25.24*	−22.46*	−25.46*	−22.15*	−24.65*
Fabr. Metals	27.13*	15.53*	2941*	1755*	−45.24*	−43.61*	−45.52*	−42.36*	−46.69*
Computers	23.10*	8.31*	1569*	1419*	−25.24*	−22.29*	−25.43*	−22.71*	−23.11*
Electrical	27.06*	10.34*	1816*	1605*	−35.45*	−33.11*	−35.27*	−32.67*	−36.95*
Machinery	21.30*	11.35*	1645*	1507*	−25.47*	−23.10*	−25.24*	−22.61*	−26.94*
Motor	17.36*	8.34*	1492*	1357*	−20.45*	−23.11*	−22.23*	−22.60*	−19.94*
Other transportation equipment	22.65*	8.84*	1654*	1495*	−22.64*	−30.45*	−20.35*	−21.10*	−20.43*
Furniture	27.49*	12.34*	1907*	1782*	−35.46*	−33.10*	−35.25*	−32.65*	−36.99*

	Equation 10								
Manufacturing	**19.66***	**11.65***	**1930***	**1831***	**−39.42***	**−46.72***	**−29.09***	**−37.84***	**−23.72***
Food	20.57*	13.41*	2387*	1994*	−43.64*	−48.55*	−30.36*	−39.81*	−25.67*
Beverages	26.84*	13.14*	1807*	1693*	−28.12*	−27.15*	−30.87*	−27.24*	−26.91*
Tobacco	25.18*	13.26*	2244*	1956*	−44.74*	−43.95*	−34.52*	−36.73*	−26.78*
Textiles	19.84*	10.45*	1854*	1687*	−21.34*	−27.34*	−26.14*	−26.40*	−25.61*
Wearing	21.49*	10.06*	1873*	1713*	−28.71*	−28.63*	−30.25*	−28.72*	−21.95*
Leather	20.28*	9.15*	1955*	1711*	−28.91*	−32.35*	−25.18*	−24.35*	−23.87*
Wood	20.45*	9.46*	1622*	1582*	−22.16*	−20.35*	−20.51*	−25.62*	−20.52*
Paper	28.92*	9.11*	1852*	1663*	−31.76*	−40.35*	−34.52*	−33.24*	−25.44*
Printing	22.36*	8.18*	1557*	1314*	−22.25*	−24.69*	−22.68*	−21.39*	−20.34*
Coke	29.57*	9.58*	1914*	1737*	−35.61*	−46.53*	−37.23*	−35.48*	−26.34*
Chemicals	28.05*	9.84*	1819*	1735*	−35.60*	−41.46*	−36.22*	−35.49*	−26.14*
Pharmac	29.24*	13.15*	2512*	1964*	−42.14*	−44.32*	−35.62*	−40.14*	−32.57*
Rubber	29.24*	10.54*	1853*	1684*	−34.65*	−46.36*	−36.51*	−34.54*	−26.95*
Other	25.73*	8.68*	1725*	1581*	−29.62*	−28.56*	−29.26*	−25.44*	−21.73*
Metals	22.27*	8.36*	1724*	1635*	−21.16*	−20.15*	−24.26*	−23.44*	−25.42*
Fabr. Metals	29.22*	14.15*	1980*	1726*	−41.60*	−42.54*	−44.25*	−43.25*	−45.38*
Computers	24.21*	8.58*	1639*	1414*	−21.63*	−20.58*	−24.23*	−23.45*	−21.08*
Electrical	28.84*	11.00*	1863*	1738*	−36.08*	−32.49*	−34.50*	−33.51*	−35.87*
Machinery	24.58*	11.09*	1874*	1644*	−21.09*	−22.41*	−24.38*	−23.52*	−25.89*
Motor	19.07*	8.74*	1651*	1498*	−11.09*	−12.43*	−22.51*	−23.54*	−24.86*
Other transportation equipment	22.34*	8.38*	1536*	1318*	−21.25*	−22.67*	−22.69*	−20.36*	−20.34*
Furniture	28.38*	11.55*	1928*	1759*	−31.08*	−32.46*	−34.57*	−33.59*	−35.84*

Notes: Food = food products, Tobacco = tobacco products, Wearing = wearing apparel, Leather = leather and related products, Wood = wood and products of wood and cork except furniture, Paper = paper and paper products, Coke = coke and refined petroleum products, Chemicals = chemicals and chemical products, Pharmac = basic pharmaceutical products and pharmaceutical preparations, Rubber = rubber and plastic products, Other = other nonmetallic mineral products, Metals = basic metals, Fabr. Metals = Fabricated metal products except machinery and equipment, Computers = computer, electrical and optical products, Electrical = electrical equipment, Machinery = machinery and equipment, Motor = motor vehicles, trailers and semi-trailers, Furniture = furniture, other manufacturing, repair and installation of machinery and equipment. Nyblom-Harvey = Nyblom and Harvey (2000) test for common stochastic trend in the panel under the null of zero common trends as a proxy for cointegration relationship. Kao = Kao (1999) developed a residual-based panel cointegration test under the null that the residuals are nonstationary with homogenous variance of the innovation process (i.e. the error term). Pedroni = Pedroni (1999) tests the null hypothesis of no cointegration. Maddala and Wu = Assume cross-sectional independence, under the null hypothesis of no cointegration. *Accepts the null hypothesis of stationarity at the 1% level.

Table 4. Long-run parameter estimates

Control variables/diagnostics	Model 1 (Equation 7)	Model 2 (Equation 8)	Model 3 (Equation 9)	Model 4 (Equation 10)
Manufacturing sector				
Intercept	0.971* (22.7)	1.065* (16.3)	0.649* (10.8)	1.175* (13.5)
INTERM	0.583* (20.9)	0.559* (14.5)	0.612* (12.7)	0.638* (13.9)
CAP	0.053* (4.84)	0.064* (5.26)	0.081* (5.23)	0.082* (5.12)
LAB/WAGE	0.046* (6.51)	0.046* (7.24)	0.060* (5.82)	0.107* (6.93)
GOPER	0.195* (5.73)	0.148* (5.11)	0.237* (5.48)	0.158* (5.93)
EMPL	0.336* (5.62)	0.319* (6.14)	0.372* (6.04)	0.341* (5.80)
***H*-statistic**	**0.682***	**0.669***	**0.753***	**0.827***
Adjusted R^2	0.65	0.67	0.61	0.63
LM	1.19 [0.40]	1.24 [0.36]	1.47 [0.23]	1.48 [0.29]
RESET	1.52 [0.15]	1.28 [0.31]	1.44 [0.19]	1.25 [0.34]
Wald test $H = 0$	53.14* [0.00]	51.26* [0.00]	46.45* [0.00]	62.34* [0.00]
Wald test $H = 1$	61.70* [0.00]	53.51* [0.00]	50.36* [0.00]	67.48* [0.00]
Food				
Intercept	0.652* (11.8)	0.671* (13.6)	0.728* (8.94)	1.084* (10.6)
INTERM	0.571* (15.1)	0.529* (12.7)	0.638* (11.6)	0.661* (12.7)
CAP	0.048* (4.90)	0.072* (5.52)	0.064* (5.72)	−0.094* (−5.84)
LAB/WAGE	0.057* (6.24)	0.038* (5.62)	0.065* (5.06)	0.092* (6.14)
GOPER	0.214* (5.53)	0.163* (5.84)	0.284* (5.88)	0.164* (5.26)
EMPL	0.398* (5.62)	0.297* (5.93)	0.324* (4.85)	0.289* (4.84)
***H*-statistic**	**0.676***	**0.639***	**0.767***	**0.659***
Adjusted R^2	0.60	0.62	0.57	0.58
LM	1.24 [0.35]	1.39 [0.30]	1.63 [0.16]	1.60 [0.24]
RESET	1.63 [0.26]	1.73 [0.18]	1.72 [0.12]	1.64 [0.19]
Wald test $H = 0$	46.37* [0.00]	42.38* [0.00]	50.38* [0.00]	48.36* [0.00]
Wald test $H = 1$	52.38* [0.00]	49.51* [0.00]	56.82* [0.00]	55.62* [0.00]
Beverages				
Intercept	0.446* (7.54)	0.845* (6.24)	0.836* (6.35)	0.847* (7.34)
INTERM	0.625* (12.30)	0.607* (11.80)	0.614* (10.60)	0.612* (9.65)
CAP	0.057* (7.84)	0.069* (5.36)	0.046* (5.26)	0.086* (5.16)
LAB/WAGE	0.062* (6.09)	0.052* (5.86)	0.054* (5.82)	0.036* (6.90)
GOPER	0.236* (5.37)	0.167* (5.57)	0.235* (5.09)	0.124* (5.48)
EMPL	0.308* (5.32)	0.313* (5.48)	0.315* (5.38)	0.281* (6.38)
***H*-statistic**	**0.744***	**0.728***	**0.714***	**0.734***
Adjusted R^2	0.61	0.60	0.57	0.62
LM	1.47 [0.23]	1.35 [0.59]	1.65 [0.18]	1.44 [0.32]
RESET	1.31 [0.38]	1.40 [0.35]	1.25 [0.24]	1.63 [0.19]
Wald test $H = 0$	63.56* [0.00]	60.45* [0.00]	52.36* [0.00]	50.35* [0.00]
Wald test $H = 1$	69.05* [0.00]	72.26* [0.00]	58.96* [0.00]	56.90* [0.00]
Tobacco				
Intercept	0.874* (7.94)	0.706* (10.4)	1.003* (6.44)	0.845* (7.65)
INTERM	0.549* (9.15)	0.571* (11.3)	0.684* (10.3)	0.624* (11.4)
CAP	0.056* (4.64)	0.085* (5.73)	0.081* (5.26)	0.113* (5.52)
LAB/WAGE	0.052* (5.46)	0.046* (5.25)	0.048* (4.75)	0.074* (6.37)
GOPER	0.229* (5.36)	0.184* (5.46)	0.236* (5.81)	0.215* (5.84)
EMPL	0.318* (5.24)	0.284* (5.36)	0.286* (4.99)	0.253* (5.12)
***H*-statistic**	**0.657***	**0.702***	**0.813***	**0.811***
Adjusted R^2	0.55	0.57	0.60	0.61
LM	1.29 [0.32]	1.46 [0.32]	2.04 [0.11]	2.06 [0.13]
RESET	2.18 [0.13]	1.98 [0.13]	1.24 [0.11]	1.82 [0.16]
Wald test $H = 0$	44.62* [0.00]	57.45* [0.00]	52.79* [0.00]	51.52* [0.00]
Wald test $H = 1$	53.90* [0.00]	64.83* [0.00]	58.94* [0.00]	60.63* [0.00]

(*continued*)

Table 4. Continued

Control variables/diagnostics	Model 1 (Equation 7)	Model 2 (Equation 8)	Model 3 (Equation 9)	Model 4 (Equation 10)
Textiles				
Intercept	0.678* (7.32)	0.661* (7.65)	0.637* (7.43)	0.744* (8.13)
INTERM	0.694* (10.50)	0.636* (14.50)	0.697* (8.31)	0.614* (19.30)
CAP	0.048* (6.54)	0.052* (5.37)	0.054* (5.41)	0.093* (5.56)
LAB/WAGE	0.062* (6.68)	0.038* (4.95)	0.039* (5.26)	0.042* (6.95)
GOPER	0.235* (5.81)	0.155* (5.28)	0.235* (5.91)	0.136* (5.35)
EMPL	0.285* (5.59)	0.306* (5.87)	0.315* (5.76)	0.302* (7.34)
***H*-statistic**	**0.804***	**0.726***	**0.790***	**0.749***
Adjusted R^2	0.63	0.58	0.59	0.60
LM	1.39 [0.37]	1.57 [0.51]	1.46 [0.22]	1.53 [0.29]
RESET	1.56 [0.26]	1.43 [0.29]	1.60 [0.21]	1.49 [0.28]
Wald test $H = 0$	51.38* [0.00]	64.58* [0.00]	41.35* [0.00]	56.78* [0.00]
Wald test $H = 1$	56.28* [0.00]	72.39* [0.00]	48.24* [0.00]	63.46* [0.00]
Wearing				
Intercept	0.749* (8.14)	0.548* (10.4)	0.852* (6.54)	0.845* (13.4)
INTERM	0.616* (11.3)	0.594* (11.6)	0.672* (10.8)	0.695* (11.6)
CAP	0.064* (5.74)	0.104* (5.74)	0.070* (5.26)	0.085* (5.47)
LAB/WAGE	0.073* (6.29)	0.064* (5.91)	0.061* (5.26)	0.082* (6.47)
GOPER	0.285* (6.10)	0.141* (5.13)	0.273* (5.73)	0.194* (5.67)
EMPL	0.363* (5.84)	0.303* (5.53)	0.310* (5.56)	0.295* (4.49)
***H*-statistic**	**0.753***	**0.762***	**0.803***	**0.862***
Adjusted R^2	0.64	0.66	0.61	0.59
LM	1.74 [0.31]	1.75 [0.25]	1.84 [0.13]	1.66 [0.22]
RESET	1.90 [0.20]	2.14 [0.12]	1.42 [0.19]	1.85 [0.14]
Wald test $H = 0$	42.84* [0.00]	46.72* [0.00]	59.57* [0.00]	52.36* [0.00]
Wald test $H = 1$	52.37* [0.00]	53.06* [0.00]	68.46* [0.00]	64.94* [0.00]
Leather				
Intercept	0.934* (6.83)	0.605* (7.65)	0.763* (6.45)	0.783* (13.40)
INTERM	0.528* (10.30)	0.595* (13.60)	0.684* (13.8)	0.749* (15.30)
CAP	0.056* (4.97)	0.081* (5.23)	0.095* (5.25)	0.103* (5.94)
LAB/WAGE	0.073* (5.46)	0.047* (5.25)	0.083* (5.66)	0.052* (5.46)
GOPER	0.248* (5.37)	0.194* (5.49)	0.259* (5.47)	0.148* (5.67)
EMPL	0.360* (5.24)	0.248* (5.33)	0.347* (4.57)	0.227* (4.45)
Hindex	**0.657***	**0.723***	**0.862***	**0.904***
Adjusted R^2	0.64	0.61	0.60	0.55
LM	1.28 [0.33]	1.74 [0.24]	1.65 [0.15]	1.95 [0.17]
RESET	1.71 [0.20]	2.25 [0.11]	1.90 [0.10]	1.38 [0.26]
Wald test $H = 0$	50.93* [0.00]	60.31* [0.00]	51.35* [0.00]	44.83* [0.00]
Wald test $H = 1$	57.84* [0.00]	68.58* [0.00]	58.36* [0.00]	53.61* [0.00]
Wood				
Intercept	0.861* (6.74)	0.741* (10.50)	0.807* (7.45)	0.855* (9.64)
INTERM	0.612* (9.16)	0.581* (11.30)	0.645* (10.30)	0.698* (11.20)
CAP	0.073* (5.84)	0.084* (5.27)	0.082* (5.25)	0.108* (5.45)
LAB/WAGE	0.079* (6.45)	0.050* (5.26)	0.081* (5.62)	0.102* (6.46)
GOPER	0.262* (5.37)	0.187* (5.41)	0.259* (5.74)	0.177* (5.60)
EMPL	0.364* (5.28)	0.258* (5.38)	0.345* (4.56)	0.242* (4.41)
Hindex	**0.764***	**0.715***	**0.808***	**0.908***
Adjusted R^2	0.62	0.60	0.59	0.63
LM	1.48 [0.31]	1.82 [0.21]	1.90 [0.12]	1.84 [0.20]
RESET	1.94 [0.18]	2.51 [0.11]	2.03 [0.10]	2.12 [0.13]
Wald test $H = 0$	56.36* [0.00]	56.31* [0.00]	48.92* [0.00]	50.45* [0.00]
Wald test $H = 1$	63.99* [0.00]	62.09* [0.00]	56.72* [0.00]	58.93* [0.00]

(*continued*)

Table 4. Continued

Control variables/diagnostics	Model 1 (Equation 7)	Model 2 (Equation 8)	Model 3 (Equation 9)	Model 4 (Equation 10)
Paper				
Intercept	0.766* (7.84)	0.712* (11.0)	0.762* (7.45)	0.685* (8.92)
INTERM	0.608* (12.30)	0.584* (10.20)	0.683* (10.50)	0.682* (10.40)
CAP	0.069* (6.92)	0.086* (5.24)	0.092* (5.25)	0.113* (5.47)
LAB/WAGE	0.075* (6.45)	0.072* (5.44)	0.073* (5.83)	0.083* (6.46)
GOPER	0.261* (5.33)	0.185* (5.53)	0.294* (5.84)	0.189* (5.61)
EMPL	0.364* (5.20)	0.314* (5.35)	0.315* (4.57)	0.325* (6.54)
***H*-statistic**	**0.752***	**0.742***	**0.848***	**0.878***
Adjusted R^2	0.61	0.66	0.56	0.63
LM	1.72 [0.24]	1.62 [0.53]	1.67 [0.15]	1.84 [0.20]
RESET	1.88 [0.17]	1.84 [0.14]	1.79 [0.10]	1.91 [0.15]
Wald test $H = 0$	74.52* [0.00]	58.59* [0.00]	49.88* [0.00]	64.55* [0.00]
Wald test $H = 1$	79.86* [0.00]	68.94* [0.00]	56.36* [0.00]	73.24* [0.00]
Printing				
Intercept	0.645* (7.16)	0.657* (7.45)	0.691* (7.32)	0.872* (8.44)
INTERM	0.693* (8.94)	0.594* (8.32)	0.679* (13.50)	0.647* (6.53)
CAP	0.038* (5.54)	0.047* (5.27)	0.053* (5.72)	0.124* (5.84)
LAB/WAGE	0.086* (6.11)	0.082* (5.85)	0.096* (5.45)	0.098* (6.95)
GOPER	0.247* (5.81)	0.139* (5.22)	0.243* (5.61)	0.191* (5.50)
EMPL	0.311* (5.74)	0.311* (5.87)	0.324* (7.45)	0.311* (6.75)
***H*-statistic**	**0.817***	**0.723***	**0.828***	**0.869***
Adjusted R^2	0.59	0.60	0.63	0.60
LM	1.28 [0.33]	1.48 [0.54]	1.50 [0.28]	1.65 [0.26]
RESET	1.42 [0.35]	1.37 [0.29]	1.67 [0.19]	1.51 [0.32]
Wald test $H = 0$	45.64* [0.00]	63.46* [0.00]	49.08* [0.00]	62.10* [0.00]
Wald test $H = 1$	53.51* [0.00]	68.98* [0.00]	56.73* [0.00]	68.24* [0.00]
Coke				
Intercept	1.084* (9.35)	1.185* (9.62)	1.248* (7.93)	1.548* (9.23)
INTERM	0.674* (10.60)	0.613* (13.60)	0.658* (11.2)	0.653* (13.60)
CAP	0.071* (6.28)	0.109* (5.44)	0.114* (5.53)	0.126* (5.71)
LAB/WAGE	0.095* (6.55)	0.085* (5.38)	0.085* (5.39)	0.057* (6.69)
GOPER	0.284* (5.96)	0.196* (5.31)	0.273* (5.40)	0.157* (5.11)
EMPL	0.325* (5.77)	0.329* (5.54)	0.338* (5.73)	0.308* (6.43)
***H*-statistic**	**0.840***	**0.807***	**0.857***	**0.836***
Adjusted R^2	0.65	0.68	0.60	0.67
LM	1.94 [0.16]	1.47 [0.57]	1.74 [0.13]	1.59 [0.28]
RESET	1.36 [0.35]	1.29 [0.30]	1.38 [0.19]	1.95 [0.14]
Wald test $H = 0$	59.08* [0.00]	50.56* [0.00]	65.58* [0.00]	58.93* [0.00]
Wald test $H = 1$	68.46* [0.00]	59.35* [0.00]	77.62* [0.00]	69.43* [0.00]
Chemicals				
Intercept	0.894* (8.45)	0.784* (10.80)	0.697* (8.51)	0.805* (7.23)
INTERM	0.638* (11.90)	0.605* (14.60)	0.695* (13.10)	0.662* (13.70)
CAP	0.085* (6.25)	0.069* (5.45)	0.059* (5.56)	0.126* (5.78)
LAB/WAGE	0.061* (6.58)	0.081* (5.93)	0.083* (5.32)	0.062* (6.69)
GOPER	0.277* (5.82)	0.211* (5.38)	0.307* (5.49)	0.157* (5.11)
EMPL	0.328* (5.08)	0.349* (5.50)	0.338* (5.67)	0.310* (6.40)
***H*-statistic**	**0.784***	**0.755***	**0.837***	**0.850***
Adjusted R^2	0.62	0.69	0.58	0.61
LM	1.84 [0.22]	1.49 [0.59]	1.94 [0.12]	1.46 [0.27]
RESET	1.59 [0.28]	1.89 [0.12]	1.62 [0.16]	1.18 [0.31]
Wald test $H = 0$	57.44* [0.00]	45.62* [0.00]	56.72* [0.00]	59.44* [0.00]
Wald test $H = 1$	67.36* [0.00]	53.46* [0.00]	65.38* [0.00]	69.25* [0.00]

(*continued*)

Table 4. Continued

Control variables/diagnostics	Model 1 (Equation 7)	Model 2 (Equation 8)	Model 3 (Equation 9)	Model 4 (Equation 10)
Pharmac				
Intercept	0.671* (8.43)	0.625* (8.06)	0.627* (7.94)	0.657* (9.12)
INTERM	0.639* (10.80)	0.559* (11.50)	0.650* (15.60)	0.664* (15.10)
CAP	0.061* (6.25)	0.070* (5.45)	0.068* (5.59)	0.102* (5.76)
LAB/WAGE	0.086* (6.54)	0.052* (5.28)	0.078* (5.36)	0.063* (6.68)
GOPER	0.280* (5.29)	0.171* (5.34)	0.249* (5.43)	0.149* (5.19)
EMPL	0.321* (5.06)	0.307* (5.59)	0.297* (6.76)	0.316* (6.45)
***H*-statistic**	**0.786***	**0.681***	**0.796***	**0.829***
Adjusted R^2	0.57	0.64	0.59	0.61
LM	1.36 [0.33]	1.75 [0.48]	1.78 [0.13]	1.54 [0.29]
RESET	1.94 [0.14]	1.69 [0.23]	1.50 [0.19]	1.67 [0.28]
Wald test $H = 0$	62.15* [0.00]	58.92* [0.00]	51.48* [0.00]	60.24* [0.00]
Wald test $H = 1$	75.21* [0.00]	70.26* [0.00]	64.06* [0.00]	68.42* [0.00]
Rubber				
Intercept	0.863* (8.31)	0.763* (10.40)	0.624* (6.54)	0.651* (6.25)
INTERM	0.639* (9.32)	0.547* (7.24)	0.628* (7.52)	0.614* (7.43)
CAP	0.058* (5.24)	0.064* (5.43)	0.073* (5.54)	0.105* (5.78)
LAB/WAGE	0.042* (6.59)	0.057* (5.18)	0.057* (5.31)	0.052* (5.64)
GOPER	0.238* (5.29)	0.163* (5.38)	0.238* (5.48)	0.171* (5.11)
EMPL	0.310* (5.07)	0.283* (5.56)	0.309* (4.73)	0.319* (5.40)
***H*-statistic**	**0.739***	**0.668***	**0.758***	**0.771***
Adjusted R^2	0.55	0.53	0.53	0.56
LM	1.24 [0.38]	1.47 [0.59]	1.50 [0.19]	1.60 [0.28]
RESET	1.56 [0.29]	1.68 [0.25]	1.63 [0.17]	1.52 [0.32]
Wald test $H = 0$	42.11* [0.00]	59.35* [0.00]	50.12* [0.00]	51.24* [0.00]
Wald test $H = 1$	50.25* [0.00]	70.25* [0.00]	57.84* [0.00]	58.35* [0.00]
Other				
Intercept	0.618* (8.45)	0.794* (8.20)	0.626* (7.56)	0.854* (8.25)
INTERM	0.637* (9.37)	0.637* (8.26)	0.659* (13.7)	0.647* (13.8)
CAP	0.052* (6.26)	0.074* (5.46)	0.074* (5.54)	0.125* (5.79)
LAB/WAGE	0.093* (6.55)	0.068* (5.29)	0.062* (5.39)	0.052* (6.60)
GOPER	0.228* (5.42)	0.194* (5.53)	0.248* (5.49)	0.158* (5.15)
EMPL	0.328* (5.38)	0.285* (5.57)	0.356* (5.68)	0.313* (6.46)
***H*-statistic**	**0.782***	**0.779***	**0.795***	**0.824***
Adjusted R^2	0.54	0.63	0.59	0.60
LM	1.58 [0.29]	1.26 [0.65]	1.82 [0.11]	1.35 [0.29]
RESET	1.63 [0.27]	1.38 [0.27]	1.61 [0.18]	1.73 [0.22]
Wald test $H = 0$	46.79* [0.00]	55.27* [0.00]	58.92* [0.00]	59.65* [0.00]
Wald test $H = 1$	55.24* [0.00]	63.62* [0.00]	67.28* [0.00]	68.46* [0.00]
Metals				
Intercept	0.681* (9.82)	0.773* (9.05)	0.672* (7.58)	0.865* (8.24)
INTERM	0.637* (11.60)	0.597* (11.10)	0.639* (8.54)	0.653* (13.70)
CAP	0.052* (6.25)	0.065* (5.45)	0.068* (5.54)	0.126* (5.77)
LAB/WAGE	0.058* (6.58)	0.042* (5.29)	0.048* (5.39)	0.063* (6.68)
GOPER	0.236* (5.19)	0.162* (5.31)	0.258* (5.47)	0.138* (5.16)
EMPL	0.310* (5.47)	0.284* (5.58)	0.329* (5.61)	0.302* (6.47)
***H*-statistic**	**0.747***	**0.704***	**0.755***	**0.842***
Adjusted R^2	0.58	0.62	0.58	0.60
LM	1.26 [0.38]	1.84 [0.47]	1.40 [0.28]	1.57 [0.29]
RESET	1.59 [0.26]	1.40 [0.23]	1.71 [0.16]	1.84 [0.19]
Wald test $H = 0$	51.25* [0.00]	72.35* [0.00]	50.99* [0.00]	40.92* [0.00]
Wald test $H = 1$	58.73* [0.00]	81.64* [0.00]	64.51* [0.00]	45.63* [0.00]

(*continued*)

Table 4. Continued

Control variables/diagnostics	Model 1 (Equation 7)	Model 2 (Equation 8)	Model 3 (Equation 9)	Model 4 (Equation 10)
Fabr. Metals				
Intercept	0.584* (7.46)	0.625* (7.40)	0.629* (7.53)	0.857* (8.24)
INTERM	0.639* (11.90)	0.549* (8.93)	0.659* (14.90)	0.625* (9.45)
CAP	0.048* (5.25)	0.067* (5.44)	0.063* (5.57)	0.131* (5.78)
LAB/WAGE	0.057* (6.51)	0.062* (5.28)	0.063* (5.34)	0.064* (6.69)
GOPER	0.236* (5.28)	0.153* (5.32)	0.257* (5.46)	0.172* (5.15)
EMPL	0.312* (5.27)	0.308* (5.58)	0.359* (7.74)	0.306* (6.47)
***H*-statistic**	**0.744***	**0.678***	**0.785***	**0.820***
Adjusted R^2	0.58	0.59	0.62	0.59
LM	1.26 [0.35]	1.45 [0.58]	1.55 [0.24]	1.62 [0.28]
RESET	1.49 [0.30]	1.47 [0.25]	1.63 [0.18]	1.55 [0.29]
Wald test $H = 0$	46.72* [0.00]	42.46* [0.00]	45.43* [0.00]	54.66* [0.00]
Wald test $H = 1$	55.25* [0.00]	68.94* [0.00]	52.16* [0.00]	62.38* [0.00]
Computers				
Intercept	1.683* (8.45)	1.248* (14.10)	1.625* (9.52)	1.847* (8.23)
INTERM	0.657* (15.6)	0.618* (15.30)	0.690* (16.70)	0.658* (11.30)
CAP	0.072* (6.25)	0.106* (5.45)	0.102* (5.54)	0.124* (5.75)
LAB/WAGE	0.093* (6.51)	0.085* (5.38)	0.081* (5.35)	0.081* (6.68)
GOPER	0.249* (5.28)	0.151* (5.34)	0.248* (5.43)	0.147* (5.13)
EMPL	0.306* (5.29)	0.339* (5.58)	0.287* (5.74)	0.310* (6.46)
***H*-statistic**	**0.822***	**0.809***	**0.873***	**0.863***
Adjusted R^2	0.64	0.67	0.59	0.65
LM	1.84 [0.20]	1.42 [0.58]	1.55 [0.23]	1.59 [0.28]
RESET	1.57 [0.25]	1.39 [0.30]	1.61 [0.18]	1.48 [0.32]
Wald test $H = 0$	65.61* [0.00]	51.63* [0.00]	62.35* [0.00]	51.45* [0.00]
Wald test $H = 1$	76.72* [0.00]	64.59* [0.00]	72.16* [0.00]	62.33* [0.00]
Electrical				
Intercept	0.647* (7.43)	0.626* (7.06)	0.623* (7.54)	0.854* (8.21)
INTERM	0.619* (11.8)	0.597* (11.60)	0.649* (8.53)	0.658* (11.20)
CAP	0.064* (6.25)	0.082* (5.43)	0.064* (5.54)	0.083* (5.75)
LAB/WAGE	0.092* (6.56)	0.058* (5.39)	0.059* (5.32)	0.062* (6.69)
GOPER	0.277* (5.28)	0.171* (5.33)	0.263* (5.49)	0.140* (5.13)
EMPL	0.318* (5.25)	0.319* (5.58)	0.304* (4.77)	0.316* (7.43)
***H*-statistic**	**0.775***	**0.737***	**0.772***	**0.803***
Adjusted R^2	0.60	0.56	0.58	0.58
LM	1.38 [0.39]	1.52 [0.58]	1.42 [0.24]	1.74 [0.25]
RESET	1.51 [0.29]	1.46 [0.27]	1.64 [0.18]	1.68 [0.23]
Wald test $H = 0$	57.82* [0.00]	41.25* [0.00]	55.60* [0.00]	44.51* [0.00]
Wald test $H = 1$	69.35* [0.00]	48.72* [0.00]	62.74* [0.00]	52.26* [0.00]
Machinery				
Intercept	0.648* (7.43)	0.727* (7.05)	0.720* (7.55)	0.654* (8.21)
INTERM	0.636* (9.34)	0.599* (13.70)	0.639* (8.51)	0.642* (7.48)
CAP	0.061* (6.24)	0.080* (5.45)	0.058* (4.59)	0.102* (5.76)
LAB/WAGE	0.058* (5.37)	0.063* (5.19)	0.066* (5.32)	0.050* (5.64)
GOPER	0.244* (5.29)	0.158* (5.34)	0.270* (5.45)	0.137* (5.12)
EMPL	0.328* (5.27)	0.328* (5.56)	0.274* (6.71)	0.257* (6.41)
***H*-statistic**	**0.755***	**0.742***	**0.763***	**0.794***
Adjusted R^2	0.62	0.61	0.57	0.55
LM	1.65 [0.28]	1.51 [0.58]	1.55 [0.23]	1.47 [0.29]
RESET	1.62 [0.24]	1.53 [0.24]	1.38 [0.29]	1.32 [0.31]
Wald test $H = 0$	52.25* [0.00]	44.45* [0.00]	41.52* [0.00]	60.93* [0.00]
Wald test $H = 1$	63.26* [0.00]	52.32* [0.00]	48.75* [0.00]	73.48* [0.00]

(*continued*)

Table 4. Continued

Control variables/diagnostics	Model 1 (Equation 7)	Model 2 (Equation 8)	Model 3 (Equation 9)	Model 4 (Equation 10)
Motor				
Intercept	0.539* (7.42)	0.626* (6.51)	0.602* (7.56)	0.527* (6.21)
INTERM	0.572* (6.35)	0.549* (8.25)	0.622* (14.70)	0.612* (13.80)
CAP	0.049* (6.23)	0.066* (5.45)	0.061* (5.52)	0.134* (5.72)
LAB/WAGE	0.048* (6.51)	0.051* (5.39)	0.061* (5.33)	0.046* (6.60)
GOPER	0.253* (5.19)	0.142* (5.36)	0.229* (5.45)	0.137* (5.11)
EMPL	0.311* (5.06)	0.275* (5.59)	0.253* (5.62)	0.309* (6.43)
***H*-statistic**	**0.669***	**0.666***	**0.744***	**0.792***
Adjusted R^2	0.56	0.59	0.53	0.56
LM	1.52 [0.29]	1.54 [0.58]	1.36 [0.27]	1.25 [0.34]
RESET	1.40 [0.27]	1.25 [0.32]	1.37 [0.19]	1.52 [0.30]
Wald test $H = 0$	40.98* [0.00]	56.46* [0.00]	58.25* [0.00]	48.72* [0.00]
Wald test $H = 1$	47.57* [0.00]	62.29* [0.00]	69.06* [0.00]	53.44* [0.00]
Other transportation equipment				
Intercept	0.743* (7.53)	0.745* (11.70)	0.675* (8.12)	0.854* (7.35)
INTERM	0.669* (10.80)	0.636* (12.70)	0.656* (10.20)	0.682* (12.10)
CAP	0.037* (6.54)	0.049* (5.56)	0.029* (5.66)	0.112* (5.86)
LAB/WAGE	0.071* (6.88)	0.108* (5.35)	0.114* (5.26)	0.127* (6.95)
GOPER	0.236* (5.29)	0.241* (5.87)	0.324* (5.91)	0.159* (5.27)
EMPL	0.348* (5.85)	0.338* (5.57)	0.326* (5.72)	0.319* (6.05)
***H*-statistic**	**0.777***	**0.793***	**0.799***	**0.921***
Adjusted R^2	0.64	0.66	0.59	0.60
LM	1.64 [0.28]	1.43 [0.64]	1.75 [0.19]	1.42[0.32]
RESET	1.51 [0.34]	1.59 [0.23]	1.52 [0.23]	1.19 [0.30]
Wald test $H = 0$	46.56* [0.00]	49.86* [0.00]	50.61* [0.00]	62.35* [0.00]
Wald test $H = 1$	52.33* [0.00]	54.62* [0.00]	57.52* [0.00]	68.94* [0.00]
Furniture				
Intercept	0.739* (7.45)	0.725* (8.40)	0.612* (7.56)	0.549* (5.24)
INTERM	0.652* (16.70)	0.575* (6.24)	0.649* (13.80)	0.614* (15.60)
CAP	0.055* (6.24)	0.067* (5.43)	0.057* (5.51)	0.083* (5.74)
LAB/WAGE	0.051* (6.54)	0.063* (5.83)	0.052* (5.34)	0.063* (6.62)
GOPER	0.219* (5.49)	0.152* (5.30)	0.238* (5.46)	0.153* (5.15)
EMPL	0.311* (5.06)	0.301* (5.57)	0.271* (4.39)	0.302* (6.40)
***H*-statistic**	**0.758***	**0.705***	**0.758***	**0.760***
Adjusted R^2	0.60	0.58	0.53	0.57
LM	1.53 [0.29]	1.51 [0.59]	1.39 [0.25]	1.52 [0.28]
RESET	1.60 [0.24]	1.49 [0.24]	1.42 [0.19]	1.61 [0.23]
Wald test $H = 0$	56.87* [0.00]	46.42* [0.00]	51.45* [0.00]	42.33* [0.00]
Wald test $H = 1$	65.60* [0.00]	52.36* [0.00]	58.23* [0.00]	49.35* [0.00]

Notes: t-Statistics and probability values are reported in parentheses and square brackets, respectively. LM is the Lagrange Multiplier test for serial correlation. RESET is Ramsey's regression equation specification error test. *Statistical significance at the 1% level.

The *H*-statistic ranges from 0.639 (food sector) to 0.921 (printing sector and other transportation equipment sector). On average, the estimated *H*-statistics of this study do not appear particularly high *vis-à-vis* other OECD countries (Maioli, 2004; Bottini and Molnár, 2010; Christopoulou and Vermeulen, 2012), but the average reveals large differences across sectors (heterogeneity). This is not surprising given that on the one hand, sector-specific characteristics affect the mark-up companies' pricing behavior (prices above average costs), while on the other hand, the regulatory barriers (i.e. legal systems) vary considerably across sectors, distorting the level of competition. It is worth mentioning that the observed heterogeneity supported by our results is in alignment with similar empirical studies (Maioli, 2004; Bottini and Molnár, 2010; Christopoulou and Vermeulen, 2012).

While the *H*-statistic tends to be higher in highly regulated and less tradable manufacturing industries across the OECD countries, the *H*-statistic in food sector is significantly low. This outcome contradicts the empirical literature since according to previous studies (see e.g. Bottini and Molnár, 2010; Christopoulou and Vermeulen, 2012) the food sector in the European Union (EU) countries tends to be more concentrated than other sectors. This could be explained by the presence of vertical integration of retailers and food processors allowing for high mark-ups that can be passed on to consumers in the form of higher prices owing to high concentration in the retail food sector and to occasional symptoms of collusive behavior among major players. Another possible explanation may be the very high specialization in high-value-added sub-segments,such as fruits and vegetables, which allows for charging higher mark-ups. The aforementioned discrepancy could be explained by the different methodology employed (the P-R model versus the mark-up ratio).

By contrast, sectors such as computers, printing, chemicals and other transportation equipment appear to have high *H*-statistic, ranging from 0.804 (textiles) to 0.921 (other transportation equipment). It is worth mentioning that these sectors are characterized by a small number of players and significant barriers to entry. However, the recent debt financial crisis, along with the extended recession in the real economy, has negatively affected the relevant sectors across the OECD countries, thus overshooting the magnitude of the H index.

Finally, the Wald statistic for testing the hypothesis that the *H*-statistic is equal to zero ($H = 0$) is rejected at any conventional level of significance across all four model specifications, depicting the presence of noncompetitive conditions for the OECD two-digit manufacturing sectors over the period under investigation.

Having estimated the magnitude of the *H*-statistic for the two-digit OECD manufacturing sectors, we try to range which sectors are closer to competitive or monopolistic conditions based on the average estimations of the four alternative specifications of the P-R model (see Equations 7–10).[3] Figure 1 depicts the average *H*-statistic of the two-digit manufacturing sectors for the period under study in an ascending order. As mentioned above, it is evident that more concentrated sectors such as food and beverages, motor vehicles and furniture have low levels of *H*-statistic being thus less competitive than other industries (i.e. metals, textiles, leather, wearing, etc.). More specifically, the magnitude of the *H*-statistic for these sectors ranges from 0.685 (food sector) to 0.745 (furniture) revealing a low competition level compared to other industries such as computers (0.842), other transportation equipment (0.823), printing (0.809) and chemicals (0.807), where the magnitude of the *H*-statistic is closer to unity.

This finding warrants some regulatory intervention to remedy this situation by lifting some of the regulatory barriers (i.e. legal restrictions) which are evident in the aforementioned industries. Further, given the primarily indications regarding the low levels of the *H*-statistic in these sectors, a suitable *ex ante* policy is linked with a thorough investigation of mergers and acquisitions. Regarding the food sector which has the lowest *H*-statistic equal to 0.685, it is worth mentioning that the relevant industry is largely regulated by standardized norms for health, safety and hygiene, in compliance with the OECD framework. However, there are certain regulatory barriers to competition in the main industries within the food processing sector (i.e. dairy and bakery industries). Specifically, in some OECD countries (Greece, Portugal, Italy), the legislation provides restrictive definitions of bread, milk, yogurt and other dairy products (OECD, 2014).

VI. Concluding Remarks

This article examined the competitive conditions of the OECD manufacturing sectors over the period 1970–2011. Based on the P-R methodology, we assessed the extent of the *H*-statistic for each of the two-digit sectors of the manufacturing industry in the ten OECD countries with the aim of investigating possible heterogeneity across different subsectors of the above industries. For this reason we used panel

[3] We thank a referee for suggesting this extension to the reporting of our results on a previous version of the article.

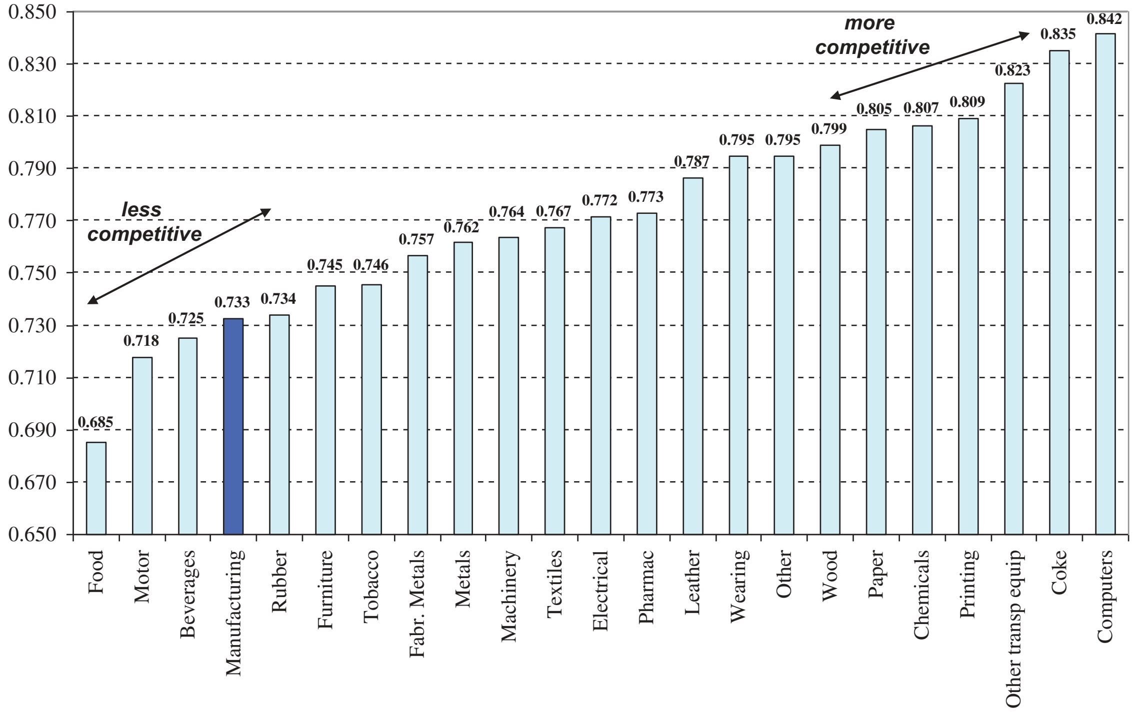

Fig. 1. Average *H*-statistic for the OECD manufacturing sectors
Source: Authors' elaboration based on Table 4.

cointegration analysis and the FMOLS which tackles the problem of endogeneity that may arise in standard estimation methods, (e.g. OLS) often employed in practice.

The empirical findings indicated that the entire OECD manufacturing industry as well as each subsector of the two-digit industries operates in noncompetitive conditions over the period under investigation, since the estimated *H*-statistics are smaller than one across all four model specifications. The empirical results were robust and consistent with similar studies, leading to the rejection of perfect collusion and perfect competition, while provided sufficient evidence in favour of monopolistic competition. Similarly to other empirical studies, *H*-statistics are heterogeneous across the manufacturing sectors.

Our analysis will be a useful policy tool to achieve structural micro-economic goals in the light of the existing financial crisis that hit a number of OECD countries (i.e. Greece, Portugal and Spain). First, given the primarily indications regarding the monopolistic competition prevailing over the sample industries, a suitable *ex ante* policy is linked with a thorough investigation of mergers and acquisitions. Second, in order to enhance the level of internationalization in manufacturing, the governments may pursue horizontal strategies focusing on the further opening of the markets. Since the vast majority of the manufacturing firms in the OECD economies are small and medium sized (SMEs), the governments must improve the access of micro- and SMEs to existing financial support mechanisms and to relevant information sources.

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