An investigation of the degree of market power in the Greek manufacturing and service industries

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Abstract: This paper investigates the degree of market power in the Greek manufacturing and service industries over the period 1970-2007. The markup model developed by Hall (1988) and Roeger (1995) is taken into consideration where market power is expressed as the difference between the selling price and the marginal cost of production. The analysis will be conducted in three steps; the first step estimates the price-cost margin of the manufacturing and services industries over 1970-2007; the second step applies the cross section specification under which the markup ratio is obtained for the 23 manufacturing and 26 service 2-digit ISIC sectors of the panel sample; and the third step estimates the price-cost margin of the manufacturing and services industries for each year over 1973-2007 by employing the Hall-Roeger time series specification. The empirical findings suggest that both industries exert a positive markup ratio; however, the service industry appears to be less competitive than the manufacturing industry.

Keywords: Markup ratio, Greece, Manufacturing industry, Service industry, Competition, Market power, Hall-Roeger approach.

JEL Classifications: L16, L13, L60, D43, E31

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1. Introduction

The Greek markets have been criticized over the years because of their imperfect competitive structure. In particular, the European Commission and the OECD are in favour of boosting competition in the most influential markets of any economy. If competition is enhanced, then social welfare will tend to be equal to the optimal level proposed by perfect competition. Thereby, the markets will be operating efficiently by utilizing the production capabilities of the firms to their fullest. The European Commission (2012) has announced the formulation of a policy framework under which the European Union members can reach new growth levels by developing fully integrated networks. The main intention of this framework is similar to the Single Market Mechanism (SEM) which was introduced in 1987. It corresponds to the facilitation of an efficient market structure in which the setting price of the firms will tend to be equal to their marginal cost.

Moreover, the OECD (2012) provides evidence that the Greek markets are the most heavily regulated within the OECD members due to a number of legislations that do not allow competition to flourish. They impose a number of restrictions, such as barriers to entry or very high fixed costs that discourage new firms to enter the market, thus providing the incumbent firms with market power. The main argument of the aforementioned reports is that competition results in increased output growth by enhancing economic activity. Consequently, increased production will lead to additional employment which will boost gross national income and the purchasing power parity of consumers.

If this happens, then firms will gain more revenue due to increased sales and innovation will be used as a tool of competition. For this reason, there is a need of particular indicators expressed in terms of pricing and production decisions that can identify the degree of market power in various industries and sectors. In this context, the price-cost margin can be used as an indicator of price markup over the cost of inputs, such as intermediate inputs, labour and capital. As a result, whenever the price level exceeds the marginal cost of inputs, there is a degree of market power reflected by a higher price level compared to the optimal level of perfect competition.

The methodology provided by Hall (1988) and Roeger (1995) will be employed in this study in order to identify the market structure of the two most influential industries of the

Greek economy: the service and the manufacturing industry[3]. This methodology is known as the Hall-Roeger approach, under which the nominal growth rate of the Solow residual is independent of the growth rate of nominal capital productivity. Under perfect competition, the growth rate of value added must be equal to the growth rate of inputs. This equality is significant for market efficiency because it provides consumers with higher product quality as a result of lower prices and higher innovation (Rezitis and Kalantzi, 2013). However, if the former growth rate exceeds the latter, the market is characterized by imperfect competition. This happens because the price level is higher compared to the one of perfect competition, thus resulting in under-production.

This study applies the Hall-Roeger approach in the Greek manufacturing and service industries under a three-step approach as introduced by Rezitis and Kalantzi (2011). The first step concerns the estimation of the price-cost margin in both industries over the period 1970-2007. The second step employs the cross section specification by identifying the price markup in the 23 manufacturing and the 26 service 2-digit ISIC sectors of the panel data set individually. Lastly, the third step employs the time series specification through the estimation of the price cost margin of both industries for each year over 1973-2007. Consequently, this study aims to complement the findings of Rezitis and Kalantzi (2011, 2012a, 2012b, 2013) and Polemis (2014a, 2014b, 2014c) of the degree of market power in the Greek manufacturing and service sectors.

This paper is organized as follows: Section 2 provides the literature review of the price cost margin approach; Section 3 develops the model formulation; Section 4 presents the methodology; Section 5 provides and discusses the empirical findings; and section 6 offers a conclusion.

2. Literature review

An important contribution to the price-cost margin literature was made by Hall (1988) under the assumption that markets are perfectly competitive when the price level is equal to the marginal cost of the firms. When the price level is higher, the market structure is considered to be uncompetitive. However, while the price level is observable, the marginal production cost of the firms may not be known. As a result, Hall overcame this drawback by showing that the nominal growth rate of the Solow residual is independent of the growth rate of

[3] The service industry contributes to Greek annual nominal GDP by approximately 80.4%, while the manufacturing industry contributes by 15.8% (World Bank, 2016).

nominal capital productivity. The price-cost margin approach was applied in the United States manufacturing industry and provided evidence of market power as the price level was higher than the marginal cost of production.

In particular, Solow (1957) introduced the concept of residual in the production process by taking into account a production function which allowed technical change to be included along with the inputs of labour and capital. By applying this formulation in the United States over 1909-1949, where output per hour approximately increased by 100%, he found that 12.5% of the increment in labour productivity could be attributed to increase capital per hour. However, the remaining 77.5% is explained by different factors than labour and capital accumulation which refer to the Solow residual. For this reason, the calculation of such unobserved shocks may not be feasible and thus, they may restrict the calculation of the price-cost margin.

Nevertheless, Roeger (1995) expanded this framework by taking into consideration the difference between the production-based (primal) Solow Residual (*PRS*) and the cost-based (dual) Solow Residual (*DSR*). This formulation is used in order to eliminate the unobservable shock of productivity and thus, obtain an unbiased estimate of market power. The indicator of market power is reflected by the difference between the growth rate of value added and the growth rate of inputs. Consequently, this is the final form of the markup equation which is employed by many studies over a number of industries in various economies.

In particular, there have been several studies that utilize the Hall-Roeger approach in order to test the degree of market power in the United States manufacturing industry. Shapiro (1987) and Norrbin (1993) found evidence in favour of markups consistent with oligopolistic pricing decisions as the manufacturing firms have been operating under imperfect competitive conduct. Bhuyan and Lopez (1998) validated such results for the United States food and tobacco sectors. They found that the price-cost margin resulted in oligopoly-induced allocative efficiency losses equal to 5% of sales over 1987. On the other hand, Mazumder (2014) contradicts such findings by employing a generalized version of the Hall-Roeger approach. The new version includes a relaxation of the assumption that labour can be adjusted at a fixed wage rate at no cost. The results support the presence of countercyclical and decreasing price-cost margins since the 1960s because the main factor influencing this

measure is the share of imports in this industry. As a result of increasing foreign competition, the price level fell, thus converging to the one of perfect competition.

Moreover, Martins et al. (1996) applied the Hall-Roeger approach in 14 OECD manufacturing industries over the period 1970-1992. The model took into account output in terms of gross value added and for this reason, the variable of intermediate inputs was added in the cost function. The findings support the presence of positive and significant markups across the industries, thus verifying the presence of imperfect competition. Bloch and Olive (2003) investigated the presence of markups in the manufacturing industries of the United Kingdom, the United States, Germany and Japan over 1970-1991. The evidence rejected the markup model in many industries; however, a positive relationship between the price-cost margin and the level of industrial concentration was identified. Concentrated industries are more likely to exhibit higher markups which are influenced by competing foreign prices. As a result, markups are either pro-cyclical or a-cyclical.

Görg and Warzynski (2003) studied the markup behaviour of the United Kingdom manufacturing industry over 1990-1996. The results provided evidence that exporting firms tend to exhibit higher markups than non-exporting firms. In addition, higher markups also depend on the degree of product differentiation. In sectors with homogenous products the price-cost margin tends to be lower compared to sectors with differentiated products. Boyle (2004) estimated the price-cost margin of the Irish manufacturing sectors over 1991-1999. The sample was differentiated into output-oriented and input–oriented sources of market power. The findings do not support the presence of imperfect competition in output-based markets; however, there is strong evidence of imperfect competitive conduct in certain input-based markets. Dobrinsky et al. (2004) applied the Hall-Roeger approach to a panel of Hungarian and Bulgarian manufacturing firms over 1974-1990. They found evidence that support the presence of positive markups associated with production technology and scales of economy.

In addition, Dobbelaere (2004) studied the markup behaviour of the Belgian manufacturing firms over 1988-1995. The product and labour markets were taken into account in order to investigate the degree of heterogeneity in the price markup and the bargaining power of unions. The results indicate that the inclusion of the labour market in the analysis of the product market is essential as the value of markup is underestimated when the study of the latter market is conducted independently. Consequently, sectors with higher

labour bargaining power tend to exhibit higher price-cost margins. Wilhelmsson (2006) investigated the degree of market power in the Swedish food and beverages sector over 1990-2002 and the effects imposed by the competitive forces of the European sectors. The estimates show that many firms exhibit positive price-cost margins; however, increased competition from the European Union sectors resulted in reduced market power. Thereby, foreign competition had a negative effect on the markup level of domestic firms.

In a relevant study, Molnár (2010) estimated the price-cost margin for the manufacturing and service industries of Slovenia over 1993-2006. The estimates conclude that the price-cost margin appears to be higher on average in the service than the manufacturing sectors. Similar results were obtained by Molnár and Bottini (2010) for a number of OECD European countries over 1993-2006. The estimated markups tend to be higher for particular sectors, such as real estate and professional service and lower for sectors such as retail and wholesale trade. Moreover, the forces of competition appear to be more persistent in the sectors of the United Kingdom and the Scandinavian countries, except Sweden, and lower in Central European countries (see Polemis, 2014c).

Christopoulou and Vermeulen (2012) also formed a panel set of European countries and investigated the markup ratio to identify the degree of market power. As in the previous study, the average markup ratio in the service industry is higher compared to the manufacturing industry, thus concluding that the service sectors are more flexible exercising their market power on the price level. Noria (2013) investigated the effect of the North American Free Trade Agreement on the price-cost margin of the Mexican manufacturing sectors over 1994-2003. The findings support the fall of that margin in 1994 as an immediate interaction to foreign competition, but its pattern is uncertain over the following years. The author differentiates the sample into sectors that were liberalized in 10 years and sectors that were liberalized in 5 years. Competition was more intense in the former group by forcing those sectors to adjust the price level to their marginal cost of production. On the other hand, the market structure of the latter group remained imperfectly competitive due to various domestic factors.

Similar studies have been performed for the Greek manufacturing and service industries by employing the Hall-Roeger approach. Rezitis and Kalantzi (2011, 2012a, 2012b, 2013) investigated the price-cost margin in the Greek food and beverages sector and the manufacturing industry overall. The findings support the presence of positive and significant

markups in every sector and every year over 1984-2007. In addition, Polemis (2014a, 2014b, 2014c) provides a similar analysis for the Greek manufacturing and service industries over 1970-2007. The results validate the presence of positive markups in both industries, thus confirming the presence of imperfect competition.

Overall, the aforementioned studies conclude that the majority of the constituent industries and sectors exhibit a degree of market power expressed in terms of positive price-cost margins. This means that the price level exceeds the marginal cost of production, thus allowing firms to enjoy positive profit levels through under-production. As a result, the degree of social efficiency is not at its optimal level as consumer surplus is exploited by firms. In this context, the Hall-Roeger approach provides a sufficient empirical tool of analysis that allows the investigation of market power in several industries.

3. Model formulation and data

The approach employed in this study corresponds to the model developed by Hall (1988) and extended by Roeger (1995) in order to provide an unbiased estimate of market power. In particular, an industry is assumed that produces output (y_t) according to a homogeneous production function f using three inputs: intermediate inputs (m_t)[4], labour (l_t) and capital (k_t)

$$y_t = \theta_t f(m_t, l_t, k_t) \tag{1}$$

where θ_t is an index of total factor productivity (Hicks neutral productivity term) reflecting technological progress and *t* denotes the time interval. Any output variation is independent of input fluctuations through disembodied changes in technology. According to such production function, Hall (1988) showed that the production-based (primal) Solow Residual can be defined as the difference between output and input growth weighted by their shares in total value added. However, in this study, output is expressed in terms of gross output and thus, total value added is replaced by this measure. For this reason, the variable of intermediate inputs is included in the production function in order to avoid biased overestimated markup values.

[4] In this study, the parameter of intermediate inputs refers to the goods and services used in the production process to produce the final good or service for consumption. Raw materials, energy, and semi-finished goods can be considered as some of those inputs.

The main assumptions of this formulation are (i) constant returns to scale, (ii) imperfect competition in product markets, and (iii) perfect competition in the input markets. Therefore, the Solow Residual for this study is given by

$$SR = \frac{\Delta y_t}{y_t} - a_{mt}\frac{\Delta m_t}{m_t} - a_{lt}\frac{\Delta l_t}{l_t} - (1 - a_{mt} - a_{lt})\frac{\Delta k_t}{k_t} =$$

$$= LI_t\left(\frac{\Delta y_t}{y_t} - \frac{\Delta k_t}{k_t}\right) + (1 - LI_t)\frac{\Delta \theta_t}{\theta_t} \quad (2)$$

where $a_{m_t} = pm_t m_t / p_t y_t$ is the share of intermediate inputs in gross output, pm_t refers to the price of intermediate inputs, $a_{l_t} = w_t l_t / p_t y_t$ is the share of labour in gross output, w_t corresponds to the wage rate and p_t is the price level of output. The coefficient LI_t is the Lerner index that measures the market power of the industry and it is expressed as $LI_t = (p_t - mc_t)/p_t = 1/(1 - \mu_t)$, where mc_t is the marginal cost of production and μ_t is the price markup over marginal cost[5]. However, the estimation of LI_t is problematic in equation (2) due to the presence of correlation between the measure of productivity growth and the error term, thus resulting in biased and inconsistent markup estimates. This weakness was identified by Roeger (1995) who pointed out that the difference between the change in price and the weighted change in factor input prices must be taken into consideration. By applying this formulation, one obtains

$$DSR = a_{mt}\frac{\Delta pm_t}{pm_t} + a_{lt}\frac{\Delta w_t}{w_t} + (1 - a_{mt} - a_{lt})\frac{\Delta u_t}{u_t} - \frac{\Delta p_t}{p_t}$$

$$= -LI_t\left(\frac{\Delta p_t}{p_t} - \frac{\Delta u_t}{u_t}\right) + (1 - LI_t)\frac{\Delta \theta_t}{\theta_t} \quad (3)$$

where u_t is the rental cost of capital. By subtracting (3) from (2) the productivity shock θ_t is cancelled out, thus obtaining

$$\left(\frac{\Delta y_t}{y_t} + \frac{\Delta p_t}{p_t}\right) - a_{mt}\left(\frac{\Delta m_t}{m_t} + \frac{\Delta pm_t}{pm_t}\right) - a_{lt}\left(\frac{\Delta l_t}{l_t} + \frac{\Delta w_t}{w_t}\right) - (1 - a_{mt} - a_{lt})\left(\frac{\Delta k_t}{k_t} + \frac{\Delta u_t}{u_t}\right) =$$

$$= LI_t\left[\left(\frac{\Delta y_t}{y_t} + \frac{\Delta p_t}{p_t}\right) - \left(\frac{\Delta k_t}{k_t} + \frac{\Delta u_t}{u_t}\right)\right] \quad (4)$$

[5] When the Lerner index is equal to zero, the industry is under perfect competition because $p_t = mc_t$. A value over $0 < LI < 1$ indicates non-competitive conditions and lastly, a value equal to unity denotes monopoly.

This is the final equation provided by Roeger (1995) that reflects the degree of market power. By re-arranging the terms, it follows

$$\left(\frac{\Delta y_t}{y_t}+\frac{\Delta p_t}{p_t}\right)-\left(\frac{\Delta k_t}{k_t}+\frac{\Delta u_t}{u_t}\right)=\mu_t\{a_{mt}\left[\left(\frac{\Delta m_t}{m_t}+\frac{\Delta pm_t}{pm_t}\right)-\left(\frac{\Delta k_t}{k_t}+\frac{\Delta u_t}{u_t}\right)\right]+$$

$$a_{lt}\left[\left(\frac{\Delta l_t}{l_t}+\frac{\Delta w_t}{w_t}\right)-\left(\frac{\Delta k_t}{k_t}+\frac{\Delta u_t}{u_t}\right)\right]\} \quad (5)$$

This is the main formulation developed and utilized by Rezitis and Kalantzi (2011) and it is the markup equation which is going to be employed in the present study. For simplicity, it is assumed that

$$\Delta Y_t=\left(\frac{\Delta y_t}{y_t}+\frac{\Delta p_t}{p_t}\right)-\left(\frac{\Delta k_t}{k_t}+\frac{\Delta u_t}{u_t}\right) \quad (5a)$$

$$\Delta X_t=a_{mt}\left[\left(\frac{\Delta m_t}{m_t}+\frac{\Delta pm_t}{pm_t}\right)-\left(\frac{\Delta k_t}{k_t}+\frac{\Delta u_t}{u_t}\right)\right]+a_{lt}\left[\left(\frac{\Delta l_t}{l_t}+\frac{\Delta w_t}{w_t}\right)-\left(\frac{\Delta k_t}{k_t}+\frac{\Delta u_t}{u_t}\right)\right] \quad (5b)$$

where ΔY_t reflects the growth rate of gross output per unit of capital, and ΔX_t is the growth rate of intermediate inputs and labour expenses per unit of capital. Moreover, according to this formulation, when the value of the price-cost margin μ_t is equal to unity, the market structure is perfectly competitive because the growth rate of gross output is equal to the growth rate of inputs. A value above unity shows that the industry sets a price level higher than the marginal cost of production and thus, it is described by imperfectly competitive conduct.

Consequently, the first step of the analysis will estimate equation (5) for the manufacturing and service industries over 1970-2007 in order to obtain the price-cost margin at the aggregate level. For simplicity, equation (5) is also expressed as

$$\Delta Y_t=\mu\Delta X_t+\varepsilon_t \quad (6)$$

where μ reflects the price-cost margin of the aggregated manufacturing and service industry respectively over 1970-2007. The estimated parameter takes into account the whole panel of manufacturing and service sectors separately in order to obtain an aggregate estimation for both industries.

The second step of the analysis will employ the cross section specification of the Hall-Roeger approach by identifying the price-cost margin of the constituent manufacturing and service sectors individually over 1970-2007. Thereby, equation (6) is transformed into

$$\Delta Y_t = \sum_{i=1}^{N} \mu_i DS_i \Delta X_t + \varepsilon_t \quad (7)$$

where μ_i is the markup ratio of each 2-digit sector i for both industries and DS_i is a cross section dummy variable (i=1,..,N denotes the number of the constituent sectors) which is set to unity for sector i and zero otherwise. This variable allows for the estimation of individual effects reflected by the manufacturing and service sectors on the price-cost margin.

The third and last step of the analysis refers to the time series specification of the Hall-Roeger approach. It provides evidence of the markup level of the aggregate industry for each year over 1973-2007. As a result, equation (6) is transformed into

$$\Delta Y_t = \sum_{t=1973}^{2007} \mu_t DT_t \Delta X_t + \varepsilon_t \quad (8)$$

where μ_t is the annual markup ratio estimated for the manufacturing and service industries separately over 1973-2007 and DT_t is a time dummy variable (t=1973,…,2007 is the number of years) which is set to unity for year t and zero otherwise. This specification will identify the markup value for each year individually for the manufacturing and service industries.

The data set is obtained from the EU KLEMS[6], the AMECO and the World Bank database. The sample comprises of 23 2-digit ISIC manufacturing sectors and 26 2-digit ISIC service sectors over the period 1970-2007 as presented in Table A in appendix. The interpretation of the variables included in equations (6), (7) and (8) is as follows: p_t and y_t reflect gross output price and volume indices respectively (1995=100), pm_t and m_t are the intermediate inputs price and volume indices (1995=100), l_t is the number of employees, w_t is the labour cost expressed in terms of the compensation of employees and k_t is the capital compensation at basic current prices. The observations of these variables were obtained directly by the EU-KLEMS database. On the other hand, the rental cost of capital u_t is obtained by

$$u_t = [(i - \pi_e) + \delta]F_t \quad (9)$$

[6] The EU-KLEMS project aims to create a complete database of economic measures of the manufacturing and service sectors for EU members and the US, Japan and Canada. Some of those measures refer to production, economic growth, capital formulation, labour compensation and gross output. For more information see http://www.euklems.net.

where $(i - \pi_e)$ reflects the real interest rate, F_t is the deflator of fixed asset investment and δ is the depreciation rate which is fixed at 5% across all sectors (Martins et al., 1996). The observations were obtained by the AMECO and the World Bank database and have been fixed for all manufacturing and service sectors.

4. Methodology

The estimation process of the aforementioned equations takes into account the fixed and random effects models in order to identify the individual effects in the panel sample. According to Baltagi (2001), a general case of a one-way linear unobserved individual effects model for *N* individual observations and *T* dated periods has the following form

$$y_{it} = \alpha + X'_{it}\beta + n_i + e_{it}, \text{ for } i=1,\dots,N \text{ and } t=1,\dots,T \quad (10)$$

where y_{it} is the dependent variable for individual *i* and time *t*, α denotes the overall constant term of this regression, X'_{it} represents the transpose time variant regressors' vector (*1xk*), n_i corresponds to the time invariant individual effects term which also addresses the cross-section effects (random or fixed) and e_{it} is the idiosyncratic error term. Unlike the vector of regressors $X'_{it,}$ the time invariant individual effect n_i cannot be easily estimated (i.e. due to historical or institutional factors). The fixed effects model considers that the heterogeneous individual effects term is correlated with the vector of regressors. Since n_i cannot be controlled directly, the fixed effects model demeans equation (10) by using the following transformation

$$y_{it} - \bar{y}_i = (X'_{it} - \overline{X'}_i)\beta + (n_{it} - \bar{n}_i) + (e_{it} - \bar{e}_i) \quad (11)$$

where $\bar{y}_i = \frac{1}{T}\sum_{t=1}^{T} y_{it}$, $\bar{X}'_i = \frac{1}{T}\sum_{t=1}^{T} X'_{it}$ and $\bar{e}_i = \frac{1}{T}\sum_{t=1}^{T} e_{it}$. Since the time invariant individual effect is fixed, the difference from its mean will be zero and thus, its effect from equation (10) is eliminated.

On the other hand, a simple random effects model has the following form

$$y_{it} = \beta_{0i} + X'_{it}\beta_1 + e_{it}, \text{ for } i=1,\dots,N \text{ and } t=1,\dots,T \quad (12)$$

and $\beta_{0i} = \beta_0 + v_i$

By substituting the latter into the former equation, one obtains

$$y_{it} = \beta_0 + X'_{it}\beta_1 + (v_i + e_{it}) \quad (13)$$

where y_{it} is the dependent variable for individual i and time t, β_0 denotes the overall constant term and X'_{it} represents the transpose time variant vector of regressors ($1xk$). Those terms can be viewed as the fixed part of this model. On the other hand, the random part consists of the two terms v_i and e_{it} which are correlated. In particular, v_i is the individual effect for each sector $i=1,\ldots,N$, which is not correlated with X'_{it} and allows for differential intercepts over the given time sample and e_{it} corresponds to the error term. As a result, the random effects model is preferable to the fixed effects model when correlation emerges between the individual effects and the error term of the model. Such effects can be captured by parameter v_i and test whether the fixed or the random effects model is more suitable.

5. Empirical results

The estimation process of the manufacturing and service industries is conducted in three steps under which the Hall-Roeger approach is applied. The first step estimates the price-cost margin of both industries by aggregating the panel sample; the second step provides the markup values for each manufacturing and service sector individually over 1970-2007; and the third step presents the results of industrial pricing decisions for each year over 1973-2007. This process will provide evidence about the degree of market power in the constituent industries and sectors and whether the findings suggest imperfect competitive conduct.

Table 1: Diagnostic test results of the three Hall-Roeger approaches for the Greek manufacturing and service sectors.

Manufacture	Hall-Roeger model (6)	Hall-Roeger cross sectional model (7)	Hall-Roeger time series model (8)
Estimation technique	FGLS	FGLS	FGLS
Breusch and Pagan test (LM)[a]	1334.65** [0.000]	1266.621 ** [0.000]	1323.981** [0.000]
Hausman test[b]	3.940* [0.0471]	201.958** [0.0000]	-
White test[c]	117.026** [0.0000]	239.907** [0.0000]	69.003** [0.0000]
Breusch and Godfrey test (LM)[d]	130.594** [0.000]	113.896** [0.0000]	-
R-squared	0.993	0.997	0.985
Service			
Estimation technique	FGLS	FGLS	FGLS

Breusch and Pagan test (LM)[a]	474.111** [0.000]	1288.703** [0.000]	632.011** [0.000]
Hausman test[b]	51.651** [0.0000]	158.221** [0.000]	-
White test[c]	108.182** [0.0000]	168.201** [0.0000]	61.935** [0.0000]
Breusch and Godfrey test (LM)[d]	75.164** [0.0000]	103.078** [0.0000]	-
R-squared[e]	0.968	0.991	0.966

Notes: The numbers in brackets indicate *p-values.*

[a] H_0: Cross sectional independence (OLS) versus H_1: Cross sectional dependence (Random Effects Model).

[b] H_0: Random Effects Model versus H_1: Fixed Effects Model.

[c] H_0: Homoskedasticity versus H_1: Heteroskedasticity of unknown form.

[d] H_0: No serial correlation versus H_1: Serial correlation of at least $k=4$ order.

[e] $R^2 = 1 - \sum(y - \hat{y})/\sum y^2$ as discussed by Kvålseth (1985), where y is the dependent variable and $\hat{y}$ denotes the fitted value of y.

* Significant at the 5% level of significance.

** Significant at the 1% level of significance.

Table 1 presents the diagnostic tests for each estimated equation under the three step procedure. The first test corresponds to the Breusch and Pagan LM test (Bresuch and Pagan, 1980) for the identification of cross section dependency in the panel sample. The results suggest that the three Hall-Roeger specifications for both industries are subject to such dependency, thus preventing the use of the pooled OLS estimation technique due to this form of contemporaneous correlation. In addition, the fixed effects model is formulated using the dummy variables least squares technique (LSDV); while the random effects model is estimated using the generalized least squares (GLS) in order to take into consideration the presence of correlation between the individual effects and the error term. Therefore, the Hausman test (Wu, 1973; Hausman, 1978) is employed in order to identify which model is best suited under the null hypothesis that the individual effects are not correlated with the explanatory variables. Moreover, White's test (White, 1980) and the Breusch and Godfrey LM test (Bresuch, 1978; Godfrey, 1978) are used in order to identify the presence of heteroskedasticity and serial correlation in the panel data sample.

According to the results, the three specifications for both industries are estimated using the fixed effects model. However, given the presence of heteroskedasticity and serial correlation, the feasible generalized least squares (FGLS) estimation technique is applied in order to take into consideration those problems.

Table 2: Aggregate, cross sectional and time series markup estimations for the Greek manufacturing sectors.

Parameters	Hall-Roeger model	Parameters	Hall-Roeger cross-sectional model	Parameters	Hall-Roeger time-series model
μ	1.180** (406.69)	μ_{15}	1.135** (221.96)	μ_{1973}	1.176** (66.33)
		μ_{16}	1.554** (149.52)	μ_{1974}	1.170** (14.97)
		μ_{17}	1.220** (130.46)	μ_{1975}	1.177** (73.47)
		μ_{18}	1.315** (180.98)	μ_{1976}	1.174** (48.61)
		μ_{19}	1.307** (77.05)	μ_{1977}	1.174** (10.88)
		μ_{20}	1.354** (142.40)	μ_{1978}	1.177** (11.12)
		μ_{21}	1.111** (112.84)	μ_{1979}	1.175** (84.81)
		μ_{22}	1.197** (104.82)	μ_{1980}	1.177** (104.05)
		μ_{23}	1.152** (180.29)	μ_{1981}	1.169** (65.17)
		μ_{24}	1.139** (132.92)	μ_{1982}	1.164** (93.17)
		μ_{25}	1.153** (139.25)	μ_{1983}	1.181** (101.66)
		μ_{26}	1.179** (83.57)	μ_{1984}	1.148** (42.17)
		μ_{27}	1.121** (260.64)	μ_{1985}	1.083** (22.12)
		μ_{28}	1.194** (190.88)	μ_{1986}	1.180** (14.10)
		μ_{29}	1.113** (289.53)	μ_{1987}	-
		μ_{30}	1.340** (40.33)	μ_{1988}	-
		μ_{31}	1.154** (68.27)	μ_{1989}	-
		μ_{32}	1.194** (112.77)	μ_{1990}	1.183** (128.80)
		μ_{33}	1.134** (103.29)	μ_{1991}	1.164** (161.84)
		μ_{34}	1.072** (228.90)	μ_{1992}	1.163** (95.87)
		μ_{35}	1.140** (63.80)	μ_{1993}	1.093** (28.78629)

	μ_{36}	1.447** (48.13)	μ_{1994}	1.135** (15.44)
	μ_{37}	-	μ_{1995}	1.193** (21.24)
			μ_{1996}	1.151** (36.01)
			μ_{1997}	1.182** (67.78)
			μ_{1998}	1.212** (52.23)
			μ_{1999}	1.121** (30.89)
			μ_{2000}	1.146** (50.26)
			μ_{2001}	1.263** (53.83)
			μ_{2002}	1.215** (74.42)
			μ_{2003}	1.244** (60.13)
			μ_{2004}	1.201** (59.42)
			μ_{2005}	1.120** (31.91)
			μ_{2006}	1.212** (62.69)
			μ_{2007}	1.096** (45.83)

Notes: The values in parentheses are *t*-statistics. "-" denotes lack of observations in some variables.
* Significant at the 5% level of significance.
** Significant at the 1% level of significance.

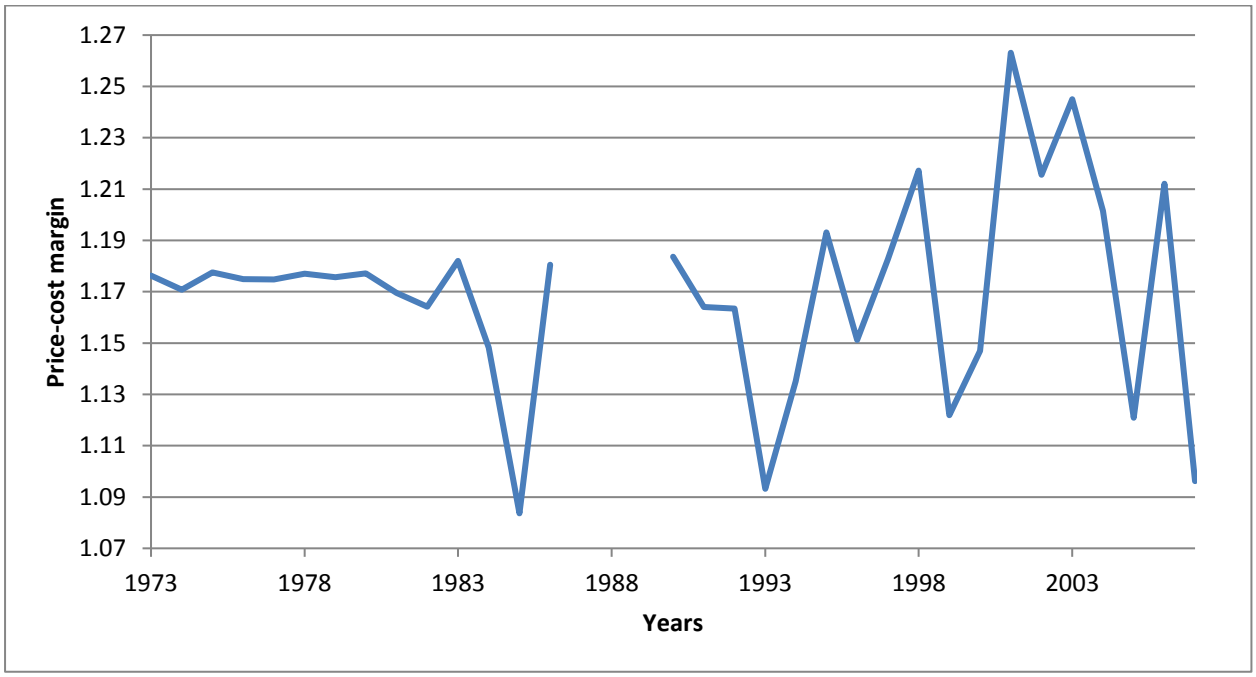
The estimated markups for the manufacturing industry are presented in Table 2. The price-cost margin is equal to 1.180. A value equal to unity suggests that the growth rate of gross output is equal to the growth rate of inputs and thus, the price level is equal to the marginal cost of production. The value of the manufacturing industry shows that the price level exceeds the marginal cost of production by 18% over 1970-2007. As a result, the industry has been operating under imperfect competitive conduct charging a higher price level compared to the one of perfect competition.

The results of the cross section specification are presented in the second column. This particular specification allows the inclusion of cross section individual effects in the panel sample to identify the price markup of each sector according to the value of the whole industry. The values range over 1.072-1.554 suggesting that all manufacturing sectors exert a

positive price markup, thus operating under imperfect competitive conditions. The lowest values are obtained by the sectors of motor vehicles, trailers and semi-trailers (i.e. 34), of pulp paper and paper (i.e. 21) and of other machinery products (i.e. 29). The highest values are estimated for the sectors of tobacco (i.e. 16), of other manufacturing products (i.e. 36) and of wood and cork (i.e. 20). This shows that the markup ratio of the manufacturing sectors is similar to the value of the aggregate industry. The difference between those values may be due to the number of firms operating in each sector and/or their ability to innovate. It is expected that sectors with a limited number of firms will tend to be more oligopolistic compared to sectors with many firms. Also, innovating firms will have the option to charge a higher price level as a result of increasing the quality of their products, thus rendering them more attractive to both domestic and foreign markets[7].

However, in order to conclude that the manufacturing industry operates under imperfect competition, we must also estimate the price-cost margin for each year individually. For this reason, the Hall-Roeger time series specification is applied on equation (6) to identify the annual markup ratios over 1973-2007.

Figure 1: The price-cost margin of the Greek manufacturing industry over 1973-2007.



Source: Estimations of equation (8).

[7] Nevertheless, Giokas, Eriotis and Dokas (2015) argue that the capital stock of the Greek manufacturing sectors was not improved significantly over 1995-2003. This means that technological progress on average was not the main tool of competition.

The results are presented in the last column of Table 2 and illustrated in figure 1. Over the period 1973-1983 the price-cost margin was quite stable around 1.17. However, in the following years (1984-1985) it rapidly fell to 1.08 only to be increased in 1986. An interpretation of this behaviour may refer to the introduction of the Single European Market (SEM) which was about to be implemented in 1987. For this reason, firms tried to attract more customers in the short-run in order to increase their profits.

The markup values over the years 1987-1989 are not available given some limitations in the rental cost of capital. The Single European Market was gradually implemented in 1987 and completed in 1992. It can be seen that the market power in 1990 remained the same as in the previous years, but it gradually fell up to 1993. This outcome may refer to the successful implementation of this framework that enhanced competition in the Greek manufacturing industry through free trading networks with the European countries. In addition, in 1993 there was an attempt to boost the competitive forces of the manufacturing firms by increasing production and reducing the price-cost margins. A number of developmental laws and operational programs, such as the "Operational Programme for Research and Technology II" and the "Industrial Research Development Programme" contributed to the research and technological innovation and infrastructure of the Greek firms (Rezitis and Kalantzi, 2011).

Over the following years there is an increasing trend in the markup ratio with a temporary under-spike in 1999, reaching its climax in 2001. The price level exceeds the marginal cost of production by 26% and the main reason of such increase corresponds to the introduction of the euro currency in the Greek economy. The new currency resulted in additional Purchasing Power Parity for consumers and thus, the manufacturing firms aimed to take into advantage additional levels of consumer surplus created by this shock.

Subsequently, the markup level started to fall, reaching a value equal to 1.20 in 2004, under which the hosting of the Olympic Games occurred. Even if domestic and foreign demand were boosted over this year, the results show that the price-cost margin did not rapidly increase but instead, it remained in a relatively high level. Over the last years, there is a significant increase in 2006 but subsequently, the markup ratio was reduced to a level equal to 1.09. This outcome may have been caused by the increasing price of intermediate inputs[8] over 2007-2009 and the slow adjustment rate of the price level to such changes. In addition, the upcoming financial crisis of 2008 might have rendered the manufacturing firms more

[8] Such inputs refer to rotation soybeans, rotation corn and continuous corn.

reluctant to acquire additional market power due to future demand uncertainty, even when the aggregate economy was growing.

The evidence presented for the manufacturing industry validate the results of Rezitis and Kalantzi (2011, 2012a, 2012b, 2013) and Polemis (2014a, 2014b, 2014c) about the imperfect competitive market structure. The values may vary because of the different data set and the underlying methodology but the empirical suggestions point to the direction of imperfect competition in the industry.

Table 3: Aggregate, cross-sectional and time series markup estimations for the Greek service sectors

Parameters	Hall-Roeger model	Parameters	Hall-Roeger cross-sectional model	Parameters	Hall-Roeger time-series model
μ	1.311** (145.92)	μ_{50}	2.363** (85.47)	μ_{1973}	1.439** (24.90)
		μ_{51}	1.761** (132.30)	μ_{1974}	1.497** (6.31)
		μ_{52}	2.206** (151.60)	μ_{1975}	1.380** (30.68)
		μ_{H}	1.833** (129.51)	μ_{1976}	1.444** (19.89)
		μ_{60}	1.517** (62.40)	μ_{1977}	1.066 (1.30)
		μ_{61}	1.530** (33.51)	μ_{1978}	1.231** (8.13)
		μ_{62}	1.074** (64.10)	μ_{1979}	1.416** (35.31)
		μ_{63}	1.184** (51.38)	μ_{1980}	1.399** (42.45)
		μ_{64}	1.965** (42.32)	μ_{1981}	1.385** (24.18)
		μ_{65}	1.800** (59.61)	μ_{1982}	1.398** (39.17)
		μ_{66}	0.999** (124.19)	μ_{1983}	1.389** (42.03)
		μ_{67}	2.286** (75.89)	μ_{1984}	1.353** (16.24)
		μ_{70}	10.987** (71.32)	μ_{1985}	1.127** (18.42)
		μ_{71}	2.297** (87.41)	μ_{1986}	1.025** (11.11)
		μ_{72}	1.197** (69.98)	μ_{1987}	-
		μ_{73}	1.140** (58.08)	μ_{1988}	-
		μ_{74}	1.840** (40.48)	μ_{1989}	-
		μ_{L}	0.998** (493.34)	μ_{1990}	1.408** (52.49)

	μ_M	1.174** (95.56)	μ_{1991}	1.415** (65.16)
	μ_N	1.708** (91.50)	μ_{1992}	1.359** (42.32)
	μ_O	1.545** (123.40)	μ_{1993}	1.118** (16.16)
	μ_{90}	1.367** (68.90)	μ_{1994}	1.214** (4.65)
	μ_{91}	1.231** (51.49)	μ_{1995}	1.201** (6.50)
	μ_{92}	1.451** (92.32)	μ_{1996}	1.049** (8.64)
	μ_{93}	2.385** (75.72)	μ_{1997}	1.393** (24.19)
	μ_P	-	μ_{1998}	0.999** (8.71)
			μ_{1999}	1.161** (12.65)
			μ_{2000}	1.458** (16.07)
			μ_{2001}	1.397** (24.06)
			μ_{2002}	1.070** (9.78)
			μ_{2003}	1.293** (22.25)
			μ_{2004}	1.366** (19.84)
			μ_{2005}	1.081** (8.19)
			μ_{2006}	1.337** (27.53)
			μ_{2007}	1.383** (14.24)

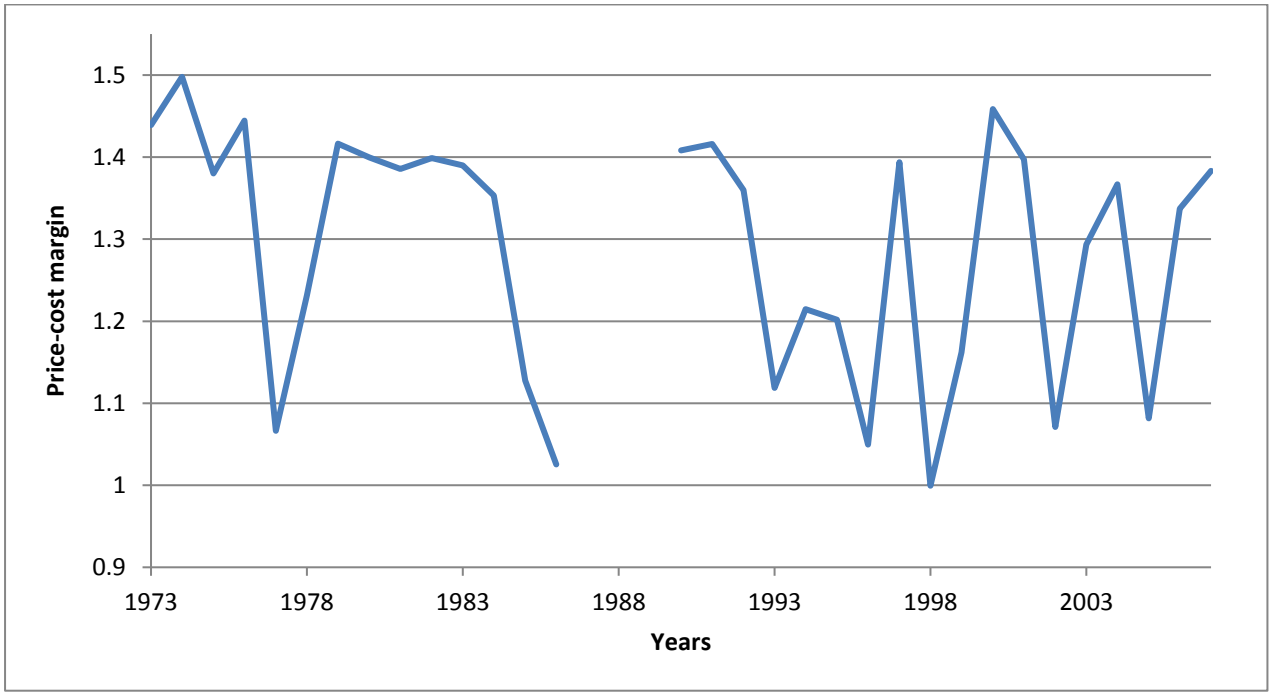
Notes: The values in parentheses are *t*-statistics. "-" denotes lack of observations in some variables.
*Significant at the 5% level of significance.
** Significant at the 1% level of significance.

The markup estimates for the service sectors are presented in Table 3. In particular, the value for the service industry is equal to 1.311 denoting that the industry has been charging a price level 31% higher than marginal cost over 1970-2007. This value is higher compared to the one of the manufacturing industry, thus indicating that the service industry is less competitive. This outcome validates the suggestions of several studies, such as Molnár (2010) and Molnár and Bottini (2010) in favour of higher markup levels exercised by the service industry.

This argument is also validated by the sectorial estimates obtained under the Hall-Roeger cross section specification. The values are presented in the second column of Table 3;

however, there are sectors with high markup ratios and sectors with markups equal to unity. This means that even if the aggregate service industry operates under imperfect competitive conduct, there are sectors that behave according to perfect competition. In particular, the lowest price-cost margins are estimated for the sectors of insurance and pension funding (i.e. 66) and of public administration and defence (i.e. L) which are almost equal to unity. This outcome suggests that the price level of those sectors corresponds to the marginal cost of service provision. The highest values are estimated for the sectors of real estate activities (i.e. 70), and of other service activities (i.e. 93). The latter values reflect a price level that exceeds marginal cost by more than 100% suggesting that the market structure of those sectors is highly oligopolistic. These markup ratios may be interpreted according to the degree of product differentiation, as service provision is considered to be quite heterogeneous across firms and sectors.

Figure 2: The price-cost margin for the Greek service industry over 1973-2007.



Source: Estimations of equation (8).

The third and final step provides the estimates of the service industry for each year over 1973-2007. The markup values are presented in the last column of Table 3 and illustrated in figure 2. Unlike the behaviour of the manufacturing industry, the service industry experienced more volatile fluctuations in the price-cost margin. In particular, the degree of market power is relatively high over the period 1973-1986 where the highest value

is observed in 1974. With the exception of 1977, where the markup rate fell rapidly, the service industry experienced a stable trend over 1973-1984 with an average value equal to 1.40. This may be a result of the limited number of firms operating in the industry over that period. Consequently, limited competition led to increased price-cost margins due to market power acquisition. Over the following years (1985-1986), the price markup fell close to the level of perfect competition, but four years later it converged to its average value. Over the period 1990-1993, the ratio fell due to the implementation of the SEM which enhanced competition. Therefore, the outcome of this framework led to increased competitive interactions in both industries of this study.

The following years are characterized by volatile fluctuations as 1998 is considered to be the year over which the industry was operating according to perfect competition. However, 2000-2001 is a period exerting increased price markups as a result of the new currency. As in the case of the manufacturing industry, the service sectors tried to acquire more profits through the exploitation of consumer surplus due to the increased level of Purchasing Power Parity. In 2002 the markup ratio temporarily fell, only to increase over 2003-2004 because of the hosting of the Olympic Games. A temporary fall is also observed in 2005 but subsequently, the markup trend tends to increase given the conditions of the aggregate economy that allowed for imperfect competitive conduct to persist.

The empirical findings suggest that the pricing decisions of the service industry were different compared to the ones of the manufacturing industry. An interpretation of this outcome may lie on the market power that each constituent sector possesses. In general, the markup ratio of the manufacturing sectors is lower than the service sectors; however, there exist two service sectors that operate according to perfect competition. This means that even if the service industry exhibits a higher price-cost margin than the manufacturing industry, the pricing decisions of the constituent sectors may not be reflected by the aggregate value.

Overall, the manufacturing and the service industries have been operating under imperfect competitive conditions over 1970-2007. The results obtained for both industries validate the presence of positive price-cost margins. However, the values across the manufacturing and service sectors are not similar to the ones obtained by Polemis (2014a, 2014b, 2014c). An interpretation of this outcome may lie on the econometrics procedure and

the panel techniques employed in this study[9]. Moreover, the cross section and time series specification extend the analysis to the investigation of sectorial and annual industrial pricing behaviour. Consequently, the present study complements the argument that (i) the Greek manufacturing and service industries exert positive markup levels and (ii) the service industry is less competitive than the manufacturing industry.

6. Conclusion

This study extended the market power investigation in the Greek manufacturing and service industries by employing the markup model formulated by Hall (1988) and Roeger (1995). The results suggest that both industries appear to have positive price-cost margins over 1970-2007. In addition, the constituent sectors exhibit a positive markup ratio with the exception of two service sectors (i.e. 66 and L) that set their selling price equal to the marginal cost of service provision. These suggestions are complemented by the annual markup values obtained for both industries at the aggregate level over 1973-2007. Consequently, it can be concluded that the Greek manufacturing and service industries operate under imperfect competitive conduct.

A possible remedy that would enhance the forces and incentives of competition in these industries might refer to the re-introduction of developmental and operational programs, as in 1993, that will contribute to the innovative and technological infrastructure of the Greek sectors. In particular, the European Commission (2012) is working on a policy framework for the European Union members under which domestic markets will achieve new levels of growth by developing fully integrated networks that will enhance the economies overall. One of the most important factors that may contribute to this outcome is the enhancement of business environment by introducing opportunities for active and new entrepreneurs.

A possible barrier that prevents such opportunities may refer to barriers to entry due to market power acquisition by the incumbent firms. According to IOBE (2014), the Greek business environment leaves little place for new firms to operate because of the presence of heavy regulation and monitoring imposed by oligopolistic firms. Consequently, barriers to entry in oligopolistic markets should be eliminated so that new entrepreneurs can start their business in the Greek manufacturing and service industries.

[9] Polemis (2014b) suggests that the manufacturing markup on average is higher than the markup ratio of the service industry which contradicts the findings of the present study.

Moreover, the findings of this study complement the arguments of the OECD that the Greek economy and in particular, the manufacturing industry is under-performing (OECD 2012, 2014). There are 555 problematic regulations identified where 329 of them could be improved by enhancing competition. This means that the Greek manufacturing industry is heavily regulated, thus constraining its efficiency and capacity that results in welfare losses and market power exploitation. The second report focuses on the sectors of beverages (i.e. 11); textiles, clothing apparel and leather (i.e. 13, 14 and 15); machinery and equipment (i.e. 28); and coke and refined petroleum products (i.e. 19). The findings are once again in favour of regulations that harm competition. This argument is validated by the positive price-cost margins presented in Table 2. As a result, the OECD makes 88 recommendations on improving legal frameworks by utilizing the EU legislation that minimizes barriers to entry and promotes incentives for innovation.

To this end, innovation can be considered as a significant factor of competition through which firms will achieve economies of scale and diversify their products in order to enhance their sales. If innovation leads to this outcome, particular firms will gain competitive advantage against their competitors. When the same rationale is adopted by every market participant, the degree of imperfect competition will be reduced. Therefore, the Scumpeterian creative destruction will run its course by forcing inefficient and non-competitive firms to exit the market (Reinert and Reinert, 2006).

Overall, the present study provides evidence of an imperfect competitive market structure in the Greek manufacturing and service industries. Future research could take into consideration more disaggregated data at a firm level and test the pattern of the price-cost margin of the manufacturing and service firms. Moreover, the same methodology can be applied in the economies of the European Union and investigate whether the markup ratios across countries appear to be correlated because of the SEM framework. As a result, the market structure in the European manufacturing and service sectors will be investigated over time and be compared to the imperfect competitive structure of the Greek sectors.

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Appendix

Table A: Classification of sectors according to ISIC Rev. 3

15	Manufacture of food and beverages
16	Manufacture of tobacco
17	Manufacture of textiles
18	Manufacture of wearing apparel, dressing And dying of fur
19	Manufacture of leather, leather and footwear
20	Manufacture of wood and of wood and cork
21	Manufacture of pulp, paper and paper
22	Manufacture of printing, publishing and reproduction
23	Manufacture of coke, refined petroleum and nuclear fuel
24	Manufacture of chemicals and chemical products
25	Manufacture of rubber and plastics
26	Manufacture of other non-metallic mineral
27	Manufacture of basic metals
28	Manufacture of fabricated metal
29	Manufacture of other machinery products
30	Manufacture of office, accounting and computing machinery
31	Manufacture of other electrical machinery and apparatus
32	Manufacture of radio, television and communication equipment
33	Manufacture of medical, precision and optical instruments
34	Manufacture of motor vehicles, trailers and semi-trailers
35	Manufacture of other transport equipment
36	Manufacture of other manufacturing products
37	Manufacture of recycling
50	Sector of sale, maintenance and repair of motor vehicles and motorcycles; retail sale of fuel
51	Sector of wholesale trade and commission trade, except of motor vehicles and motorcycles
52	Sector of retail trade, except of motor vehicles and motorcycles; repair of household goods
H	Sector of hotels and restaurants

60	Sector of inland transport
61	Sector of water transport
62	Sector of air transport
63	Sector of supporting and auxiliary transport activities; activities of travel agencies
64	Sector of post and telecommunications
65	Sector of financial intermediation, except insurance and pension funding
66	Sector of insurance and pension funding, except compulsory social security
67	Sector of activities related to financial intermediation
70	Sector of real estate activities
71	Sector of renting of machinery and equipment
72	Sector of computer and related activities
73	Sector of research and development
74	Sector of other business activities
L	Sector of public admin and defence; compulsory social security
M	Sector of education
N	Sector of health and social work
O	Sector of other community, social and personal service
90	Sector of sewage and refuse disposal, sanitation and similar activities
91	Sector of activities of membership organizations
92	Sector of recreational, cultural and sporting activities
93	Sector of other service activities
P	Sector of private households with employed persons